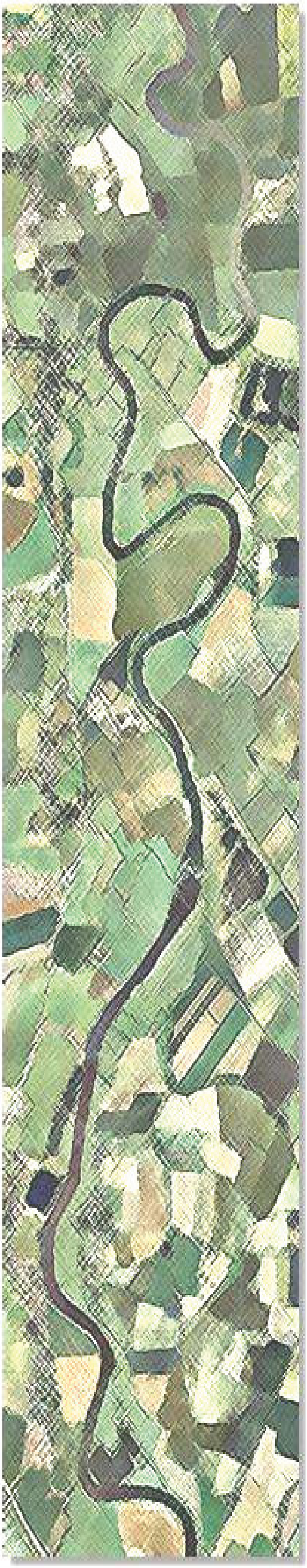

ASSESSING THE GEOARCHAEOLOGICAL DEVELOPMENT OF CATCHMENT TRIBUTARIES AND THEIR IMPACT ON THE HOLOCENE EVOLUTION OF THE RIVER TRENT

Draft Assessment Report

Funded by Aggregates Levy Sustainability Fund
Administered by English Heritage

Keith Challis, Andy J Howard, Derek Moscrop and Emma Tetlow

Trent Valley GeoArchaeology

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PN3850

ENVIRONMENT AGENCY

Supported by the Environment Agency

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Draft Assessment Report

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June 2006

PNUM 3850

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1 INTRODUCTION

1.1 BACKGROUND

This report documents the results of geoarchaeological assessments of two of the principal tributary valleys of the Trent (the Rivers Dove and Idle) undertaken to assess the impact of their evolution on the main valley floor. Study of the Idle and Dove was complimented, to a limited extent, by consideration of two lesser valleys, (the Devon and the Dover Beck; Figure 1) with the overall aim of identifying landscapes and resources in these tributaries that might elucidate key issues in the study of the main Trent Valley.

Study of these tributary valleys is considered important both because of the direct impact of past, present and future aggregate extraction on their cultural heritage and landscape and because research in other major river systems suggests that cultural and climatic signals are less blurred in tributary systems (Brown and Quine, 1999) and their study can therefore provide a detailed understanding of processes occurring upon the main valley floor.

For example, in the Trent river system study of human impact and environmental processes in tributary valleys might be expected to elucidate the apparent onset of large scale alluviation during the Romano-British period (*cf* Buckland and Saddler, 1985) or the reworking of large parts of the main valley floor from the Neolithic (Salisbury *et al.,* 1984). Overall, the study contributes information to inform strategic management of the geoarchaeological resource in the tributary valleys and enhance understanding of the Trent Valley itself.

1.2 REPORT STRUCTURE

This document reports on the collation and analysis of a variety of historic environment record (HER) and remotely sensed data in the project GIS and on a programme of fieldwork aimed at assessing the geoarchaeological character of the studied river valleys and recovering sample for palaeoenvironmental assessment. As far as is possible, given the novel nature of the work, the report is delivered in the guise of a MAP2 Assessment Report. An updated project design, describing a programme of further analysis of selected project data will be delivered under separate cover.

Section one of the report comprises a brief introduction describing the study areas and the aims and objectives of the work. **Section two** comprises an assessment of the geoarchaeological record compiled from HER data, remote sensing and field investigation. **Section three** comprises an assessment of the subsurface geology and geometry of the drift deposits in the studied valleys compiled form analysis of borehole records and through fieldwork. Section four comprises an environmental assessment of the studied valleys based on field investigation and analysis of the past work of others. **Section five** presents a summary and some conclusions and **section six** comprises a full bibliography.

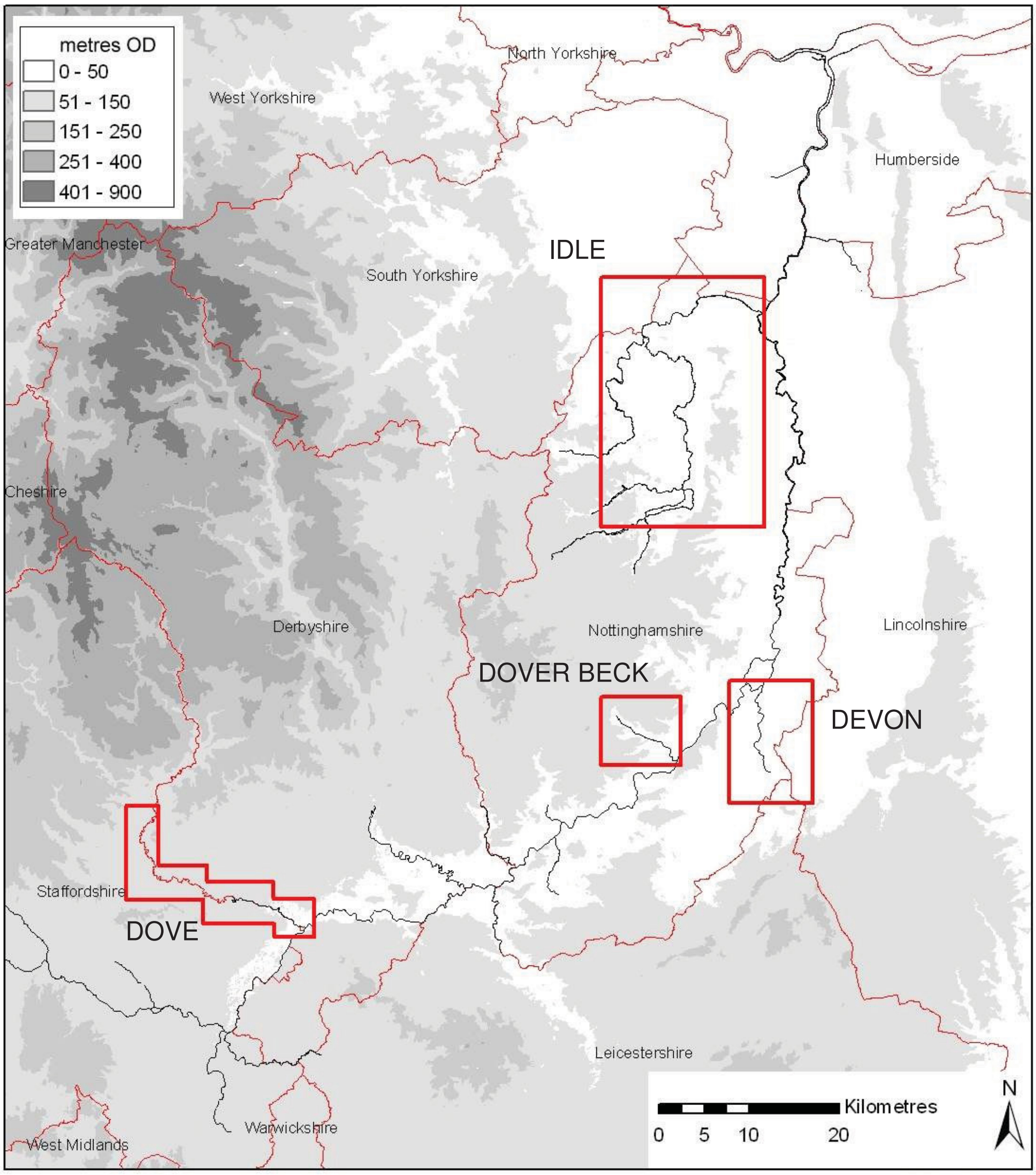


Figure 1. Topographic map of the midlands showing the Trent river system and the two principal and two supplementary tributary study areas.

1.3 THE STUDY AREAS

The research has examined two of the principal tributary valleys of the Trent: the Dove (joining the upper Trent opposite Newton Solney: Figure 2) and the Idle (joining the lower Trent at West Stockwith; Figure 3). In addition, some supplementary additional study has been undertaken on two lesser and physiographically contrasting valleys, the Dover Beck (joining the middle Trent at Caythorpe; Figure 4) and the Devon (joining the middle Trent at Newark; Figure 4). These valleys were selected to provide contrasting physiographic contexts, land-use histories and geomorphological inputs and processes, which have all been demonstrated through empirical research to affect thresholds within the geomorphic system and hence the evolution of the valley floors.

The Idle and Dove Valleys are directly affected by aggregate extraction (at Misson, Sutton and Lound, Finningley, Blaco Hill, Tiln, Scrooby, Eggington and Leasowes Farm), the Devon and Dover Beck are not presently affected by aggregated extraction, but geological survey mapping shows the presence of river terrace sand and gravel deposits that are potentially of commercial value. Details of future aggregate extraction proposals within the study areas are contained within the Mineral Local Plans (MLP) produced by Nottinghamshire, Derbyshire and Staffordshire Councils, which cover strategic planning up to 2006.

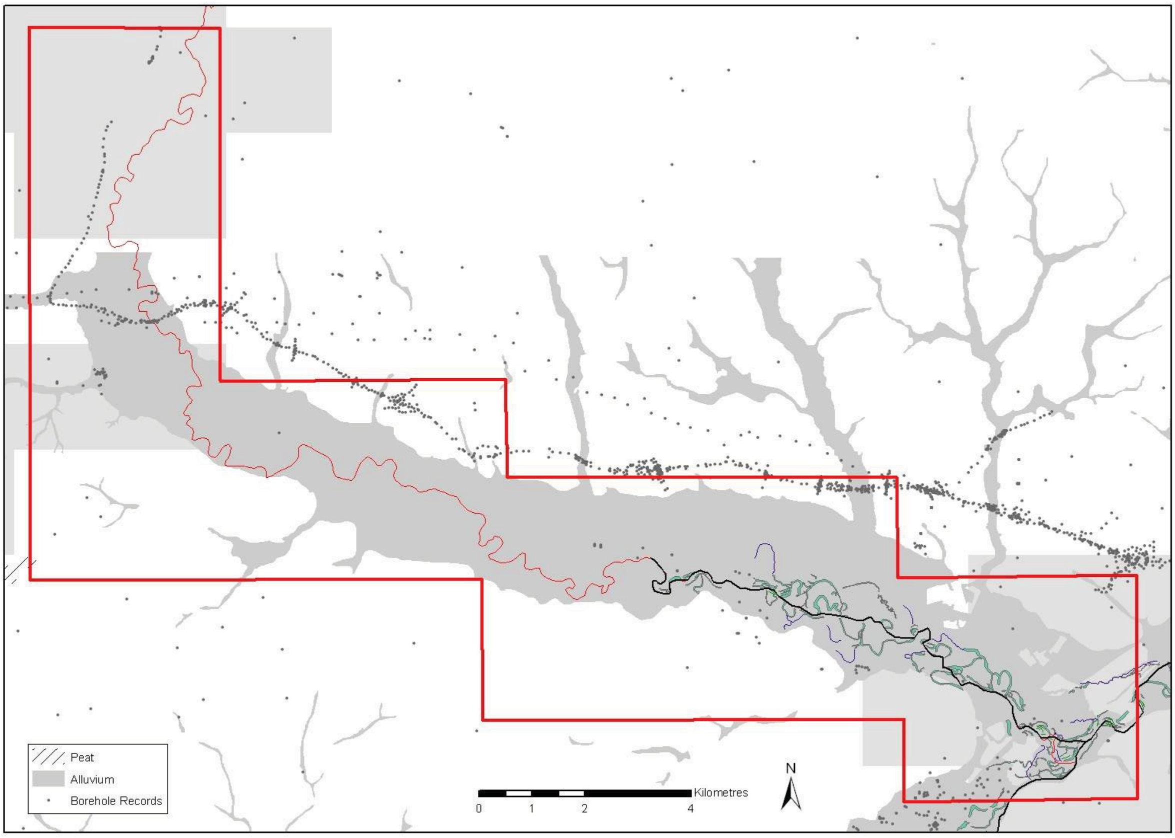


Figure 2. The Dove study area in relation to the upper Trent Valley. The map includes information from the TVG2002 GIS, including palaeochannels of the Trent. The maximum extent of the study area is indicated by the red outline. Pale grey tone indicates the limited extent of lidar data available from EA.

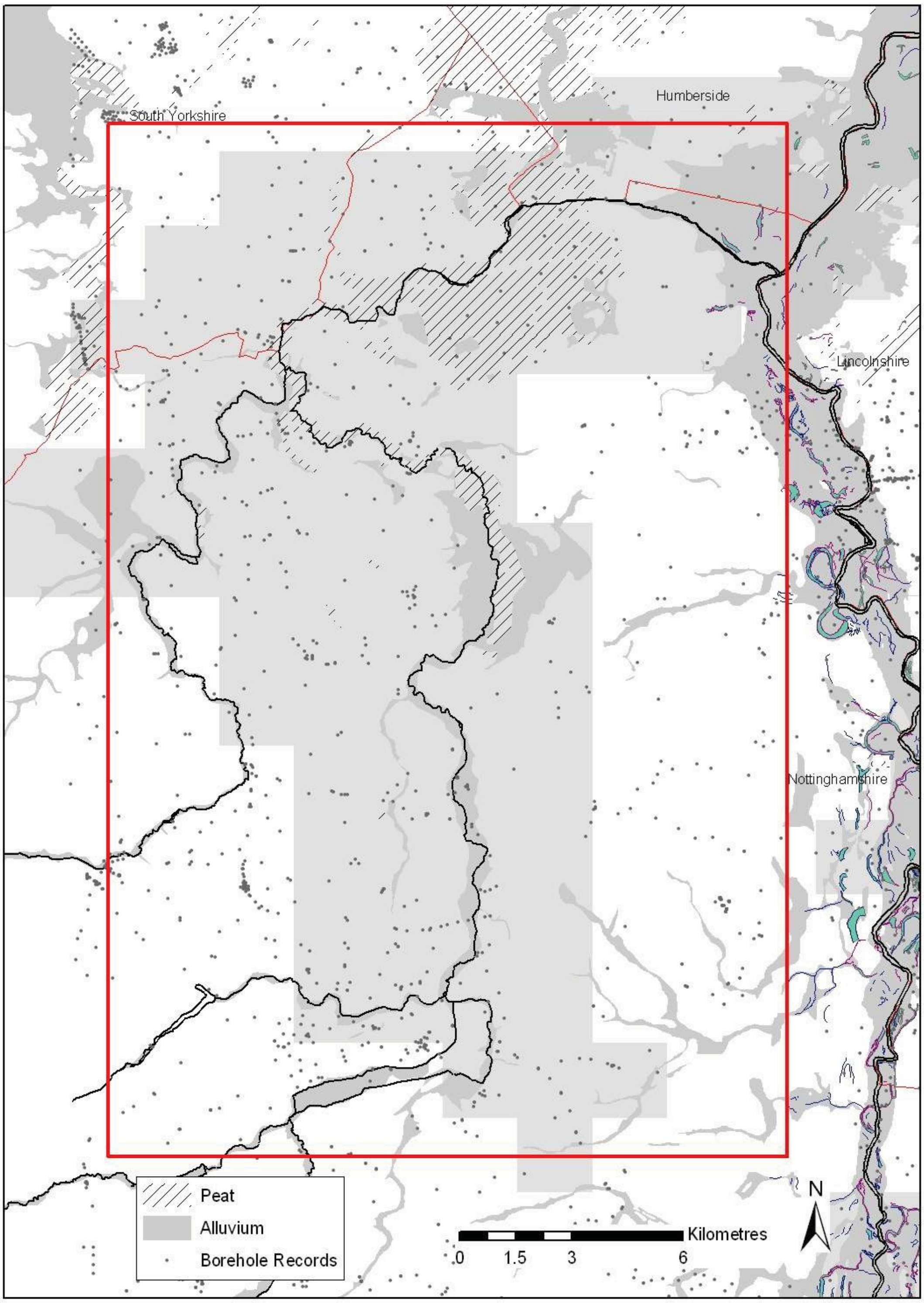


Figure 3. The Idle study area in relation to the lower Trent Valley. The map includes information from the TVG2002 GIS, including palaeochannels of the Trent. The maximum extent of the study area is indicated by the red outline. Pale grey tone indicates the extent of lidar data available from EA.

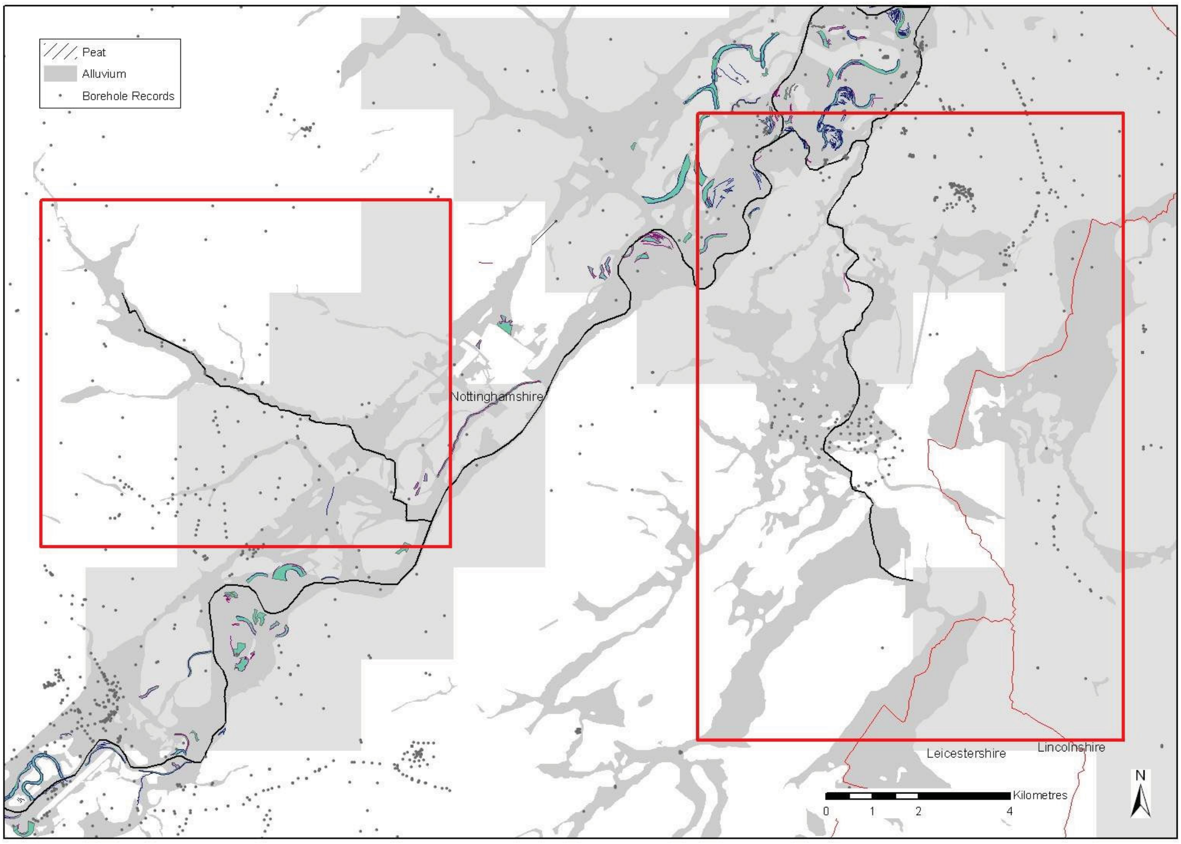


Figure 4. The Devon and Dover Beck study areas in relation to the middle Trent Valley. The map includes information from the TVG2002 GIS, including palaeochannels of the Trent. The maximum extents of the study areas are indicated by the red outline. Pale grey tone indicates the extent of lidar data available from EA.

1.4 AIMS AND OBJECTIVES

A number of specific research and management questions were posed as part of this study:

- Identification of key areas in which each studied tributary valley contributes to major themes in the archaeology and landscape development of the Trent river system.
- Identification and spatial isolation of areas of key significance so as to produce a landscape risk map of the tributary valleys (*cf* TVG 2002 component 4)
- Assessment of the impact of proposed future aggregate extraction in the study area in terms of areas of significant geoarchaeological resource.
- Review understanding of the geoarchaeological resource of individual tributary valleys and their catchment-wide significance and contribution to strategic management decisions in the main Trent Valley.

In order to address these broad objectives, the proposed research comprised two interlinked modules focused around (1) mapping of landform assemblages, (2) alluvial architecture and palaeoenvironmental analysis. The research was programmed to take place in two phases (following the guidelines set out in MAP2) and this report documents the results of Phase 1: data collection, integration, fieldwork and assessment report, archive and project design for phase 2. It should be noted that the Updated Project Design will be submitted once the results of radiocarbon age estimates for selected sediments have been received from the Scientific Dating Team at English Heritage (estimated July 2006).

Phase 2 will comprise comprehensive analysis of data gathered in phase one and lead to further archive, reporting, publication and dissemination of the results of the research. Phase 2 will be completed by March 2007.

2 ASSESSMENT OF THE SURFACE GEOARCHAEOLOGICAL RECORD

2.1 METHODOLOGY

In order to elucidate the evolution of the tributary valley floors, palaeochannels and other landforms were identified and mapped from rectified aerial photographs and lidar elevation data. The work was conducted according to the methodology developed by Baker (2003) for mapping landform assemblages in other areas of the Trent Valley. All data were collated within a project Geographical Information System (GIS). The GIS was developed using ESRI's ArcGIS 9.1, which provides compatibility with the system devised for Trent Valley Geoarchaeology 2002 (PNUM 3307). The GIS includes:

- Base map data - Edina Digimap 1:10,000 and 1:50,000 Ordnance Survey mapping, Edina Digimap Ordnance Survey historic mapping, British Geological Survey drift geology mapping and Historic Environment Records data;

- Raster lidar and IFSAR elevation data. Selected raster lidar intensity data;

- Polygon and polyline shapefile data showing palaeochannels, digitised from rectified vertical aerial photographs and lidar elevation data;

- Attribute data, attached to each palaeochannel, recording information such as the location and character of mapped channels, and the original information source for each feature.

2.2 GIS BASE MAP

2.2.1 Ordnance Survey topographical mapping

Ordnance Survey 1:10,000 and 1:50,000 scale raster images, supplied as 5km² and 20km² tiles, were downloaded, in TIF format from the EDINA Digimap service and assembled to provide general topographical coverage for the project study areas. The 1:50,000 mapping was also used, in conjunction with lidar to provide spatial reference information for geo-referencing aerial photographs.

2.2.2 Drift geological mapping

British Geological Survey 1:50,000 DigMap geological mapping covering the study areas (excluding the upper Dove Valley) was already available to the project from the TVG 2002 study. The remaining data required for the River Dove (Ashbourne, Sheet EW124) was obtained using the existing TVG licence. The DigMap data, supplied as 20km² tiles in ArcView shapefile format, was assembled to create seamless drift geology maps for the project study areas. This data was then filtered to produce maps showing drift geological formations of particular relevance to the present study – i.e. (Devensian and Holocene) sand and gravel terraces and (silt and clay) alluvium. The filtered maps were also used to refine the project area for borehole data acquisition using in subsurface assessment.

2.2.3 Historic Mapping

Ordnance Survey 1st Edition historic mapping, supplied as 5km² tiles in raster TIF format, was downloaded from the Edina DigiMap service. In addition, a selection of earlier mapping was scanned and geo-referenced for the project. This comprised:

- George Sanderson's 1835 Survey of '*Twenty miles around Mansfield*', covering the Idle, Devon and Dover Beck study areas.
- Burdett's survey of Derbyshire 1767 (1975 reprint), covering the Dove study area.

It proved impossible to locate a copy of Yates' survey of Staffordshire 1775 (for the Dove survey area) suitable for scanning and geofererencing. The omission of this anticipated source of historic mapping was felt to be more than compensated for by the inclusion of OS historic mapping, made possible by the completion of a CHEST agreement for supply of these data between UK Universities and the Ordnance Survey.

The historic mapping was particularly useful for identifying aspects of floodplain topography associated with recent river engineering and channel changes.

2.2.3.1 Geo-referencing of historic maps

The early maps were scanned as JPG raster images (a format which is compatible with ESRI's ArcGIS geo-referencing software) at a resolution of 150dpi. The scans were then trimmed to remove borders and any other erroneous information and imported into ArcGIS for geo-referencing using the same methodology adopted for the APs outlined in Section 2.3.

The Sanderson maps were rectified using the 1st Edition digital mapping supplied by EDINA. The early OS maps were preferred to modern mapping for this purpose as they generally provided more corresponding reference control points. On the 1st Edition maps, in most areas, there had been little change to the landscape since the publication of the Sanderson survey, whereas some other parts of countryside had been radically altered on the modern mapping. The 1st Edition maps were also very accurate in relation to the digital OS 1:10,000 mapping, displaying a relatively low general error of between 5m and 10m. The geo-referenced Sanderson scans that were produced were accurate to between 25m and 50m. This reasonably high degree of error was introduced by the slightly formalised 'rectilinear' style of depiction of features on the 1835 map. The geo-referenced scans were still, however, accurate enough to allow river courses on the historic and modern maps to be compared.

Burdett's 1767 map was geo-referenced using a combination of the 1st Edition and modern 1:10,000 and 1:50,000 OS mapping. Due to the larger scale and less detailed nature of depiction of the survey, it was difficult to identify many corresponding locations on the historic and modern mapping. The resulting rectified scans of Burdett's map displayed a particularly large error of between 70m and 115m and could only be used to make generalised observations regarding landscape development.

2.2.4 Historic Environment Record (HER) data

In order to allow an understanding of past settlement, land use and exploitation of the floodplain, terraces and adjacent areas of each tributary valley, the following HER has been incorporated into the project GIS:

- Sites and Monuments Records (SMR)
- National Mapping Programme (NMP) air-photo cropmark plots
- National Monument Record (NMR) AMIE (formerly Monarch) data

The SMR data for the River Dove study area was obtained from Staffordshire and Derbyshire County Councils. The data for Derbyshire was provided as MapInfo MIF files, which were converted to shapefile point, line and polygon format for incorporation into the project GIS (using ESRI's MIF to Shape converter). The Staffordshire SMR information was supplied as an Excel Worksheet containing X and Y co-ordinate points for each site. This data was imported into ArcGIS and the information was then used to create shapefile point data. Data for the remaining study areas was provided by Nottinghamshire County Council in MapInfo MIF format. The data was converted to shapefile polygon, polyline and point format using the method described previously.

English Heritage's National Mapping Programme (NMP) air-photo cropmark plots were provided as geo-referenced raster images by the National Monument Record (NMR). The plots were supplied as 5km² tiles in TIF format. The data covered all of the project study areas apart from the River Dove where only limited mapping has been carried out.

The air-photo plots were converted to vector format to produce simple line-work using the ArcScan module of ArcGIS. Anomalous data on the plots was removed using the ArcGIS editing extension. The MORPH2 tabular databases, which contain the attribute information for the cropmark sites, were also supplied by the NMR.

NMR AMIE (formerly Monarch) monument and event data was also obtained for the project. The data for each study area was provided as polygon, polyline and point shapefiles. The monument data was supplied with attached attribute data, including a field entitled 'Summary' providing period information and monument type for each site. Period and site type information for the event data was included on 'Activity Report Forms', which were provided in PDF format by the NMR. The relevant information from the forms was edited and attached as attribute data to the event shapefiles for each study area.

2.3 AERIAL PHOTOGRAPH ACQUISITION AND PROCESSING

In general, acquisition, digitising, processing and analysis of air-photography within the present project has followed the method adopted for Trent Valley Geoarchaeology 2002 (Baker 2003), which used vertical photographs from two decades (1940s and 1970s). The majority of the late photographs obtained for the project were sourced from the 1970s commercial county survey collections held at the county SMRs. Additional late photography (taken between 1970 and 1993) was obtained from the NMR air-photo archives. In this instance, photographs were only selected if they showed additional geoarchaeological information, or if they helped to elucidate the nature of possible palaeochannel features identified on the county council prints.

RAF verticals taken in the 1940s and 1950s were acquired from the NMR. In particular, the early photographs were used to identify palaeochannels and other significant landscape features that were not visible on the later prints because they had had been destroyed by ploughing, gravel extraction or other forms of development.

2.3.1 Identification and acquisition

The 1970s photographs were sourced from the collections of Nottinghamshire and Derbyshire County Councils. The Derbyshire photographs were scanned by the county council, whilst the Nottinghamshire images were digitised on site by project staff from the original prints. Both sets of photographs were scanned at 150dpi to TIF format. No charge was made for the scans by either organisation (copyright for the photographs having been recently transferred to the county councils by former owners: Simmons Aerofilms; Chris Mawson, Simmons Aerofilms Library Manager, pers comm).

A cover search of the NMR air-photo archive was commissioned to identify flights covering the project study areas. In total, 1626 individual sorties were identified by the search. To reduce this amount to a manageable level, it was decided to only examine photographs from flights that took in the river corridors of each tributary valley. Also, to reduce the number of prints for the larger tributaries (the Dove and Idle), a selection of sorties from sample areas was examined at the NMR to identify high quality images, preferably from sorties that were flown at a time of year when conditions were favourable for the visibility of palaeochannels and other landforms. Where possible, subsequent air-photo collation for the Dove and Idle study areas was concentrated on the key sorties identified by this process. A single sample of sorties, with a primary focus on early flights, was examined for the River Devon and the Dover Beck.

Early RAF coverage was collated covering the majority of the floodplain and lower terraces of the Dove, Idle and Devon. No early air-photos were acquired from the sorties examined for the Dover Beck, as these were generally found to be either of poor quality, or they did not provide any useful supplementary information to that shown on the later prints. A selection of later photographs providing additional or complementary information to the 1970s images acquired from the SMRs, was also obtained from the NMR for the Idle and Dove study areas. The prints were scanned at 150dpi by the NMR and delivered in TIF format. Details regarding the air-photos collated for the project are summarised in Table 1.

Table 1. Details of the air-photos collated for the project.

	NMR Early	NMR Late	DCC	NCC	Study Area Totals
Dove	24	14	19	NA	57
Idle	72	40	NA	97	209
Devon	15	0	NA	26	14
Dover Beck	0	0	NA	14	41
Total	111	54	19	137	321

2.3.2 Processing and geo-referencing

The air-photo scans were trimmed to remove borders and imported into ArcGIS for geo-referencing. The minimum-maximum stretch facility within ArcGIS was used to edit colour ramp values in order to emphasise particular tonal areas within each image. The ArcGIS Effects Module was also used to adjust the contrast and brightness of the images.

A pre-selection process was carried out to reduce the number of photographs to be rectified. The main exception to this rule was the early coverage for the Dove, which was particularly good for identifying palaeochannel features; hence all of these scans were geo-referenced (excluding the extreme eastern part of the study area for which no suitable coverage was available). A selection of the late prints provided by the NMR for the River Idle study area were geo-referenced because they provided extra or complementary data to the rectified scans.

The scans were rectified using ESRI's ArcMap 9.0 Geo-referencing Module. A combination of lidar data, where available, and digital OS 1:10,000 mapping was used to provide reference control points for rectifying the images. lidar, which has a high spatial resolution, is an ideal tool for geo-referencing, although digital 1:10,000 mapping provided a suitable alternative where the latter was not available. The photographs were re-sampled using a 2^{nd} Order Polynomial Transformation, which required a minimum of six control points, although, in general, to obtain an even stretch across the whole of the image, an average of nine points had to be used. An acceptable residual RMS (root mean square) error of <5m was achieved for the majority of the rectified prints. The scans were re-sampled to TIF format to produce rectified images at a resolution of 1 pixel = 1.25m.

2.4 LIDAR ACQUISITION AND PROCESSING

Lidar data was provided by project partners the Environment Agency as part of their contribution to this research project. The data was supplied as 2m spatial resolution elevation product provided as ArcGIS ASCII grid files, which were converted to ArcGIS raster grid format for incorporation into the project GIS using the ArcMap ASCII to Raster Conversion Module.

A lidar Digital Surface Model (DSM) was created for each study area, which was examined to identify significant landscape features, such as palaeochannels and terraces. lidar data was available covering all of the River Idle floodplain (Figure 5) and the majority of the Dove Valley (Figure 6). Partial lidar coverage was only available for the River Devon and the Dover Beck (Figure 7). In addition, the lidar DSM was used to provide "elevation at surface" values for borehole assessment and three-dimensional sub-surface modelling (see Section 3). The lidar DSM was also used, in conjunction with Edina Digimap 1:10,000 mapping to provide reference control points for rectifying air-photos (see Section 2.3.2).

2.5 ANALYSIS OF EA FP, LP AND LIDAR BACKSCATTERED INTENSITY

The normal EA lidar data product comprises a digital surface model (DSM), filter mask and bare earth digital terrain model (DTM). Access to original unprocessed lidar data make possible the generation of DSM from first pulse (FP) and last pulse (LP) laser returns (Challis, 2005b) as well as examination of the intensity of the laser return. These latter data provide an indication of the amplitude of reflection of the laser pulse. Initial examination suggests that there is a fall-off in the intensity of the reflected light that corresponds with landscape features such as palaeochannels. Variations in the reflectivity of various earth surface materials to laser light of differing wavelength are quite well documented and damp soil conditions are known to reduce reflectivity. It is possible that the increased soil-moisture associated with palaeochannels and perhaps other associated variations in soil and vegetation properties, are responsible for the reduced reflectivity of the laser pulse.

Systematic study of FP and LP returns has been undertaken as part of other English Heritage funded studies by the present authors (Trent-Soar, PN 3357; Challis, 2005a) and is not duplicated here. Study of the utility intensity data for characterising earth surface materials is underway as part of a further English Heritage funded study (Lidar Intensity, PN 4782; Challis *et al* 2006). For the present study Environment Agency were able to supply original first pulse, last pulse and intensity data for a small part of the Idle Valley around Retford in the form of an ASCII XYZI point cloud. These data were processed using QT Modeller software to generate continuous surfaces based on FPZ, FPI, LPZ and LPI returns (Figure 8). These data were examined within ArcGIS to determine to what extent geomorphological features identified using other techniques, or from the standard EA lidar product, might be better distinguished using unprocessed data and the results incorporated into the overall geomorphological mapping of the study areas.

