ALSF AGGREGATE EXTRACTION IN THE RIBBLE VALLEY

Second Stage Two Preliminary Report

Oxford Archaeology North

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English Heritage

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CONTENTS

1. INTRODUCTION

1.1 BACKGROUND

1.1.1 This report presents the results of the mid-Stage 2 tasks of the ALSF Ribble Valley Aggregate Extraction project. The work was undertaken as a joint project between University of Liverpool and Oxford Archaeology North (OA North), and was funded by the Aggregates Levy Sustainability Fund and under the overall management of English Heritage. The responsibility of the project was split such that the geological and geomorphological elements of the project were undertaken by Liverpool University and the archaeological elements were undertaken by OA North; the palaeobotanic work was split between both organisations.

1.1.2 The programme of work is as defined within a project design (March 2005) submitted by University of Liverpool and OA North. These tasks (33-35, as defined in the project design) represent the collation and analysis of the preliminary phases of the project, following on from the initial characterisation and ground truthing of archaeology data in Stage 2, for which a report was submitted in December 2005 (Liverpool University and OA North 2005).

2. AGGREGATE EXTRACTION: STAGE 2 SECOND PROGRESS REPORT

2.1 WORK PROGRESSION FROM THE LAST MONITORING MEETING

2.1.1 By the last monitoring meeting tasks 21, 23, 24 and 25 had been completed. The following tasks were in progress 10, 19, 28 and 33, additionally, ahead of schedule, good progress had been made on Tasks 28 and 31 (OSL samples and testing). The altitudinal survey, Task 26, has been and is still delayed in order to move ahead with Task 28 and also because the quality of the LiDAR far exceeded expectations rendering the altitudinal survey a lower priority. Further work to confirm height relationships between the river terraces outside the LiDAR limit will be carried out. Tasks 20 (processing and analysis of LiDAR), 24 (refinement of characterisation) and 27 (borehole archives) were on-going.

2.2 CURRENT PROGRESS

2.2.1 ***Task 20 - Acquisition and incorporation of Lidar data:*** the task is complete in the context of Lidar data and NextMap data which are now available for the gap in LIDAR coverage around the M6 motorway.

2.2.2 ***Task 26 - Altitudinal Survey:*** this is still delayed mainly because the quality of the LiDAR has far exceeded expectations rendering the altitudinal survey a lower priority, and consequently other tasks have had a higher priority. Height range information is already available for the entire catchment from Lidar, NextMap and other sources.

2.2.3 **Task 27 Borehole survey: t**he archive work on the borehole survey is now complete; an extension collection of borehole data has been compiled, which is allowing a comprehensive assessment of the fluvial deposits. It is also enabling a more detailed understanding of the flanking glacial terrain in the lower Ribble and lowland Lancashire. These data are now being incorporated to improve the preliminary analyses of the geological datasets (Task 10).

2.2.4 ***Task 28, 29, 30, 31 and 32:*** these tasks all relate to the dating strategy to secure a chronosequence for the river terrace sequences, the glacial geology and palaeoecological datasets. A meeting with Derek Hamilton and Peter Marshall approved a first tranch of 60 radiocarbon dates, with the opportunity to re-evaluate and obtain further dates in May 2006. Further to this an application for additional critical OSL assays has been made in the Variation Bid.

2.2.5 ***Task 28*** is complete except for the need for additional fieldwork for the second tranch of dates. This is not a large job and will involve no delay to project progression, and would include the targeting of the youngest palaeochannel fills on already dated terraces for the Lower Ribble and Ribble floodbasin, and would also include in fill dating for the palaeoenvironmental research detailed in the variation proposal.

2.2.6 ***Task 29:*** relating the faunal remains to the overall objectives of the project is difficult given the time that has elapsed since the Preston docks excavations; this renders it difficult to link the sand and gravels to the current geomorphic sequence. The materials are already relatively well dated and it is difficult to envisage how new dates would add to our understanding. The value of the finds from Preston Docks will be discussed in terms of the geomorphic evolution and geoarchaeological heritage of the Ribble within the project outcomes. The dating or otherwise of this faunal archive remains a subject for the agenda at the decision time for the second tranch of radiocarbon dates.