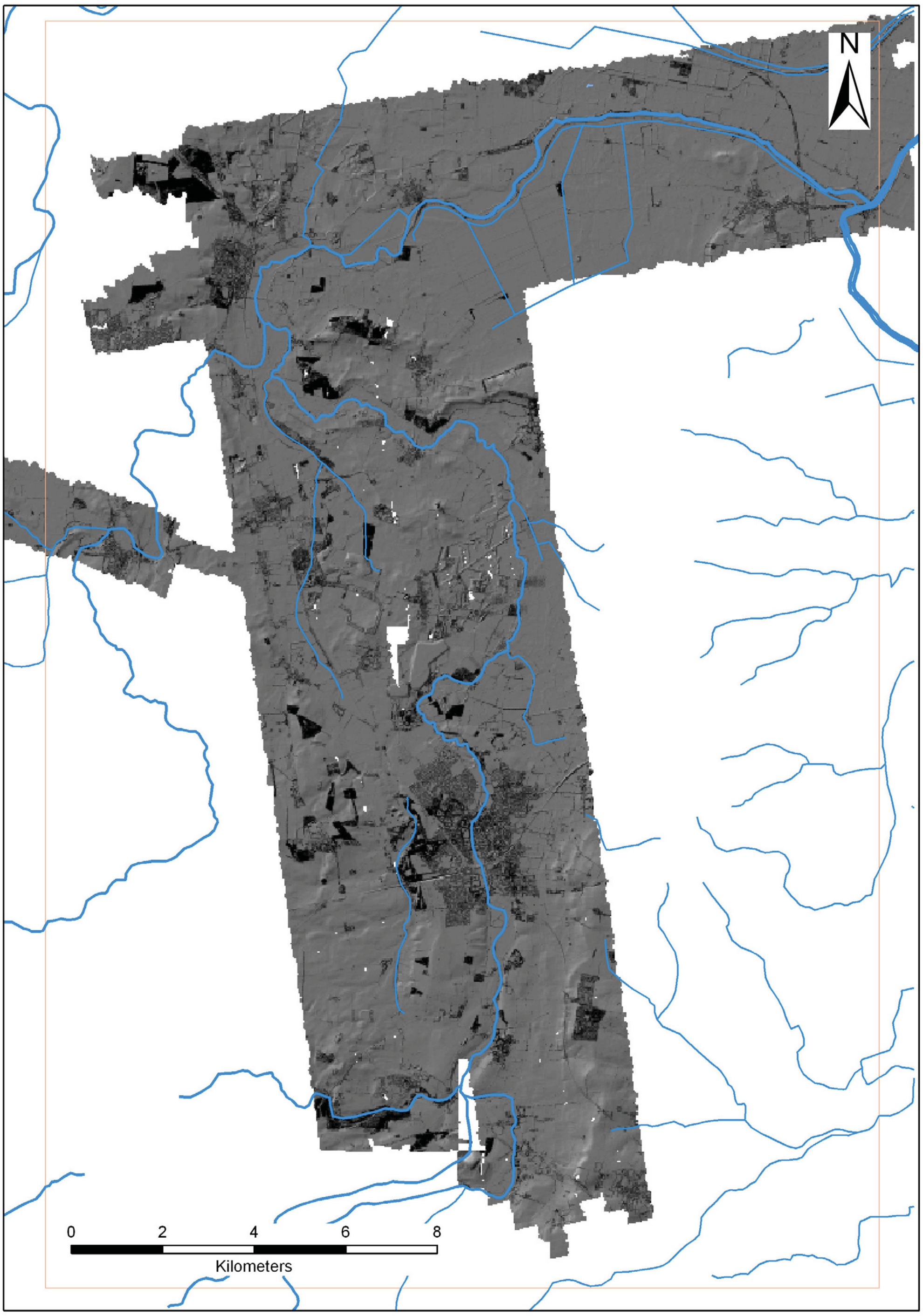


Figure 5. lidar coverage for the River Idle study area

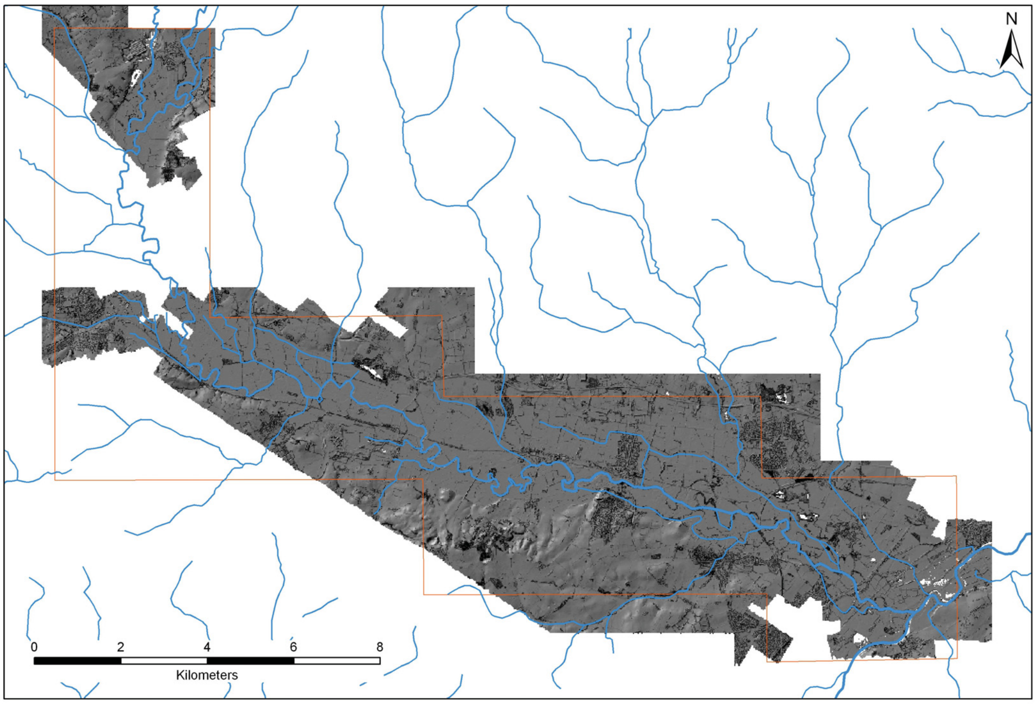


Figure 6. lidar coverage for the River Dove study area

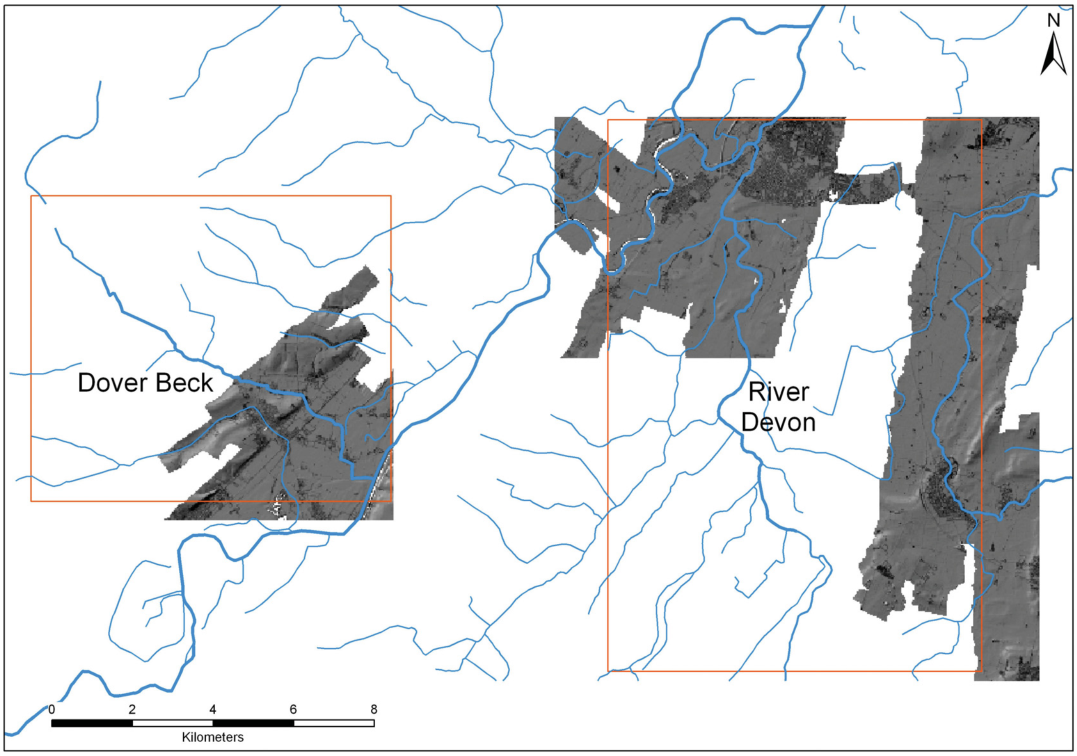


Figure 7. lidar coverage for the Dover Beck and River Devon study areas

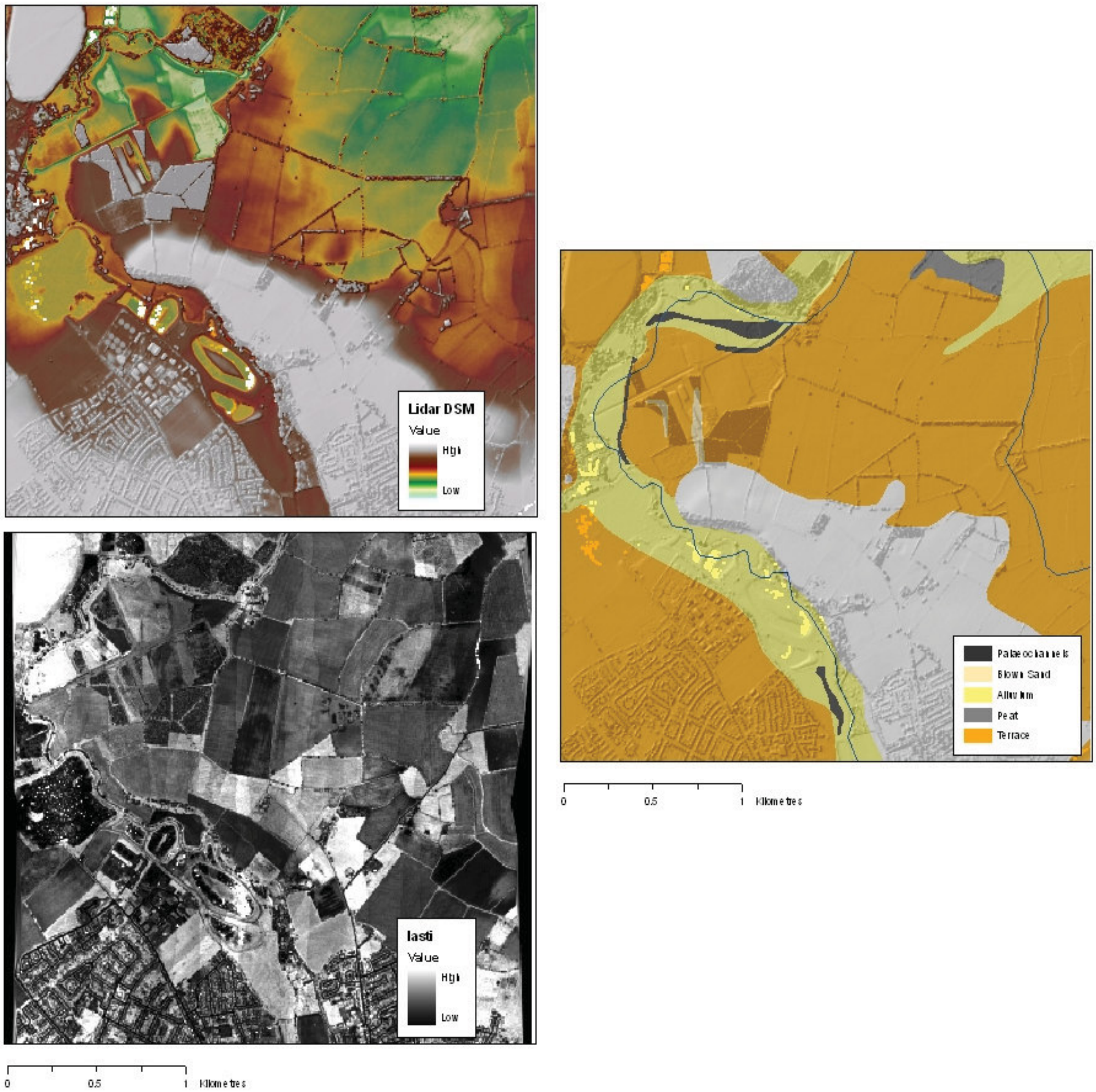


Figure 8. Lidar DSM (top) and last pulse intensity (bottom) for part of the Idle Valley near Retford. Mapped geology and palaeochannels shown for comparison.

2.6 IFSAR ACQUISITION AND PROCESSING

In addition to lidar elevation data, a lower resolution elevation product derived from airborne radar survey was incorporated into the project GIS. Airborne radar uses radio waves to measure the distance between an aircraft mounted senor and the ground surface. Interferometry relies on picking up the returned radar signal using antennas at two different locations. Each antenna collects data independently, although the information they receive is almost identical, with little separation (parallax) between the two radar images. Instead the phase difference between the signals received by each of the two antennas is used as a basis for calculating changes in elevation. The results are enhanced by using processing techniques during data collection to generate a synthetic aperture of much greater size than the physical antenna used and so enhance resolution (Intermap, 2003). Combining the principals of Synthetic Aperture Radar with Interferometry, Interferometric Synthetic Aperture Radar (IFSAR) is capable of producing both a radar image of the ground surface and calculating elevation changes to enable production of a digital surface model (DSM).

Intermap has undertaken IFSAR surveys of the entire of the UK. The results of the surveys are available in the form of 5m spatial resolution DSM with a vertical accuracy of between 0.5 and 1.0m and a 1.25m spatial resolution radar image. The project acquired an IFSAR DSM for the entire study area (Figure 9).

IFSAR DSM data in ASCII raster format were imported into the project GIS for processing and analysis. Assessment of the IFSAR DSM complemented that for the lidar DSM (ie mapping of significant landscape features to support field mapping, provision of elevation data for boreholes and geomorphological modelling of landscape development). The lower resolution of the IFSAR DSM when compared to lidar limited its effectiveness in defining fine landscape detail and IFSAR has generally proven an unsatisfactory source of elevation data for identifying and mapping landscape features of archaeological and geomorphological significance. In the event, the greater than anticipated extent of the lidar coverage has meant that IFSAR has been little used to achieve anticipated research outcomes.

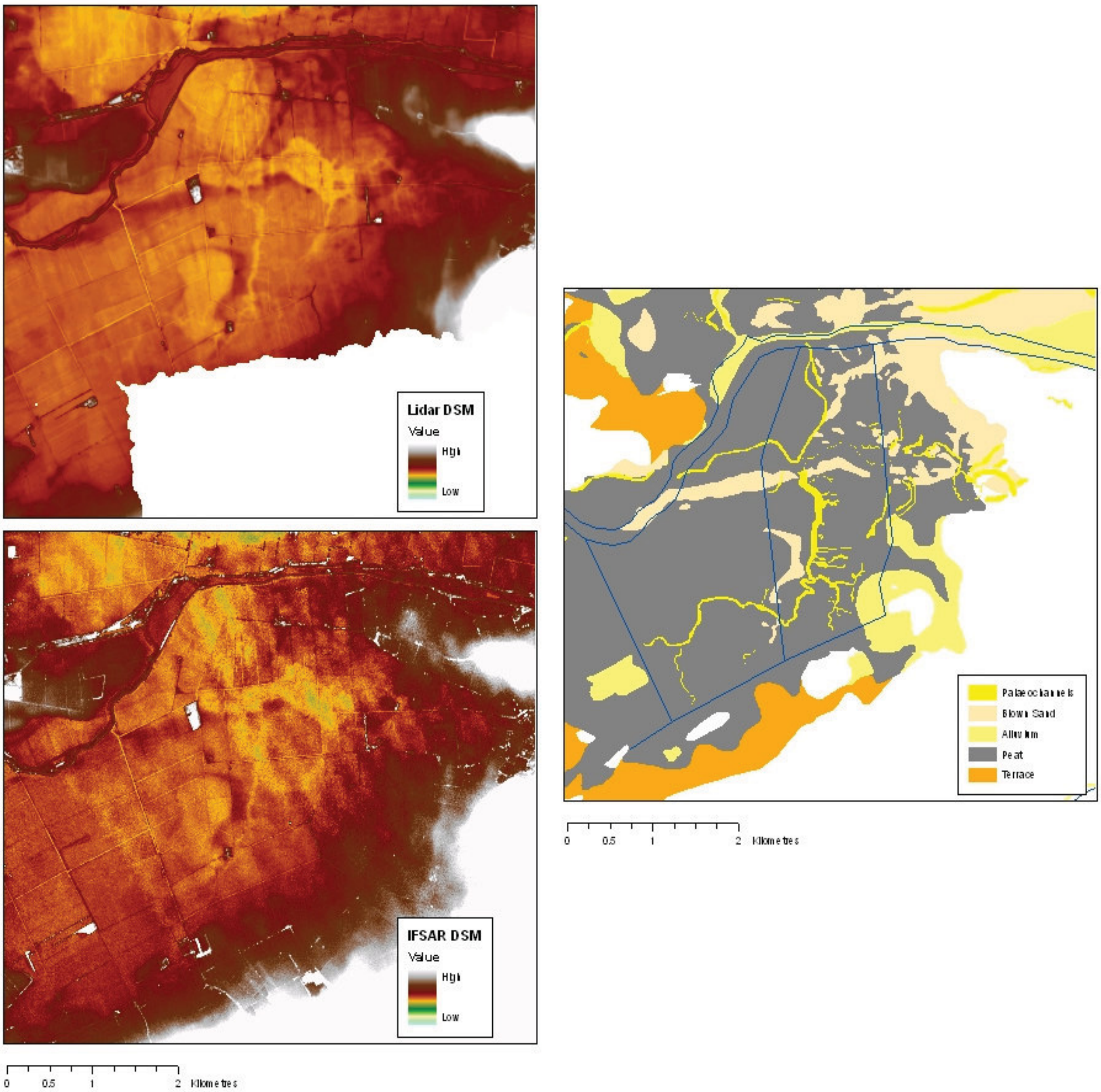


Figure 9. Comparison of Lidar (top) and IFSAR (bottom) digital surface models of the Idle Valley around Misterton Carr showing the extent to which each elevation source is able to define geomorphological features. Mapped geology and palaeochannels mapped from air-photographs and lidar are shown for comparison.

2.7 LANDFORM ASSEMBLAGE IDENTIFICATION AND PLOTTING

The most distinctive and ubiquitous landforms mapped from aerial photographs and lidar comprised palaeochannels. Following Baker (2003) these features were divided into seven type categories, according to how they appeared on aerial photographs. These categories were:

1. Relict channels containing standing water
2. Depressions in the floodplain surface (often overlaps with category 1)
3. Cropmarks, soil marks or moisture marks
4. Bands of vegetation
5. Boundary features following the line of old channels
6. Parish boundaries drawn up along the line of a former water course
7. Ridge and swale (a succession of bars and intervening channels created during the process of meander formation)

For this project, two additional categories have been included in the database:

8. Earlier river courses depicted on historic mapping
9. Features recorded solely from lidar data

Adopting the methodology of the TVG study, the nine categories have been entered into the GIS database as follows:

- Categories 1 – 4, and 8 - polygon shapefile features
- Categories 5, 6 and 7 – polyline shapefile features
- Category 9 - polygon and polyline shapefile features

Sets of individual ridge and swale features associated with single channel meander cores have been recorded as a group value, with each one being allotted a sub-group number (eg. 1/1, 1/2, 1/3 etc) [1].

Using the above method, the following shapefiles have been created for each study area:

- River Dove – “Dove_palaeopoly.shp”, “Dove_palaeoline.shp” and “Dove_swaleline.shp”
- River Idle – “Idle_palaeopoly.shp”
- River Devon – “Devon_palaeopoly.shp” and “Devon_palaeoline.shp”
- Dover Beck – “DoverBeck_palaeopoly.shp” and “DoverBeck_palaeoline.shp”

As in the TVG study, each of the shapefiles includes an attribute database recording such things as descriptive and location data and the source of individual features (Table 2). For this study, some of the tables include an additional field recording whether a feature had already been identified by the TVG study.

[1] For this project, a different terminology has been used for recording ridge and swale features to that adopted by the TVG study, where they were included in a shapefile entitled “ridgeline.shp”. This was deemed appropriate as the features that have been plotted are actually the depressions (swales) rather than the ridges.

Table 2. Example of attribute database recording descriptive information relating to palaeochannels.

Attribute field	Example of value
Unique ID	10001
Type	3
Notes	Positive crop mark associated with sinuous field boundary
Notes 2	Parish boundary (Elvaston/Draycott and Church Wilne)
NGR	SK48513735
Photosource 1	HSL UK 69 222_23_0917
Photosource 2	RAF 106G/UK/646_3120
Mapsource 1	OS 1" sheet 29 (1851); shown as active channel
Mapsource 2	
Borehole record	SK58NW/1-6
Palaeo potential	Peat
Date Years BP	1150 +/- 125
Date source	C14 Beta 12345
Comment	Investigated by TPAU (Howard 2008)

- Unique ID: numbered from 10001 upwards.
- Type: 1-9 (after Baker, 2003). Where types overlap (for example a cropmark followed by a field boundary), the lowest possible number is given (in this case 3: cropmark). Where more than one type occurs within the length of a feature (for example a depression which continues as a cropmark in a ploughed field), a decision will be made as to which type constitutes the majority of the feature. In both cases, the additional information will be recorded in the *Notes* attribute.
- Notes: additional descriptive information supplementing the *Type* category.
- Notes 2: additional descriptive information, generally relating to parish boundary data.
- NGR: an eight-figure National Grid Reference given at a central point on the feature.
- Photo-source 1: the primary photograph on which the feature was identified and plotted.
- Photo-source 2: any other photograph which provided secondary information on the feature.
- Mapsource 1: reference to any historic map on which the feature is shown; text description of how the feature is depicted (e.g. stream course, active channel, relict channel).
- Mapsource 2: for use in future investigations.
- Borehole record: for use in future investigations.
- Palaeoenvironmental potential: for use in future investigations.
- Date in years AD/BC: for use in future investigations.
- Date source: for use in future investigations.
- Comment: for use in future investigations.
- Features previously identified for the TVG study.

Where possible, palaeochannels have been digitised from the lidar data, since this was the most spatially accurate resource available. Due to the general low spatial error introduced during the AP rectification process (see Section 2.3), there is an occasional slight discrepancy between the location of features plotted from lidar and those on the geo-referenced images.

Features recorded during the previous TVG 2002 study, close to the tributary valley confluences, have been incorporated into the palaeochannel database constructed for this project. The features recorded during TVG 2002 were identified from aerial photographs; in order to obtain greater positional accuracy, these features have been re-mapped using lidar data during this study.

2.8 RESULTS OF LANDFORM ASSEMBLAGE MAPPING DATABASE

2.8.1 Overarching Assessment

In total, 424 palaeochannel features have been recorded and entered into the GIS database. The number of features identified for each study area is as follows: River Dove (249); River Idle (141); Dover Beck (21); and River Devon (13).

The number of features per shapefile for each study area is shown in Table **.

Table 3. Break down of the number of the different feature types recorded for each study area.

Shapefile	**Number of features**
Dove_palaeopoly.shp	214
Dove_palaeoline.shp	7
Dove_swaleline.shp	28 areas (118 swale features)
Idle_palaeopoly.shp	141
DoverBeck_palaeopoly.shp	17
DoverBeck_palaeoline.shp	4
Devon_palaeopoly.shp	12
Devon_palaeoline.shp	1

Table 3 provides a break down of the number of the different feature types recorded for each study area. The overall total per feature type has also been calculated and is shown in table 4.

Table 4. Total number of features by type and study area.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Dove	55	105	28	20	0	7	28	0	6
Idle	13	2	86	0	0	0	0	0	40
Dover Beck	1	0	10	3	0	4	0	3	0
Devon	4	0	6	1	0	0	0	0	1
Totals	73	107	114	24	0	11	28	3	47

2.8.2 Comparison of early and late photographic coverage

The early (1940/50s) and late (1970s) photographic coverage have proved to be complimentary sources of information. This is illustrated in Table 5, which illustrates the number of times that a photograph from either period formed the primary source for recording a palaeochannel feature. For the statistics, swale features have been entered into the Table as singular entities, because individual features from a group are often recorded from different photographic sources.

Table 5. The number of times that a photograph from either period formed the primary source for recording a palaeochannel.

	Early	**Late**
Dove	207	94
Idle	27	81
Dover Beck	None collated	15
Devon	3	8
Totals	237	198

The most striking statistic is the number of palaeochannels plotted from the early coverage obtained for the River Dove. This high number can be explained by the fact that these (early) photographs were taken in winter at a time when the sun was low in the sky causing long shadows to be cast by the landforms and other features (Figure 10). It is also clear from the statistics that the majority of the palaeochannels recorded in the River Idle were plotted from the later air-photo coverage. These results highlight the importance of examining as much available early and late coverage as possible.

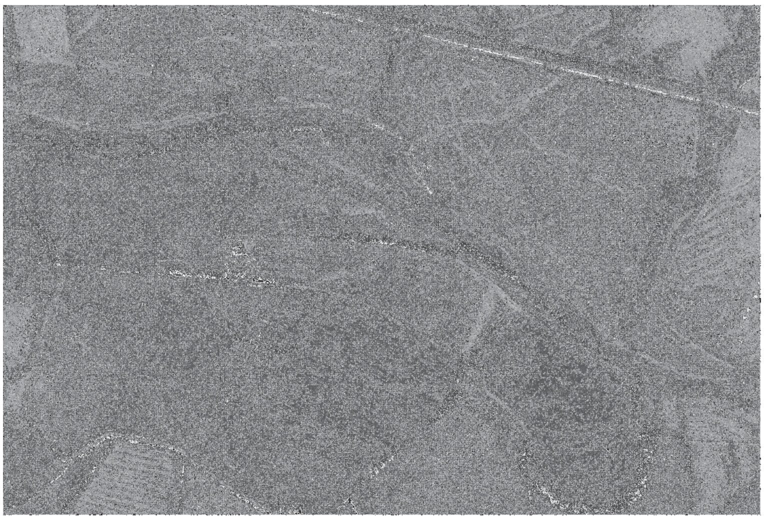


Figure 10. Example of an early air photo from the Dove Valley illustrating the effect of low angle winter sun for identifying landforms and other features.

2.8.3 Comparison of aerial photograph and lidar data

Table 6 illustrates the total number of palaeochannels visible from lidar and aerial photographs for each study area. The figures indicate that a considerable percentage of features were apparent on both. However, overall, the air-photos have proved to be the primary source for mapping landforms and other features. However, this is mainly due to the fact that a considerably higher number of palaeochannels have been plotted from the aerial photographs for the River Idle study area. This may be because the majority of features for this area are visible only as cropmarks, many of which may represent 'ploughed-out' palaeochannels for which there are no significant surface expression remaining. The lack of fluvial relief in the Idle Valley reflects the stability of the river within its floodplain and the dominance of sedimentation through vertical accretion (hence masking relief picked out from lidar elevation data.

However, when examining the statistics, the lack of lidar coverage for certain areas must also be taken into consideration.

Table 6. The total number of palaeochannels visible from lidar and aerial photographs for each study area

	lidar	**APs**	**Both**	**No lidar coverage**
Dove	288	299	255	22
Idle	62	105	38	18
Dover Beck	2	15	2	12
Devon	6	11	3	0
Totals	358	430	298	52

2.8.4 Drift Geology

The British Geological Survey 1:50,000 mapping provides a general indication of the distribution and character of drift deposits within each tributary valley floor (Figures 11-14). Table 7 illustrates the spatial extent of key alluvial deposits (floodplain alluvium, terraces) for each study area. In the Idle Valley, peat and aeolian sand deposits are also significant components of the geological record and are therefore e included for completeness.

Table 7. Spatial extent of key geological units within the study areas.

Study Area	Total Area (km²)	Alluvium (Holocene) (km²)	% per study area	Peat (km²)	% per study area	Blown sand (km²)	% per study area	Floodplain Terrace (Devensian) (km²)	% per study area
Dove	112.1	45.02	40.2	0	0	0	0	18.03	16.1
Idle	506.3	55.13	10.9	29.04	5.7	8.99	1.8	55.62	11.1
Dover Beck	67.6	9.66	14.3	0	0	0	0	11.68	17.3
Devon	126.7	39.90	31.5	0	0	0	0	12.92	10.2

This analysis demonstrates that extensive areas of fine-grained alluvium are recorded in the Rivers Idle, Dove and Devon. This in part reflects the relatively wide nature of their floodplains and low channel gradients resulting in the potential for significant overbank alluviation. In contrast, a far lower percentage of alluvium has been recorded for the Dover Beck, reflecting the relatively narrow valley floor and high gradients associated with this system (i.e. fine grained sediments are probably flushed through the system rather than being deposited.

The presence of significant amounts of fine grained alluvium in the Idle, Dove and Devon valleys have obvious implications for the visibility of the archaeological record in these systems, especially since palaeoecological evidence from the Idle and Dove Valleys (Section 4) suggests that significant fine-grained sedimentation may have occurred during the last 1000 years.

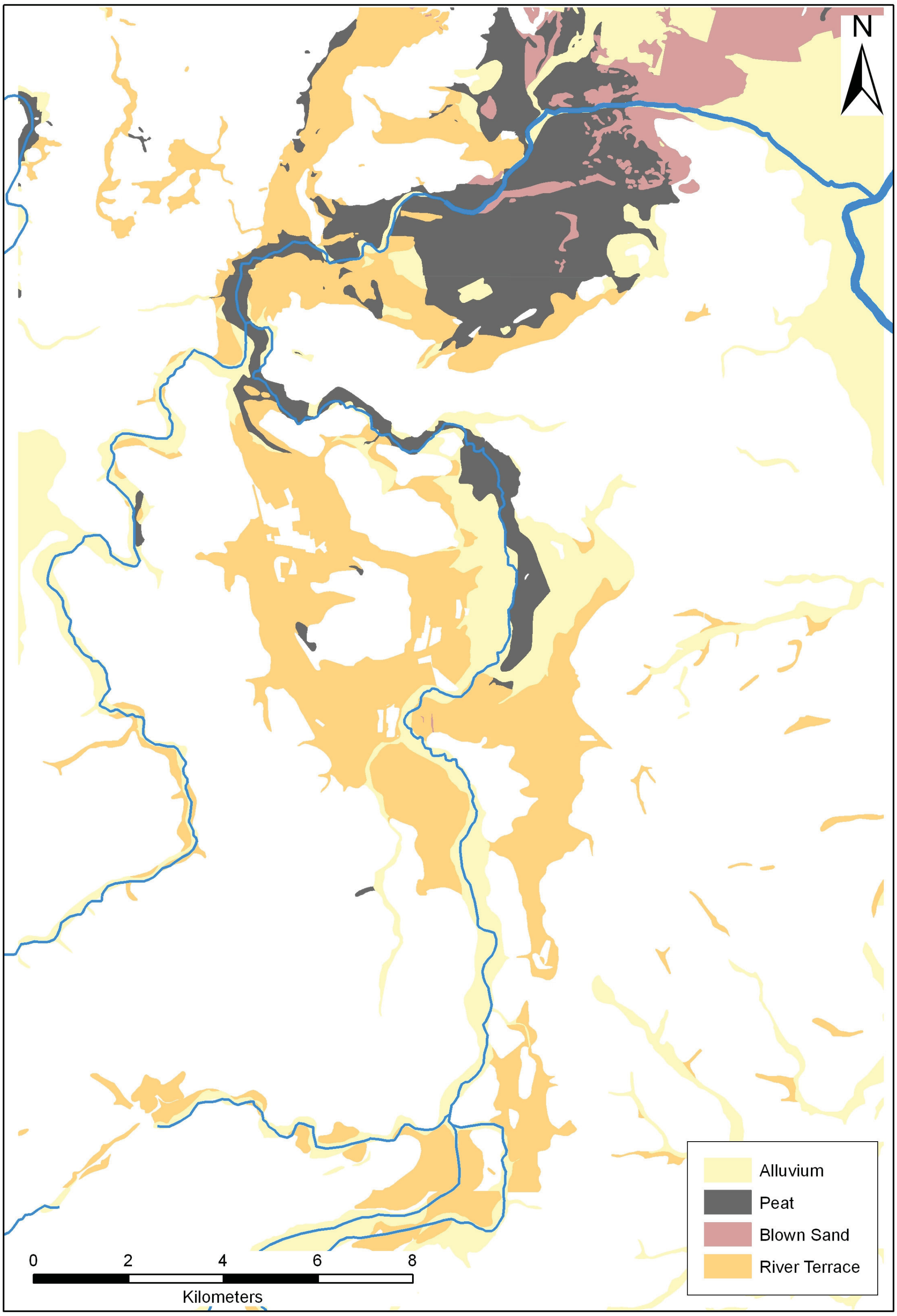


Figure 11. Map showing the extent of the alluvial deposits and aeolian sand in the Idle Valley.

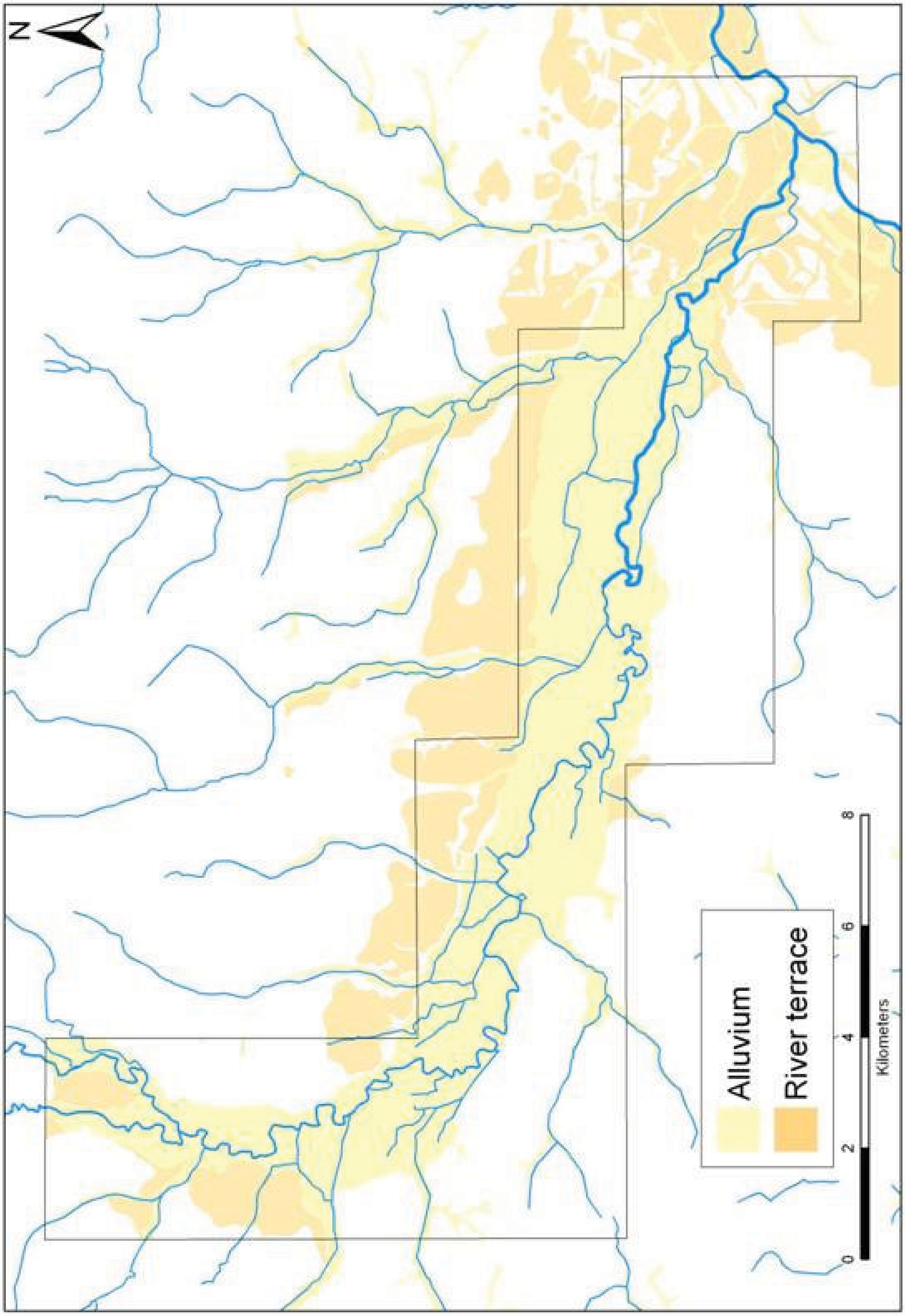


Figure 12. Map showing the extent of alluvial deposits in the Dove Valley.

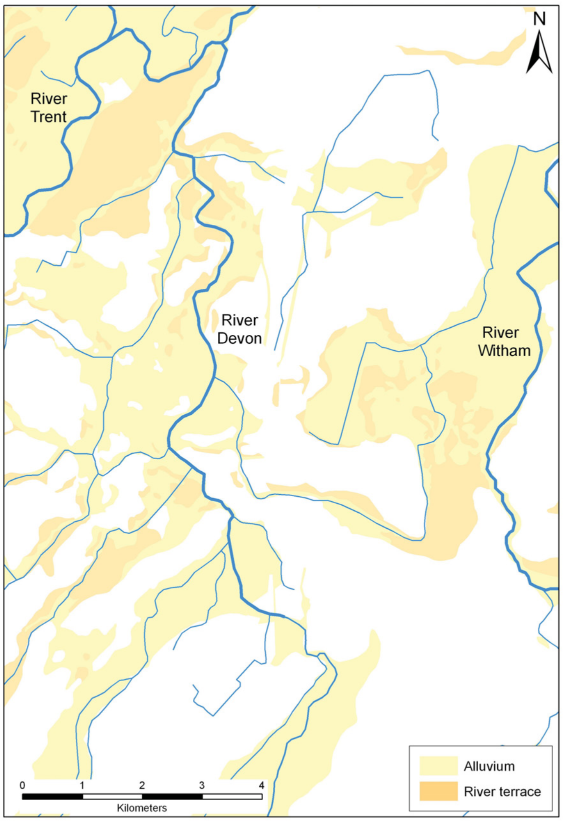


Figure 13. Map showing the extent of alluvial deposits in the Devon Valley.

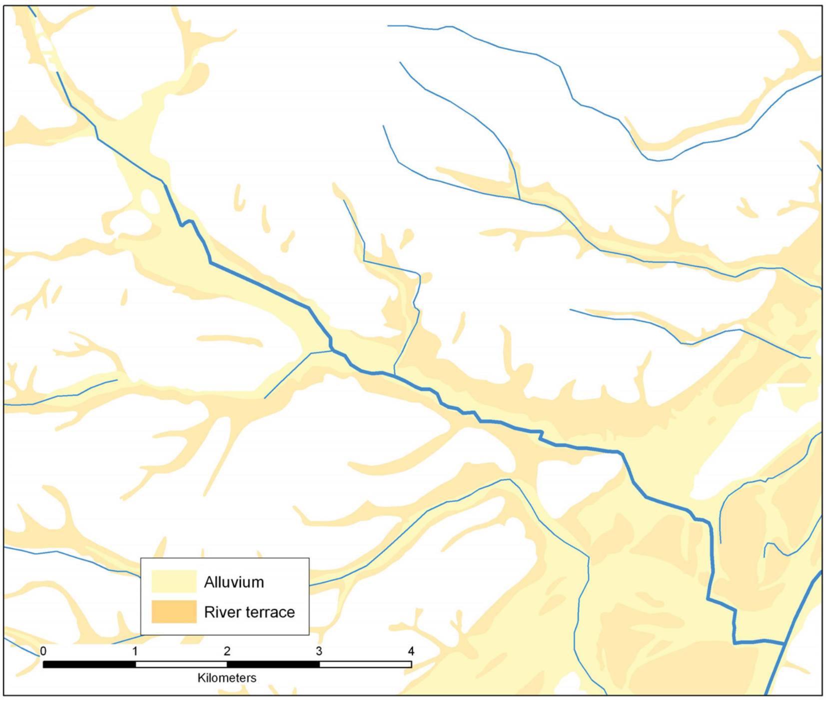


Figure 14. Map showing the extent of alluvial deposits in the Dover Beck.

Analysis of the drift geology mapping shows that a high percentage of the alluvial and organic (peat) deposits recorded in the River Idle are located in the northern part of the study area. Organic-rich alluvial sediments in this zone extend for a distance of up to approximately three kilometres on either side of the contemporary river channel and have the potential to yield high-resolution palaeoenvironmental records.

Deposits of aeolian (blown) sand are also recorded in this area. These sediments were probably initially deposited during the Loch Lomond Stadial (11-10 ka BP), but evidence from within the Idle Valley at Tiln (Howard *et al*., 1999) suggests that these sediments may have been reworked during drier episodes throughout the Holocene; this may be significant in the burial of archaeological remains.

The percentage statistics for areas of river terrace for each study area are similar. However, there are marked differences between the nature of the terrace formations for each of the tributaries. This is best illustrated by the extreme contrast between the shallow terraces associated with the northern reaches of the Idle (Figure 15), and the well developed, steeper terraces of the Dove valley (Figure 16).

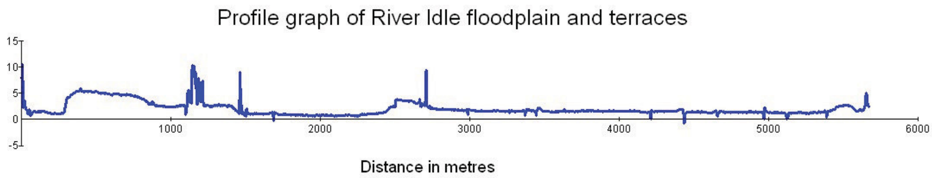


Figure 15. Profile graph of a sample section across the River Idle floodplain and terrace deposits.

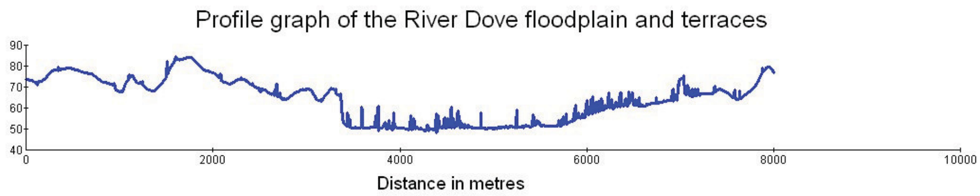


Figure 16. Profile graph of a sample section across the River Dove floodplain and terraces

This contrast in landform gradients between the two river systems reflects the major differences between the evolution of the two. The River Dove has developed as an upland-piedmont medium-energy river system (Howard and Macklin, 1999), with relatively high channel gradients, steep valley sides, and considerable vertical and lateral channel movement, which has resulted creation of pronounced terraces and abandoned palaeochannels within the landscape. In contrast, the Idle, is characteristic of a low energy 'lowland' river system, with low channel gradients and lateral stability, which has led to vertical build up of alluvial sediment, and the formation of shallow terrace units. This differentiation is important since it has significant implications for the prospection and preservation of archaeology within each system (Howard and Macklin, 1999; Passmore *et al*., 2002).

2.9 COMPARISON OF LANDFORM ASSEMBLAGES BY STUDY AREA

Table 8 provides a break down of the area statistics for recorded palaeochannels for each of the study areas. The results are presented according to each of the different palaeochannel types. The analysis is only applicable to those features possessing area (i.e. polygonal anomalies – Categories: 1 - 4, 8 and 9).

Table 8. Spatial extent of palaeochanels (by type) in each study area.

Type	**Dove** (km²)	%	**Idle** (km²)	%	**Dover Beck** (km²)	%	**Devon** (km²)	%
1	0.24	16.9	0.02	1.0	<0.01	3.25	0.01	3.57
2	0.62	42.2	<0.01	0.04	0	0	0	0
3	0.21	14.3	1.09	49.9	0.02	50	0.07	47.87
4	0.37	25.9	0	0	<0.01	17.25	0.04	25.34
8	0	0	0	0	0.01	0	0	0
9	0.01	0.7	1.07	49.06	0	29.5	0.04	23.22
Total	1.45		2.18		0.04		0.16	

Baker (2003) demonstrated that the type of land use and the nature of the topography are significant factors effecting palaeochannel representation. For the Idle Valley, an intensely farmed arable landscape, within a stable valley floor that has evolved through vertical accretion, a high percentage of the palaeochannels recorded from aerial photographs are identified as cropmarks (Type 3; Figure 17); very few are observed as visible depressions on the ground surface. However, the statistics show that most of the remainder of the recorded palaeochannels for the Idle were plotted from the lidar elevation DSM (mainly as faint, broad anomalies; Figures 26 and 27), which indicates that they represent the remains of shallow, ploughed-out channels that are generally not pronounced enough to be visible from the air.

Figure 17. River Idle study area: Cropmark evidence is prominent in this stable alluvial landscape, which is intensely farmed under arable regimes.

In contrast, in the Dove Valley, approximately 60% of the plotted channels consist of visible depressions on the floodplain (Figure 18); only a small proportion have been recorded as crop- or soil marks. These features survive for a number of reasons: (1) the high rates of vertical incision (Figure 19) enhance preservation, since these deeper channels are less likely to be infilled; and (2) the majority of these features are situated on unploughed grassland. Extensive areas of ridge and furrow within the floodplain indicate that large parts of the landscape have probably not been cultivated for arable crops since Medieval times.

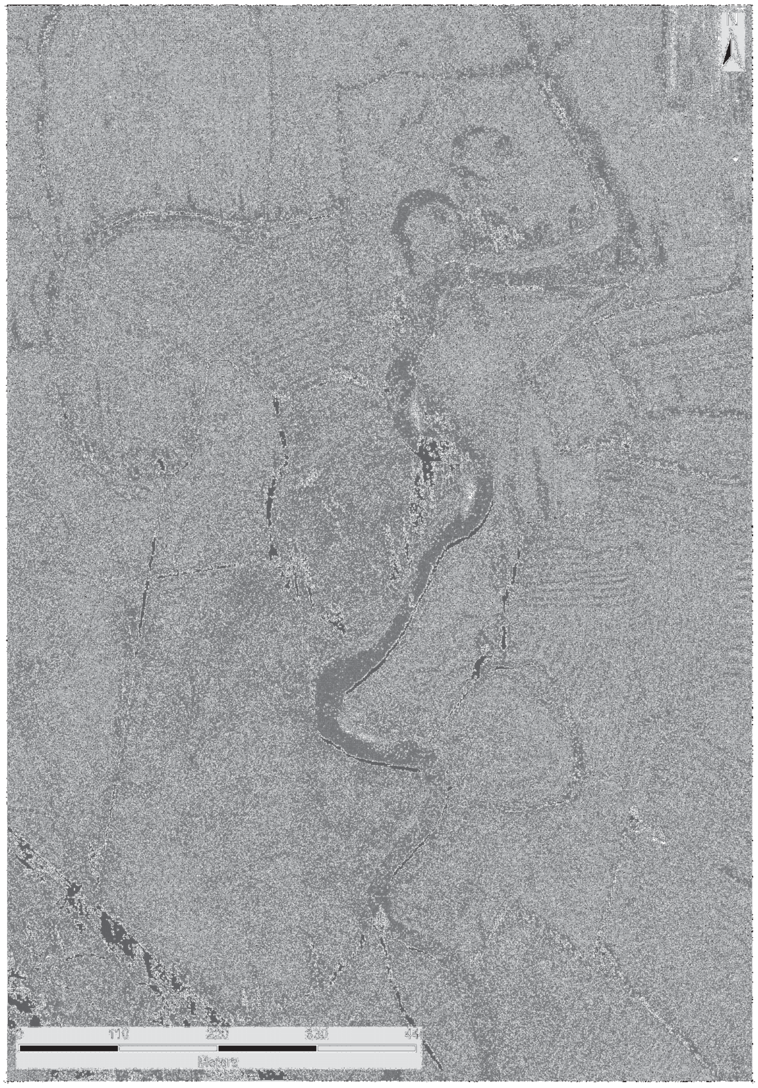


Figure 18. The majority of the evidence for palaeochannels in the Dove Valley consists of depressions on the valley floor, many of which contain standing water.

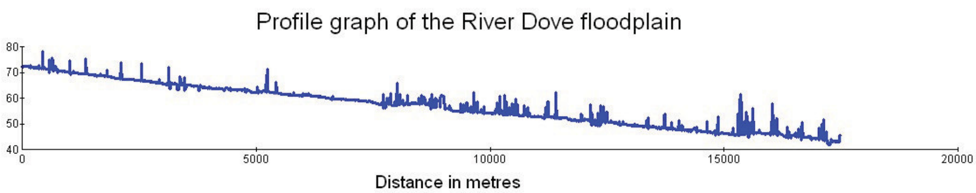


Figure 19. Profile graph illustrating the relatively steep gradient of the River Dove.

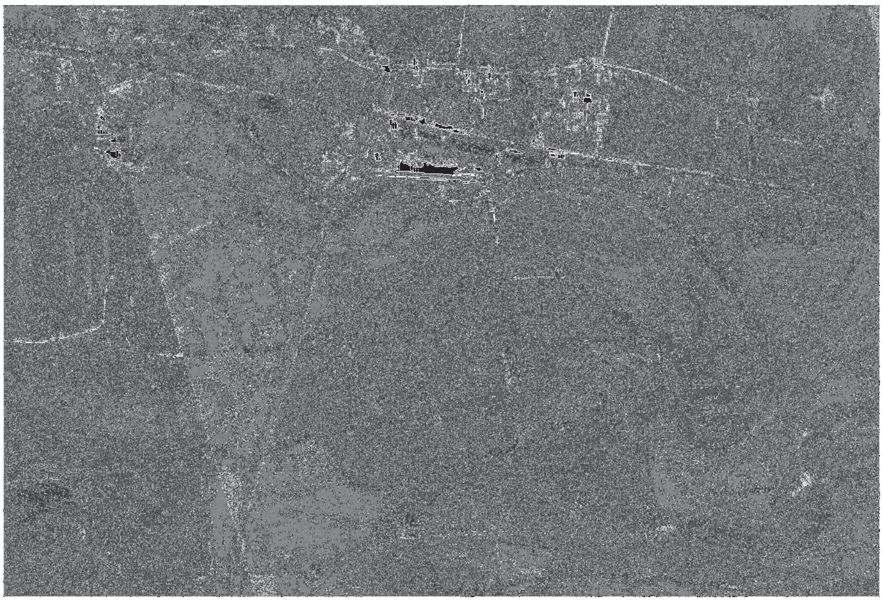


Figure 20. Aerial photograph showing the dynamic nature of the River Dove.

The fact that almost a third of the palaeochannels plotted for the Dove Valley are recorded as holding standing water (Figure 20) suggests regular inundation of the floodplain and recent geomorphological activity, a conclusion that is corroborated to some extent by historic mapping evidence, which shows that some parts of the river have altered course within the last 150 years (Figures 21 -22). This recent mobility obviously has significant implications for archaeological preservation and prospection.

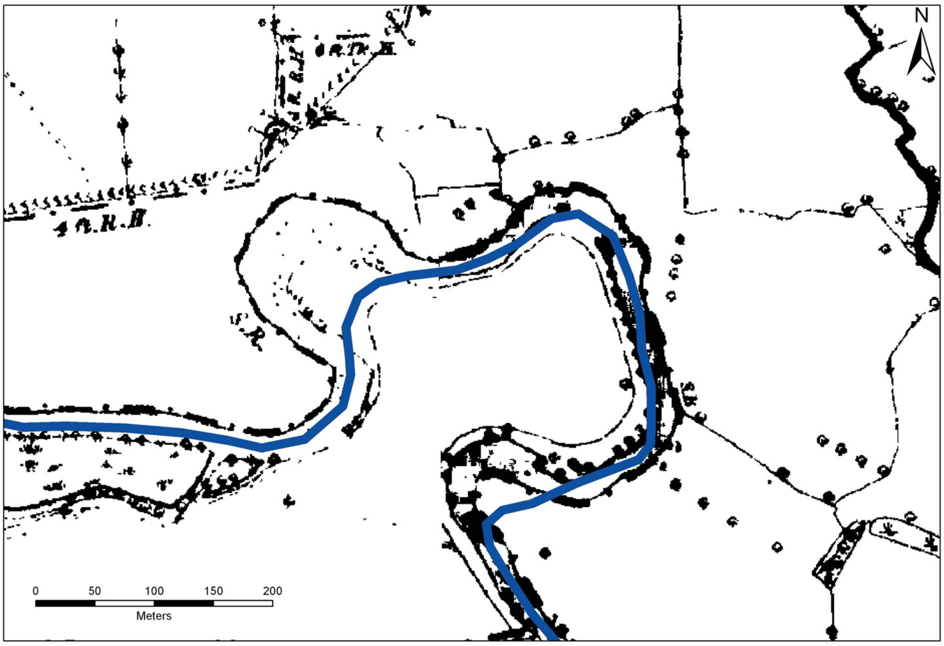


Figure 21. Ordnance survey 1st Edition historic mapping showing a former channel meander of the River Dove (the current course of the river is shown in blue).

Figure 22.Aerial photo taken in 1948 showing the channel meander depicted in Figure 19.

2.9.1 The Dove Valley

The palaeochannels identified for the River Dove are distributed relatively evenly along the valley floor (Figure 23). All of the features are mapped on the Holocene floodplain (denoted by fined-grained alluvium on the British Geological Survey maps) within a relatively narrow corridor on either side of the river. A large proportion of the channels are 'classic meanders' with a sinuosity index of more than 1.5. A high number of ridge and swale features have also been identified providing evidence for significant lateral channel migration and meander core growth.

2.9.2 The Idle Valley

The majority of palaeochannels recorded in the River Idle are located around Misterton Carr in the northern part of the study area, and intimately associated with extensive deposits of peat and fine-grained alluvium (Figures 24). This area contains a complex network of major channels and tributaries. Of particular note, are two large, sinuous channels on either side of the modern river (Figures 25 and 27). Both features are similar in appearance and may have once formed part of the same channel, possibly incorporating part of the course of the present day river. Analysis of historic maps by the Humber Wetlands Project (Dinnin 1997) certainly suggests that prior to large scale drainage of the area in the 17th and 18th Centuries, a number of rivers in the Humberhead Levels were characterised by anastomosed channel systems.

Around Misterton, it is notable that a number of minor channels are evident branching from a more major channel (Figures 25 and 27). These minor channels are remarkably reminiscent of salt marsh creek systems and the influence of tidal conditions in the creation of this part of the floodplain is not inconceivable, given its close proximity to the Trent, which is known to have been affected by tidal processes during various periods of the Holocene.

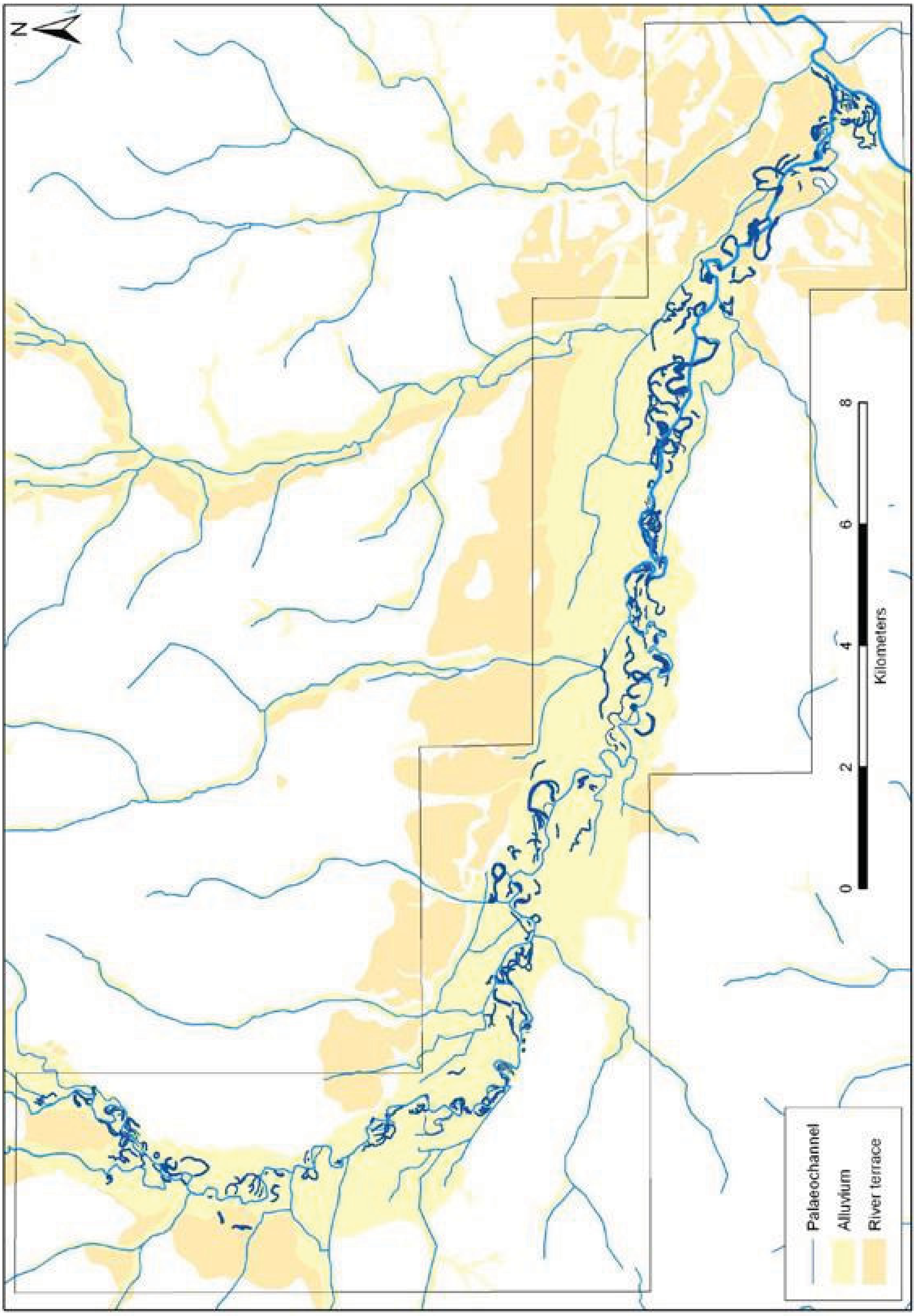


Figure 23. Map showing the distribution of palaeochannels with respect to the mapped alluvial geology of the Dove Valley.

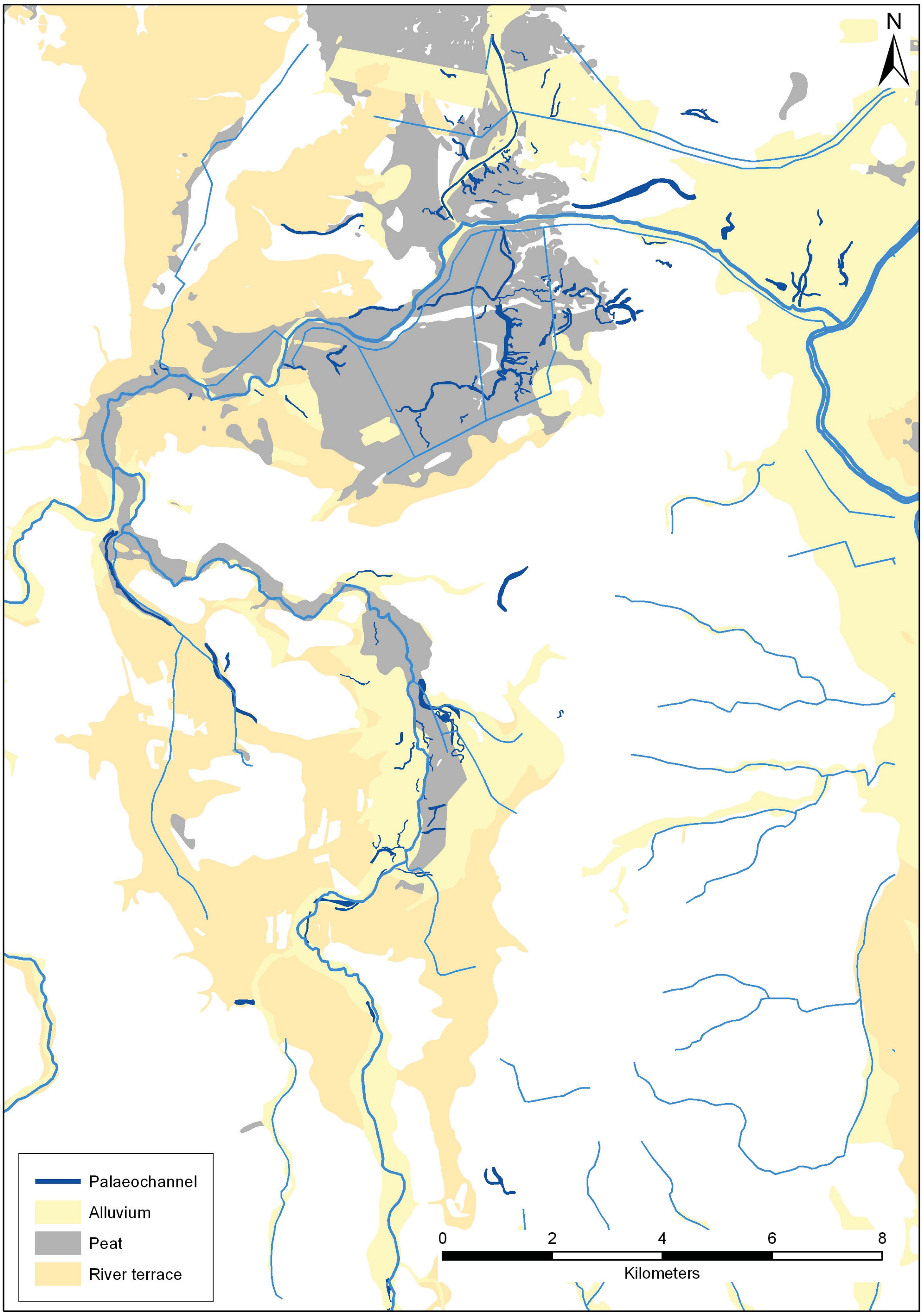


Figure 24. Map showing the extent of the palaeochannels and alluvial deposits in the Idle Valley.

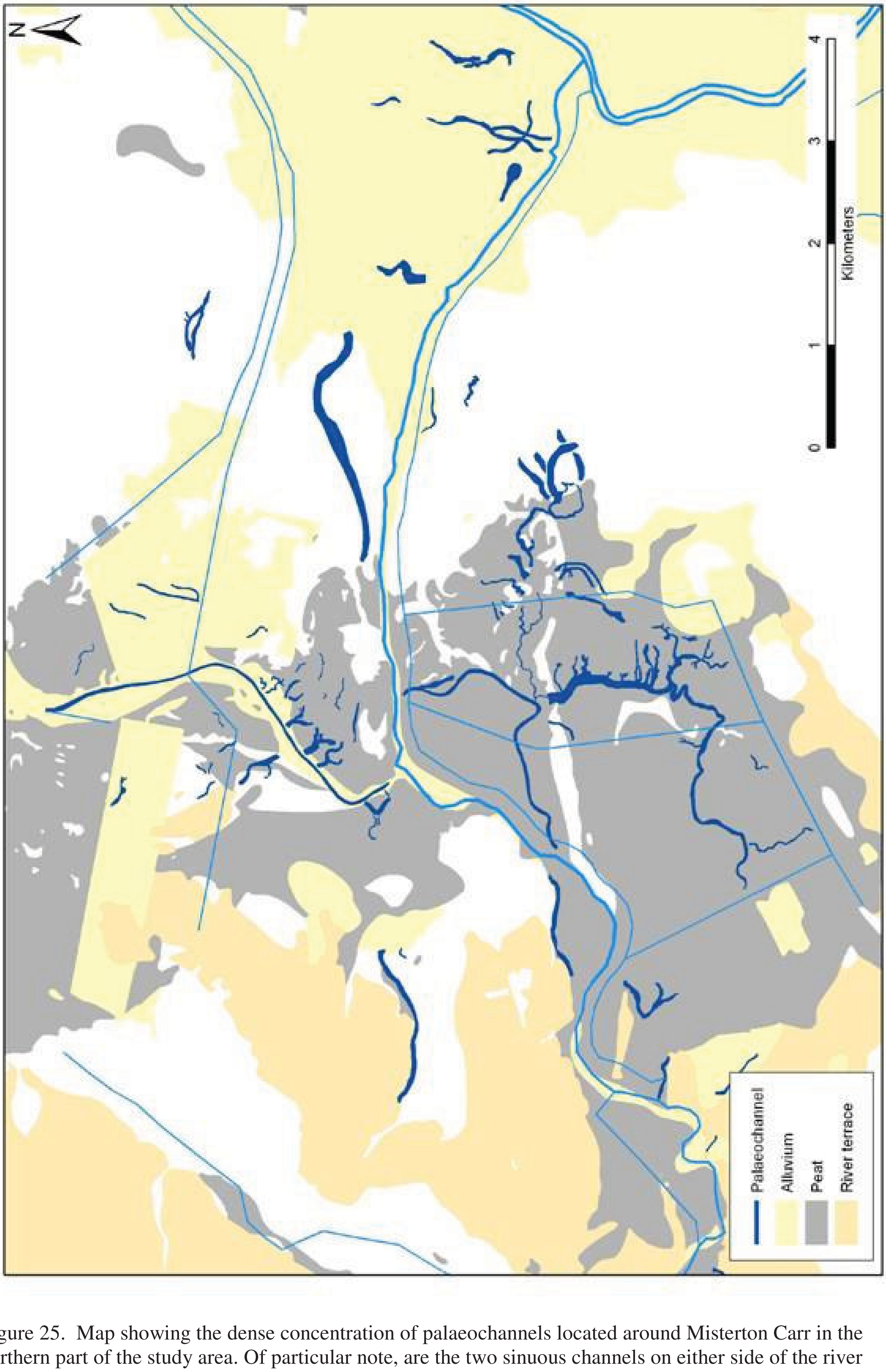


Figure 25. Map showing the dense concentration of palaeochannels located around Misterton Carr in the northern part of the study area. Of particular note, are the two sinuous channels on either side of the river (located towards the centre of the map).

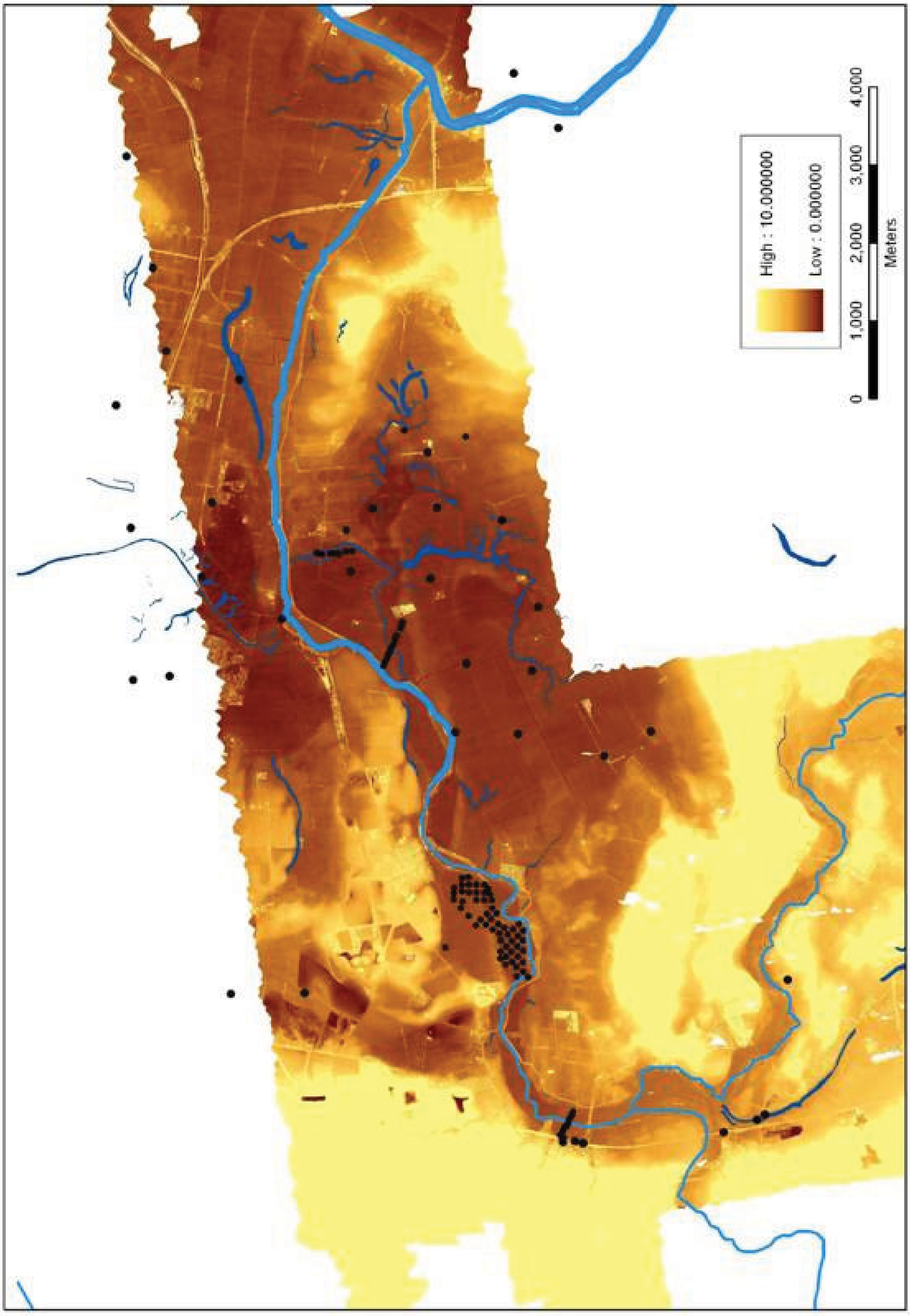


Figure 26. Mapped palaeochannels and lidar elevation data for the northern part of the study area. The floodplain of the Idle is clearly visible running east-west across the centre of the image.

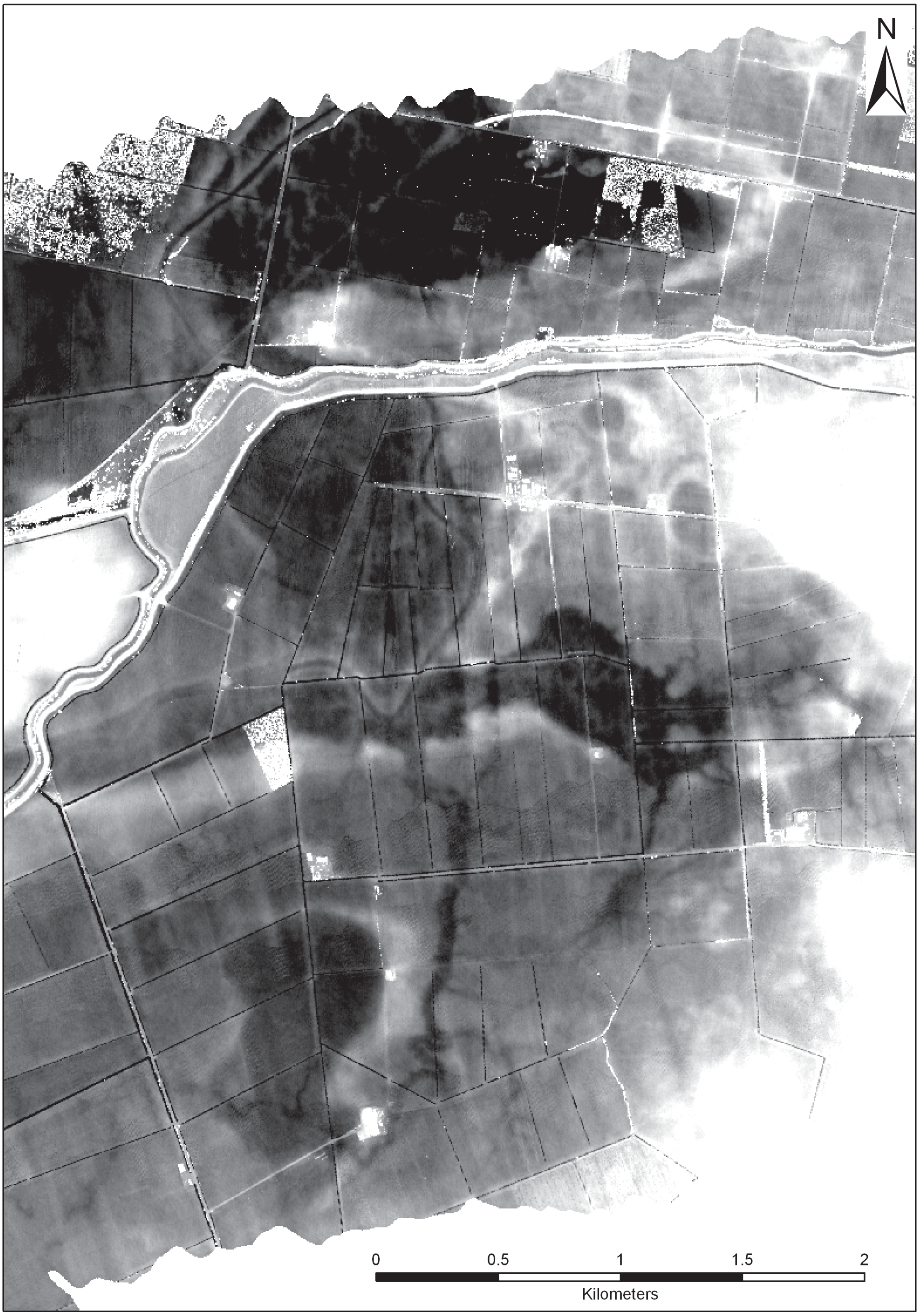


Figure 27. Lidar DSM showing palaeochannels and large depressions located in the Misterton Carr area and immediately to the north of the River Idle.

2.9.3 River Devon and the Dover Beck

The results of palaeochannel mapping for the River Devon (Figure 28) and the Dover Beck (Figure 29) have been disappointing. Very few features have been identified from the lidar and aerial photographic data. The results for the Devon are particularly poor considering that it is a reasonable-sized channel and floodplain and that there are fairly extensive alluvial deposits recorded by the BGS along certain parts of the valley floor.

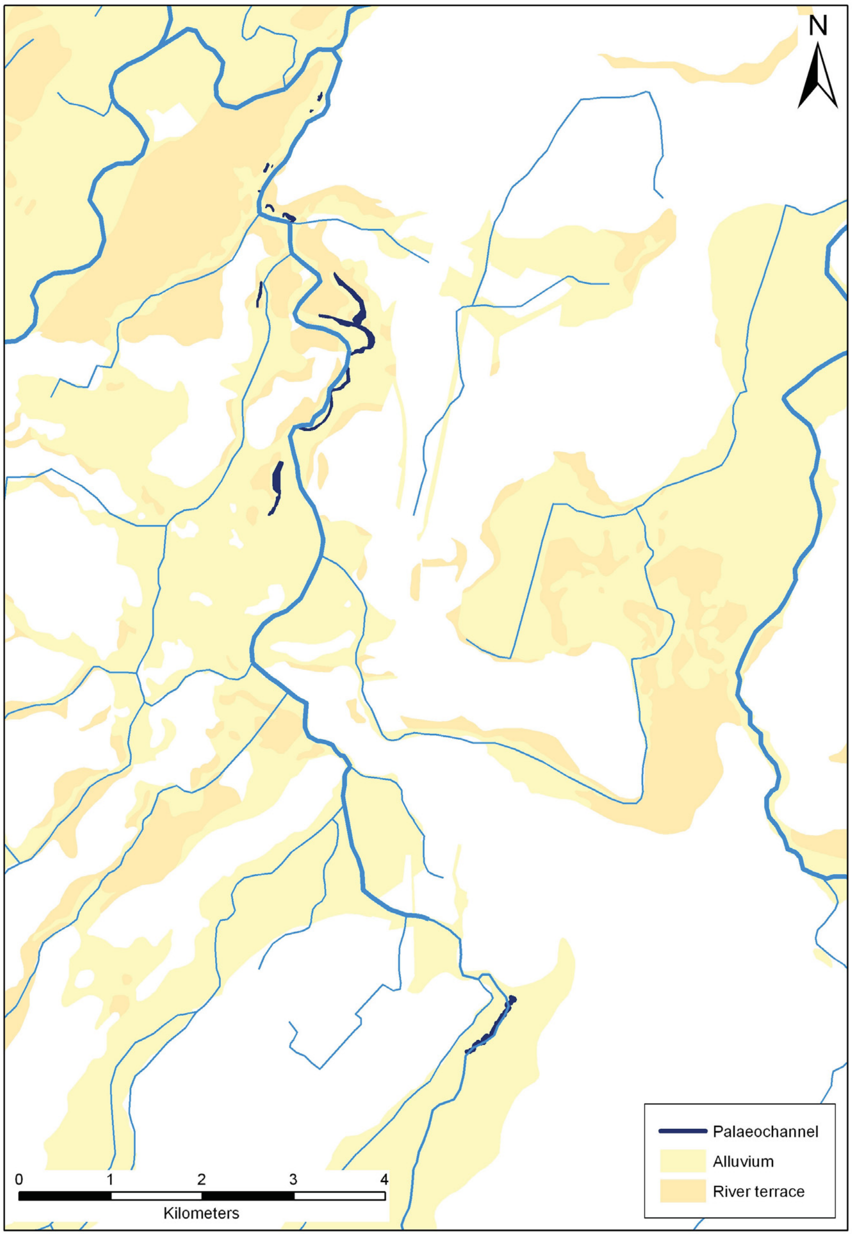


Figure 28. Map showing the extent of the floodplain and river terraces of the River Devon and the location of all of the palaeochannels mapped.

Along the Dover Beck, a large proportion of the features that have been identified are associated with former channels whose course has been altered by relatively recent river engineering.

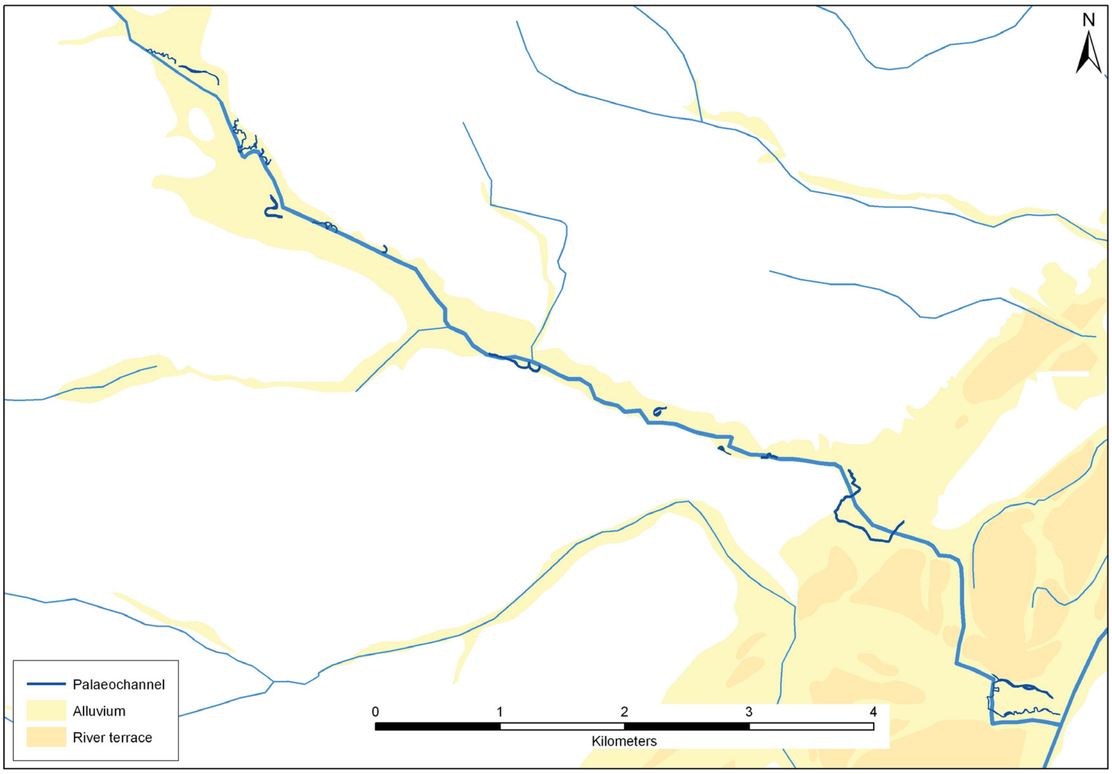


Figure 29. Map showing the extent of the floodplain and river terraces of the Dover Beck and the location of all of the palaeochannels mapped for the study area.

3 ANALYSIS OF THE SUBSURFACE RESOURCE THROUGH ALLUVIUM DEPTH AND CHARACTER MODELLING

3.1 INTRODUCTION

This component of the project involved the analysis, interpretation and digitisation of data from borehole records in order to map and model the subsurface alluvial architecture of the valley floors of the Rivers Dove and the River Idle. This work was conducted according to the methodology that was devised for investigating the character of alluvial deposits within the floodplain of the Trent Valley (Challis 2001; Challis and Howard 2003, Challis 2004).

The component objectives were:

- The creation of a GIS incorporating borehole data for the floodplain and younger (Devensian) terraces of the studied rivers;
- The development of a lithostratigraphic model of key alluvial units;
- The production of GIS derived maps showing the broad character of alluvial deposits for the studied rivers, including for example, mapping the thickness of fine-grained alluvial deposits and the distribution of peat deposits within alluvium as a guide to the presence of palaeochannels and environmental resources;
- The creation of sub-surface digital elevation models (DEM) and fence diagrams of key stratigraphic horizons to attempt to identify and map key features such as buried palaeochannels and palaeolandsurfaces.

The data generated from this component was also used to assist in field mapping of the study areas and to select suitable sites for coring.

3.2 METHODOLOGY

Borehole digitisation was carried out using the data model adopted for the Trent Valley (TVG 2002 component 3, Challis 2004). In order to create three-dimensional sub-surface models using heterogeneous borehole data, a relatively simple data model was devised for the Trent, which recorded only substantial, spatially contiguous stratigraphic units; in total, the model records the details of at least four:

Unit 1: fine grained silt and clay alluvium
Unit 2: coarse grained sand and gravel
Unit 3: bedrock
Unit 4: organic deposits such as peat

Provision has been made within the data model to include additional stratigraphic units, such as the aeolian deposits common in parts of the lower Trent Valley, or finer sedimentological distinctions, such as local variations in the character of fine-grained alluvium. For this component, additional units that have been recorded include aeolian (blown) sand and 25ft drift (Lake Humber deposits) in the Idle Valley.

3.3 RESULTS OF SUBSURFACE MODELLING

In total, 942 borehole records have been examined and digitised as part of the project (Table 9). The majority of the data was digitised from logs held at the National Geological Data Centre (NGDC), at the British Geological Survey (BGS), Keyworth (for a discussion of issues regarding the availability and quality of borehole data at BGS the reader is referred to

Challis 2004). Additional records have been transcribed for the Newington area of the Idle Valley. Borehole logs from an auger transect survey incorporating the northern part of the River Idle study area, undertaken as part of the Humberhead Wetlands Project (Van de Noort and Ellis, 1997), have also been digitised. The table below provides a break down of the collated borehole data.

Table 9. Summary of borehole records collated as part of this project.