2.2.7 ***Task 30:*** the preparation of samples for OSL and 14C dating is complete for the first tranch, but was a more lengthy time consuming task than was originally envisaged largely because of the number of dates allocated to the project. The materials are with English Heritage, and most have been sent to SUERC for dating. Others are receiving additional identification. The dated samples for radiocarbon dating are listed below.

Lower Ribble: Lower House Farm

Terrace 2 – Core LH T2 C2

1. 200-210 cm 1) *Alnus* wood and 2) detrital Root fragments
2. 90-100 cm 1) wood fragments and 2) monocot stems and roots

Terrace 3 – Core LH T3 C4

1. 136 cm 1) wood unident. and 2) amorphous wood
2. 261-262 cm 1) *Alnus/Betula* wood and 2) *Prunus* stone fragments

Terrace 4 – Core LH T4 C5 or C6

1. 433-443 cm 1) wood 2) wood fragments 3) collection of seeds
2. 88-93 cm soil 1) humic acid 2) humin fraction

Lower Ribble: Osbaldeston Hall Farm

Terrace 1 – Core OS T1 C1

1. 294-296 cm 1) wood – unidentified 2) woody twigs – *Rubus* and *Sambucus*
2. 360-342 cm 1) *Alnus* wood 2) *Corylus* nut
3. 118-120 cm 1) leaves 2) wood
4. 266-268 cm 1) bark and wood 2) twigs and moss fragments

Terrace 2 – Core OS T2 C2

1. 333-343 cm 1) Alnus seeds/scales 2) woody buds/twigs/leaves 3) seeds/fronds
2. 80-100 cm Soil 1) humic acid 2) humin fraction

Terrace 3 – Core OS T3 C3

1. 250-240 cm 1) wood and 2) twigs
2. 81-76 cm 1) leaves 2) wood + twigs 3) woody buds 4) seeds/flower

Upper Ribble

Terrace 2 – Core LB T2 C2

1. 92-95 cm Peat: humic acid and humin fraction
2. 83-86 cm Peat: humic acid and humin fraction

Terrace 3 – Core NH T3 C6

1. 275-279 cm 1) wood 2) wood fragments
2. 186-191 cm 1) wood 2) leaves, stems, seeds

Calder

Terrace 1 – CAL/C5

1. 122-127 cm – Soil 1) humic acid 2) humin fraction
2. 156-161 cm – 1) woody bark 2) woody budscales
3. 170-175 cm – 1) wood 2) woody bud-scales
4. 245-250 cm – 1) wood 2) selection of seeds

Terrace 2 – CAL/C6

1. 312-307 cm – 1) *Alnus* seeds and catkins 2) *Corylus* nuts
2. 103-109 cm – 1) *Alnus* catkins and seeds 2) *Corylus* twigs

Terrace 3 – CAL/C4

1. 92-83 cm – 1) *Salix* wood 2) other wood
2. 245-253 cm – 1) wood 2) other wood

Terrace 4 – Bank Section

1. 90- 100 cm – 1) wood 2) charcoal 3) seeds
2. 180-184 cm – 1) wood 2) other wood 3) bryophyte stems

Terrace 4 – Peat Section

1. 0-2 cm (Base) – 1) leaves 2) wood
2. 24-26 cm (Top of peat) – 1) leaves 2) wood

2.2.8 ***Task 31:*** Luminescence dating is in progress and will remain so for some months as it takes some considerable time for the production of OSL dates. We have assurances that the dating will be complete within the time constraints of the project.

2.2.9 ***Task 32:*** the forms and details for the English Heritage radiocarbon dating group are being compiled, and further reports will be completed as and when the results are received. The production of detailed reports for the radiocarbon dating sites is in progress, particularly to clarify and present the geomorphic significance of radiocarbon at the meander loops. These targeted sites will secure a chronosequence for the lower Ribble, lower Calder and upper Ribble, and so site specific reports have been generated. An example of a report is included as an appendix (Appendix 1) which presents the data for the Calder sites. The production of reports for the OSL methodology is in progress, and a preliminary report was presented at the last meeting.

2.3 GEOMORPHIC AND HYDROLOGICAL MODELLING (TASK 39)

2.3.1 Modelling of hydrology and geomorphic change to identify threats to the geoarchaeology will be under taken in the context the main likely drivers, namely climate change and future land use. The protocols for this phase of research are heavily affected by the availability and types of data, and are our approach is outlined here.

2.3.2 The Ribble is well represented in the National River Flow Archive, with the responsibility for the 13 gauging stations within the Ribble basin lying with the Environment Agency. In terms of characterising flow within the main channel and major tributaries the following stations are important: for the main Ribble the Samlesbury station, for the Darwen the Blue Bridge station, Whalley Weir for the Calder, Hodder Place for the Hodder, and Henthorn for the upper Ribble. Daily discharge are readily available for Samlesbury from the National River Flow Archive (Fig 1), data from the other sites needs to be sourced from the Environment Agency

(Phil Catherall). River discharge obviously responds to several factors: precipitation, land use, regulation (reservoirs, abstraction and channel management). Precipitation data are available for several meteorological stations across the Ribble catchment, with the longest hourly record available from Preston. There appears to be a strong relationship between daily discharge at Preston and rainfall at the top (Stainforth) and bottom (Preston) of the catchment. Comparison of the annual rainfall totals shows a increase of 200-350 mm between the lowland Ribble and the Pennines headwaters. Consequently rainfall data from Preston, which are the most complete and provide hourly time-step data, are appropriate for characterising both the precipitation pattern and discharge response of the Ribble.

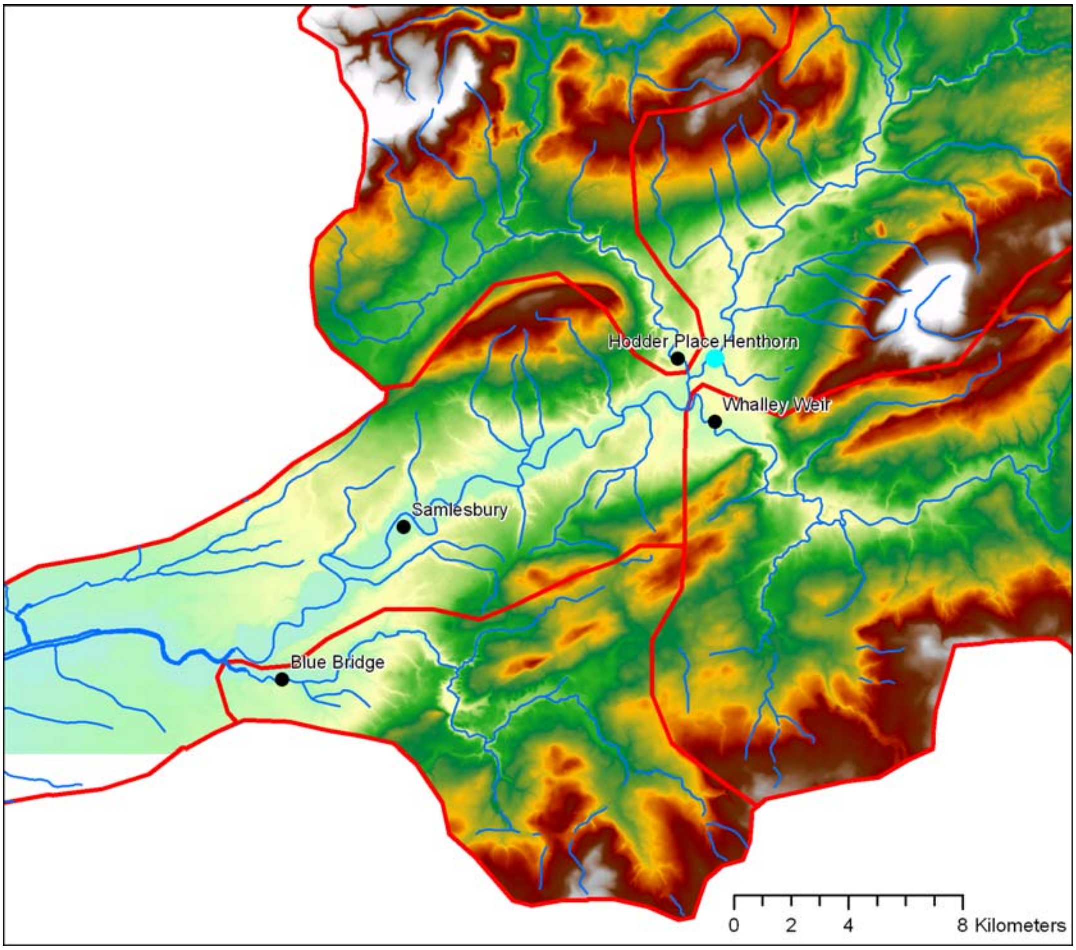


Fig 1 Location of gauging stations and catchment subdivision

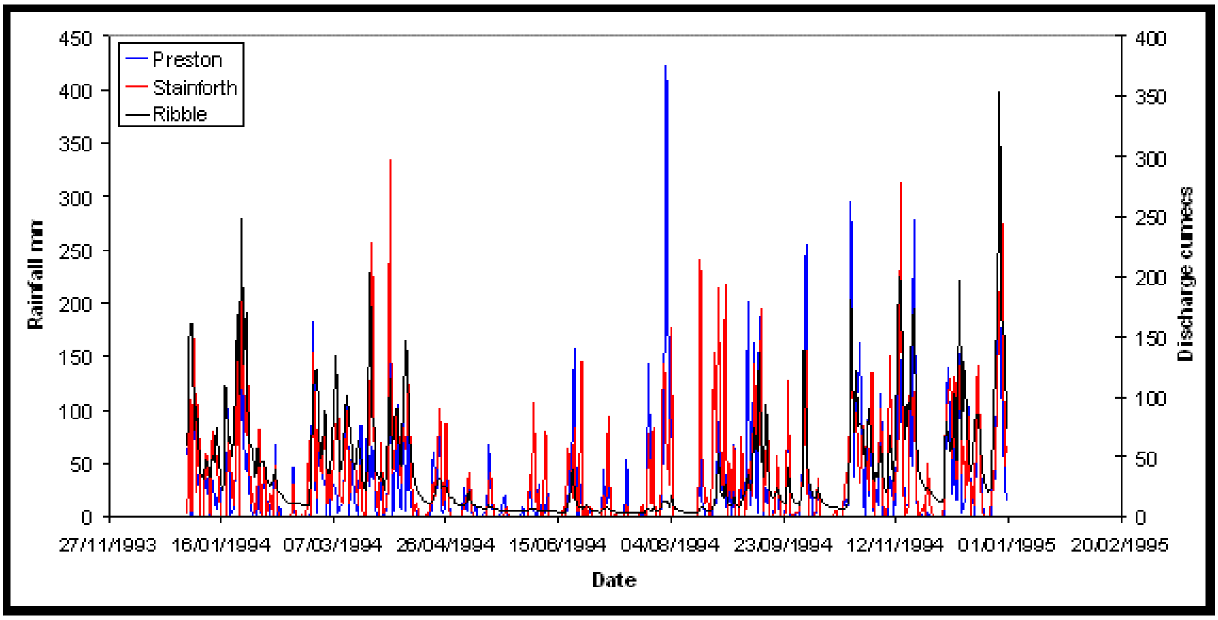
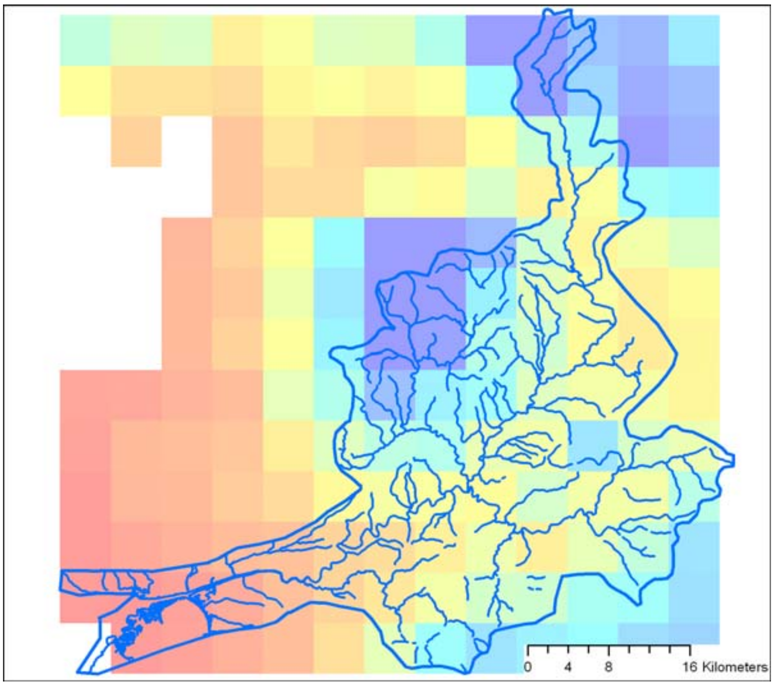