	Dove	**Idle**	**Idle: BGS**	**Idle: Newington**	**Idle: Humber Wetlands**
Total boreholes	488	454	264	112	78

3.3.1 Dove Valley

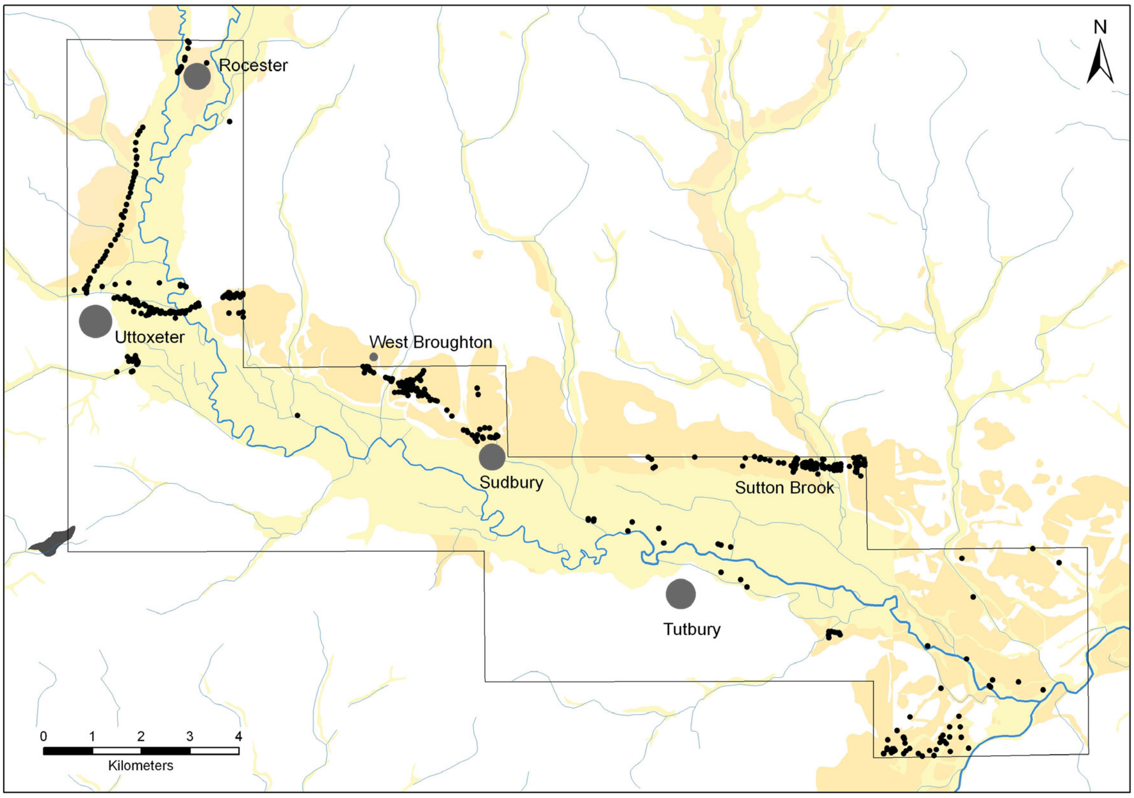


Figure 30. Map showing the extent of the floodplain and terraces of the River Dove and the location of all borehole records examined for this study area. The figure also shows the location of places referred to in the text.

Alluvial deposits have been identified in 201 boreholes in the Dove Valley study area. Organic material was recorded in 67 of these records (Table 10, Figures 30 and 31). Unfortunately, the majority of these borehole are not located on the Holocene valley floor, but are confined to the higher older terraces of pre-Devensian age on the northern valley-side (many of these boreholes were drilled in advance of construction of the Doveridge Bypass and Stoke-Uttoxeter-Derby trunk road). Therefore, they do not provide a good overall picture of the alluvial stratigraphy of the valley floor (there is particularly poor coverage for the area between Uttoxeter and Sudbury). However, they do provide important insights into the pre-Devensian deposits, which are important in terms of Lower and Middle Palaeolithic heritage.

Table 10. Borehole records assessed from discrete stratigraphic units along the Dove Valley.

	Dove
Unit 1: Fine-grained alluvium	201
Unit 2: Sand and gravel	444
Organics	67
Unit 3: Bedrock	295
Total boreholes	488

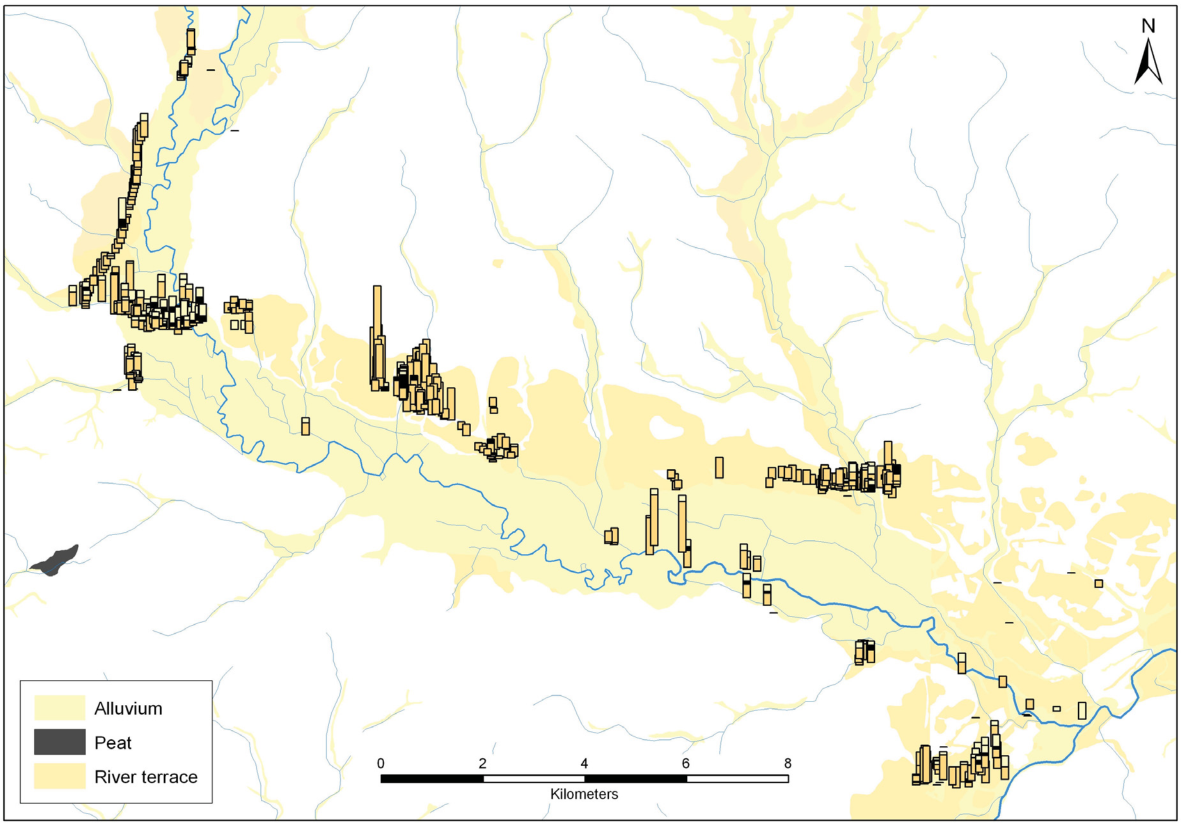


Figure 31. Map showing the extent of the floodplain and terraces of the River Dove and the location all borehole records examined for this study area. Borehole data are shown as stacked bar charts indicating the location and thickness of the principal stratigraphic units.

A high percentage of the alluvial and peat deposits recorded for the study area come from boreholes associated with the construction of the A50 (Doveridge Bypass) where it crosses the Dove, immediately to the east of Uttoxeter (Figures 32 and 33). The presence of peat in this area is significant, since this is one of the few reaches of the valley floor for which there is very little evidence of palaeochannels. During construction of the Doveridge Bypass, peaty deposits were recorded and sampled during a watching brief and demonstrated to be of early Holocene age. Thin deposits of alluvium have also been recorded in a line of boreholes associated with the B5030, which skirts the western edge of the floodplain of the Upper Dove, between Uttoxeter and Rocester.

Further deposits of alluvium and organic material are recorded along the line of the A50 adjacent to the Sutton Brook, an important tributary of the Dove located just to the north-west of its confluence with the River Trent, and at West Broughton, immediately north-west of Sudbury.

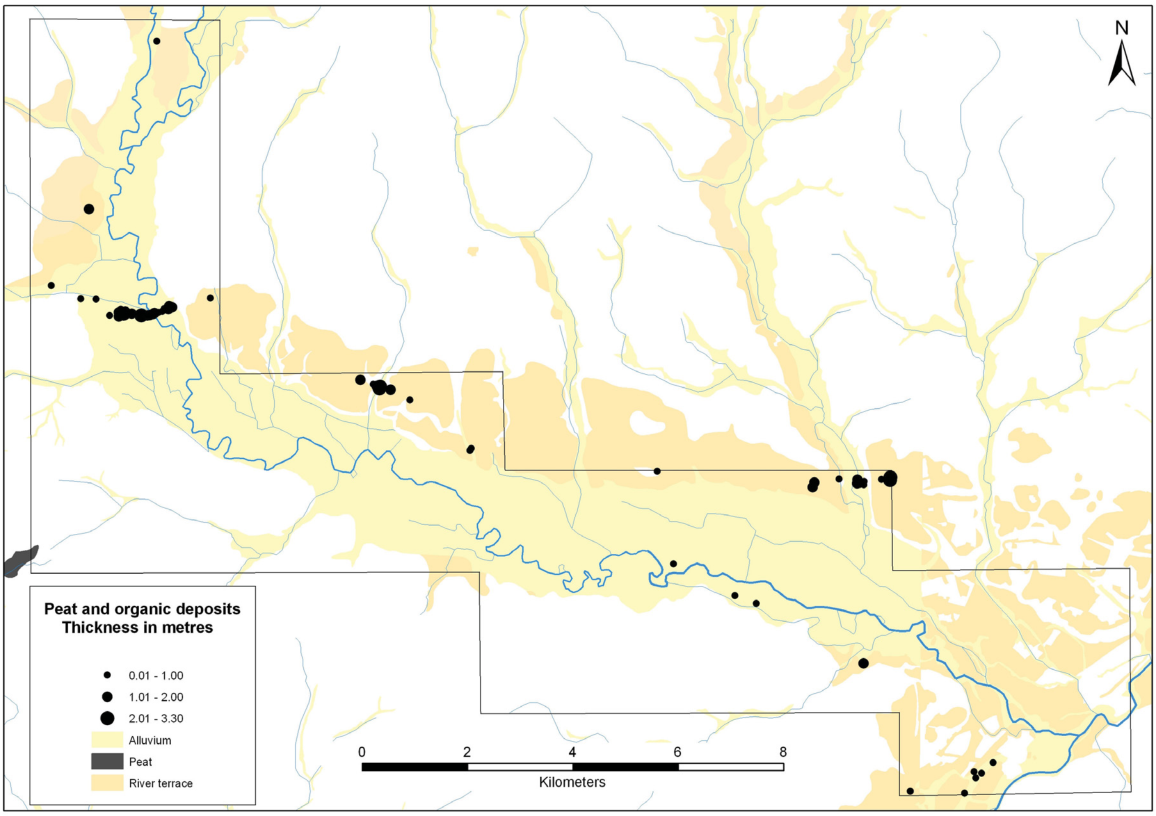


Figure 32. Map showing the extent of the floodplain and terraces of the Dove Valley and the location of all boreholes where organic sediments were recorded. The data is displayed as proportional circles indicating the thickness of peat.

3.3.2 River Dove: Sub-surface modelling

Due to the uneven distribution of boreholes containing alluvial deposits, it has not proved feasible to construct a sub-surface DEM representing the base of Unit 1 (fined-grained alluvium). Challis and Howard (2003) describe the problems of interpolating surfaces from irregularly spaced boreholes. However, in some parts of the study area, there are lines of boreholes associated with road construction, which provide the opportunity to construct cross-sections through the alluvial deposits. Cross-sections have been created (using Rockware's Rockworks software) from the digitised records for boreholes associated with the A50 to the west of Uttoxeter and around Sutton Brook, to the north-west of Tutbury.

The fence diagram shown below (Figure 33) was created from the line of borehole records to the east of Uttoxeter and demonstrates a substantial thickness of fine-grained alluvium in this area.

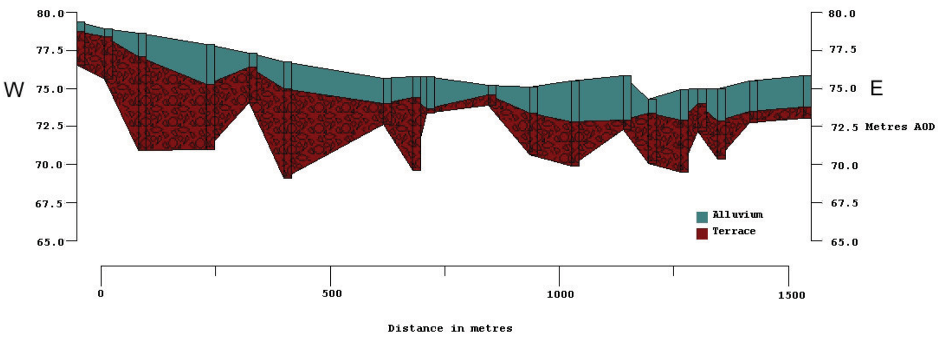


Figure 33. Cross-section of alluvial stratigraphy for area to the east of Uttoxeter

Similarly, the section across the Sutton Brook (Figure 34) shows a continuous spread of fine-grained alluvial sediment, in this case, masking terrace sands and gravels. Fine-grained alluvium is also recorded in a group of boreholes adjacent to the river, immediately to the north of Tutbury.

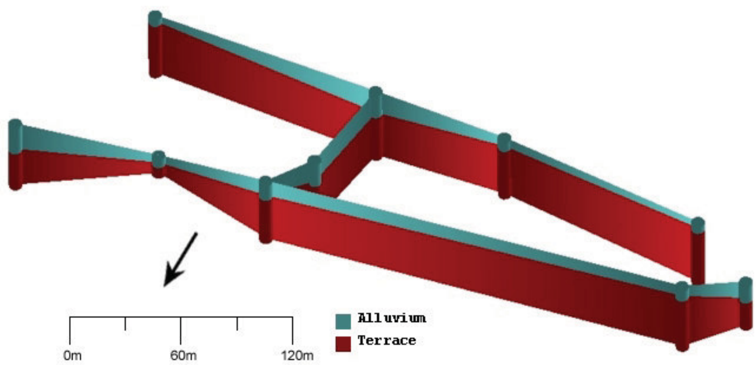


Figure 34. Fence diagram showing alluvial stratigraphy for Sutton Brook area

Whilst the evidence from boreholes is limited, it demonstrates that there may be extensive deposits of alluvium located across most of the valley floor and this has significant implications for the visibility and preservation of archaeology in the Dove Valley. In addition, organic deposits up to 3m thick have been recorded in the Uttoxeter area and up to 2m thick around Sutton Brook (Figures 34 and 35). Such thicknesses of organic sediment have the potential to provide proxy records of climate and land-use of significant interest to the archaeological community.

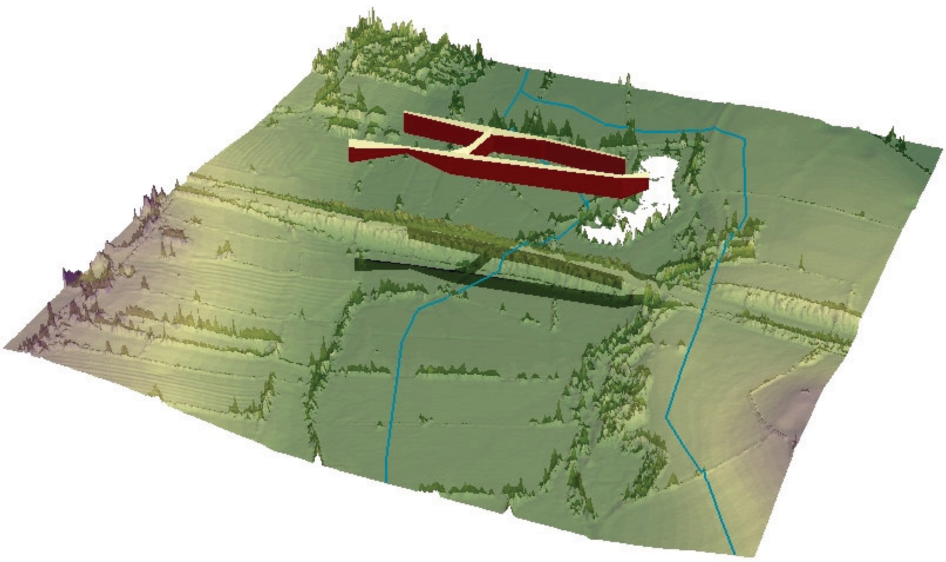


Figure 35. Fence diagram created using Rockware's Rockworks software illustrating the stratigraphy of alluvial deposits recorded in boreholes along the A50 across the Sutton Brook. The data has been superimposed onto an opaque representation of the lidar DSM for the area.

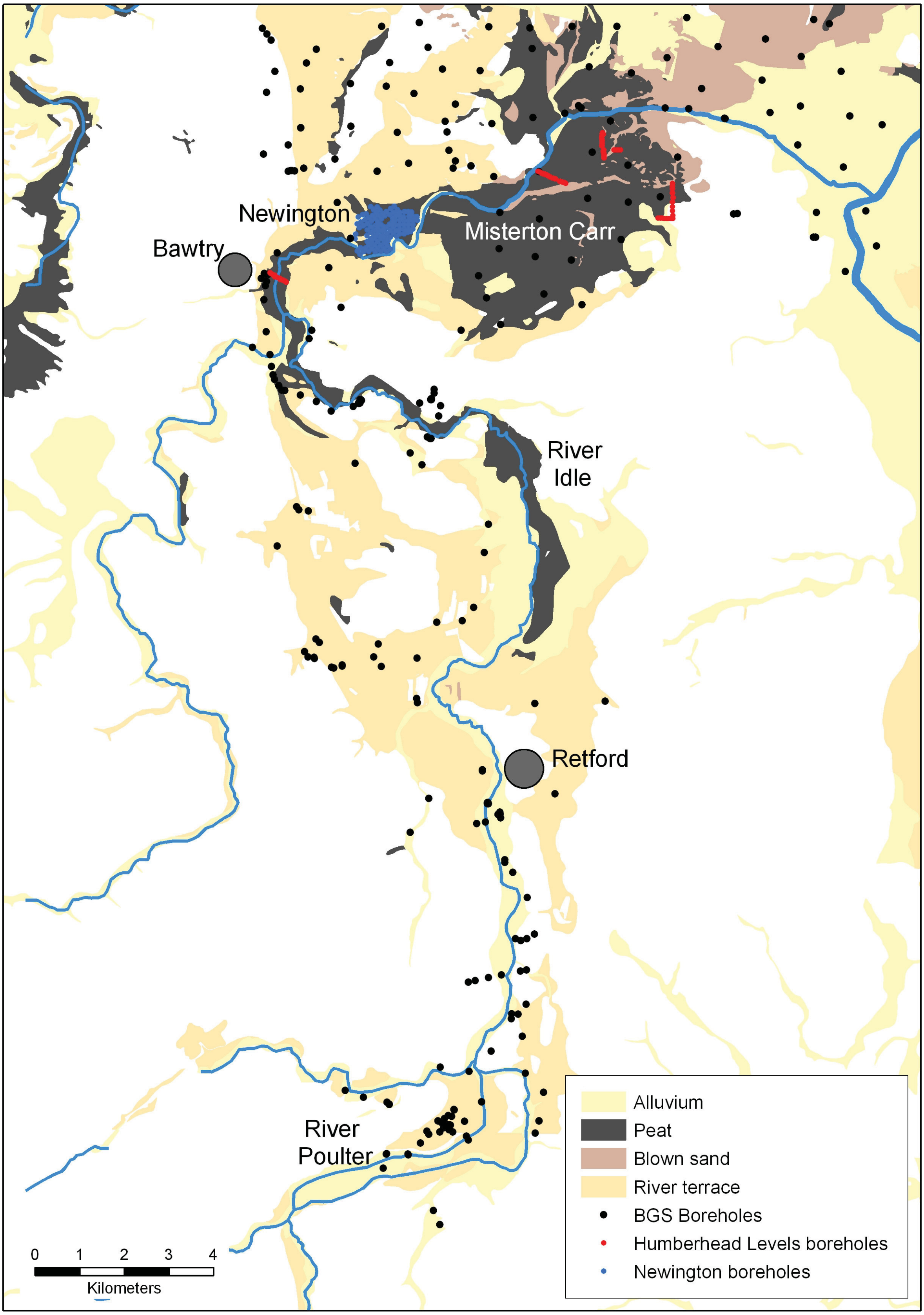


Figure 36. Map showing the extent of the floodplain and lower terraces of the Idle Valley and the location all borehole records examined for the study area. The figure also shows the location of places referred to in the text.

3.3.3 The Idle Valley

The greater spatial density of boreholes in the Idle Valley has allowed more analysis to be undertaken, than was possible for the records from the Dove Valley. The database has been considerably enhanced by the addition, to the British Geological Survey data, of borehole records from intensive surveys carried out in the Newington area, and in the northern part of the study area for the Humberhead Wetlands Project (Figure 36).

In total, alluvial deposits have been identified in 245 boreholes in the Idle Valley (Table 11). Organic deposits have been recorded in 150 boreholes.

Table 11. Borehole records assessed from discrete stratigraphic units along the Idle Valley.

	Idle	**BGS**	**Newington**	**Humberhead Levels**
Unit 1: Alluvium	245	70	112	63
Unit 2: Sand and gravel	290	114	112	64
Organics	150	51	56	43
Blown sand	14	14	0	0
25ft drift	33	33	0	0
Unit 3: Bedrock	224	112	112	0
Total boreholes	454	264	112	78

A significant proportion of the recorded organic and alluvial deposits are concentrated in the northern third of the study area; there are fewer records of alluvium and no records of peat for the central area (Figure 37). In the southern area, few records exist, apart from a concentrated group of boreholes recording alluvial and peat deposits adjacent to the River Poulter, a major tributary of the Idle.

The deposits recorded from boreholes in the northern part of the study area correlate closely with the mapped drift geology. A significant concentration of peat and fine-grained alluvium is recorded around Misterton Carr (Figure 37), corresponding with the location of a major concentration of palaeochannels identified for AP/lidar imagery. Notable, are the particularly deep organic deposits recorded in boreholes following a broadly north-south line on either side of the river. Misterton Carr is known as an important focus of Mesolithic settlement (Buckland and Dolby, 1973) and this dataset could provide important contextual information for future archaeological studies. Occasional organic remains are also recorded in association with coversands in the north-eastern part of the study area.

The data from the Humberhead Wetlands Project (Transects 2 and 3) adds localised detail to the general overall picture for the Misterton Carr area. Figure 39 illustrates how peat deposits recorded for auger Transects 2 and 3 relate to one of the major palaeochannels plotted during this project; the auger survey also helped enhance information provided by the lidar elevation data. The deeper deposits of organic material and alluvium along Transect 2 (Figure 40) are generally confined within the wide depression running east-west across the centre of image, whilst the shallower deposits are recorded across the area of terraces between the large palaeochannel and the contemporary channel of the Idle. However, it is difficult to determine whether these organic remains are associated with the major channel (represented by the broad anomaly detected from the lidar), or a number of smaller channels intimately associated with it (Figure 41).

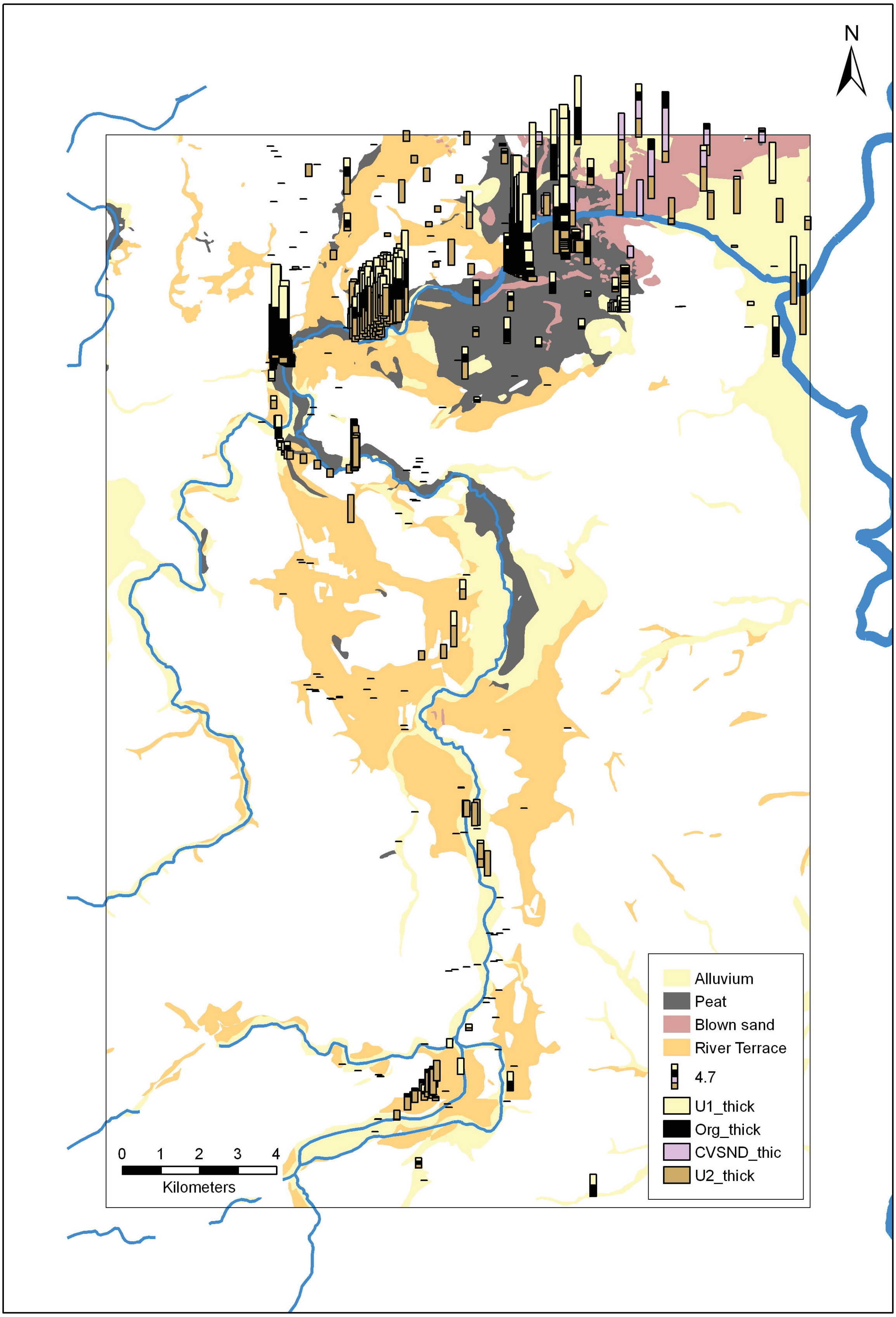


Figure 37. Map showing the drift geology of the Idle Valley and the location of all borehole records examined. Borehole data are shown as stacked bar charts indicating the location and thickness of the principal sedimentary units.

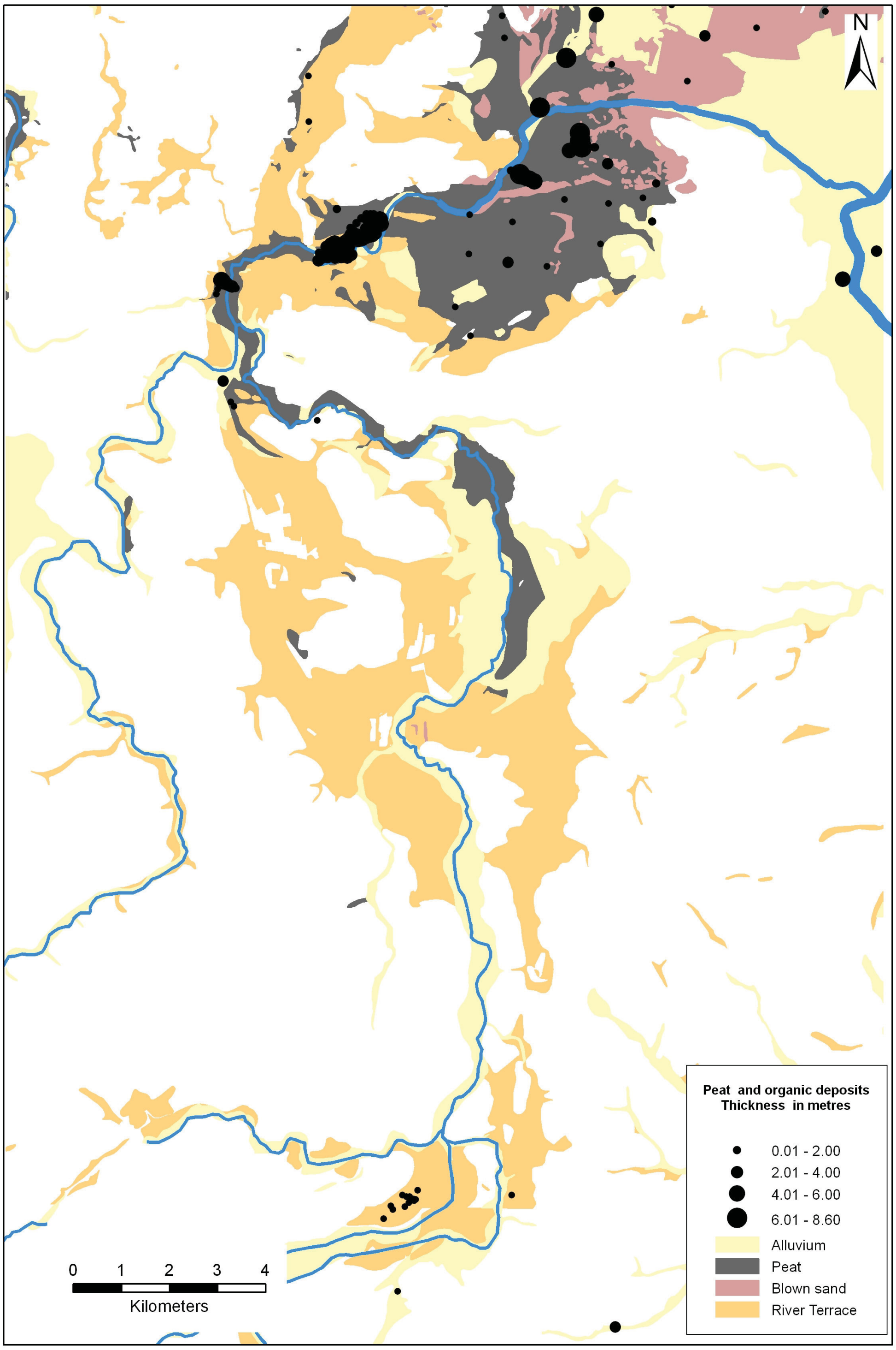


Figure 38. Map showing the drift geology of the Idle Valley and the location of all boreholes where organic deposits are recorded. The data is displayed as proportional circles indicating the thickness of peat.

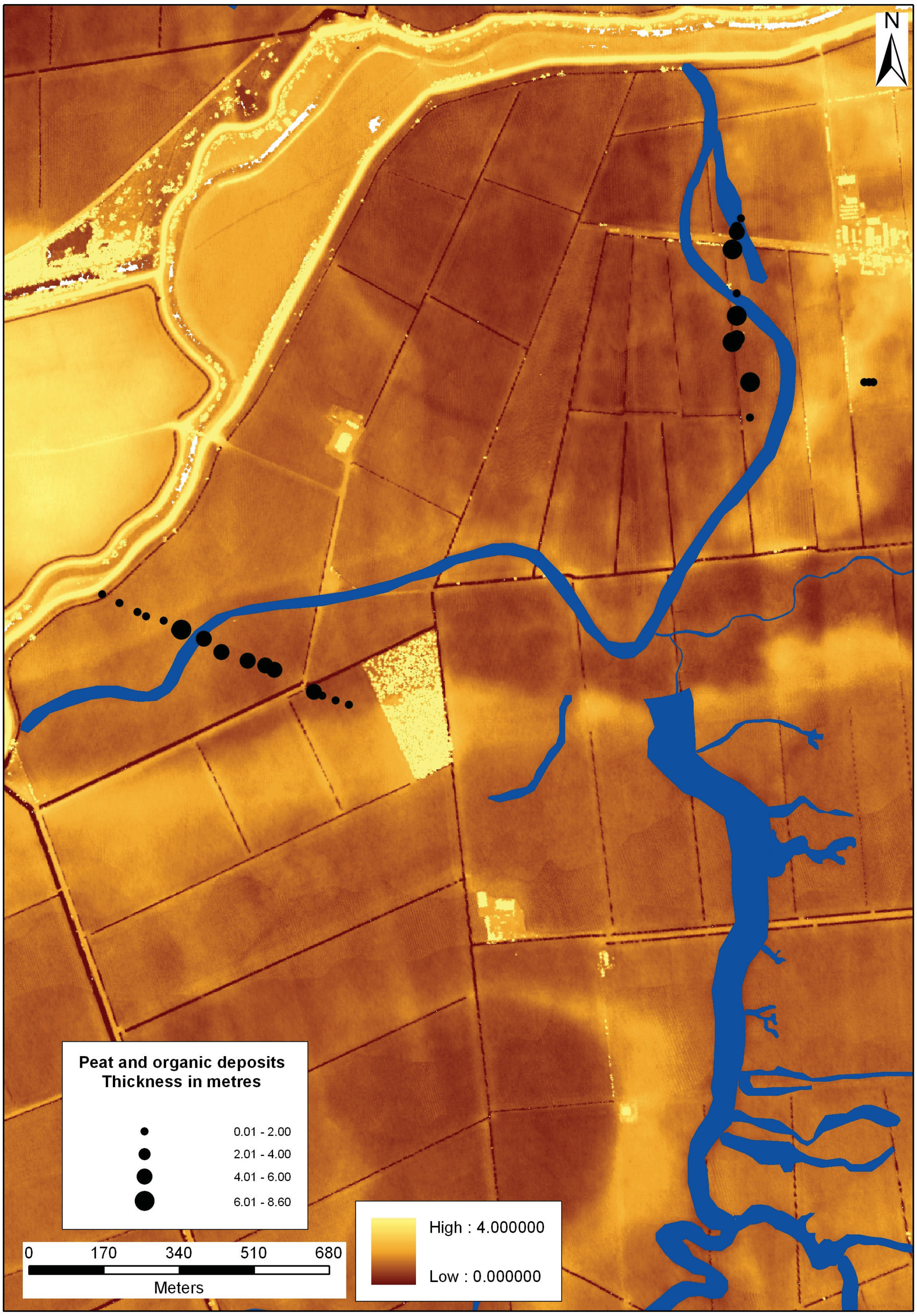


Figure 39. Map showing the location of the cores for Transects 2 and 3 of the Humber Wetlands Survey in combination with lidar DSM elevation data and palaeochannels mapped during this study (shown in blue). The position of each core is indicated by black circles showing the depth of peat deposits.

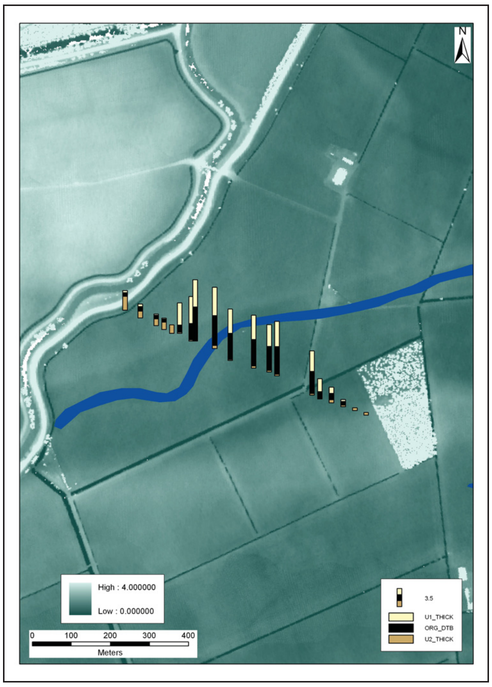
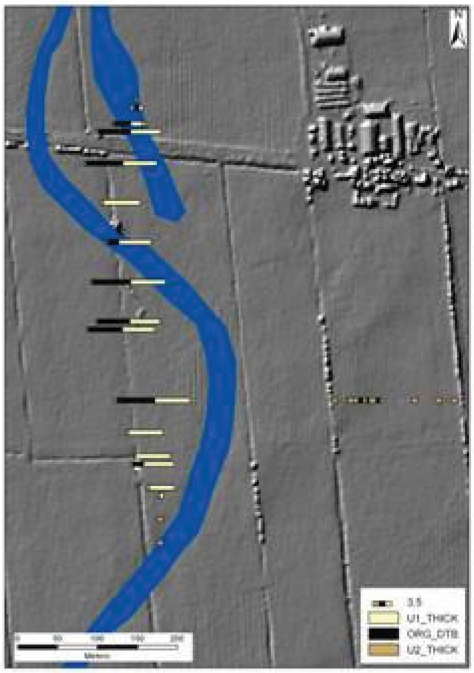


Figure 40. Map showing the location of the cores for Transect 2 of the Humber Wetlands Survey in combination with lidar DSM elevation data and palaeochannel data (shown in blue). The core data is shown as stacked bar charts indicating the location and thickness of the principal sedimentary units.

Substantial organic deposits were recorded by the Humber Wetlands team in Transect 3 (Figure 41), which suggest the presence of a further channel (or channels) in this area. Alternatively, these organic sediments could indicate the presence of blanket peat deposits sealed beneath later alluvium. It is also possible that there may be extensive areas of peat associated with the large depression (visible on the lidar data, Figure 41) immediately west of Transect 3.

Figure 41. Map showing the location of the cores for Transect 3 of the Humber Wetlands Survey in combination with lidar DSM elevation data and palaeochannel data (shown in blue). The core data is shown as stacked bar charts indicating the location and thickness of the principal sedimentary units.



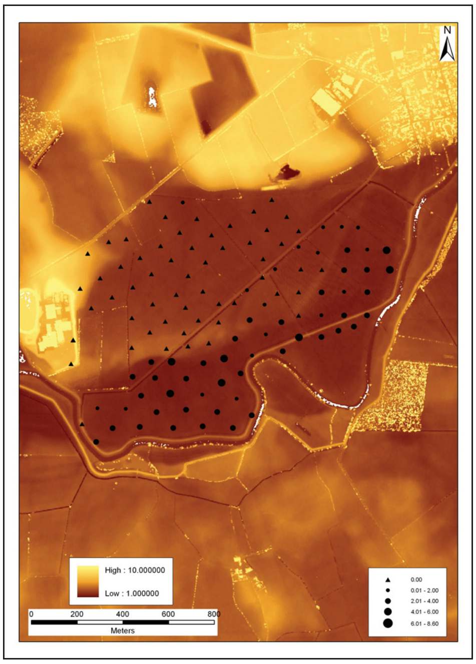


Figure 42. Figure showing the location of boreholes around Newington in combination with lidar DSM elevation data. The borehole data has been displayed as proportional circles indicating the location and thickness of peat deposits.

Borehole data for the Newington area to the west of Misterton Carr provides a detailed picture of the alluvial stratigraphy for this part of the Idle Valley (Figures 42 and 43). This indicates a significant blanket of peat across the modern floodplain, but little organic material across the terrace that crops out in the northern part of the study area. The terrace sands and gravels are blanketed however, by a thin cover of fine-grained alluvium.

Figure 43. Map showing the location of the boreholes for the Newington survey in combination with lidar DSM elevation data. The borehole data is shown as stacked bar charts indicating the location and thickness of the principal sedimentary units.

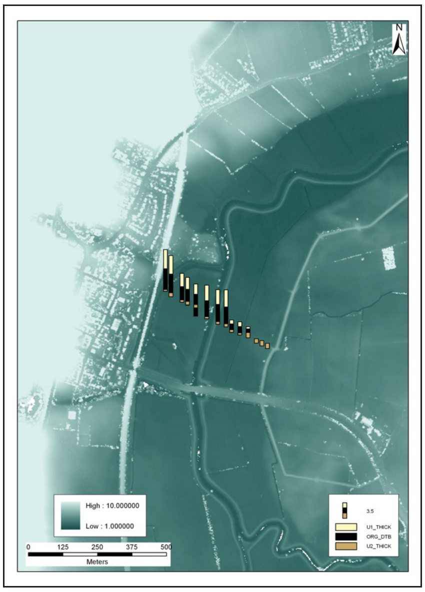


Figure 44. Map showing the location of the cores recorded along Transect 1 (Humber Wetlands Survey) in combination with lidar DSM elevation data. The core data is shown as stacked bar charts indicating the location and thickness of the principal sedimentary units.

Thick sequences of alluvium and organic deposits have also been recorded to the south-west of Newington, around Bawtry (Humberhead Wetlands Survey - Transect 1; Figures 44 and 45). These deposits become thicker from east to west across the floodplain (indicated by the darker band on the lidar image), between the contemporary channel and a possible palaeochannel. The data from the intensive surveys at Newington and Bawtry are particularly useful, since very few palaeochannels have been identified in close proximity to the Idle from the lidar and AP data. These additional boreholes indicate that parts of the floodplain immediately adjacent to the river possess the potential to preserve organic deposits capable of providing proxy records of climate and land use. However, the thick deposits of alluvium may also blanket archaeological resources.

Figure 45. Map showing the location of the cores of Transect 1 (Humber Wetlands Survey) in combination with lidar DSM elevation data. The core data has been displayed as proportional circles indicating the location and thickness of peat deposits.

3.3.4 River Idle: Subsurface Modelling

Only in the northern part of the River Idle study area were there were sufficient borehole records, with a relatively even distribution, to create meaningful sub-surface digital elevation models for the base of the alluvium, the river terrace sand and gravels, and the upper surface of the bedrock.

3.3.4.1 Modelling of Unit 1 – Base of Alluvium

In total, 190 borehole records from the northern part of the study area were used to generate the DEM (Figure 46).

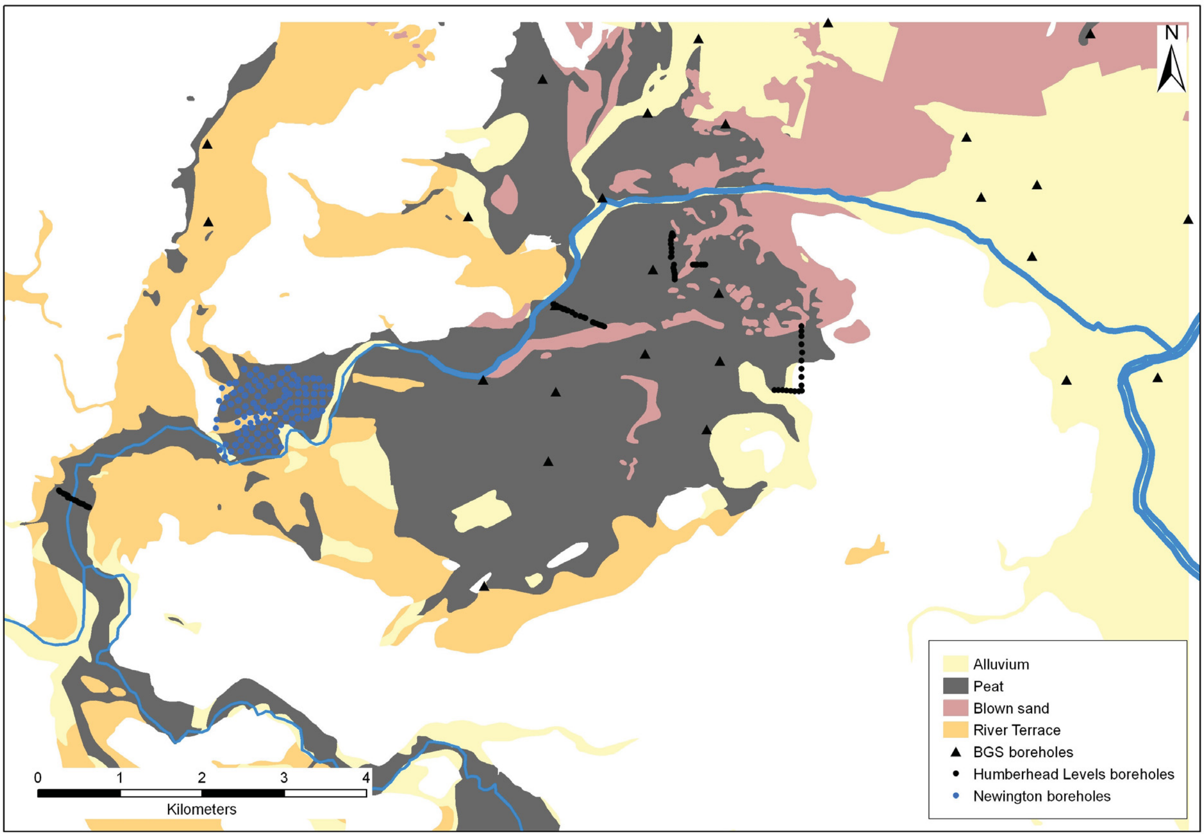


Figure 46. Map showing the extent of the floodplain and terraces of the River Idle and the location all of the borehole records used to create the DEM for the base of the alluvium.

The most striking feature of the DEM is the marked linear depression orientated on a southwest-northeast axis immediately to the north of the River Idle (Figure 47). Thick organic deposits associated with this feature suggest the possible presence of a major channel (Figure 48), an hypothesis confirmed by surface investigation and coring. There are suggestions that this channel may extend to the south-east of the River Idle, where there are further records of substantial peat deposits. Comparison of the DEM features with palaeochannel plots shows that these depressions correspond with major channels, which have been identified on either side of the river. The dimension and morphology of both channels is very similar and it is possible that they once formed part of a continuous watercourse, which may have incorporated part of the present day river system.

There are also a few isolated depressions visible on the DEM immediately to the south of this area. Borehole records indicate peat deposits within these areas and suggest the presence of channels that have not been identified from the remotely sensed data, possibly because they are buried beneath later alluvial sediments.

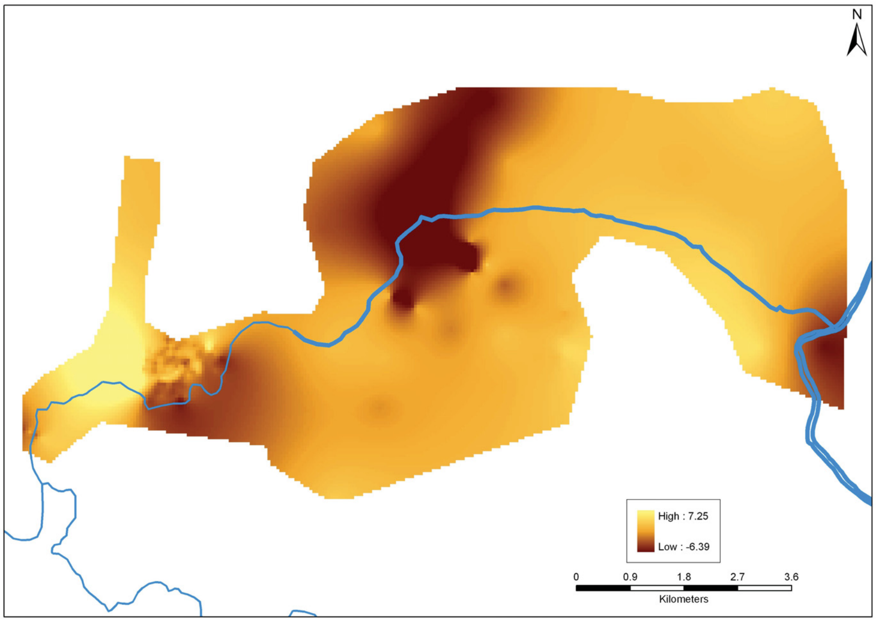


Figure 47.DEM illustrating the sub-surface topography at the base of the alluvium.

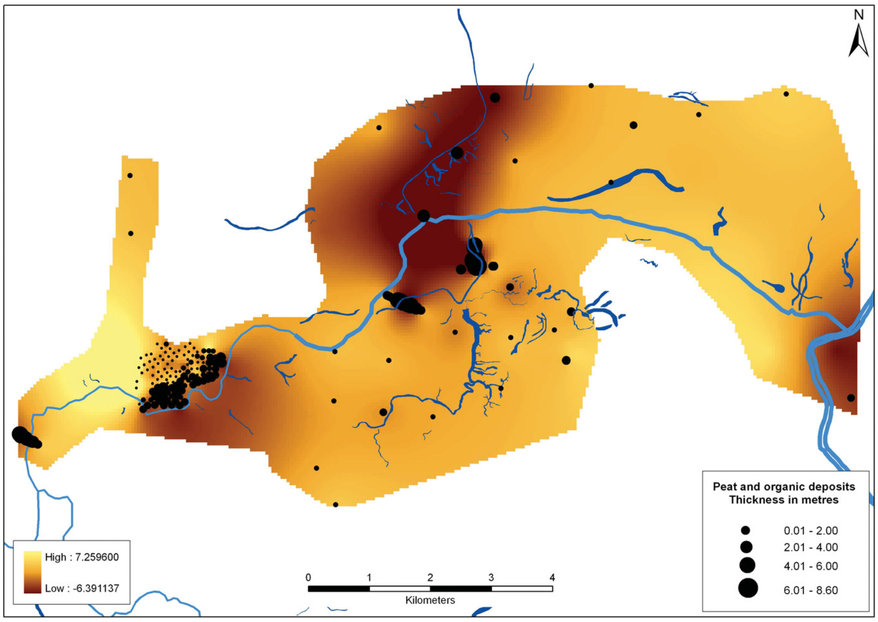


Figure 48. DEM illustrating the sub-surface topography at the base of the alluvium. Black circles indicate the location and thickness of organic deposits. The palaeochannels (shown in blue) are also illustrated.

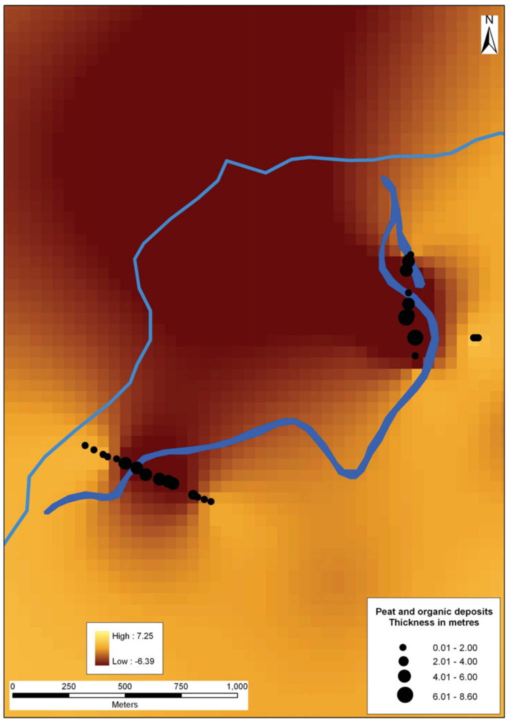


Figure 49.Detail of DEM illustrating the sub-surface topography at the base of the alluvium. Data from the Humber Wetlands Survey (Transects 2 and 3) is also shown. Black circles indicate the location and thickness of organic deposits. For comparison, one of the major palaeochannels (shown in blue) is also illustrated.

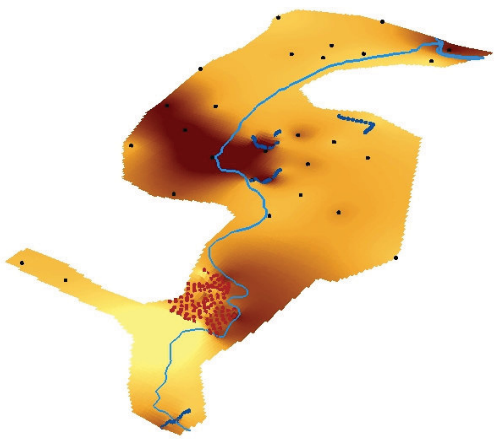


Figure 50.Three-dimensional view of DEM illustrating the sub-surface topography at the base of the alluvium. Black circles indicate data points used to construct the model.

3.3.4.2 Modelling of Units 2 and 3: River Terrace Sand and Gravels and Bedrock

In total, 158 borehole records (46 from BGS and 112 from the Newington survey) included details of Unit 2 stratigraphy and could be used to create a DEM for the base of the sand and gravel (Figure 51).

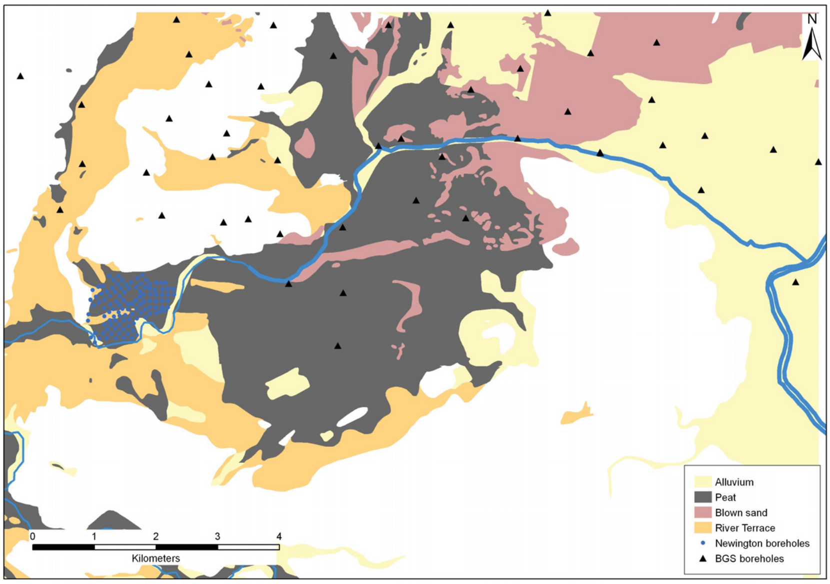


Figure 51. Map showing the extent of the floodplain and terraces of the River Idle and the location all borehole records that were used to create the DEM for the base of the sand and gravel.

A surface model of the top of the bedrock was created using 168 borehole records (56 from BGS and 112 from the Newington survey; Figure 52).

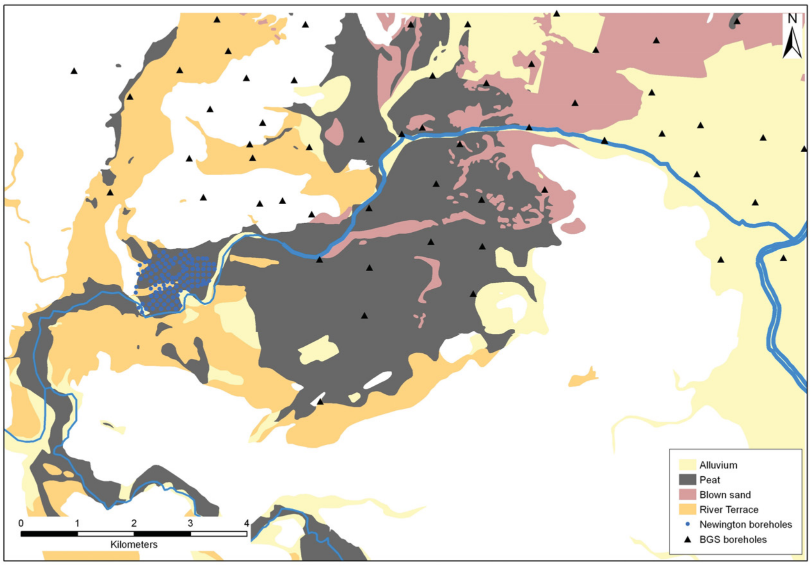


Figure 52.Map showing the extent of the floodplain and terraces of the River Idle and the location all borehole records that were used to create the DEM for the upper surface of the bedrock.

The most notable feature on the DEMs for the base of the sand and gravel (Figures 53 and 54) and bedrock (Figures 55 and 56) is a roughly oval-shaped depressed area, which corresponds with the position of the majority of recorded peat deposits and palaeochannels. It is possible that this feature may in part have been created by episodes of incision and scouring associated with some of the more substantial channels identified from the aerial photographs, lidar and borehole data. It is interesting to note that, in general, there is little indication of a depressed area in the sand and gravel and bedrock surfaces associated with the position of the River Idle itself, especially towards its confluence with the River Trent.

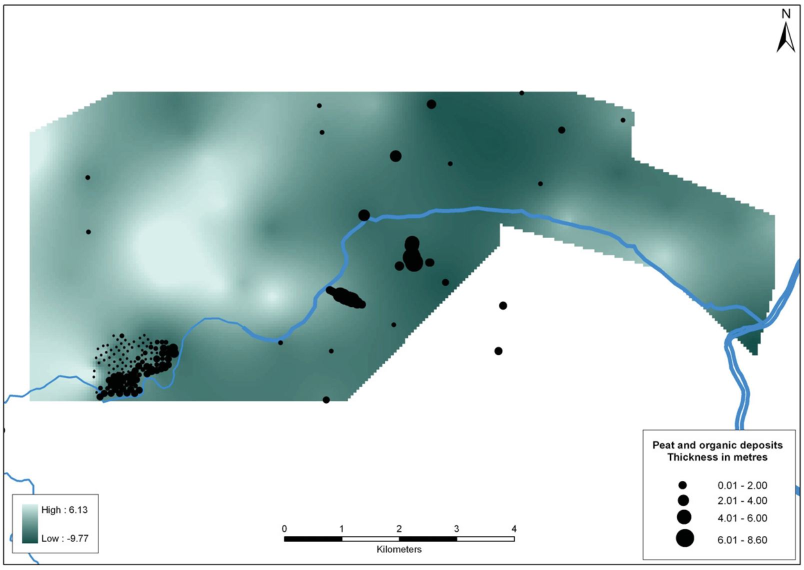


Figure 53. DEM illustrating the sub-surface topography at the base of the sands and gravels. Black circles indicate the location and thickness of organic deposits.

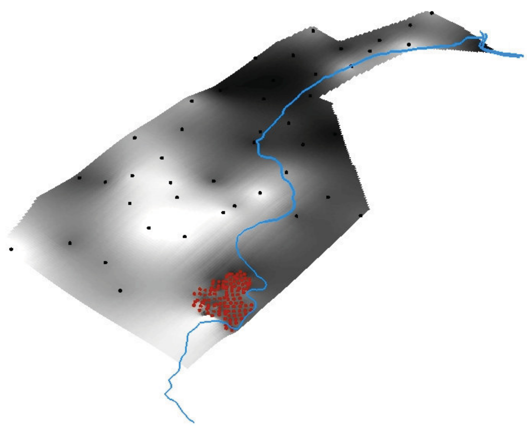


Figure 54. Three-dimensional view of DEM illustrating the sub-surface topography at the base of the sands and gravels. Black circles indicate BGS data points used to construct the model.

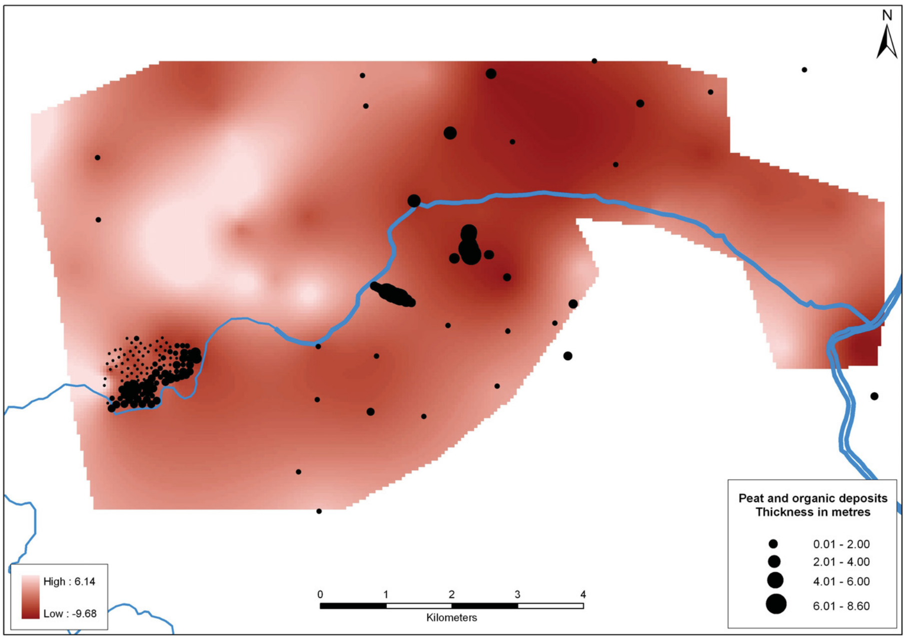


Figure 55. DEM illustrating the sub-surface topography at the base of the bedrock. Black circles indicate the location and thickness of organic deposits.

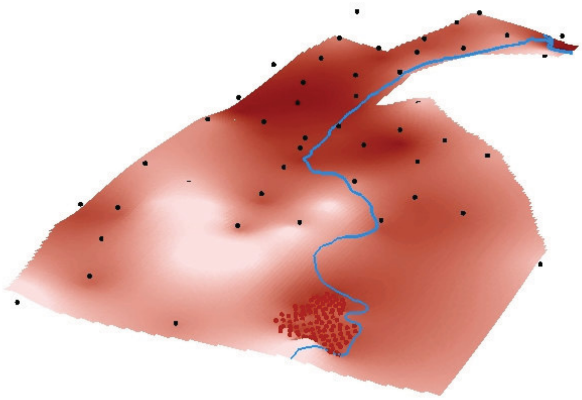


Figure 56. Three-dimensional view of DEM illustrating the sub-surface topography at the base of the bedrock. Black circles indicate data points used to construct the model.

3.3.4.3 Fence diagrams and cross-sections of the sub-surface stratigraphy

The intensive (grid-like) borehole surveys carried out for the Newington area and as part of the Humber Wetlands Survey provide ideal datasets for the creation of detailed three-dimensional models of the sub-surface stratigraphy.

The fence diagram shown in Figure 57, which has been created from a sample of the Newington borehole records, illustrates the subtle variations in the depth of alluvial sediment across this area. Such data provides the opportunity for a more detailed understanding of the development of the floodplain adjacent to this part of the river and could be used to predict the nature of alluvial architecture in similar locations elsewhere in the region. The ability to produce such detailed representations of the floodplain topography is therefore obviously very important in terms of archaeological prospection and resource management and also for providing useful information to the minerals industry.

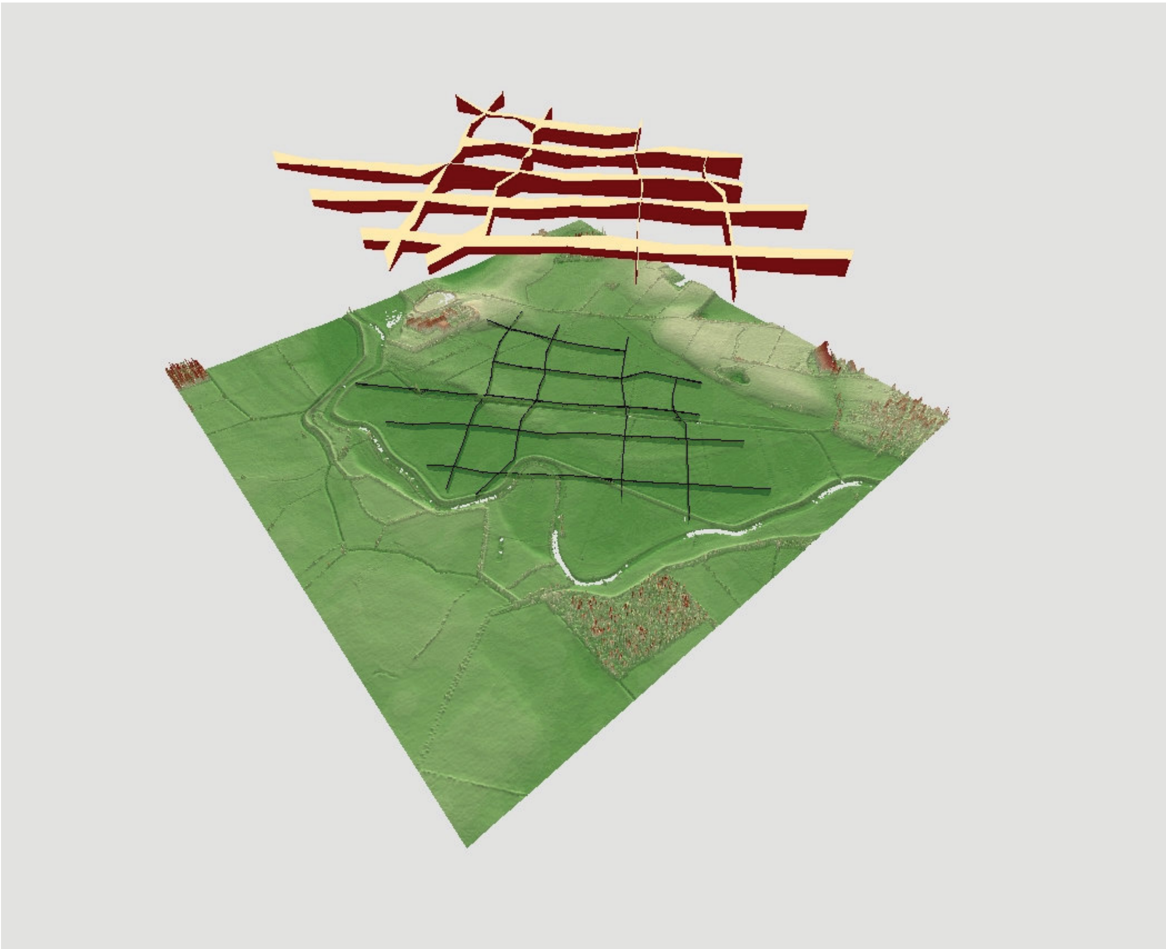


Figure 57. Stratigraphic fence diagram created using Rockware's Rockworks software, of alluvium and terrace deposits recorded for the Newington area. The data has been superimposed onto lidar DSM elevation data.

Figure 58 shows cross-sections of the stratigraphy constructed from Transects 2 and 3 (Humber Wetlands Survey) located in the Misterton Carr area. This demonstrates that there is a clear correlation between the alluvial deposits identified for Transect 2 (in the foreground) and the substantial linear depression (visible as a darker area on the lidar elevation data) running east-west across the area. The three-dimensional relationship between the deep alluvial deposits (identified in the cores for Transect 3) (located towards the top of the picture), a sinuous palaeochannel and a large, irregular-shaped depression is also evident.

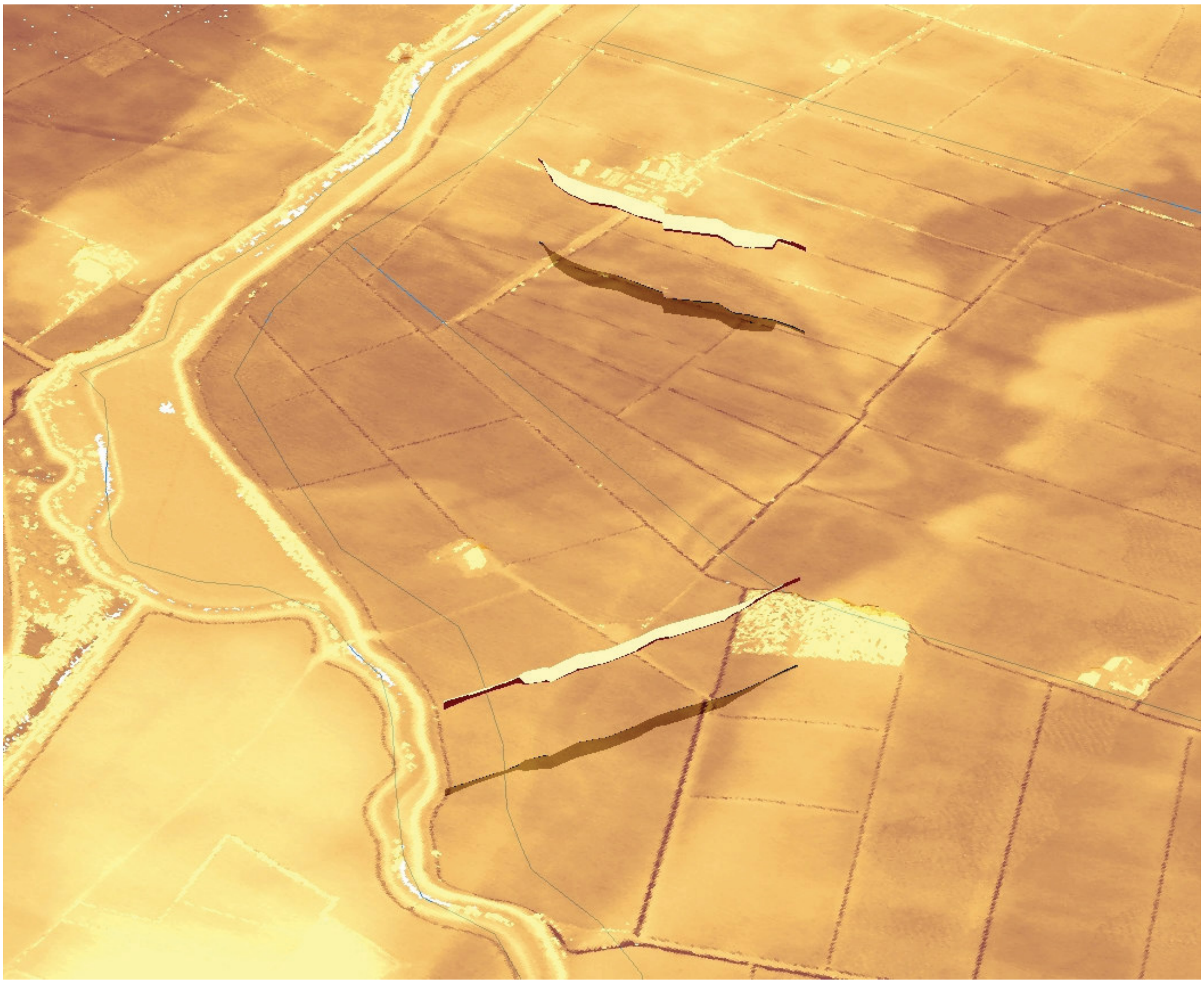


Figure 58.Cross-sections of the stratigraphy from the Idle constructed from core Transects 2 and 3 (the Humber Wetlands Survey), located in the Misterton Carr area. The data has been superimposed onto an opaque representation of lidar DSM elevation data.

3.4 SUMMARY

In total, 942 borehole records have been examined and digitised for this component of the project (488 for the River Dove and 455 for the River Idle). In the Dove Valley, 201 boreholes were identified containing alluvium, 67 of which contained organic remains. Alluvium was identified in 245 of the boreholes examined for the Idle; organic material was present at 150 locations, sometimes in associated with major palaeochannels. Organic deposits which do not correlate with known palaeochannels suggest the presence of further palaeochannels, or possible areas of blanket peat formation.

Poor spatial coverage of borehole data for the Dove Valley prevented detailed assessment of the valley floor. Nevertheless, fairly extensive deposits of alluvium and occasional concentrations of organic material can be located in certain parts of the study area.

The analysis of borehole records from the Idle Valley met with more success. Thick deposits of peat and alluvium have been identified in association with a major network of alluvial channels mapped in northern part of the study area. Construction of sub-surface DEMs generated from the borehole data indicate marked depressions at the base of the alluvium, the river terrace sands and gravels, and the bedrock, which correspond with some of these mapped channels and recorded organic deposits. These depressions may be the result of episodes of incision and scouring associated with some of the deeper channels in the area.

It must be borne in mind that the DEMs created for this study only provide a very generalised picture of the sub-surface stratigraphy. The overall resolution of the models was quite poor. The DEM for the alluvium, for example, was created from 27 borehole records spread over a wide area in combination with 163 records divided between 5 specific zones, in essence only 32 borehole locations. Also, isolated deep deposits at specific locations tend to skew the data, giving the impression that substantial features only exist in these areas. As stated by Challis (2004), sub-surface DEMs should be seen "as providing indicative models of sub-surface topography and stratigraphy as a spur to more detailed research".

The study has demonstrated that Rockworks is a robust software package suitable for modelling sub-surface stratigraphy.

4 ENVIRONMENTAL ASSESSMENT AND HISTORY

4.1 INTRODUCTION

Building on the mapping of landform assemblages and subsurface modelling, suitable areas of the tributary valley floors were selected for environmental assessment, in order to elucidate the environmental history. Cores and other bulk samples were collected from a range of channel features and other exposures of sedimentary deposits. Assessment involved the analysis of pollen, insect and where applicable, macroscopic plant remains.

4.2 THE DOVE VALLEY

The River Dove flows a distance of 65 km to its confluence with the River Trent and drains an area of 1,017km^2 of the northern uplands and lowlands bordering the Midland Plain. Today, it forms the border between Derbyshire and Staffordshire for much of its length (Dalton and Fox 1988).

The Dove study area defined for this broad landscape study extends from Rocester (SK3905 1002) in the north, to the confluence of the Dove and Trent at Newton Solney (SK2609 2701) to the south east. Prior to this study, palaeoenvironmental and geoarchaeological research in the Dove catchment has been extremely limited (e.g. Dalton and Fox, 1988). More archaeological work has been undertaken in the valley, but on the whole this has been focused on the nationally important Palaeolithic artefacts of the Hilton Terrace discovered within high level sand and gravel around Hilton and Etwall (Armstrong, 1942; Posnansky, 1963). These artefacts and the associated contexts of their deposition are the focus of a further ALSF project co-ordinated by the Universities of Durham and Birmingham (PIs: Dr Mark White; Dr David Bridgland and Dr Andy Howard; 3495 MAIN). Therefore, no consideration of the Lower and Middle Palaeolithic record or the associated Pleistocene sediments is undertaken here and this project focuses on the very late Pleistocene and Holocene geoarchaeological records.

Extraction of sands and gravels at numerous quarries along the Trent Valley has produced a plethora of environmental data and artefactual evidence ranging in age from the Palaeolithic to the medieval periods. This information has been recorded by a range of archaeological methods from fieldwalking, aerial photographic interpretation through to both set piece excavations and watching briefs (Knight and Howard, 2004). In contrast, much of the floodplain of the River Dove, one of the principle tributaries of the River Trent, remains unexploited, despite containing extensive suites of sand and gravel. At present, aggregate extraction is restricted to a single locality in the middle reaches of the valley close to UttoxEter (Bardon Spathe Quarry, Uttoxeter), although Cemex are exploring options for their quarry at Willington to extend into the confluence zone around Newton Solney.

The relatively undisturbed nature of this River Dove valley floor in relation to the River Trent provides an unparalleled opportunity to assess the geoarchaeological resource of this part of the Trent catchment. A number of researchers have suggested that Trent is unique amongst lowland river valleys in Britain since it has remained energetic throughout much of the Holocene, migrating back and forth across its valley floor, continually reworking earlier sediments and re-depositing sands and gravels initially aggraded during the late Pleistocene. In addition, large floods issuing down the tributary valleys, principally the Dove and the Derwent, may in some periods (such as the Little Ice Age) have led to the complete transformation of the river from a single channel to a braided system (e.g. Brown, 1998, Brown et al., 1999, Knight and Howard, 2004). Therefore, understanding the hydrological development of the Dove through the Holocene and the associated human impact on the valley floor is critical in elucidating the wider evolution of the Trent catchment and understanding key issues in the regional archaeological record.

The aim of this report is to report of the results of this extensive study.

4.2.1 Solid Geology and Pleistocene Sediments

For much of its upper course, the River Dove flows through the Carboniferous Limestone of the White Peak District. Close to the southern edge of the limestone, near Ashbourne, its flows through the narrow gorge of Dovedale, a tourist honey pot, which has been the inspiration to numerous landscape painters, poets, as well as containing important archaeologically-rich cave sites.

Below Ashbourne, the valley floor widens and the Carboniferous Limestones are replaced by soft brown mudstones and harder sandstones of the Triassic age Mercia Series, around Uttoxeter and which underly the rest of the Dove valley floor (Stevenson and Mitchell 1955).

The solid geology is overlain by glaciofluvial sands and gravels infilling the valley floor, deposited towards the end of the last glaciation from a lobe of ice occupying the Dove Valley (K. Ambrose, British Geological Survey, pers. comm.). It is these deposits which are currently the focus of mineral extraction by Bardon Aggregates at Uttoxeter. In places, these sands and gravels are associated with glacial tills (Stevenson and Mitchell 1955). At higher elevations on the northern interfluves of the valley, sands and gravels deposited before the last glaciation (i.e. pre-Devensian) are recorded (Stevenson and Mitchell 1955) and these have been the focus of much archaeological attention following the discovery of Lower and Middle Palaeolithic artefacts within these deposits at Hilton and Etwall. As mentioned previously, these deposits and their associated archaeological remains are the focus of another ASLF study and are therefore not considered in this study.

4.2.2 Holocene Fluvial Morphology and Sedimentology

From its source, the River Dove flows south to Uttoxeter, where it turns eastwards towards the confluence with the River Trent at Newton Solney. This morphology is most probably inherited from the last glaciation.

Throughout much of the catchment and certainly within the study area south of Rocester, the river is single thread with well developed meanders (Figure 59). Inspection of maps, aerial photographs and previous research (e.g. Dalton and Fox, 1988) indicates a mosaic of palaeochannels across the valley floor and suggests that the energetic nature of the river system has been a feature of the channel(s) for at least the last few hundred years and most probably further back into prehistory.

For much of its length, the River Dove either forms, or runs parallel to, the border between Derbyshire and Staffordshire (Dalton and Fox 1988); in places the county boundary follows the courses of relict meanders, such as at Marston on Dove (Figure 60). The research of Dalton and Fox (1988) demonstrates that the current border between Derbyshire and

Staffordshire has existed as a 'political/social boundary' within the landscape since at least the 10th century AD, and possibly from the Middle Ages.

Such channel mobility is also characteristic of the middle Trent, between Burton on Trent and Newark (e.g. Large and Petts, 1996). Brown (1998) and Brown *et al*. (2001) demonstrated that during the Medieval Warm Period and Little Ice Age, channel mobility and change within the valley floor between Hemington and Colwick could be linked to climate change and the impact of major floods destabilising the hydrological balance of the River Trent. Critically, Brown *et al*. (1999) demonstrated the impact of this stabilisation on the archaeological record, especially the destruction of medieval bridges discovered at Hemington Quarry during gravel extraction.