Fig 2 Ribble discharge at Samlesbury and rainfall recorded at Preston and Stainforth during 1994

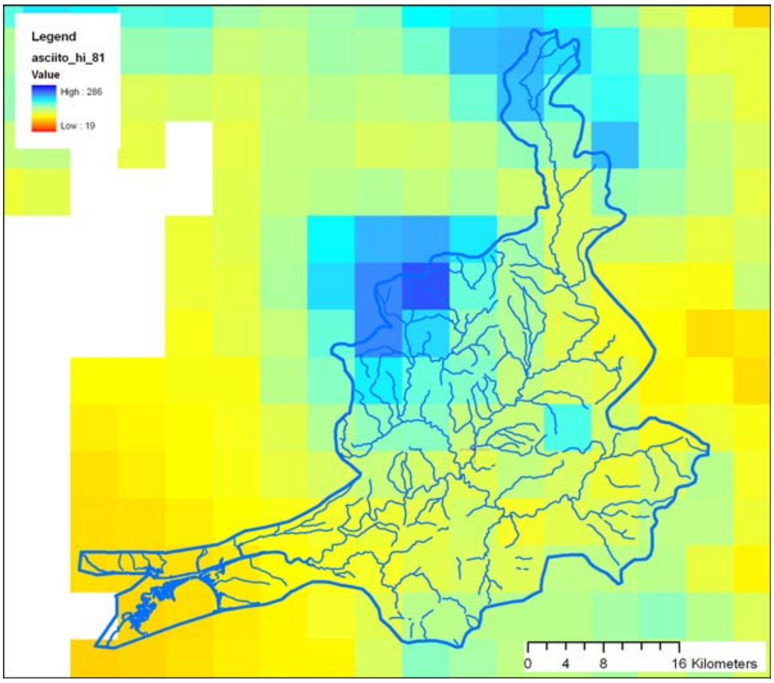
2.3.3 Historical and future climate modelled data are available from the UK Climate Impacts programme (UK CIP). These data can be used to identify the average climate for the catchment, for example to produce average monthly rainfall and annual rainfall totals for the catchment (Fig 3). Given the aim for this modelling work is to use daily Preston rainfall data to drive a dynamic geomorphic model, the average catchment rainfall will be used to moderate rainfall input.



MIN	51.4
MAX	114.9
RANGE	63.5
MEAN	76.4
STD	14.5

Fig 3 Long term average April rainfall in mm across the Ribble catchment and extracted summary statistics for the drainage basin.

2.3.4 Future precipitation patterns could also be factored into a geomorphic model using the UK CIP scenarios for future precipitation for each of the three climate change scenarios (low, medium and high emissions) for 2020s 2050s and 2080s. For example the UKCIP rainfall predictions for August in 2080 under a high emissions scenario are shown in Fig 4.



MIN	44.0
MAX	103.0
RANGE	59.0
MEAN	63.8

Fig 4 Future precipitation for August rainfall in mm during 2080 following a high emissions scenario across the Ribble catchment and extracted summary statistics for the drainage basin (UKCIP, 2002).

2.3.5 Land use scenarios will be informed by trends in the agricultural economy and activity by Agricultural Censuses: 1995; 2000 and 2003, which show changing levels of animal stocking density, area in differing classes of agricultural production.

2.4 INTRODUCTION TO THE CAESAR MODEL

2.4.1 CAESAR (Cellular Automaton Evolutionary Slope and River model) is a dynamic geomorphological model that simulates the movement of water and sediment and the development of landforms in river catchments and on flood plains (Coulthard et al., 2001). The model is based on a regular grid of cells within a digital elevation model (DEM) representation of the landscape. A catchment hydrological model drives the downstream movement of both water and sediment from slopes to tributary streams and the main river channel. Each cell stores key geomorphological data – elevation, slope, water and sediment discharge, grain size distribution – and these are updated over small time steps (i.e. seconds to minutes) across the entire catchment. The outputs from the catchment model can then be used to drive a model of fluvial geomorphological change on the valley – floor, based on high – resolution DEM data, such as the Environment Agency's LIDAR. The CAESAR model has been successfully applied to model geomorphic change over time scales ranging from hours to millennia.