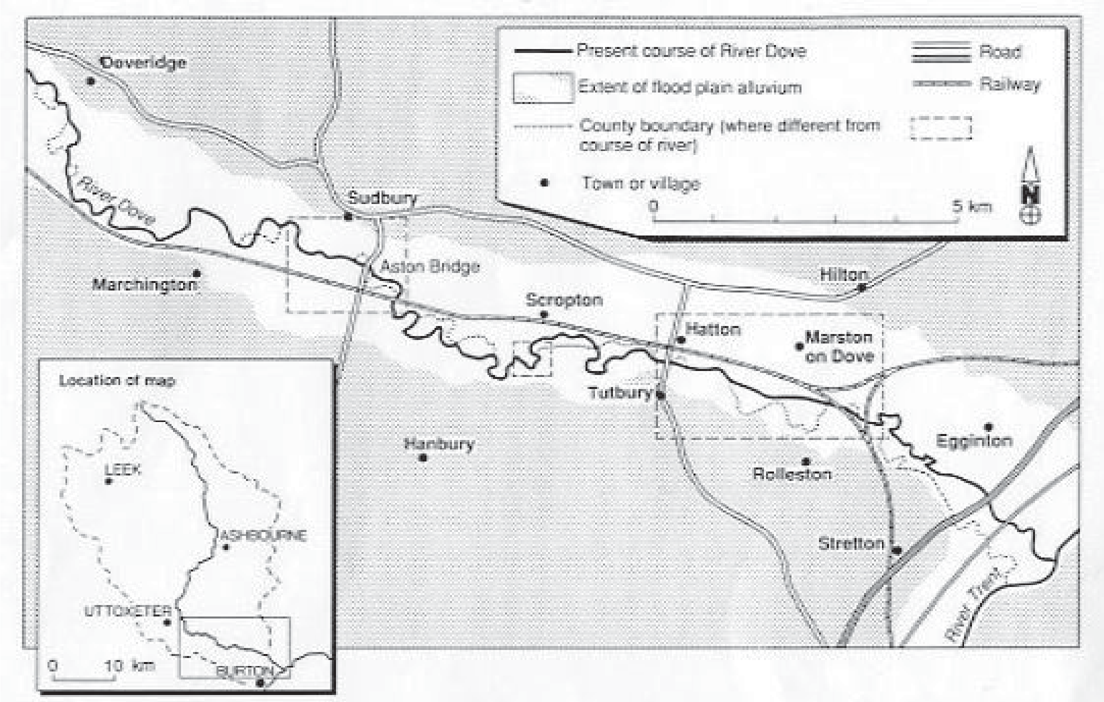


Figure 59. Significant areas of meander migration and channel change (reproduced from Dalton and Fox 1988)

One of the most significant effects on channel movement over the last 200 years was the construction during the mid 19th century of the embanked railway line, which skirts the southern edge of the floodplain (Dalton and Fox 1988). Persistent flooding of the railway line following construction resulted in straightening of the river and the construction of flood banks along lengthy reaches by the 1880's (Dalton and Fox 1988). However, despite these modifications, erosion monitoring between 1933 and 1952 by the water authority provides further evidence of continued channel instability into the 20th Century with high levels of erosion between Doveridge and Woodford and Aston Bridge to Scropton (Dalton and Fox 1988). At Scropton, a single meander was monitored and lateral migration of 12.5m was recorded during a single year (Dalton and Fox 1988).

Despite this evident channel mobility over the last few hundred years, it is possible to find preserved remnants of terrace, which provide evidence for earlier periods of floodplain development. The longest record of floodplain development known is currently from Tutbury (SK2101 2902), where an extensive series of palaeochannels dissect floodplain and older terraces in the shadow of Tutbury Castle. These channels and terrace landforms were the subject of detailed survey and investigation by (Hudson Edwards *et al*. 2002) as part of a previous ALSF study (Trent Valley Geoarchaeology 2002; PNUM 3307), which is described in more detail below.

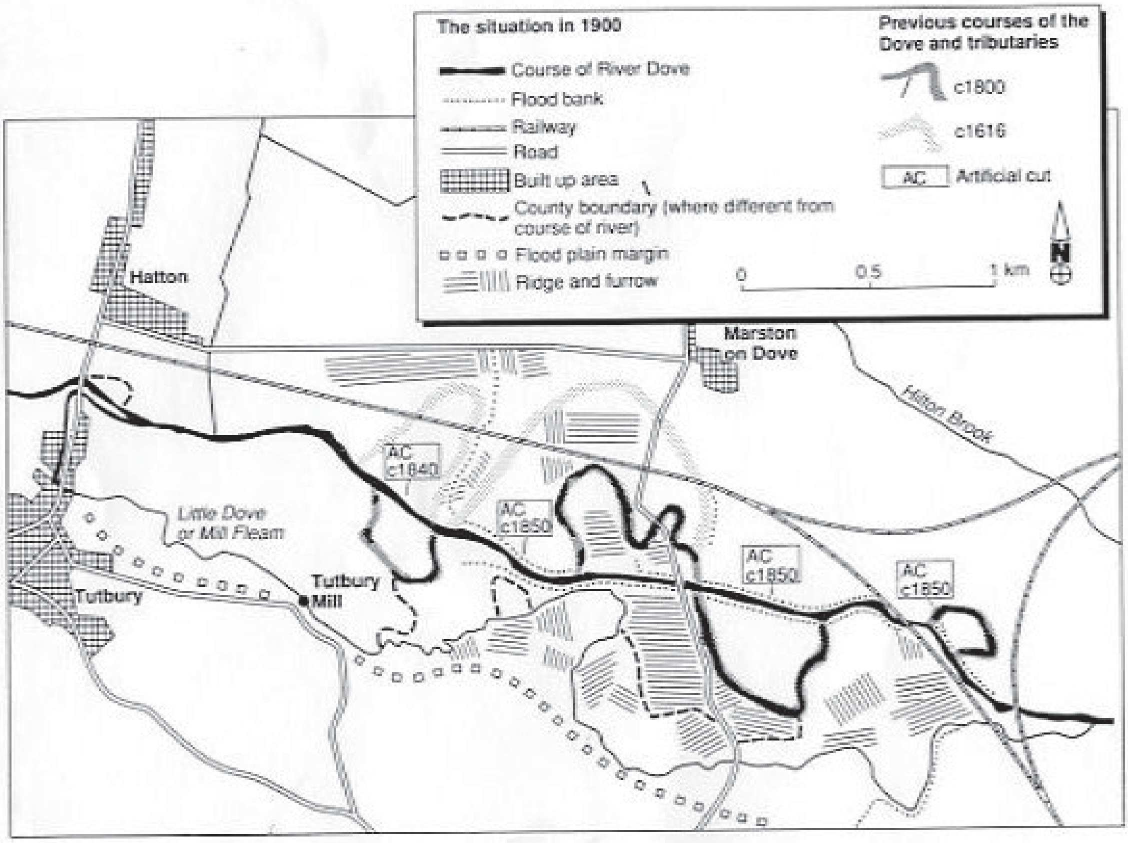


Figure 60. Channel change at Marston-on-Dove since 1616 (Dalton and Fox 1998).

4.3 PREVIOUS ARCHAEOLOGICAL AND PALAEOENVIRONMENTAL SURVEY

4.3.1 The Palaeolithic

Significant numbers of Lower and Middle Palaeolithic artefacts have been recovered from the high level sands and gravels recorded on the interfluves of the Dove Valley around Hilton and Etwall (the Hilton Terrace deposits of Clayton, 1953; Posnansky 1963); the deposits were aggraded during a pre-Devensian cold stage, but precisely when is the focus of much debate.

The sand and gravel deposits infilling the contemporary valley floor are much younger and were aggraded as glaciofluvial outwash during the last glaciation, probably between 25-14 ka BP. To date, no artefacts or palaeoenvironmental deposits, such as mammalian remains, have been recorded from these sediments.

4.3.2 The Mesolithic

Lengthy prehistoric occupation at Rocester is alluded to by Barfield and Kalai (1996), however finds are limited to worked flints, which consist of a core and and a bi-polar blade core dating to the late Mesolithic/early Neolithic period (Ferris *et al*. 2000). However, palaeoenvironmental evidence was recorded from the floodplain of the Dove around Dove Villa (SK1004 3408) during a watching brief associated with the construction of the Doveridge Bypass and these deposits are currently the earliest dated deposits Dove catchment. The material, silty peat recorded in scour channels underlying inorganic alluvium indicate sedimentation during the early Mesolithic *c*. 9370±60 ^{14}C years BP (Beta-100929, 10490-10190 cal BP, 8540-8240 cal BC, Howard & Knight 2004). The insect remains, especially a number of Elmidae or 'riffle' beetles including *Helichus substriatus*, *Limnius volkmari* and *Esolus parallelepipedus* all indicate clear, fast flowing waters (Friday 1988). Several species such as the Scolytidae *Scolytus scolytus* (the elm bark beetle) and *Pteleobius vittatus* indicate elm and the scolytid *Drycoetes alni* is found on alder (Koch 1992). Together, this indicates the presence of mixed deciduous woodland upon the valley floor (Smith 1996).

4.3.3 Neolithic to Bronze Age

One of the most significant multi-phase later prehistoric sites within the region lies close to the Dove-Trent confluence at Willington. Two major phases of excavation have occurred at Willington and both have been funded in response to aggregate extraction. The first excavations took place in the early 1970's when gravel extraction began at the site (Wheeler 1979). These excavations recorded several phases of occupation from the Late Neolithic through to the Anglo-Saxon period. Prehistoric domestic and ritual activity is represented by two settlements and two barrows. Settlement 1 consists of a series of post holes in seven distinct groups, three of which were rectilinear; Settlement 2 was more restricted, but lithics, Beaker and Groove Ware pot were found in both areas (Wheeler 1979).

The second campaign of archaeological excavation was associated with quarry extensions during the early 1990s and included the recording of two burnt mounds, post holes post holes and a series of ring cairns (Beamish 2001; Beamish and Ripper 2000). The two burnt mounds were dated to the late Neolithic and Bronze Age on the basis of artefactual evidence including lithics and 'Peterbrough-ware' pot sherds (Ripper and Beamish 2000). Both burnt mounds were recorded adjacent to palaeochannels and structural evidence in the form of a wooden trough was recorded within the younger mound. Palaeoenvironmental evidence recorded in the burnt mounds at Willington included a calcined cow tooth, charred nuts and fruit stones, possibly suggesting feasting and ritual at the site (Beamish 2001; Beamish and Ripper 2000). More conclusive evidence of domestic activity was found in the form of hearths, fire cracked stone and possible midden material (Beamish 2001).

The insect faunas from a number of samples associated with the late Neolithic burnt mound at Willington suggest that the channels were filled with slow moving water and surrounded by rough grassland, subject to grazing and possibly woodland (Smith and Tetlow 2005). Limited numbers of species associated with human habitation were found; one species of particular note is the dermestid *Dermestes lardarius*, which lives amongst cured hides and food waste (Smith and Tetlow 2005). Many species such as the Curculionidae *Mecinus pyraster* and *Gymnetron* spp. live on plaintains (*Plantago* spp.); *Apion aethiops* is associated with docks (*Rumex* spp.) and *Sitona* spp. with clovers (*Trifolium* spp.); together they suggest scrubby grassland (Koch 1992). A number of Scarabaeidae or dung beetles such *Geotrupes* spp. and *Aphodius* spp. suggest large herbivore grazed around the site (Jessop 1986).

Although the archaeological evidence suggests that settlement at Willington continued into the later Bronze Age, evidence for later Bronze Age settlement from the Trent catchment as a whole is somewhat lacking (Knight and Howard 2004).

4.3.4 Iron Age

Evidence of Iron Age occupation in the Dove Valley is also restricted to the multi-period site at Willington. Occupation during this period is argued to have been essentially ephemeral and probably seasonal (Wheeler 1979). Structural evidence for occupation comprises a classic round house, a large palisaded enclosure and a possible field system, all of which are interpreted as evidence for agricultural activity (Wheeler 1979). However, substantial palaeoenvironmental evidence for agricultural activity is lacking; only limited assemblages of animal bone have been recovered and charred cereal remains are restricted to residues attached to a rotary quern (Wheeler 1979).

4.3.5 Romano-British Period

Evidence of anthropogenic activity during the Romano-British period is considerably more extensive in the lower reaches of Dove Valley than that of other periods. To the north of the study area, a significant Roman settlement was located at Rocester and included an auxiliary fort built after 69 AD (Esmonde Cleary and Ferris 1996).

Two Romano-British farmsteads were also excavated at Willington (Wheeler 1979). The earlier farmstead consisted of a series of ditches, fence footings and stock pounds and evidence suggests a second phase of activity occurred around the 3rd or 4th century AD (Wheeler 1979). No field systems were recorded and only limited environmental evidence was recovered, including a few animal bones and the residue of charred plants. Evidence of cereal processing was recorded and included the remains of a grain store, a corn dryer and several rotary querns (Wheeler 1979).

4.3.6 Anglo-Saxon and Later

Excavation at Willington unearthed three Anglo-Saxon ‘grubenhäus’ and artefacts, which included pot sherds, loom weights and bronze ornaments (Wheeler 1979). Later Medieval field systems and settlement-related earthworks have been recorded at Egginton (SK2604 2808), approximately 1.5 km from Willington (Elliot *et al*. 2004). An unsubstantiated claim also suggests that an Anglo-Saxon settlement was present to the south of the modern village of Marston-on-Dove (SK2305 2904).

Evidence of medieval field systems are ubiquitous throughout the middle and lower Dove Valley. Large tracts of ridge and furrow exist between Doveridge (SK1172 3399) and Woodford (SK1168 3167) and smaller areas exist south of Rocester, close to the confluence of the River Dove and River Churnet (SK1025 3755).

Palaeoenvironmental evidence from deposits radiocarbon dated to the post-medieval period (*c*. 17th and 18th century) is recorded close to the confluence of the Rivers Dove and Trent (Havelock *et al*. 2002). The remains of macroscopic, waterlogged plant and insects were limited; pollen evidence suggests sedge dominated the vegetation of the wetter areas, but gave way to grassland with herbaceous taxa such as dandelions (*Taraxacum* spp.) and buttercups (*Ranunculus* spp.) in dryer parts of the valley floor (Havelock *et al*. 2002).

At Dove Bridge, Southgate *et al*. (1999) recorded a riverside revetment structure (kid-weir), which may support of the idea of floodplain instability. Initially constructed around *c*. 1610

AD and continually repaired and/or added to until *c*. 1631 AD, this structure was probably constructed to repair channel bank damage and prevent further bank erosion during a time of severe flooding associated with the climatic deterioration of the Little Ice Age.

4.4 FIELDWORK

Systematic mapping of the valley floor landform assemblages (terraces, palaeochannels etc) from aerial photographs and lidar resulted in the construction of geomorphological map for the entire valley floor. This allowed the selection of key localities for environmental prospection using a gouge auger, and where possible, the inspection of natural cut bank exposures. Following extensive field investigation, two areas were selected for further environmental assessment: an extensive drainage ditch at the edge of the valley floor at Eaton Dovedale (SK 1002 3704); and a well defined, deep stratified sequence associated with a palaeochannel below Tutbury Castle.

4.5 EATON DOVEDALE

Eaton Dovedale (SK 1002 3704), is the highest upstream reach selected for survey and environmental assessment and lies just below the confluence of the River Dove and its tributary, the River Churnet (SK 1006 3703). Situated in the lower reaches of the Upper Dove Valley, the floodplain at Eaton Dovedale is almost 2km wide and the modern river channel is single thread, but sinuous. The edge of the valley floor to the east is defined by the escarpment of Mercia Mudstone which rises to 152m OD. To the west, the edge of the valley floor is less well defined, though the surrounding hills rise to 91m OD. In addition to the natural landform assemblage, remnants of a medieval field system are visible on lidar images to the east and the west of the confluence zone.

Evidence from aerial photographs suggests that the river has been highly mobile in this reach over time. Palaeochannels are located to the east and west of the modern river and terraces are evident to the east of the channel, below Eaton Dovedale Farm. It is also possible that a higher terrace, almost certainly of late Pleistocene age, is present at the western margin of the valley near to the village of Crakemarsh.

4.5.1 Sedimentology

A re-cut modern drainage ditch, located 200m east from the contemporary channel contained a series of organic rich deposits with significant environmental potential (Table 12). The ditch is approximately three metres deep and drains in a southerly direction towards the current River Dove. Inspection of aerial photographs and historic maps indicated that this ditch was probably excavated through a former river channel flowing along the eastern margin of the valley floor.

Two sections along the ditch were excavated and cleaned for further stratigraphic and palaeoenvironmental analysis. Dove 1 (SK 1047 3723) was located in the lower reaches of the drainage ditch, close to its confluence with the main river channel. The section was 2.6m deep and divided into five, stratigraphic units. The second section, Dove 2 (SK1045 BNG3701), was slightly deeper and stratigraphically more complex and divided into nine units, with at least one possible flood horizon at 2.16m.

Table 12. Sedimentology and potential palaeoenvironmental contexts at Eaton Dovedale.

	Sedimentology	Visible Organics	Comments
Section 1 (m)			
0-1.5	Red brown silt with topsoil developed		
1.5-1.75	Unit 2, Grey/brown gleyed silt	Modern rootlets, bioturbation.	Iron pan
1.75-1.90	Unit 3; Grey/brown peaty silt	Rootlets, degraded mollusca	Iron pan around stones
1.90-2.60	Unit 4, Grey/black peaty silt. Organic rich lenses	Mollusc rich lens	Iron pan around stones
2.60 +	Unit 5, Grey/brown medium sand		Sharp, irregular contact with upper unit

	Sedimentology	Visible Organics	Comments
Section 2 (m)			
0-1.50	Unit 1, Red brown silt with topsoil developed		
1.50-1.98	Unit 2, Grey/brown gleyed silt	Modern rootlets, bioturbation.	Iron pan
1.98-2.16	Unit 3, Grey/black humic sandy silt.	Waterlogged plant remains	Iron pan
2.16-2.24	Unit 4, Grey/brown medium sand		Iron pan. Flood horizon
2.24-2.29	Unit 5, Grey silt		
2.29-2.34	Unit 6, Brown, medium sand		
2.34-2.56	Unit 7, Grey/black sandy silt	Waterlogged plant remains & wood. Mollusc rich.	Sharp irregular contact
2.56-2.71	Unit 8, Brown, medium sand	Mollusc rich	Sharp irregular contact
2.71 +	Unit 9, Fine to medium gravel		

Plate 1.Eaton Dovedale, section Dove 1

Plate 2.Eaton Dovedale, section Dove 2

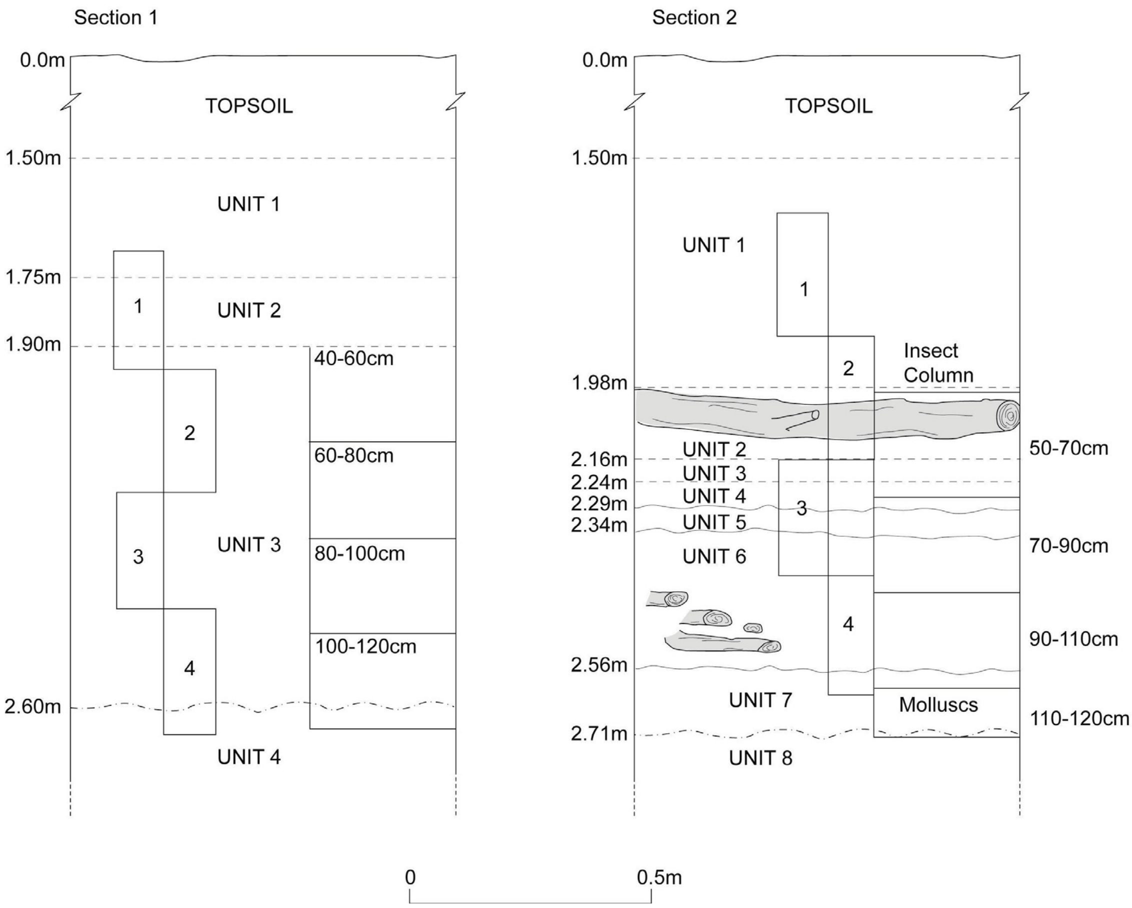


Figure 61. Eaton Dovedale sections Dove 1 (section 1) and Dove 2 (section 2)

Dove 1 (Plate 1, Figure 61)

Unit 1, a red brown silt was 1.5m thick and included topsoil development in the first half metre. This was underlain grey/brown gleyed silt (Unit 2) showing evidence for bioturbation and modern rootlet penetration; iron pan was visible throughout. Unit 3 comprised grey/brown peaty silt with visible iron panning around larger rootlets and associated with pebble inclusions; the unit contained abundant, but degraded remains of mollusca. Unit 4 comprised a grey/black peaty silt, with organic-rich lenses and a sharp, irregular basal contact. Unit 5 comprised grey-brown, medium sand.

Dove 2 (Plate 2, Figure 61)

The upper two units of Dove 2 correlate with Units 1 and 2 described for Dove 1. Subsequently, sedimentary development between the two sections appears to be disparate and considerably more complex around Dove 2. Units 3, 5 and 7 comprised predominantly silty materials and were separated by thin, medium sand horizons, tentatively interpreted as higher energy (flood) events. The final two units in this section are correlated with Unit 5 of Dove 1.

4.5.2 Palaeoenvironmental Analysis

A complete suite of samples was recovered for the analysis of pollen, insect and waterlogged plant remains from suitable contexts in both sections. No samples were recovered for either palaeobotanical or palaeoentomological analysis from Unit 1 or the basal sands and gravels. However, the basal units from Dove 2 contained abundant mollusca and were subsampled accordingly. Where appropriate, samples were also recovered for radiocarbon dating.

Table 13. Palaeoenvironmental samples from Eaton Dovedale.

Site	Feature/Area	Sample no.	Insects	Pollen	Waterlogged	Molluscs
Eaton Dovedale	Dove Section 1	40-60	√	√	√	
		60-80	√	√	√	
		80-100	√	√	√	
		100-120	√	√	√	
Eaton Dovedale	Dove Section 2	50-70	√	√	√	
		70-90	√	√	√	√
		90-110	√	√	√	√
		110-120				√

Table 14. Stratigraphic units and related palaeoenvironmental samples, Dove 1.

	Sedimentology	Samples		
Dove 1 Section 1 (m)		**Pollen***	**Insect****	**Macros**
0-1.50	Red brown silt with topsoil developed			
1.50-1.75	Grey/brown gleyed silt			
1.75-1.90	Grey/brown peaty silt			
1.90-2.60	Grey/black peaty silt. Organic rich lenses	0-25cm (1/1.95m)		
		24-5cm (2/2.2m)	40-60cm (2.1m)	40-60cm
		49-74cm (3/2.45m)	60-80cm (2.3m)	60-80cm
2.60 +	Grey/brown medium sand	72-97cm (4/2.70)	80-100cm (2.5m)	80-100cm
			100-120cm (2.7m)	100-120cm

Table 15. Stratigraphic units and related palaeoenvironmental samples, Dove 2.

	Sedimentology	**Samples**			
Dove 2 Section 2		**Pollen**	**Insect*****	**Macros**	**Molluscs**
0-1.50	Red brown silt with topsoil developed				
1.50-1.98	Grey/brown gleyed silt	1.6-1.85m (Monolith 1)			
1.98-2.16	Grey/black humic silt. Sand rich.	1.65-2.1m (Monolith 2)	50-70cm (2m)	50-70cm	
2.16-2.24	Grey/brown medium sand	2.1-2.35m (Monolith 3)	70-90cm (2.2m)	70-90cm	70-90cm
2.24-2.29	Silt				
2.29-2.34	Sand	2.35-2.6m (Monolith 4)			
2.34-2.56	Grey/black sandy silt		90-110cm (2.4m)	90-110cm	90-110cm
2.56-2.71	Brown, medium sand				110-120cm
2.71 +	Gravel				

For the purposes of initial palaeoenvironmental assessment pollen samples were acquired from the top, middle and bottom of monoliths from Dove Section 1 (1.95m, 2.48m, 2.77m) and Dove Section 2 (1.6m, 2.1m, 2.6m). Seven bulk samples were assessed for insect and waterlogged plant remains and three samples from mollusc-rich horizons (Dove 2, .7-.9m, .9-1.10m and 1.10-1.20m). Radiocarbon samples were recovered from the top and bottom of the organic rich sediments at both sites 1 and 2. These samples have been submitted to the Dating Team at English Heritage and a supplementary report will be prepared once the age estimates are available.

4.6 ENVIRONMENTAL ASSESSMENT, EATON DOVEDALE

4.6.1 Terrestrial Environment and Landscape Use

Palaeobotanical evidence from the both sections at Eaton Dovedale suggest similar terrestrial environments throughout deposition. Pollen data indicates grassland colonised by a variety of forbs, which include buttercups (Ranunculaceae), dandelions and other daisy like flowers (lactuacae). Waterlogged plant remains also included buttercup, Knotweeds (*Persicaria* spp.) and chickweed (*Stellaria media*). More disturbed ground is indicated in the pollen record by ribwort plantain (*Plantago lanceolata*); this species is also reflected in the insect record by the curculionid *Mecinus pyraster* (Koch 1992). Waterlogged plant remains include nettle (*Urtica dioica*), orache (*Atriplex* spp.) and docks (*Rumex* spp.). Insect taxa of disturbed ground include *Phytobius* spp. and *Rhinoncus* spp. and the chrysomelid *Chaetocnema concinna* found on bistorts and docks (Polygonaceae); both *Apion urticarium* and the nitidulid *Brachypterus urticae* are found on the common nettle (*Urtica dioica*) (Bullock 1993, Koch 1992).

Despite the overwhelming similarities, the insect taxa from Dove Section 1 do suggest that conditions may have been wetter than those of Dove Section 2. An assemblage of Chrysomelidae or 'leaf beetles' often know collectively as 'reed beetles' were recovered from the Dove Section 1 samples; the *Plateumaris* and *Donacia* families are associated with sedges and reed species, whilst the Pselaphidae *Brachygluta* spp. are found on sedge tussocks and moss polsters in bogs and marshes (Pearce 1957). Sedge fruits, sweet grass (*Glyceria* spp.) and abundance of rush seeds were also found amongst the waterlogged plant remains from Dove Section 1 samples. In contrast, only a single seed from either species was recovered from Dove Section 2.

A further disparity is the unequivocal evidence of woodland from the uppermost sample from Dove Section 1. Insect taxa include the Scolytidae *Leperisinus varius* and *Hylesinus* spp., both commonly found on ash (*Fraxinus* spp.), and the Anobiidae *Grynobius planus* and *Anobium punctatum* are serious pests of dry wood and are found on dead, dry limbs of a variety of deciduous trees (Koch 1989b, 1992). No woody species were recovered from the waterlogged plant remains, but pollen of alder and hazel was recorded.

Palaeobiological evidence also suggests both pastoral and arable farming. *Cannabis*-type and *Avena-Triticum*-type pollen are both present in the upper samples of both Dove sections 1 and 2. Scarabaeidae or ‘dung beetles’, which suggest grazing animals, were also found throughout.

Worthy of note is the increase in heather (*Calluna* spp.) and birch (*Betula* spp.) pollen in the upper pollen samples of both Dove Sections 1 and 2. This appears concurrent with the expansion of farming in the area.

4.6.2 Aquatic Regime and channel vegetation

Proxy environmental evidence suggests that the aquatic environment at Eaton Dovedale is in a constant state of flux throughout deposit formation. Insects from Dove Section 1 (sample 100-120cm) are indicative of clear, flowing, well oxygenated water, fringed by water plantain (*Alisma plantago aquatica*), pondweed (*Potamogeton*) and rushes (*Juncus* spp.). None of these species are particularly associated with flowing water; for example, water plantain is associated with ponds and ditches (Haslam *et al.* 1995). The basal samples from Dove Sections 1 and 2 suggest low energy sedimentation in a tranquil backwater. The aquatic and semi-aquatic insects such as the Hydraenidae are all found in shallow, muddy ephemeral pools; the Gyrinidae are found in deeper standing waters (Hansen 1987, Nilsson and Holmen 1995). Insect species associated with flowing water are absent. Aquatic vegetation includes water plantain, pondweed and watercress (*Rorippa* spp.). However, moving up through the sequence, species associated with slow moving water are replaced by large numbers of the Elmidae *Esolus parallelipepidus* and *Oulimnius* spp, which suggests faster flowing conditions.

In the upper most sample from Dove Section 1, the insect species suggest a return to low energy, backwater conditions once more. The Elmidae are absent and have been replaced by Hydraenidae, Hydrophilidae and Dytiscidae, all found in standing water. The large hydrophilid’s *Cymbiodyta marginalla* and *Hydrobius fuscipes* are found in nutrient rich, standing waters. The return to these low energy conditions is also associated with an increase in the number of aquatic plants and evidence indicates the presence of the common reed (*Phragmites australis*).

4.7 TUTBURY

The floodplain below the town of Tutbury and the castle ruins (Figure 62) has historically, been one of the most geomorphologically active reaches of the River Dove. The floodplain has experienced large-scale channel migration throughout the Holocene; between 1616 and 1807, the river experienced a lateral shift of 1km around Tutbury (Dalton and Fox 1988). It has also been the focus of human manipulation since at least Medieval times and probably earlier. The 'Mill Fleam' (also known as the 'Little Dove'), which rejoins the main channel at Rolleston-on-Dove, was constructed prior to 1086 and modified in 1645.

The floodplain in this area has already received limited attention as part of Trent Valley Geoarchaeology 2002 (Hudson-Edwards *et al*. 2002). This previous survey mapped four terraces and a number of palaeochannels.

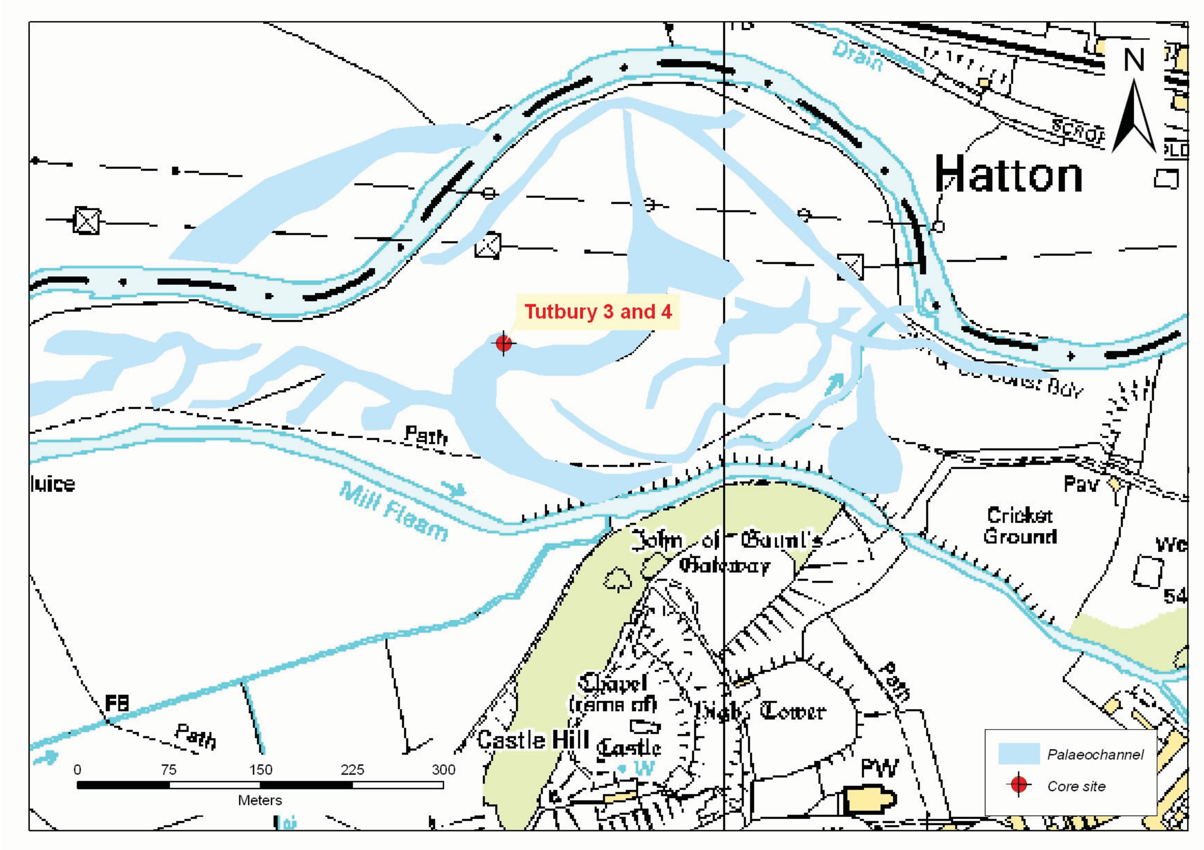


Figure 62. The floodplain of the River Dove at Tutbury, showing palaeochannels mapped from the air and the locations of samples 3 and 4.

Terrace 1

The oldest terrace (equivalent to the Holme Pierrepoint Sand and Gravel of the British Geological Survey [BGS], MIS 2 *c*.26-11 ka BP) crops out to the north of the modern river and abuts the railway line and is the location of the modern village of Hatton. Part of this high terrace is inundated by floodwaters and the sand and gravel is overlain by a thin layer of silt and clay alluvium.

Terrace 2
Terrace 2 comprises sands and gravels and is equivalent to the Hemington Terrace of the BGS (MIS 1, post 10ka BP, ~5-3 ka BP). It forms the most extensive terrace deposit mapped across the valley floor and is blanketed by a thin veneer of silt and clay alluvium.

Terrace 3
Deposits of Terrace 3 are significantly less extensive and recorded close to the modern channel. It is composed of fine-grained silt and clay alluvium and contains artefactual evidence including tile, pottery, slag and clay pipe.

Terrace 4
This terrace constitutes the modern floodplain. It is composed of fine grained silt and clay, again with significant evidence for human activity (including tile, pottery, slag and clay pipe).

Following prospection of a number of channels, samples for further palaeoenvironmental analysis were recovered from adjacent cores within the central part of a substantial meandering palaeochannel recorded on the floodplain, below Tutbury Castle (SK2082 2948).

Table 16. Details of sediments and radiocarbon sample location from Tutbury Core 34

Core 34	**Sedimentology & Stratigraphy**	**Depth of ^{14}C # (m)**	**Material Type**
m			**Radiocarbon**
0 - 0.7	Red brown silty clay		
0.71–0.9	Grey, gleyed silt	S1 - 0.90	Unident. organic detritus
0.91-1.6	Organic rich silt		
1.61–1.77	Peat		
1.78–1.81	Coarse sand (flood horizon)		
1.82–1.83	Peat		
1.84–1.86	Coarse sand (flood horizon)		
1.87–1.93	Peat		
1.94–2.0	Coarse sand (flood horizon)		
2.01–3.2	Organic rich silt		
3.21–3.4	Peat		
3.41 +	Sand and Gravel		

Of particular note in the sedimentary sequence were three coarse sand layers within the fine-grained organic sequence (Plate 3). These are interpreted as possible flood horizons and organic material from both above and below these layers have been sent to the EH Dating Team for radiocarbon age assessment.

Plate 3. Possible flood deposits in Core 3 from the Floodplain at Tutbury.

4.7.1 The Environmental Data from the floodplain at Tutbury, Staffordshire.

A complete suite of samples was recovered for the analysis of pollen, insect and waterlogged plant remains from suitable contexts within the recovered cores. Where appropriate, samples were also recovered for radiocarbon dating.

<u>Sample depth 2.5-3.4m</u>

The insect, pollen and waterlogged plant remains from this level are all indicative of low growing, damp pasture. Insect remains from this depth indicate such as the Chrysomelidae *Plateumaris* and *Donacia* spp. are suggestive of damp, sedge fen (Menzies and Cox 1996, Walker 1970). Sedge fruits (*Carex* spp.) were also recovered from these samples, as were the seeds of the spike rush (*Eleocharis* spp.). The latter is commonly found at the edges of ponds and ditches; also suggestive of boggy, marshy ground is the marsh marigold (*Caltha palustris*) (Stace 1997).

Any distinct aquatic coleopteran fauna from the base of the deposits is virtually absent, which suggests that there was no standing water in the meander cut off during this episode of deposit formation. Riparian vegetation is primarily composed of taxa such as water plantain (*Alisma plantago-aquatica*). Both seeds and pollen of meadowsweet (*Filipendula ulmaria*) were also found. Whilst both taxa will withstand fluctuating water tables, they are most commonly associated with ephemeral water bodies and muddy pools (Stace 1997).

Waterlogged plant and pollen evidence also suggests that the meander cut-off was surrounded by disturbed grassland. Both seed and pollen evidence indicates the presence of docks (*Rumex* spp.) throughout these levels; the waterlogged seeds from nettle (*Urtica* *dioica*), chickweed (*Stellaria media*) and dandelion (*Taraxacum* spp.) were also recorded. The latter four species are all found on waste and disturbed ground (Stace 1997). Possible explanations for this disturbance include pastoral/arable activity and flooding. A single scarabaeid or dung beetle was recovered from these samples, which suggests grazing animals close by.

In the wider landscape, pollen evidence indicates stands of oak (*Quercus* spp.) and willow (*Salix* spp.). Remains of willow were also found amongst the waterlogged plant remains, as were dogwood (*Cornus* spp.) and elder (*Sambucus nigra*). The latter species probably suggesting stands of scrubby shrubs nearby.

<u>Sample Depth 2.5-1.9m</u>
This suite of samples is characterised by increasing disturbance and possible evidence of arable farming, especially illustrated by the pollen assemblage. Whilst grass pollen decreases and is replaced by alder (*Alnus* spp.) and hazel (*Corylus* spp.), incidence of taxa associated with disturbed, waste and cultivated ground increase and include plantain (*Plantago lanceolata*) and Lactuaceae, a family which includes low growing species such as dandelions and the common daisy (*Bellis perennis*). This increase in disturbed ground and low growing grassland taxa is reflected by evidence from both the waterlogged plant remains and terrestrial insect taxa. Seeds of docks, chickweed and buttercup persist; coleoptera associated with similar grassland are the Curculinidae *Sitona* spp., which are found on vetches (*Vicia* spp.) and clovers (*Trifolium* spp.) (Bullock 1993).

The pollen of the cultivars *Cannabis*-type (Cannabaceae) and *Avena-Triticun* type (oats, wheat) were recorded in small quantities, which suggest arable activity nearby. The Cannabaceae family comprises hemp (*Cannabis* sativa) and hops (*Humulus lupulus*) and these two species are notoriously difficult to differentiate by palynological means (Gearey *et al*. 2005). Despite the brewing tradition of nearby Burton-on-Trent, Staffordshire is not a traditional hop-growing county and therefore it seems likely that the pollen is hemp.

Beetle species associated with damp, muddy ephemeral pools such as the Hydraenidae *Hydraena* spp. *Octhebius* spp. and *Helophorus* spp. (Hansen 1987) all increase in numbers. The Hygrophilous vegetation recorded changes from low growing forbs to taller reed communities. Spike rush persists and bulrush (*Scirpus* spp.) appears in the record.

<u>Sample depth 1.9-0.9m</u>
The palaeobiological evidence suggests that flow regime changes significantly in the uppermost samples. This is most evident from the aquatic coleopteran fauna, primarily composed of Elmidae or 'riffle beetles', which are associated with rapidly flowing water. For example, *Oulimnius* spp. and *Esolus parallelepipedus* are both found exclusively in fast flowing, well oxygenated water in gravel-bed rivers and streams (Friday 1988). Aquatic plants also decreased significantly by this level within the sequence. Water crowfoot (*Ranunclus* subgenus *batrachium*) is the only aquatic species, which remains and there are many sub-species of this taxon capable of withstanding a variety of flow regimes from standing waters to strong currents. It is not unlikely that this decrease in aquatic species is related to changes in the flow regime, since established, emergent waterside vegetation can rarely tolerate significant changes to the flow regime largely due to taxa physiology.

The species associated with disturbed ground and pastures continue to dominate the palaeobotancial record. Pollen from a variety of plantains (*Plantago* spp.), knapweed

(*Centaurea niger*) and Lactuaceae, compliment the seeds of docks, nettle and knotgrasses (*Polygonum* spp.). Insect taxa from comparable samples also suggest open pasture and possibly grazing. The weevils or Curculionidae from these samples include *Apion violaceum,* which is found on garden sorrel (*Rumex acetosa*) and *Ceutorhynchus contractus* found on Brassicaceae and rocket (*Sisymbrium* spp.). The *Sitona* family are found on vetches (*Vicia* spp.) and clovers (*Trifolium* spp.) (Bullock 1993, Koch 1992). Further specimens of the Scarabaeidae *Aphodius* spp. were also found in the upper samples, which suggest that this grassland was used as pasture.

In the wider landscape, woodland and heathland appear to be expanding. Birch (*Betula* spp.) and heather (*Calluna* spp.) both increase, as does alder (*Alnus* spp.). Willow persists, although the lack of waterlogged remains suggests that it is some distance from the immediate surroundings of the palaeochannel.

4.8 THE EVOLUTION OF THE DOVE VALLEY

Both the geomorphological and environmental evidence suggests that the River Dove has been highly dynamic throughout the historical period. No radiocarbon dates are available from either Tutbury or Eaton Dovedale, so at present, chronologies are based on pollen assemblages. The increasing presence of *Cannabis*-type (Cannabaceae) is a key indicator in providing a broad and tentative timeframe for sediment deposition at both Eaton Dovedale and Tutbury. Hemp has been cultivated in Britain since at least 800AD and possibly since the Romano-British period with peak production during the early 16th century when an increasing demand for rope by the Royal Navy led to large scale, widespread cultivation (Gearey *et al*. 2005).

Environmental evidence from both sites suggests a prolonged episode of terrestrial landscape stability. At Tutbury, insect evidence clearly suggests that the floodplain was used for pastoral purposes throughout sedimentation, whilst pollen from both Eaton Dovedale and Tutbury clearly suggest increasing agricultural activity in the area during later stages of sediment deposition. The increase in heather pollen is also a possible indicator of woodland clearance, possibly in the surrounding uplands. A similar palaeoenvironmental signature has been recorded from the pollen record of prehistoric clearance in the Breckland of East Anglia, where increasing taxa associated with disturbed and open ground is accompanied by the spread of heather and heathland (Godwin 1956). Should the period of valley floor sedimentation coincide with the Medieval Warm Period (MWP), as postulated from the (current) dating evidence, this agricultural expansion and that of heathland species in the area is readily explainable as part of agricultural expansion in the valley. The remains of large Medieval field systems are a prominent feature of the valley.

The environmental (entomological) data clearly indicate changing flow regime at both Tutbury and Eaton Dovedale, particularly, the presence of Elimidae or ‘Riffle’ beetles, which indicate rapidly flowing, well oxygenated waters. The stratigraphy of deposits observed within the valley floor indicate that flow regimes fluctuated regularly throughout deposition and whilst the insects do not elucidate the possible reasons for these changes, it is notable that both the MWP and the following Little Ice Age were periods of climatic instability and changing flood frequency and magnitude (Brown, 1998; Brown et al., 1999; Rumsby and Macklin, 1996). Such over-arching climatic factors may have played a key role in the development of the Dove Valley.

The changes in flow regime are clearly recorded at both Tutbury and Eaton Dovedale. At Tutbury, the aquatic assemblage from the basal part of the sequence is composed of taxa associated with standing or very slow moving water and ephemeral pools and water bodies. This probably represents the period immediately after the channel was cut off, when the feature was still subject to sporadic inundation by floodwaters. The flow regime appears to change considerably in the upper part of the sequence and the presence of Elmidae or 'Riffle' beetles indicate persistent influxes of rapidly flowing water. It is unlikely that the channel had been reoccupied by the contemporary river; rather the presence of these species indicate the renewed inundation of the feature as a result of changing flood frequency and magnitude.

Similar insect assemblages have been recovered from palaeochannel deposits at Hemington quarries and linked to climatic change associated with the MWP (Brown *et al*. 2001). However, Smith and Howard (2004) suggest that the supposition that the Elmidae are unequivocal indicators of rapidly flowing water should be treated with some caution. It is suggested that this family would have been commonly found amongst the riverine taxa during the early and mid Holocene. During this period the morphology of British rivers in general was multi-channeled with gravel-beds and clear, well oxygenated waters; however, the Elmidae disappear from the palaeoenvironmental record with the onset of increased alluviation in the later Holocene (Osbourne 1988, Smith 2000, Smith and Howard 2004).

Environmental and geomorphological evidence in the Dove Valley suggest that the most recent period of major channel change on the floodplain was after the Saxon period, *c*.800 AD. Two pre-Saxon radiocarbon dates were obtained from a basal organic deposit recorded beneath pre-mining age terrace sediments at Tutbury suggesting sedimentation during the early Romano-British period (1654 ± 30, OxA-13033, cal AD 260-440; 1660 ± 90, OxA-13140, cal AD 130-610). However, this is the only fragment of pre-medieval sediment observed in the valley to date.

The presence of large tracts of ridge and furrow in the lower and middle reaches of the River Dove certainly suggest intensive exploitation of the valley floor over the last millennium or so (although some caution is required when using the remains a 'Medieval' field systems as a *terminus anti quem* since the plough technology that produced these features was in existence during the Romano-British period and was still used as late as the 17th and possibly 19th century [Astill, 1988]). Combined, the pollen topographic evidence clearly suggests that an increased period of fluvial activity occurred sometime after 800AD and prior to the post medieval period.

The proposed timescale for this episode of increased channel activity in the Dove Valley, probably associated with the MWP and subsequent Little Ice Age (LIA), has also been associated with increased geomorphological activity in the main valley floor of the River Trent (Brown 1998, Brown *et al*. 2001, Salisbury 1984; Large and Petts 1996).

Large-scale channel change has been recorded at Hemington and Colwick/Holme Pierrepoint in the Trent between the 10th and 15th centuries (Brown *et al*. 2001, Salisbury *et al*. 1984). A major flood event is also recorded in this reach around *c*.1300-1414AD (Salisbury *et al.* 1984). Using archaeological evidence, Salisbury et al. (1984) have suggested that channel migration at Colwick during the Anglo-Saxon period was between 0.17-0.21m per annum and by the time of the Norman invasion, had increased to between 0.39 and 0.53m per annum, before slowing during the Tudor period to 0.21-0.35m per annum. However, these rates are still considerably less than rates estimated for the Dove, which have been between 1.33 and 1.88m since 1967 (Dalton and Fox 1988).

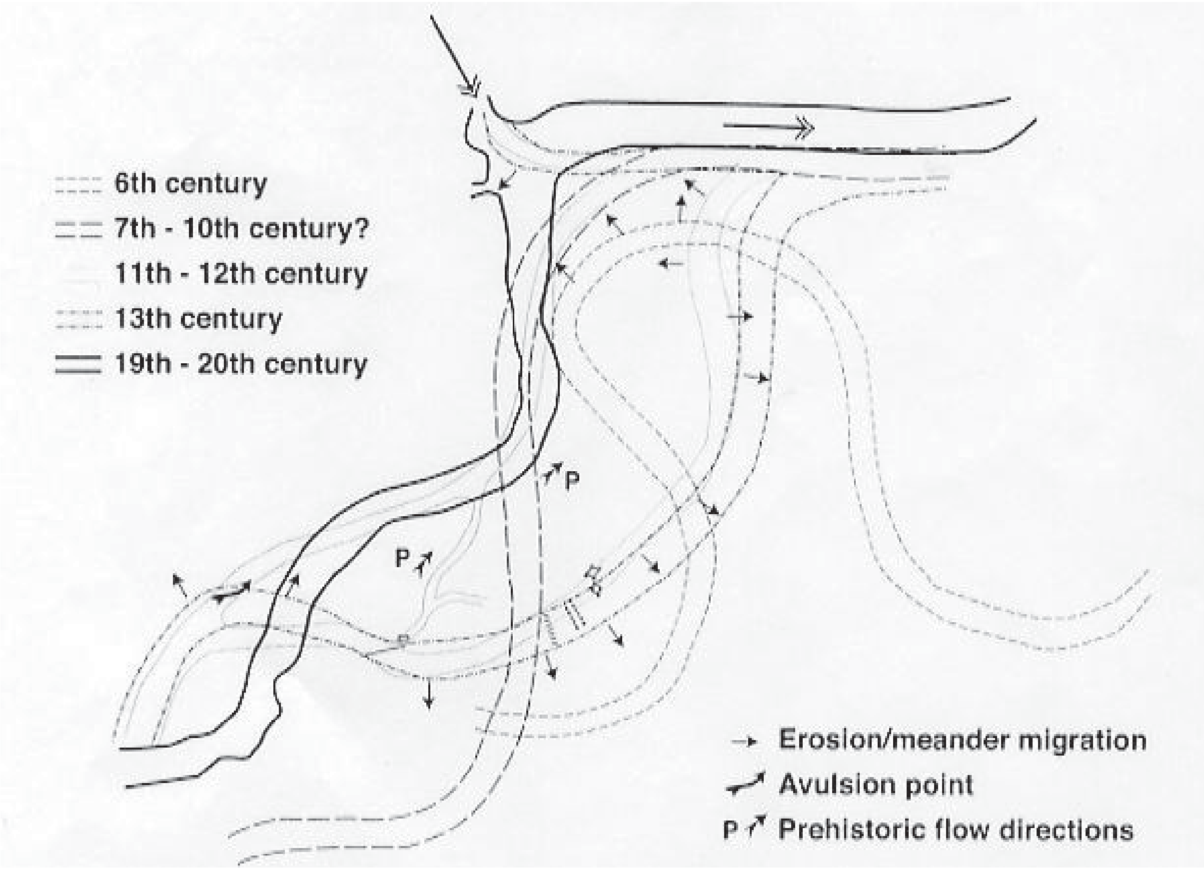


Figure 63. Suggested channel change around Hemington quarry (Brown *et al.* 2001).

This active channel migration observed in the Trent and the Dove contrasts with the majority of British lowland rivers such as the Severn and Thames, which have experienced a greater degree of system stability through the late Holocene (Brown *et al*. 2001). However, increased fluvial activity has been recorded in a number of rivers throughout Europe during the MWP and LIA including the Dneipr, Danube and a number of Spanish Rivers (Becker and Shirmer 1977, Buch 1989, Macklin and Rumsby 1996; Benito *et al*. 1996).

Climatically, the MWP is characterised by reduced rainfall juxtaposed by intense storms during late summer and wetter autumns in the late 1300-1400's (Brown 1998). At Bolton Fell Moss, two shifts to wetter conditions are recorded at the beginning and end of the MWP between 900-1100 and 1300-1500 (Barber 1994, cited in Brown 1998). It has been suggested that the River Trent, in contrast to other British rivers, is sensitive to climatic changes such as the MWP and LIA, since it is drained by two tributaries (the Derwent and Dove), which drain extensive upland areas (i.e. the Peak District) (Brown 1998). Evidence collected as part of this study has certainly demonstrated the increase in energy conditions along the Dove during the Medieval period.

4.9 THE IDLE VALLEY

The River Idle forms at the confluence of the Rivers Maun and Meden at Twyford Bridges (SK7603 7501) and flows 16 km before reaching the confluence with the River Trent at West Stockwith (SK7906 9402). The river can be classified as lowland type (Howard and Macklin, 1999) and has been largely stable within its floodplain throughout the Holocene, depositing sediments through vertical accretion. Prior to drainage and canalisation, largely from the 17th Century onwards, this resulted in the deposition of significant thicknesses of fine-grained organic-rich sediments in a series of anstomosed channels and extensive wetlands.

The Idle Valley is the focus of intensive aggregate extraction, which currently underway at Lound, Scrooby and Misson; extraction at Sutton (Bellmoor Quarry) ceased in 2004 (www.nottinghamshire.gov.org). In comparison to sand and gravel deposits of the Trent Valley, which yield over 100,000 tonnes per hectare, extraction in the Idle Valley is less significant, yielding between 20,000 and 30,000 tonnes per hectare. Nevertheless, combined aggregate extraction from the four largest quarries on the western side of the valley floor produce over 1 million tonnes per annum, a significant contribution to the output of Nottinghamshire, making it one of the largest producers in the East Midlands. It is estimated that a further 2 million tonnes of (economically viable) sand and gravel are present on the astern valley side, where extraction has yet to commence (www.nottinghamshire.gov.org).

Archaeological and environmental work in the area is relatively limited and is mainly associated with watching briefs and rescue excavations associated with aggregate extraction, for example, at Tiln (Bateman *et al.* 1997, Garton & Priest 1998, Howard *et al*. 1999), Blaco Hill and Lound (Garton, 1996, Garton and Salisbury 1995, Garton *et al*. 2000). These watching briefs and set piece excavations have highlighted the rich potential of the Idle Valley, much of which has been buried beneath later, fine-grained alluvial deposits. It is therefore likely that other reaches of the river valley have similar archaeological potential.

The lower Idle Valley has been the focus of archaeological research associated with several projects. Notable of these are the work around Misterton Carr (Buckland and Dolby, 1973) and the more extensively by the Humber Wetlands Project in the mid 1990's (Van de Noort and Ellis 1997). The latter work identified several large scatters of lithics and pot sherds, as well as peat deposits with considerable palaeoenvironmental potential (Van de Noort and Ellis 1997).

This geoarchaeological study augments the existing datasets with an extensive programme of geoarcheological survey and palaeoenvironmental analysis of promising areas identified by the AP and lidar assessment and concentrates on areas so far unaffected by mineral extraction. Many of these areas have been examined during previous survey, but given the intensive agricultural regimes practiced, it was considered pertinent to re-examine these areas.

4.9.1 Solid Geology

The rockhead throughout the Idle Valley comprises Permo-Triassic rocks (Gaunt 1994, Smith *et al.* 1973):

- Permian sands and gravels

- Lower Marl or 'Edlington Formation' (Smith *et al*. 1986)
- Upper Marl or 'Roxby Formation' (Smith *et al*. 1986)
    - both beds are composed of intercalated marls and mudstones, evaporites and magnesium limestones.
- The Bunter Sandstone or 'Bunter Pebble Beds' of the Sherwood Sandstone Group.
- Merica Mudstone Group.

The Mercia Mudstone Group crops out to the east of Misson (SK6892 9493), whilst the Sherwood Sandstone underlies the west of the valley (Gaunt 1994).

4.9.2 Quaternary Sediments

4.9.2.1 Devensian

The Idle Valley study area contains a range of Pleistocene sediments. The oldest deposits are sands, gravels and associated organic sediments of last (Ipswichian) interglacial age, which crop out around Bawtry. However, the most significant deposits in the lower Idle valley is the '25-Foot Drift' of Late Devensian age (Edwards *et al*. 1940, 1950. Mitchell *et al.*1947). These deposits are mapped at a range of altitudes between 7.6m OD and approximately 30 m OD (the 100 Foot 'strandline gravels' of Edwards *et al*., 1940; see Gaunt 1994). The stratigraphy of the 25 Foot Drift consists of a tri-partite sequence; lower sands are overlain by silts and clays, in turn buried beneath further deposits of sand (Gaunt 1994). This tri-partite sequence was deposited within an ice-dammed called 'Lake Humber'. Radiocarbon dates associated with the sediments suggest deposition between around 21 ka BP and 11 ka BP (Dinnin 1997, Ellis 1997). Mapping of deposits associated with Lake Humber suggest that the lake certainly had high and low level phases.

Deposits of the '1st Terrace' of the Idle (probably Late Devensian in age) are recorded in both the Don and Trent Valleys. In the Idle, this sand and gravel terrace fringes the eastern margin of the floodplain discontinuously from the confluence of the Maun and Meden at Twyford Bridge to Clayworth (SK 2996 7747) and from Scaftworth (SK 7280 8796) to Gringley Carr (SK 7293 9294). Along the western valley margin, the terrace crops out continuously from High Clump (SK 6777 8246) to Misson (SK 6910 9483) (Gaunt 1994, Smith *et al.* 1973).

Aeolian activity is associated with the intense downturn in temperatures associated with the Loch Lomond Stadial *c*.11-10ka BP (Gaunt 1994). Deposits of blown sand exist to the north of Misterton Carr and the modern channel of the River Idle. A number of radiocarbon dates have bracketed the main episode of activity in the area to between 11,100±200 and 10,280±120 ka BP (Buckland and Dolby 1973, Gaunt 1994 and Gaunt *et al.* 1971).

4.9.2.2 Holocene

Towards the end of the last glaciation, sea-levels were between 20-18m below OD, which resulted in deep incision of the river courses through the Lake Humber deposits as they adjusted to local base levels (Ellis 1997, Gaunt 1994). This period of channel incision ended *c*. 8500 ka BP (Gaunt 1994) and the Holocene sedimentary sequence is characterised by alluviation and peat formation in the lower lying areas, which extend between Thorne and Hatfield Moors and Misterton Carr (Gaunt 1994). This prolonged episode of peat development is thought to relate to wetter climatic conditions from *c*.7800 ka BP and waterlogging associated with poor drainage in the Humberhead Levels (Gaunt 1994). The peat varies considerable in thickness and is between 3m thick at Thorne Moors (Buckland 1979) and 0.7m at Sandtoft (Gaunt 1994). In the Idle study area, the peat has been documented as no more than 1.5m thick (Buckland and Dolby 1973).

When sea-level finally rose to Ordnance Datum, *c*. 3000 ka BP, the Trent and its tributaries overtopped their channels, subsequent flooding large tracts of low lying floodplain, precipitating the development of significant areas of wetland in Humberhead Levels (Buckland 1979, Buckland and Sadler 1985). Documentary evidence suggests that these wetlands remained in existence until large scale drainage of the region during the 17th Century. One of the principal architects of this drainage was Cornelius Vermuyden, who implemented an extensive drainage programme between 1625-27, which led to the diversion of the Idle at Idle Stop (SK7200 6996), through a substantial existing ditch known as Bykers Dyke and to its new confluence with the River Trent at West Stockwith (Buckland and Sadler 1985, Dinnin 1997, Gaunt 1994).

4.10 PREVIOUS ARCHAEOLOGICAL AND PALAEOENVIRONMENTAL WORK

In comparison to the River Dove, the River Idle has been the focus of a greater degree of archaeological survey and prospection (e.g. Garton 1996, Garton and Guilbert 1997, Garton and Salisbury 1995, Howard *et al*. 1999, Van de Noort and Ellis 1997, 1999).

4.10.1 Investigations of the Pleistocene and Palaeolithic Record

Evidence of human occupation and activity along the banks of the River Idle is recorded as early as the upper Palaeolithic. Cheddar points dating from *c*.12,500-12,000 BP have been found at Lound (Jacobi *et al*. 2001). At Bellmoor Quarry, East Retford, intercalated deposits of sand, clay and silty peat from Upper Palaeolithic contexts have been described from east of the river (around Tiln). A bulk sample from the silty peat produced an age estimate of 11,250±80 ka BP (Beta-100931, 11,769-11,280 cal BC, 13,710-13,230 cal BP, Howard *et al*.1999). A more extensive programme of archaeological fieldwork and associated environmental analysis commenced at Tiln in 2003, including the collection and analysis of two further samples from the deposit described by Howard *et al*. (1999). Limited analysis of insect remains from this new material has been undertaken and further analysis and multi-proxy study of the material recovered during this new phase is anticipated in the near future (Tetlow *et al*. 2004).

Insect material from both phases of work suggests that similar vegetation persisted throughout deposit formation. The dominant vegetation is sedges (*Carex*) and reeds (*Phragmites australis*), surrounding a standing body of water with a substrate composed of sands and gravels. A number of species in both samples also suggest drier, open country and heathland existed nearby. Both assemblages have produced similar information for the aquatic environment. The Whirlygig beetles (*Gyrinus* spp.) live in standing, open waters (Friday 1988), as does the 'diving water beetle' *Colymbetes fuscus*. A range of elmid 'riffle beetles' are also present suggesting that areas of faster, flowing water existed in this channel.

Several insects species recovered from both studies are associated with cold and glacial climates in the palaeoentomological record. The most significant species recovered is the staphylinid, *Pycnoglypta lurida*, which was found in large numbers in both samples. This species is absent from the modern British fauna, and whilst it cannot be described as an 'Arctic stenotherm', its current distribution in northern Europe is limited to montane and high latitude areas (Osborne 1973). *Pycnoglypta lurida* has also been recovered from a number of sites in Britain dating to around 12,000-11,500 ka BP. This includes Church Stretton (Osborne 1972), West Bromwich (Osborne 1973), Abingdon (Aalto *et al*. 1984) and Glanllynau (Coope and Brophy 1972) during the climatic cooling at the end of the Lateglacial and the beginning of the Loch Lomond Stadial. Another insect which is very common in the palaeoentomological record of glacial sites is *Eucnecosum brachypterum*, which although it is still found in the British Isles today, has a very limited distribution in high montane locations (Osborne 1973). Other insects with a similar restricted and northern distribution in the present day are the curculionids, *Notaris aethiops* and *Otiorhynchus ovatus* (Whittington *et al.* 1998). Similarly, the Curculionidae *Otiorhynchus auropunctatus* is often found at higher altitudes amongst dwarf shrubs (Hyman 1992).

Non-arboreal pollen dominates the basal parts of the sedimentary sequence and suggests the wider landscape was initially colonised by taxa of open ground, including plantain (*Plantago lanceolata*), sorrel (*Rumex acetosella*), mugwort (*Artemisia* spp.) and rue (*Thalictrum* spp.); these are all characteristic of Lateglacial environments (Howard *et al*. 1999). A small boreal component consists of birch, willow (*Salix* spp.) and juniper (*Juniperus* spp.), which does not suggest that the region was densely wooded (Howard *et al*. 1999). The vegetation changed little throughout deposit formation and remained consistently suggestive of tundra environment (Howard *et al*. 1999).

4.10.2 The Mesolithic

A large collection of lithics, totalling 3,808 pieces of flint and chert was recovered from three sites on a slight ridge (SK 728950), north east of Misterton Carr Farm (SK 7302 9603; Buckland and Dolby 1973). Other finds attributed a Mesolithic age have been recovered from the east of the modern channel at Scaftworth and Gringley Carr (Head *et al*. 1997). Mesolithic flint scatters were also found at Tiln north (part of the Lound Quarry complex, SK 7085) and Bellmoor Quarry (Garton *et al.* 2003, Howard *et al*. 1999). Much of the Mesolithic activity is associated with areas of sand dunes and former drier gravel islands in the Mesolithic floodplain of the Idle (Buckland and Dolby 1973, Howard *et al*. 1999).

Mesolithic environmental evidence is also available from Tiln. Pollen-bearing deposits argued to be of early Mesolithic date (*c*. 8000 ka BP) were found at the 'Pig Pens' site; the date is based on the recorded pollen assemblage, since no radiocarbon dates are currently available (Garton *et al*. 1998). Recent thermoluminescence (TL) dating of aeolian sand from Tiln produced age estimates of 7,900±700 BP and 8,300±800 BP and indicates reworking of these blown sands during the Mesolithic (Bateman *et al*. 1997). However, whether this reactivation of sedimentation can be linked to human activity, perhaps disturbance of vegetation, must remain a point of speculation.

4.10.3 The Neolithic

Evidence of human activity during the Neolithic is found throughout the Idle Valley. A small component of the Misterton Carr assemblage dates to the later Neolithic or possibly the earlier Bronze Age. Finds of Bronze Age date at Misterton Carr correspond with an episode of clearance in the surrounding oak woodland dated to 4330±100 years BP (Birm

326, 3199- 2838 cal BC, Buckland and Dolby 1973). Further Neolithic scatters were found at Gringley Carr, Misterton Carr and Scaftworth by the Humber Wetlands Survey (Head *et al*. 1997). However, the Neolithic date implied by typology from the latter two sites is not conclusive (Head *et al*. 1997).

Environmental evidence dating from the Neolithic is recorded at Newington (SK685 945) and Tiln. The early Neolithic deposits from Tiln have been dated to 4,920±70 ^{14}C years BP (no lab. code available, 3810-3625 cal BC) and suggest quite open alder/willow carr and damp, sedge dominated vegetation early on, but was rapidly replaced by boreal taxa suggestive of drier ground including pine, hazel, elm and oak (Garton *et al*. 1997). At Newington, organic deposition commenced during the later Neolithic *c*. 4050±50 ^{14}C years BP (Beta-168361, 2860-2810 cal BC, Gearey and Lillie 2002). Dense, birch dominated woodland, with an understorey of *Sphagnum* colonised the area with some alder and oak. Evidence also suggests mixed deciduous woodland, suggestive of drier conditions composed of hazel, birch and oak (Gearey and Lillie 2002).

4.10.4 The Bronze and Iron Age

Bronze Age and later prehistoric lithic assemblages have been recovered from Scaftworth and Gringley Carr; more ambiguous material, possibly from the Bronze Age, has been recovered from Misterton Carr by the Humber Wetlands Project (Head *et al*. 1997). Throughout the rest of the Idle Valley, evidence of Bronze and Iron age occupation is limited (Knight and Howard 2004), though at Crow Wood, Styrrup, the remains of a large 'marsh fort', 1.5 hectares in size, has been recorded (Knight and Howard 2004).

Evidence of agricultural clearance and possibly two subsequent episodes of woodland regeneration are recorded by fluctuating values of boreal and non-boreal pollen at Scaftworth. These potential episodes of re-generation are recorded throughout the Trent Valley, although it is unclear whether they are directly related to woodland regeneration or simply to decreased agricultural activity. Either scenario would make boreal pollen from existing woodland appear more prevalent in the pollen record, hence making a clear definition problematic (Knight and Howard 2004). Woodland expansion also appears in the later Bronze Age prior to 2690±60 ^{14}C years BP (Beta-168363, 979- 780 cal BC) at Newington, when alder forms dense carr woodland at the site, although evidence of human activity is entirely absent (Gearey and Lillie 2002). The subsequent sample, from which the quoted radiocarbon date was obtained, clearly shows a decline in boreal taxa and an increase in those of open ground and a small percentage of cereal type pollen was found. However, it seems unlikely that arable farming was occurring in the immediate environs of the site (Gearey and Lillie 2002).

Also at Newington, the substantial peat deposits contained a number of bog oaks, from which 43 samples were recovered for dendrochronological study (Tyers 2003). Subsequent analysis indicated that tree growth began c. 1552-1415 cal BC and ceased *c*. 1072-954 cal BC, a chronology extending a total of 627 years (Tyers 2003). All 43 samples from the site show evidence of growth stress particularly between 1440-1090 cal BC (Tyers 2003).

4.10.5 The Romano British Period

Evidence of the Roman occupation of Britain is significant in the Idle Valley. At Scaftworth, the most significant feature is a Roman Road (Scaftworth-5), linking *Lindum*

(Lincoln) with York. Excavation of the road by the Humber Wetlands Team during 1995-96 identified two roads, each taking slightly different paths across the floodplain. The older of the two (Road 1), was constructed using a 'raft' technique from alder and willow/poplar, whilst 'Road 2' was constructed using oak pilings infilled with gravel (Van de Noort *et al*. 1997). Road 1 appears to have been built in some haste and may be associated with either a military campaign or, was constructed as a temporary structure whilst a more substantial structure was built, i.e. 'Road 2' (Van de Noort *et al*, 1997). A triple-ditched enclosure, possibly a Roman fortlet or rural settlement (Scaftworth-10), has also been identified and has received limited excavation (Bartlett and Reilly 1958, Gilbertson and Black 1985); artefactual evidence suggests that the site was certainly occupied to the late Romano-British period (Head *et al*, 1997, Van de Noort *et al*, 1997). Extensive 'brickwork' field systems surround the settlement and the results of field walking, which produced significant finds of Romano-British pot sherds, suggest significant activity within the area (Van de Noort *et al*, 1997).

In the middle Idle Valley evidence of extensive brickwork field systems and enclosures exist around Lound and East Carr (Mattersey), suggesting intensive agricultural activity during this period. The exact nature of farming during the Romano-British period in the Trent Valley as a whole is somewhat ambiguous (Knight *et al.* 2004). At Lound, significant peat deposits within the enclosure ditches were dessicated and of no interpretable value (Garton *et al*. 1999). Evidence from the Idle Valley, both archaeological and environmental does nothing to elucidate this enigma within the valley itself. A large Brickwork Field System, enclosures and charred plant remains including spelt, emmer and bread wheat as well as oats have been recovered from Dunstons Clump (Garton 1988, Jones 1987). A possible ritual deposits of animal bones, including a virtually entire pig, was found in a Romano-British enclosure ditch at Chainbridge Lane, Lound (Eccles *et* al. 1988, Garton *et al*. 2000). A rectilinear feature at Blaco Hill, a few kilometres downstream of Lound is also reminiscent of these other enclosures; however, this feature is currently undated (Garton 2003). A crop mark enclosure and plank-lined well excavated at Wild Goose Cottage, Lound (Garton and Salisbury 1995) yielded waste deposits.

Knight *et al*. (2004) suggest that much of the palaeoenvironmental work for the Idle Valley remains as 'grey literature' in the form of unpublished specialist reports and ongoing post excavation study. Pollen analysis is available from peat deposits associated with the Roman roads at Scaftworth and from Newington Quarry. Agricultural indicators are sparse and vegetation during this episode, which is not considered to be later than the Romano-British period, is dominated sedge fen (Gearey and Lillie 2002). Pollen from the Roman roads at Scaftworth suggest an environment of carr woodland around pools or small lakes of open water, with farming possibly on the drier ground away from the wetlands (Van de Noort *et al*. 1997).

4.10.6 The Medieval Period

Probably one of the most significant areas of medieval activity in the Idle Valley is around Bawtry, which had become a significant inland port by the 12th Century. Excavations at 16-2- Church St, Bawtry recorded evidence of occupation since the later Mesolithic (Dunkley and Cumberpatch 1996). Artefacts from the site indicated the diversity of products which were passing through the port, including 'Red Ware' pottery from the Low Countries, amber beads from the Baltic and silver 'tokens' minted in Nuremburg, Germany (Dunkley and Cumberpatch 1996).

Further evidence of medieval activity is recorded around Mattersey and Mattersey Priory (SK704897). The priory was found in 1192 by Roger Fitz Ranulph De Maresay for 6 Gilbertine Priors, the Gilbertines being the only monastic order entirely based within the British Isles. The priory is described as being 'built on an Island in the River Idle', this fact is reflected in the name – "St Helen on the Isle of Mattersey" (Peers 1930). At the time of the dissolution of the monasteries, Mattersey Priory was worth only £60 (Peers 1930). The remains of the refectory and dormitory still exist on the site of the priory and traces of a medieval field system have been found to the south of Mattersey at Tiln (Bateman *et al*. 1997).

4.11 SITES TO THE NORTH OF THE MODERN IDLE

4.11.1 Fountains Farm (SK 7403 9502)

The Fountains Farm site lies close to Misterton Carr Farm, where excavations by Buckland and Dolby (1973) identified a number of scatters of Mesolithic and Neolithic lithic material. To the east, the Humber Wetlands Project recovered a scatter of lithics on the western edge of the palaeochannel of probable Neolithic and Bronze Age date (Misterton-11, Van De Noort & Ellis 1997). Aerial photographic analysis and borehole modelling identified a large organic rich depression trending south-north from the modern River Idle across the area. On the ground, this depression is very evident, running to the east of Misson Carr Nature Reserve. Field inspection identified that the palaeochannel was complex and comprised an upper and lower feature with well-developed terrace edges adjacent to each (Plate 4).

Fieldwalking of a plough field centred upon SK 71803 97249 produced over 100 pieces of lithic material from the higher (2^{nd}) terrace, some of which is diagnostic of the Mesolithic. The lithic scatter was clearly defined, and intimately associated with the river-bank the higher palaeochannel.

Following a number of prospection cores, a single core was recovered from each palaeochannel. Core FN01 (SK72087 97346) was drilled through the lower palaeochannel, and contained almost three metres of organic-rich sediment. Core, FN03 (SK71990 97359) was frilled through the higher channel feature and comprised 3.3m of open textured, fibrous peat and abundant woody remains.

Plate 4. Field inspection identified that the palaeochannel at Fountains Farm was complex and comprised an upper and lower feature with well-developed terrace edges adjacent to each. The person in the foreground is walking towards the lower channel.

4.11.1.1 Stratigraphy of Auger Cores

Auger core FN01 in the lower palaeochannel (SK 72087 97346) recorded stiff, red brown clay topsoil underlain by grey/blue silts of varying organic content (Table 17). Below 2.18m, the deposit became increasingly sandy.

Auger core FN02 (SK 71990 97359), from the higher palaeochannel recorded friable, highly organic topsoil underlain by open textured, fibrous peat, which contained abundant woody remains. At a depth of 1.47m, the peat became slightly sandy and siltier, possibly indicating flooding of the channel. At a depth of 1.69m, open textured, woody, fibrous peat is recorded once more, to a depth of 3.90m, where it is replaced by sand.

Material from the cleaned section (FN05) compares favourably with material from the upper 1.1 - 2.0m of FN03, suggesting that these fine grained sediments recorded in both the auger cores and ditch sections extend across considerable parts of the floodplain.

Table 17. Stratigraphy from auger core FN01, Fountains Farm.

Fountain Farm				
FN01	**SK72087 97346**		**Samples**	
Depth	**Sedimentology**	**Comments**	**Pollen**	**Radiocarbon**
0cm	Stiff red brown clay			
100cm	Organic rich silty clay			
110cm	Organic rich silty clay	Large, visible waterlogged plant remains	110cm	110cm
139cm		Freshwater mussel shell		
140cm	Grey/blue silty clay			
	Lost sample			
160cm	Wood and Shell			
162cm	Grey silt with large organic fragments			
185cm	Large woody fragment		217cm	
218cm	Sandy grey silt			
260cm	Lost sample			
275cm	Grey silt with fine sand			
400cm	Increasing fine sand			
415cm	Blue grey silt with fine grained sand			
435cm	Blue grey silt with fine grained sand		435cm	435cm

4.11.1.2 Ditch Sections

A number of recently cleaned and readily accessible drainage ditches, which appeared to have grey/black organic sediment at the base, overlain by approximately 1-2m of inorganic, grey alluvium, were also located close by. These organic sediments included the remains of large, mature trees, both trunks and root buttresses, which suggest well-developed woodland *in situ* during deposit formation. A series of bulk samples and monoliths were recovered from a representative site within in these drainage ditch (FN 05; SK 72482 97352) and demonstrated the presence of 0.80m of fibrous, wood rich peat and silts at the base of the section.

A series of five bulk spit samples for palaeoentomological and waterlogged plant analysis were recovered from the basal 0.8m of FN05, together with a monolith tins for pollen and samples for radiocarbon dating (Plate 5).

Plate 5. Fountains Farm section FN05 showing monolith tins for pollen analysis.

The results of insect and pollen analysis are presented below, result of radiocarbon dating are currently awaited.

Table 18. Environmental samples from the basal organic sediment, FNO5, Fountains Farm

FN05	**SK72482 97352**	**Samples**				
Depth	**Sedimentology**	**Monolith**	**Pollen**	**Insect**	**Waterlogged**	**Radiocarbon**
120cm	Peat	120-145cm	120cm	120-145cm	120-145cm	120cm
		143-168cm	155cm	145-155cm	145-155cm	
				155-165cm	155-165cm	
		166-191cm		165-175cm	165-175cm	
			191cm	175-185cm	175-185cm	191cm

4.11.2 South Carr Farm (SK7205 9604)

lidar and aerial photographic imagery identified a series of palaeochannels forming part of a large, dendritic channel network around South Carr Farm. Field inspection identified a series of depressions in a field immediately to the north of South Carr Farm, which corroborated the interpretations from remotely sensed imagery.

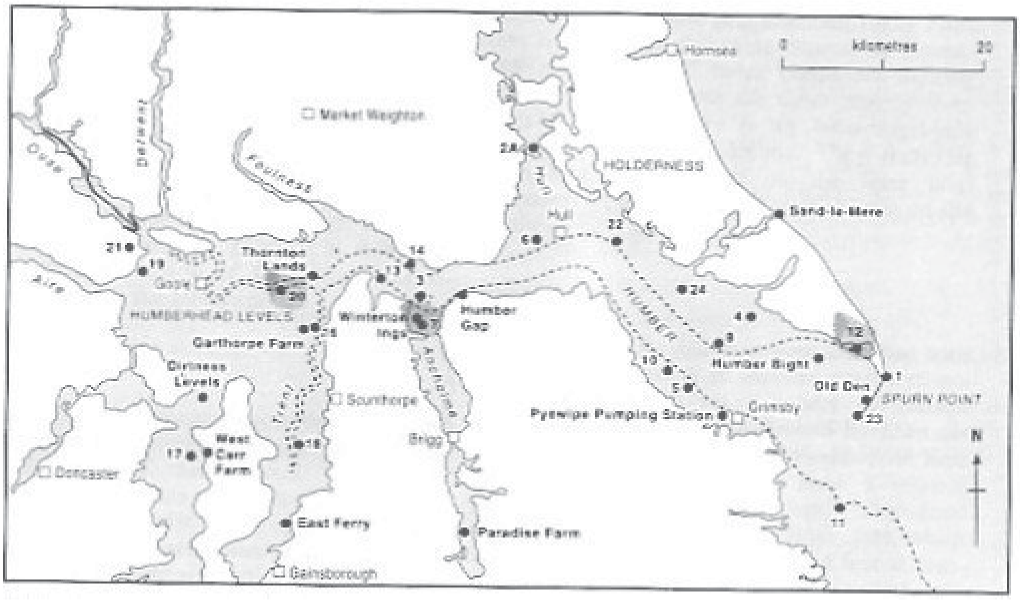


Figure 64. The Humber Wetlands – areas where Holocene estuarine and intertidal activity has been recorded (Metcalfe *et al*. 2000).

No work was undertaken in these fields due to farming activity coinciding with the final phases of fieldwork. The upper part of the Idle and Trent Valleys (Figure 64) were both subject to varying degrees of inter-tidal activity throughout the Holocene (Metcalfe *et al*. 2000). Three sea-level index points have been obtained from East Ferry, less than eight kilometres from the confluence of the Rivers Trent and Idle at West Stockwith (Metcalfe *et al*. 2000). These points suggest inter-tidal activity and positive sea-level tendencies in the area around 4890±55 ka BP (AA27615, 3793- 3629 cal BC), 1880±45 ka BP (AA22678, 49-239 cal AD) and a negative trend 3090±50 ka BP (AA23428, 1457- 1254 cal BC).

Since dendritic creek networks on this scale are more characteristic of salt marshes and the margins of lower reaches of rivers subject to tidal activity, it is possible that the creek networks identified around South Carr Farm are part of a tidally influenced system.