2.4.2 This type of dynamic modelling approach will facilitate assessment of likelihood of future geomorphic change under various scenarios, both land use and climate, and the predicted risks for the geoarchaeological heritage. To demonstrate the value of this approach two example simulations have been conducted for the extremes of likely land use and climate change: unvegetated and high discharge (Fig 5) and a vegetated lower discharge models. These preliminary models have not been calibrated to contemporary landuse conditions in the Ribble.

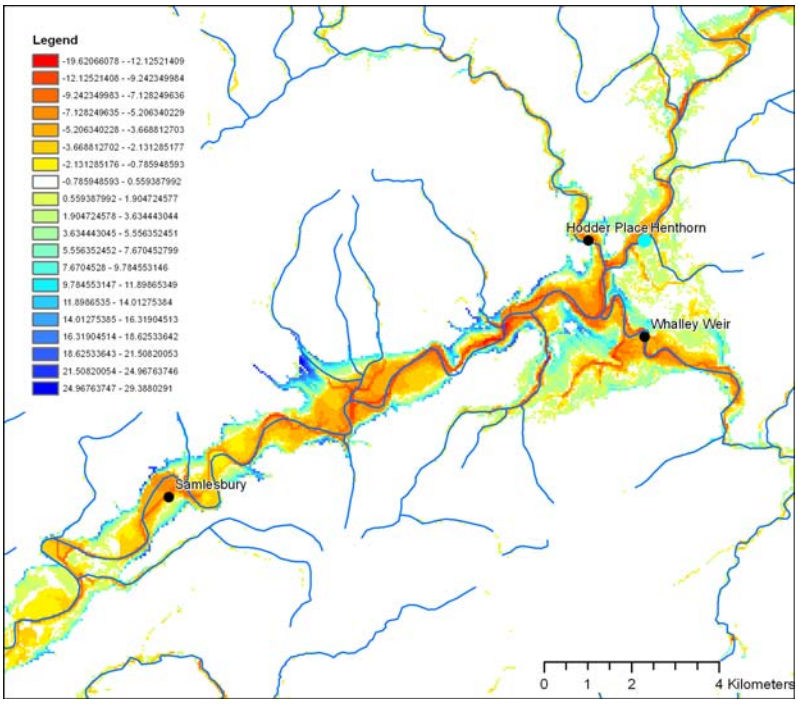


Fig 5 **U**nvegetated and high discharge CAESAR output (red = erosion and blue = deposition (mm)).

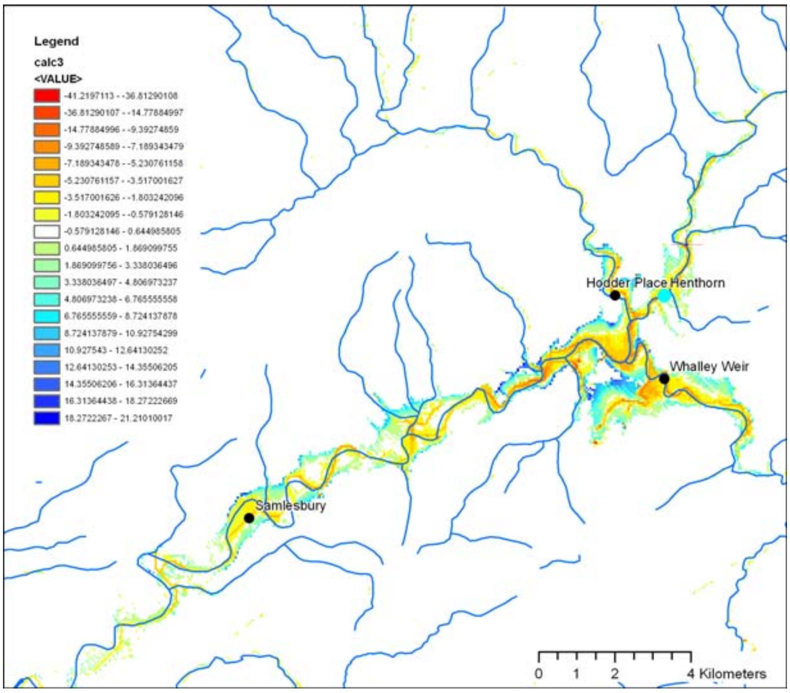


Fig 5 Vegetated and lower discharge CAESAR output (red = erosion and blue = deposition (mm)).