4.12 SITES TO THE SOUTH OF THE MODERN IDLE

4.12.1 Misterton Carr Farm (SK7302 9603)

A large, sinuous palaeochannel was recorded from lidar and aerial photographs running north/south through the area of Misterton Carr Farm. It is possible that this channel is a continuation of the large feature identified at Fountains Farm. Field inspection indicates that the feature is demarcated by soft, black peaty soil surrounded by pale grey alluvium.

To the east of the channel, higher sandier areas (? 1st terrace) are visible. A scatter of lithics of Mesolithic and Neolithic was found on this terrace during field-walking by the Humber Wetlands Project (Gringley-12, Van De Noort and Ellis 1995). Further flint was found during our initial fieldwork for this study (SK73099, BNG 95661) and during, later more detailed fieldwalking on the eastern terrace.

Plate 6. Misterton Carr Farm, section MC03

Lidar evidence also suggests a dendritic channel network and smaller palaeochannel system to the south in fields north of Cattle Carr Farm (SK 7201 9506). Further lithic scatters were also recorded on the surface of a (possible) relict sand dune (Gringley-2) during fieldwalking by the Humber Wetlands Project (Head *et al*. 1997). However, this area was under crop during our fieldwork and prevented access to this land.

4.12.1.1 Ditch Sections

A substantial peat deposit was recorded at Misterton Carr Farm in a recently cleaned field-drain (SK72578 96126; MC03, Plate 6) and comprised up to 1m of material containing mature tree trunks and substantial root buttresses as well as large fragments of the common reed (*Phragmites* spp.). Five samples were recovered from the peat for waterlogged plant and insect analysis, and 3 monoliths tins for pollen analysis (0.75 m in total). Suitable samples were also selected for radiocarbon dating.

Table 19. Environmental samples recovered from the peat of MC03 at Misterton Carr Farm

MC03	**SK72578 96126**					
Depth	**Sedimentology**	**Monolith**	**Pollen**	**Insect**	**Waterlogged**	**Radiocarbon**
127cm	Peat	127-152cm	127cm	127-142cm	127-142cm	127cm
				123-157cm	123-157cm	
		153-174cm	162cm	157-172cm	157-172cm	
				172-177cm	172-177cm	
		173-198cm	198cm	177-187cm	177-187cm	198cm

4.12.1.2 Auger Cores

Samples from a single auger core (MC 01) were obtained from the large palaeochannel at this site. (Table 19). The core passed through a peaty topsoil, which contained a significant amount of fine, pale brown sand. The topsoil was underlain by units of silt containing a variety of palaeoenvironmental indicators, including molluscs and woody fragments.

Table 20. Broad stratigraphy of the deposits around Misterton Carr Farm recorded from auger core MC01.

Misterton Carr Farm				
MC01	**SK73051 95816**		**Samples**	
Depth	**Sedimentology**	**Comments**	**Pollen**	**Radiocarbon**
0cm	Peaty topsoil			
52cm	Dark grey silt	Samples from 70cm	70cm	70cm
90cm	Dark grey silt	Sparse molluscs		
137cm		Abundant molluscs	160cm	
180cm		Wood		
200cm	Dark grey silt	Abundant wood and molluscs		
260cm	Pale grey silt	Molluscs absent		
370cm	Very pale grey silt			
390cm	End of core		390cm	390cm

4.12.2 Oatlands Farm (SK7202 9304) and Cattle Farm (SK7407 9501)

Further palaeochannels and dendritic networks channels were recorded to the north of Oatlands Farm (SK7205 9307) and a large depression was also identified to the north of Cattle Farm (SK7407 9403). The Humber Wetlands Project surveyed areas around both Oatlands Farm (termed Misterton-6) and Cattle Farm (termed Misterton-10). Finds included a scatter of Neolithic and Bronze Age lithics and Romano British pot sherds recorded to the west of a large palaeochannel (Van De Noort and Ellis 1997).

A series of cores (MC02a-MC02c; SK 74530 95298, SK 74633 94992, SK 74533 94992) were extracted to the north of Carr Ings Drain adjacent to a small pine plantation, but these recorded very thin, desiccated peat deposit (Table 21).

Table 21. Cores recording thin highly desiccated peat deposits near Carr Ings Drain.

MC02a	**SK74530 95298**
Depth	**Sedimentology**
0cm	Desiccated sandy peat
45cm	Sand

MC02b	**SK74633 95126**
Depth	**Sedimentology**
0cm	Desiccated sandy peat
40cm	Sand

MC02c	**SK74533 94992**
Depth	**Sedimentology**
0cm	Desiccated sandy peat
40cm	Sand

Two further sections in a drainage ditch located alongside a track (SK 74112 95107), due west of Carr Ings Drain were cleaned (Table 23 Plate 7). The first section, MC02d (SK 74112 95107) recorded 0.55m of modern fill (brick and slag) combined with dark silty alluvium, underlain by 0.2m of friable, desiccated red-brown peat, which had been subject to significant modern bioturbation. This, in turn, overlay yellow brown sand.

Table 22. Stratigraphy of deposits recorded in ditch section MC02d.

MC02d	**SK74112 95107**
Depth	**Sedimentology**
0cm	Compacted, reddish brown peaty silt with brick and slag
55cm	Dessicated red brown peat with modern root fragments
75cm	Light brown, blown sand

Plate 7. Desiccated peats recorded in section MCO2d

These basal yellow sands recorded in MC02a-d are most probably both fluvial and aeolian in origin. Blown sand is commonly recorded in the area, particularly on the western slopes of the Isle of Axholme (Gaunt 1994). The blown sand in the lower Idle Valley is associated with aeolian activity during the Loch Lomond Stadial, following the disappearance of Lake Humber (Gaunt 1994). Radiocarbon dates from the base of the blown sand at West Moor, part of Hatfield Chase, suggest deposition *c*.11,100±200 ka BP (no lab code available, 11433- 10815 cal BC Gaunt 1994 after Gaunt *et al*. 1971). The latest date for aeolian activity in the area is 10,550±250 (no lab code available, 11008- 9653 cal BC, Gaunt 1994 after Buckland 1982). Similar dates for the accretion of blown sand include Thermoluminescence (TL) dates from Bellmoor Quarry, Tiln, which suggest deposition began *c*. 11-12ka BP (Howard *et al*. 1999). However, further TL dates from Tiln suggest re-working around 8,500ka BP and between 8.300ka BP and 7,700ka BP (Howard *et al*., 1999).

4.12.3 Environmental analysis of samples from Fountains Farm and Misterton Carr

Pollen and insect analysis has been undertaken on material from selected samples from Misterton Carr and Fountains Farm.

The earliest episode of deposit formation at Fountains Farm and Misterton Carr is very similar at both sites. Pollen data suggests dense mixed woodland of oak (*Quercus* spp.), hazel (*Corylus* spp.) and alder (*Alnus* spp.), mixed oak and hazel occupied the drier ground, with oak and alder in wetter areas of the floodplain. Herbaceous taxa are limited and consist primarily of grasses (Poaceae) and sedges (*Carex* spp.). At Misterton Carr, overall composition is subtly different, herbaceous taxa are found in slightly larger quantities, perhaps suggesting a more open environment than at Fountains Farm. Boreal taxa are also slightly more varied and include birch (*Betula* spp.), elm (*Ulmus* spp.) and pine (*Pinus* spp.).

Vegetation development at the two sites then diverges. At Fountains Farm, boreal pollen continues to dominate with some indicators of open ground including grasses, sedges and herbaceous taxa including docks (*Rumex* spp.), ribwort plantain (*Plantago lanceolata*) and meadow-sweet (*Filipendula* spp.). Elm pollen (*Ulnus* spp.) also increases in the Fountains Farm core. At Misterton Carr, tree pollen which continues to indicate alder, oak, birch and hazel declines and is replaced by grasses and mixed herbaceous taxa of disturbed ground including thistles (*Cirisium* spp.), Apiaceae, plantain and dock. Corresponding samples from both field drain sections at Misterton Carr (MC03) and Fountains Farm (FN05) produced no interpretable pollen; whilst insect assemblages from these sections (samples MC03c-e and FN05c-e) do not elucidate *in situ* vegetation, they do suggest a backswamp environment with muddy ephemeral pools and possibly sedge and moss dominated vegetation.

The upper pollen samples from all four sections produced readily interpretable pollen, again suggesting divergent vegetation development at both Fountains Farm and Misterton Carr. At Fountains Farm, the top most pollen samples from FN01 and FN05 indicate substantial areas of woodland and grassland, the composition of which changed little from the preceding samples. In contrast, indicators of open ground dominate the assemblage from Misterton Carr. Grasses, sedges and meadow herbs such as thistle, dock, plantain and buttercup replace the woodland taxa. The small percentage of woodland pollen that does persist is primarily composed of alder. Trace values of *Cannabis*-type pollen were also found in these samples, suggesting an early Medieval-to Tudor date.

The insects from the uppermost sample (FN05a) from Fountains Farm provides a comprehensive image of the site during the final stages of formation. The assemblage continues to suggest swampy and boggy environments, primarily colonised by sedge and moss polsters with some evidence of damp woodland. Several species also indicate pine and areas of dryer land.

The hygrophilous Hydraenidae family are found in shady, muddy backswamps with ephemeral pools; *Hydraena testacea* is particularly abundant in pools covered with duckweed (*Lemna* spp.) (Hansen 1987). The carabid *Agonum assimilis* is also characteristic of damp, shady places often in deciduous woodland. The elaterid is also an indicator of open woodland and woodland margins, whilst the Cantharidae may be found in moist woodlands, meadows, bogs and swamps. A second species of *Agonum* spp. *Agonum albipes* is also found on more open ground with muddy pools (Lindroth 1974, 1986). The staphylinid *Lesteva longelytrata* is found amongst mosses and sedges and low growing vegetation on damp ground (Tottenham 1954). The Dryopidae are also commonly found in damp meadows with sedge and rush dominated vegetation, at the edges of standing and flowing waters (Koch 1989a). The remaining aquatic species from the Dytiscidae family are also found in deep pools of standing water, the nutrient status of which currently remains ambiguous and can only be elucidated by further analysis of the insect remains.

Indicators of drier surroundings include the scolytid *Hylastes* spp., which is found on pine (*Pinus* spp.), spruce (*Picea* spp.) and fir (*Abies* spp.) tree taxas more commonly associated with drier, sandy soils (Stace 1997). The carabid *Trechus quadristriatus* is a xerophilous taxa found in drier country with low growing vegetation. It is also found in more cosmopolitan habitats under rotting vegetation and cut reeds and does seem to prefer drier rotting material (Koch 1989, Lindroth 1974).

The environmental evidence suggests that the landscape at Misterton Carr changed significantly through time, from an area of woodland with patches of open ground, to a landscape almost totally devoid of woodland or substantial stands of trees (very similar to the floodplain at Misterton Carr today). In contrast, at Fountains Farm, the pollen data indicates substantial stands of trees throughout the formation of the deposit.

4.13 DATING OF DEPOSITS IN THE IDLE VALLEY AND CONTEXT OF SEDIMENTATION

Radiocarbon dates are currently awaited, however pollen evidence suggests that deposit formation commenced at some point during the late Neolithic or Bronze Age and ceased during the later historical period, either during Medieval or Tudor times. This corresponds well with the developmental timeframe and vegetation development suggested for the area by the Humber Wetlands Project (Dinnin 1997).

The Humber Wetlands team drilled four transects across the Idle Valley. The earliest evidence they recovered dated from the Younger Dryas stage of the Lateglacial, (*c*. 11,000-10,200 BP) and included pollen dominated by grasses and sedges with some evidence of pine and birch (Dinnin 1997). A similar vegetation assemblage was recorded from Lateglacial deposits at Bellmoor Quarry, Tiln (Howard *et al.* 1999, Tetlow *et al.* 2005). After this period, the Humber Wetlands team identified a hiatus in the pollen record until the Late Neolithic/Early Bronze Age when oak and alder dominated fen woodland develops in the area. Grass pollen and herbaceous taxa including nettles (*Urtica dioica*), poppy (*Papaver* spp.) docks and sorrels (*Rumex* spp.) suggest open ground nearby (Dinnin 1997).

The extensive peat deposits clearly indicate that large areas of backswamp characterise the landscape of the Idle during the Late Neolithic/Early Bronze Age (Dinnin 1997). This period is enhanced sedimentation is probably associated with marine transgression and episodes of flooding (recorded between 160 and 180cm in transect 1; Dinnin 1997). Large tracts of reed and alder dominated fen cover extended across the floodplain and in some areas, paludification and raised bog formation began. (Dinnin 1997).

5 SUMMARY AND CONCLUSION

5.1 CONCLUSIONS

5.1.1 GIS and Geoarchaeological Mapping/Analysis

The data collected as part of this project constitutes a significant resource for understanding the development of the floodplains of the studied rivers, and may also aid in understanding of their possible impact, as catchment tributaries, on the evolution of the floodplain of the River Trent.

Analysis of air-photographs and lidar data have created a significant new data set capturing details of the palaeochannels of the studied tributary valleys.

Examination, collation and digitising of public borehole records at BGS and elsewhere have provided significant insights into the sub-surface stratigraphy of the study area, in particular the presence and extent of valuable peat/organic deposits.

These data constitute the principal new components of the project GIS, which complements that developed by TVG2002. The GIS database will act as an important resource for providing information to the minerals industry and for guiding planning and policy in terms of the geoarchaeology of the tributary valleys, as well as assisting in decision making regarding future research frameworks and archaeological resource management for both valleys.

Appropriate data from the GIS database has been distributed in digital form to local planning archaeologists and to English Heritage:

- Rectified air-photo mosaics
- Palaeochannels digitised from air-photographs and lidar
- Digitiesed borehole records
- Vector NMP data (to EH only)

In addition, an on-line GIS providing interactive access to data with no licensing issues has been deployed via the Trent Valley GeoArchaeology web-site (www.TVG.org.uk).

5.1.2 Palaeoenvironmental Record

Field investigation in the Dove and Idle Valleys has recovered core samples from Eaton Dovedale and Tutbury (in the Dove Valley), Fountains Farm, South Carr Farm, Misterton Carr Farm, Outland Farm and Cattle Farm (in the Idle Valley).

Initial assessment of the recovered material suggests considerable potential for providing a high resolution palaeoenvironmental record for the studied areas.

Radiocarbon dates for the sampled deposits are awaited and the updated project design will set out a strategy for the full analysis of selected samples.

6 REFERENCES

Allen, C. 2005 *Proof of Evidence by Christina Allen - Extraction and processing of conglomerate and sandstone to produce concreting sand and aggregate for the applicants sole use at Captain's Barn Farm, Weston Coyney, Stoke on Trent.* Staffordshire CC Reference: SM.03/26 171M.

Aalto, M. M, Coope, G. R and Gibbard, P. L. 1984. Late Devensian river deposits beneath the floodplain terrace of the River Thames at Abingdon, Berkshire, England. *Proceedings of the Geologists' Association* 95, 65-79.

Armstrong, L. 1942 Palaeolithic man in the North Midlands. *Derbyshire Archaeological and Natural History Society*. 63, 28-60.

Baker, S. 2003 *The Trent Valley: Palaeochannel Mapping from Aerial Photographs.* Research report for Trent Valley GeoArchaeology. Nottingham, Trent and Peak Archaeological Unit.

Barfield, L. H. and Kalai, I. 1996 The Flint *in* Esmonde-Cleary, A. S. and Ferris, I. M. 1996 Excavations at the new cemetery, Rocester, Staffordshire 1985-1987. *Staffordshire Archaeological & Historical Society*. 35, 182-183.

Barnes, I. 2003. Aerial remote-sensing techniques used in the management of archaeological monuments on the British Army's Salisbury Plain training area, Wiltshire, UK *Archaeological Prospection* 10: 83-90.

Bartlett, J. E. and Riley, D. N. (1958) The Roman fort at Scaftworth, near Bawtry. *Transactions of the Thoroton Society of Nottingham*. 62, 24-35.

Bateman, M.D., Garton, D., Priest, V. & Sainty, D. (1997) The dating of linear banks found at Tiln, North Northamptonshire, using Thermoluminescence, *The East Midland Geographer*, 20, 42-49.

Bates, M.R. and Bates, C.R. 2000 Multidisciplinary approaches to the geoarchaeological evaluation of deeply stratified sedimentary sequences: Examples from the Pleistocene and Holocene Deposits in Southern England, United Kingdom. *Journal of Archaeological Science* 27, 845-58.

Bates, M.R. 2003 Visualising the sub-surface: problems and procedures for areas of deeply stratified sediments. in Howard, A.J. and Passmore, D. (eds) *Alluvial Archaeology in Europe.* Balkema, Rotterdam.

Beamish, M. G. 2001a. Neolithic and Bronze Age activity on the Trent flood plain: an interim note on recent excavations at Willington Quarry extension. *Derbyshire Archaeological Journal*. 121, 9-16.

Beamish, M. G. & Ripper, S. 2000. Burnt mounds in the East Midlands. *Antiquity*. 74, 37-38.

Bewley, R.H. 2003 Aerial survey for archaeology. *The Photogrammetric Record* 18 (104), 273-292.

Boswijk, G., Whitehouse, N.J., Smith, B.M. and Buckland, P.C. 2001. Thorne Moors (SE 7316). In Bateman, M.D., Buckland, P.C., Frederick, C.D. and Whitehouse, N.J. (eds) *The Quaternary of East Yorkshire and North Lincolnshire. Field Guide*. Quaternary Research Association, London. 169-177.

Brown, A.G., Challis, K. and Howard, A.J. 2004. *Predictive modelling of multi-period geoarchaeological resources at a river confluence*. Project design submitted to English Heritage (PNUM3357).

Brown, A.G., Salisbury, C.R., & Smith, D.N. (2001). Late Holocene channel changes of the Middle Trent: channel response to a thousand year flood record. Geomorphology, 39, 69-82.

Brown, A.G. and Quine, T.A. 1999. Fluvial processes and environmental change: an overview. In Brown, A.G. and Quine, T. (eds) *Fluvial Processes and Environmental Change*. Wiley, Chichester. 1-28.

Buckland, P.C. and Sadler, J. 1985. The nature of Late Flandrian alluviation in the Humberhead Levels. *East Midland Geographer* 8, 239-51.

Buckland, P. C. 1979 Thorne Moors: a palaeoecological study of a Bronze Age site. *Occasional Publications of the University of Birmingham Department of Geology*. No. 8.

Buckland, P.C. Dolby, M.J. 1973, Mesolithic and later material from Misterton Carr, Notts. - an interim report. *Trans. Thoroton Soc. Nottinghamshire* 77, 5-33.

Challis, K. in review A. Using Borehole Data for Geoarchaeological Prospection: Applications in the Alluvial Landscape of the Lower Trent Valley, England. *Archaeological Prospection.*

Challis, K. in review B. Airborne Laser Altimetry in Alluviated Landscapes. *Archaeological Prospection.*

Challis, K. Howard, A.J., Gearey, B. and Smith, D. 2006. *Analysis of the Effectiveness of Airborne Lidar Backscattered Laser Intensity for Predicting Organic Preservation Potential of Waterlogged Deposits*. English Heritage PN4782.

Challis, K. 2005a. *Predictive Modelling of Multi-Period Geoarchaeological Resources at a River Confluence Airborne Remote Sensing. Analysis of the Effectiveness of Aerial Photography, Lidar and IFSAR.* English Heritage PNUM3357.

Challis, K. 2005b. Airborne Lidar: A Tool for Geoarchaeological Prospection in Riverine Landscapes. in Stoepker, H. (ed) *Archaeological Heritage Management in Riverine Landscapes.* Rapporten Archeologische Monumentenzorg, 126: 11-24

Challis, K. 2004a. *Trent Valley GeoArchaeology 2002. Component 2b lidar Terrain Models.* Trent Valley Geoarchaeology Research Report. York, York Archaeological Trust.

Challis, K. 2004b. *Trent Valley GeoArchaeology 2002. Component 3 Alluvium Depth and Character Modelling.* Trent Valley Geoarchaeology Research Report. York, York Archaeological Trust.

Challis, K. and Howard, A.J. 2003 GIS-based modelling of sub-surface deposits for archaeological prospection in alluvial landscapes in Howard, A.J. and Passmore, D. (eds) *The Alluvial Archaeology of Europe.* Balkema, Rotterdam.

Challis, K., Dingwall, L, Gaffney, V. and Howard, A.J. 1999. *Trent Valley Survey Nottinghamshire Pilot Study.* Report to English Heritage by TPAU, BUFAU and University of Leeds.

Charlton, M.E., Large, A.R.G. and Fuller, I.C. 2003. Application of airborne lidar in river environments: the River Coquet, Northumberland, UK *Earth Surface Processes and Landforms* 28: 299-306.

Chisholm, J. I. 1988 *Ashbourne and Cheadle. Memoir for sheet E124.* London: HMSO.

Clayton, K. M. 1953 The glacial chronology of part of the middle Trent Basin. *Proceedings of the Geologists Association*. 64, 198-207.

Coates, G. 2002 *A prehistoric and Romano-British Landscape. Excavations at Whitemoor Haye, Staffordshire 1997-1999.* BAR British Series 340.

Cobby, D.M., Mason, D.C. and Davenport, I.J. 2001. Image processing of airborne scanning laser altimetry data for improved river flood modelling. *ISPRS Journal of Photogrammetry and Remote Sensing* 56: 121-138.

Coope, G. R. and Brophy, J. A. 1972. Lateglacial environmental changes indictaed by a coleopteran succession from North Wales. *Boreas* 1, 97-142.

Dalton, R.T. and Fox, H.R. 1988. Channel change on the River Dove. *East Midland Geographer.* 11(2): 40-47.

Davies, G. 2001 *Interim Statement on the Archaeological Works at Staythorpe Power Station.* Unpublished Report 438f, ARCUS, University of Sheffield.

Dinnin, M. (1997). The Palaeoenvironmental Survey of the Rivers Idle, Torne and Old River Don *In* Van de Noort, R. & Ellis, S. eds. *Wetland Heritage of the Humberhead Levels – An Archaeological Survey*. Hull: Humber Wetlands Project. pp. 81-156.

Dunkley, J. A., and Cumberpatch, C. G. with Latham, I. D. and Thorpe, R. (1996) *Excavations at 16-20 Church Street Bawtry, South Yorkshire.* Oxford: Oxbow.

Eccles, J., Caldwell, P. and Mincher, R. (1988) Salvage excavations at the Romano British site, Chainbridge Lane, Lound, Nottinghamshire, 1985. *Transactions of the Thoroton Society of Nottingham*. 92, 15-21.

Edwards , W., Mitchell, G. H. and Whitehead, T. H. (1950) Geology of the district north and east of Leeds *Memoir for one-inch sheet 70 (England and Wales)*. London HMSO.

Edwards , W., Mitchell, G. H. and Mitchell, G. H. (1940) Geology of the country around Wakefield *Memoir for one-inch sheet 78 (England and Wales)*. London HMSO.

Ellis, S. (1997) Physical background to the Humberhead Levels. *In* Van de Noort, R. & Ellis, S. eds. *Wetland Heritage of the Humberhead Levels – An Archaeological Survey*. Hull: Humber Wetlands Project. pp 7-12.

Environment Agency 2004 *A flood risk management strategy for the River Dove – Scoping Report.* Solihull.

Esmonde-Cleary, A. S. and Ferris, I. M. 1996 Excavations at the new cemetery, Rocester, Staffordshire 1985-1987. *Staffordshire Archaeological & Historical Society*. 35.

Ferris, I. Bevan, L. and Cuttler, R. 2000 *The Excavation of a Romano-British Shrine at Ortons Pasture, Rocester, Staffordshire.* BAR British Series 314.

French, C. 2004. Hydrological monitoring of an alluviated landscape in the Lower Great Ouse Valley at Over, Cambridgeshire: Results of the gravel extraction phase. *Environmental Archaeology* 9 (1) 1-12.

Friday, L. E. (1988) *A key to the adults of British Water Beetles*. Field Studied 7. 1-151.

Gaffney, V. G. and Hughes, G. 1993 *Settlement and environments on the south eastern Stafford gravels: New approaches to a threatened resource.* Birmingham University Field Archaeology Unit Report no. 237.

Garton, D. (1987) Dunstons Clump and the Brickwork plan field systems at Babworth Nottinghamshire: excavations 1981. *Transactions of the Thoroton Society of Nottingham*. 91, 16-73.

Garton, D. (1996) 'A Romano-British wood-lined well, Wild Goose Cottage, Lound, Nottinghamshire' in R.J.A.Wilson (ed.) *From River Trent to Raqqa,* 82. Nottingham University.

Garton, D., Grinter, P, Hunt, C. O. Rushworth, G. and Smith, D. N. (2003) *Assessment of the palaeobiological quality and character of the samples taken from the evaluation trenches of the proposed quarry at Tiln, North Nottinghamshire.* For Tarmac Central Limited. TPAU: TTN3.

Garton D. and Guilbert, G. (1997) Lound, Quarry Extension west of Linghurst Wood. *in* Challis, K. (ed.) Fieldwork by Trent & Peak Archaeological Trust in Nottinghamshire 1995-1996 . *Transactions of the Thoroton Society of Nottingham* 101, 25-7.

Garton, D., Leary, R. and Richards, G. (2003) A report on Fieldwalking 2003 at Tiln North, Nottinghamshire. Unpublished Report, Trent and Peak Archaeology Unit, University Park Nottingham.

Garton, D. & Priest, V. (1998) Pig Pens, Tiln (SK700844) *Transactions of the Thoroton Society of Nottingham*. 102, 139 – 142.

Garton, D. & Salisbury, C. R. (1995) A Romano-Britsih wood-lined well at Wild Goose Cottage, Lound, Nottinghamshire. *Transactions of the Thoroton Society of Nottingham*. 99, 15-43

Garton, D., Leary, R., Malone, S. & Southgate, M. (2000) Lound, Chainbridge Lane SK 705860. *Transactions of the Thoroton Society of Nottingham*. 104, 154-156

Gaunt, G.D. (1994) Geology of the country around Goole, Doncaster and the Isle of Axholme. *Memoir for one-inch sheets 79 and 88 (England and Wales)*. London HMSO.

Gaunt, G.D., Jarvis, R. A. and Matthews, B. (1971) The late Weichselian series in the Vale of York. *Proceedings of the Yorkshire Geological Society.* Vol. 38, 281-284.

Gaunt, G.D., Osborne, P. J. and Franks, J. W. (1972) An interglacial deposit near Austerfield, southern Yorkshire. *Report of the Institute of Geological Sciences.* No. 72/4.

Gearey, B. R. and Lillie, M. (2002) Palynology and Radiocarbon assessment of samples from Newington (NQ02) (SK675943). Unpublished report 02/01 to Northern Archaeological Associates. Hull: WEARC.

Gilbertson, D. D. and Blackburn, J. (1985) Scaftworth Roman 'Fortlet' *in* Briggs, D. J., Gilbertson, D. D. and Jenkinson, R. D. S. (eds) *Peak District and Northern Dukeries: Field Guide*. Sheffield: QRA 111-127.

Grattan, J. 1990. *A review of the floodplain at Lound, to the east and north of Wild Goose Cottage.* Unpublished report by Trent & Peak Archaeological Trust.

Guenther, G.C., Brooks, M.W. and LaRocque, P.E. 2000 New capabilities of the "SHOALS" airborne lidar bathymeter. *Remote Sensing of Environment.* 73:247-255.

Haslam, S 1986. *British Water Plants.*

Havelock, G., Carrot. J., Geary, B., Howard, A.J., Hall, A., Kenward, H. and Marshall, P. 2004. *Extending and Protecting Palaeoenvironmental Data: Deposit Sampling.* University of Newcastle. Trent Valley GeoArchaeology Research Report.

Head, R., Chapman, H. P., Fenwick, H., Van de Noort, R. and Lillie, M. (1997) The Archaeological Survey of the Rivers Idle, Torne and Old River Don *In* Van de Noort, R. & Ellis, S. eds. *Wetland Heritage of the Humberhead Levels – An Archaeological Survey*. Hull: Humber Wetlands Project. pp. 267-368.

Howard, A.J., Macklin. M.G., Bailey, D.W., Mills, S and Andreescu, R. (2004) Late Glacial and Holocene river development in the Teleorman Valley on the southern Romanian Plain. *Journal of Quaternary Science* 19 (3), 271-280.

Howard, A. J., Challis, K. and Macklin, M. 2001. Archaeological resource preservation and prospection in the Trent valley: the applications of Geographical Information Systems to Holocene Fluvial Environments. In D. Maddy, M. G. Macklin and J. C. Woodward (Eds.) *River Basin Sediment Systems - Archives of Environmental Change,* Balkema Rotterdam.

Howard, A. J. 1999. *Girton North: Stage 1 Geoarchaeological Evaluations* School of Geography, University of Leeds.

Howard, A. J., Hunt, C. O., Rushworth, G., Smith, D. N. and Smith, K. W. 1999 *Girton Quarry Northern Extension: Palaeobiological and Dating Assessment of Organic Samples collected during Stage 1 Geoarchaeological Evaluations.* Unpublished Report, Trent and Peak Archaeological Unit, University Park, Nottingham.

Howard, A.J. and Macklin, M.G. 1999. A generic geomorphological approach to archaeological interpretation and prospection in British river valleys: a guide for archaeologists investigating Holocene landscapes. *Antiquity* **73**, 527-541.

Howard, A.J. Batemen, D. Garton, D. Green, F.L. Wagner, P. and Priest, V. 1999. Evidence of Late Devonsian and early Flandrian processes and environments in the Idle Valley at Tiln, North Nottinghamshire. *Proceedings of Yorkshire Geological Society*, 52, 383-93.

Howard, A.J., Macklin, M.G., Black, S. and Hudson-Edwards, K.A. 1999. Holocene river development and environmental change in Upper Wharfedale, Yorkshire Dales, England. *Journal of Quaternary Science* 15, 239-252.

Howard, A.J. 1996. *The peaty deposits on the east bank of the River Idle between Mattersey Priory and Tiln Holt: A geoarchaeological Assessment of their condition.* Unpublished report by Trent and Peak Archaeological Trust.

Hudson-Edwards, K. A., Havelock, G. M. and Howard, A. J. 2002 *Advancing the Agenda in Archaeology and Alluvium Component 11c: Extending and Protecting Palaeoenvironmental Data: The sourcing of alluvial sediment within the Trent Valley.* Trent Valley Geoarchaeology.

Hyman, P. S. and Parsons, M.S. 1992. *A Review of the Scarce and Threatened Coleoptera of Great Britain* (Part 1). Peterborough: UK Joint Nature Conservation Committee.

Intermap. 2003. *Intermap Product Handbook*. Intermap Technologies.

Jacobi, R., Garton, D. and Brown, J. (2001) Fieldwalking and the late Upper Palaeolithic of Nottinghamshire. *Transactions of the Thoroton Society of Nottingham*. 105, 17-22.

Jessop, L. 1996 *Coleoptera: Scarabaeidae. Handbooks for the Identification of British Insects* 5,11. Royal Entomological Society of London.

Jones, G. (1987) The plant Remains *in* Garton, D. (1987) Dunstons Clump and the Brickwork plan field systems at Babworth Nottinghamshire: excavations 1981. *Transactions of the Thoroton Society of Nottingham*. 91, 16-73.

Kinsley, G. 1998 *Interim report on archaeological watching briefs and excavations at Girton Quarry extension, Newark.* Tarmac Papers, 2. 41-49

Knight, D. and Howard, A.J. 2004. *Trent Valley Landscapes.* Kings Lynn Heritage Marketing and Publications

Knight, D. and Howard, A. J. 2004, The later Bronze and Iron Ages: Towards an enclosed landscapes. Knight, D. and Howard, A. J. *Trent Valley Landscapes*. 79-113

Koch, K. (1992) *Die Kafer Mitteleuropas: Ökologie Band 3*. Krefeld: Goecke & Evers Verlag.

Lambrick, G., 1992. Alluvial archaeology of the Holocene in the Upper Thames basin 1971-1991: a review, in Needham, S., and Macklin, M.G., eds., *Alluvial Archaeology in Britain*: London, The Society of Antiquaries of London, 209-225

Large, A.R.G., & Petts, G.E. (1996). Historical channel-floodplain dynamics along the River Trent. Applied Geography, 16, 191-209.

Lindroth, C. H. (1974) Coleoptera: Carabidae. *Handbooks for the Identification of British Insects* 4 (2). London: Royal Entomological Society.

Lohani, B. and Mason, D.C. 2001. Application of airborne scanning laser altimetry to the study of tidal channel geomorphology. *ISPRS Journal of Photogrammetry and Remote Sensing* 56: 100-120.

Marks, K. and Bates, P. 2000. Integration of high-resolution topographic data with floodplain flow models. *Hydrological Processes* 14: 2109-2122.

Metcalfe, S. E., Ellis, S., Horton, B. P., Innes, J. B., McArthur, J., Mitlehner, A., Parkes, A., Pethick, J. S., Rees, J,., Ridgway, J., Rutherford, M. M., Shennan, I. and Tooley, M. J. (2000) The Holocene evolution of the Humber Estuary: reconstructing changes in a dynamic environment. *in* Shennan, I. and Tooley, M. J. (eds). *Holocene Land-Ocean Interactions and Environmental Change around the North Sea.* London: Geological Society Special Publications. 166, 97-118.

Moody, J.A., and Troutman, B.M., 2000, Quantitative model of the growth of flood plains by vertical accretion: *Earth Surface Processes and Landforms*, v. 25, 115-133.

NAA (Northern Archaeological Associates) 2002. *Newington Quarry, Nottinghamshire. Archaeological evaluation of Phase 1 extraction area and haul road.* Unpublished report NAA02/77, Barnard Castle.

Osborne, P. J. 1972. Insect faunas of Late Devensian and Flandrian age from Church Stretton, Shropshire. *Philosophical Transactions of the Royal Society of London* 263, 327-367.

Osborne, P. J. 1973. A Lateglacial insect fauna from Lea Marston, Warwickshire. *Proceedings of the Coventry and District Natural History and Scientific Society* 4, 209-213.

Passmore, D.G., Waddington, C. and Houghton, S.J. 2002. Geoarchaeology of the Milfield Basin, Northern England; towards an integrated archaeological prospection, research and management framework. *Archaeological Prospection* 9, 71-91.

Peers, C. (1930) Mattersey Priory, Nottinghamshire. *Archaeological Journal*. 87.

Posnansky, M. 1960 The Pleistocene succession in the Middle Trent Basin. *Proceedings of the Geologists Association*. 71, 285-311.

Posnansky, M. 1963. The Lower and Middle Palaeolithic Industries of the English East Midlands. *Proceedings of the Prehistoric Society* **29**, 357-94.

Priest, V. & Garton, D. (1997) 'Tiln' *in* Challis, K. (ed.) 'Fieldwork by Trent & Peak Archaeological Trust in Nottinghamshire 1995-1996' . *Transactions of the Thoroton Society of Nottingham*. 101, 25-7.

Rango, A., Chopping, M., Ritchie, J., Havstad, K., Kustas, W. and Schmugge, T. 2000 Morphological characteristics of shrub coppice dunes in desert grasslands of southern New Mexico derived from scanning LIDAR. *Remote Sensing of Environment* 74:26-44.

Robinson, M., and Lambrick, G., 1984, Holocene alluviation and hydrology in the Upper Thames basin: *Nature* (London), v. 308, 809-814.

Rumsby, B. and Macklin, M.G. 1996. River response to the last neoglacial (the 'Little Ice Age') in northern, western and central Europe. In Branson, J., Brown, A.G. and Gregory, K.J. (eds) *Global Continental Changes: the Context of Palaeohydrology*. Geological Society of London Special Publication **115**, Bath. 217-234.

Salisbury, C.R., Whitley, P.J., Litton, C.D. and Fox, J.L. 1984. Flandrian courses of the River Trent at Colwick, Nottingham. *Mercian Geologist* 9, 189-207

Smith, B. 1985. *A palaeoecological study of raised mires in the Humberhead Levels*. Unpublished PhD thesis, University of Wales, Cardiff.

Smith, D. B., Harwood, G. M., Pattison, J. and Pettigrew, T. H. (1986) A revised nomenclature for Upper Permian strata in eastern England *in* Smith, D. B. and Harwood, G. M. (eds). *The English Zechstein and related topics.* Oxford: Blackwell.

Smith, D. B., Rhys, G. H. and Goossens, R. F. (1973) Geology of the Country around East Retford, Worksop and Gainsborough*. Memoir for one-inch sheets 101.* London: HMSO.

Smith, D. N. 1996 *Dove Villa: the Insect Remains*. Unpublished University of Birmingham Environmental Services Report.

Smith, D. N. and Tetlow, E. A. 2005 *The insect remains from the Burnt Mound, Willington Quarry extension, south Derbyshire.* Unpublished University of Birmingham Environmental Services Report no. 108

Southgate, M.A., Salisbury, C.R., Howard, R.E., Laxton, R.R. and Litton, C.D. 1999. A Seventeenth-Century Kid-Weir at Dove Bridge, Derbyshire. *Derbyshire Archaeological Journal* **119**, 261-72.

Stace, C. (1997) *New Flora of the British Isles.* Cambridge: University Press.

Stevenson, I. P. & Mitchell, G. H. 1955 *Geology of the country between Burton upon Trent, Rugeley and Uttoxeter Memoir for the 1:50,000 geological sheet 140 (England and Wales)* London: HMSO

Tetlow, E. A., Garton, D. and Smith, D. N. (2005) *An Assessment of the Lateglacial Deposits at Bellmoor Quarry, Tiln, North Nottinghamshire.* TPAU Report.

Tottenham, C.E. 1954. *Coleoptera. Staphylinidae, Section (a) Piestinae to Euaesthetinae*. (Handbooks for the Identification of British Insects, IV, 8(a)). London: Royal Entomological Society.

Tyers, I. (2003) Dendrochronological spot-dates of samples from Newington Quarry, nr. Misson (NQ02), Nottinghamshire. Unpublished report 573B to Northern Archaeological Associates. University of Sheffield: ARCUS.

Van de Noort, R. & Ellis, S. eds. (1997) *Wetland Heritage of the Humberhead Levels – An Archaeological Survey*. Hull: Humber Wetlands Project.

Van de Noort, R. & Ellis, S. eds. (1998) *Wetland Heritage of the Ancholme and Lower Trent Valleys*. Hull: Humber Wetlands Project.

Van de Noort, R., Lillie, M., Taylor, D. and Kirby, J. (1997) The Roman period landscape at Scaftworth. *In* Van de Noort, R. & Ellis, S. eds. *Wetland Heritage of the Humberhead Levels – An Archaeological Survey*. Hull: Humber Wetlands Project. pp. 409-428.

Whitehouse, N.J., Buckland, P.C., Boswijk, G. and Smith, B.M. 2001. Hatfield Moors (SE 7006). In Bateman, M.D., Buckland, P.C., Frederick, C.D. and Whitehouse, N.J. (eds) *The Quaternary of East Yorkshire*

Wehr, A. and Lohr, U. 1999. Airborne laser scanning – an introduction and overview *ISPRS Journal of Photogrammetry and Remote Sensing* 54: 68-82.

Wheeler, H. 1979 Excavation at Willington, Derbyshire, 1970-1972. *The Derbyshire Archaeological Journal*. 58-224.

Whittington, G.,Connell, R. E., G. Coope, G. R., Edwards, K. J., Hall, A. M., Hulme, P. D. and Jarvis, J. 1998. Devensian organic interstadial deposits and ice sheet extent in Buchan, Scotland. *Journal of Quaternary Science* 13, 309-323.

Wilkes, S and Barrat, G. 2004 . *Where Rivers Meet:An Aggregate Levy Sustainability Fund Project (Preliminary Report) GIS Data Integration & Topographic Modelling.* HP VISTA Birmingham Archaeology, University of Birmingham.

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