2.4.3 The reduction in geomorphic change in the lower part of the Ribble basin generated by increasing vegetation cover and reducing discharge fits with expected patterns. The next stages for this modelling approach are:-

- Calibrate the land-use to produce expected hydrological response in the Ribble sub-catchments.
- Refine the DEM so that it reflects the contemporary topography
- Run model for the various future climate and land use scenarios over 50-100 years
- Retro-validate the model by running over the historical period and contrasting with known change derived from Ordnance Survey and AP data

Produce zoned risk map for geomorphic change highlighting the threats from change in the fluvial system

2.5 REPORT PRODUCTION (TASK 41)

2.5.1 Production of the final report: - progress has been made on sections reporting:- the geomorphic evolution of the Ribble; glacial geomorphology and deglacial history of the Ribble basin; and the aggregate potential of sand and gravel deposits in the Ribble.

3. ADDITIONAL SITE CHARACTERISATION (TASK 24)

3.1 CONTINUED ASSESSMENT OF ARCHAEOLOGICAL CHARACTER

3.1.1 The refinement of character for the archaeological monument point data has continued as an ongoing process, in order to determine the significance, if any, of the patterning of the distribution of known historical and archaeological sites within the study area. The ultimate aim of this is to enhance the overall HER data for the area and to determine the threat of aggregate extraction on a predicted archaeological resource. The initial work, which created maps of potential, was continued to create extra data sets for the area, and once again all the vector data sets of site distribution were used to create cell-based maps utilising the Spatial Analyst extension within ArcGis 9.

3.1.2 The first task was to focus on the area of gravel terraces only, extracting the sites which occur upon them, and again run the elevation, slope and aspect tests. This work was carried out using the same Ordnance Survey 10m separation contour data used in the initial potential mapping. It was found that the topography of terraces exhibits little variation at a 10m interval value, with almost all of the terraces falling within the 30m interval band.

3.1.3 The slope and aspect tests (which are based on the digital elevation model created from the OS 10m data) were also limited at this broad level of contour detail, as all the slope of the terraces was found to fall within a range of between 0-32 degrees with respect to the horizontal. The aspect test gave equally broad results in that those sites north of the river were located on south facing aspects, whereas the site to the south of the river were located on north facing aspects. This is a fairly typical pattern of landscape within a river valley, particularly on the primary terraces or floodplain.

3.1.4 To increase the number of contour intervals this work will be carried out again utilising a combination of Lidar and Next Map height data, and although this will not provide a continuous set of data for statistical analysis it will allow the distribution and frequency of the each monument type to be shown at a height interval of 0.1m. This will demonstrate whether site type and location is dependent upon subtle differences in the landscape. It will also show if archaeological sites are located on or close to previously unmapped features such as the palaeochannels.

3.1.5 In response to these limited results a different series of tests and comparisons were run to ascertain distribution patterns within the available data sets. Firstly it was decided to look at the occurrence of archaeological records, sorted by NMR broadclass, which occur on the Ribble gravel terraces, to look for patterns between archaeological type and terrace type.

3.1.6 ***Method:*** firstly each of the NMR Broadclass cell based-maps, which had been previously created were combined with a cell-based map of the Ribble gravel terraces, created from data supplied by Liverpool University. The cell size was again set to 5m as they had been for the aspect, elevation and distance to water calculations which had been previously created in the initial characterisation. This produced a new suite of maps which contained a record of each combination of monument type and Ribble gravel terrace type. This was done for the lower Ribble study area only as the northern area contains only a small number of sites located on the terraces. In addition the terrace model does not cover the entirety of the study area and does not provide a suitable continuous data set for analysis.

3.1.7 The terraced data contained nine 'types' (including those as yet unclassified) which were combined with each of the NMR broad groups creating 108 combinations of archaeology and terrace type. Again, as before, these results were exported to Excel and the Kolmogorov-Smirnov Goodness-of-Fit-Test was used to identify any significant correlation.

3.1.8 ***Results:*** the results of this showed that there were no monument types which were found in combination with every terrace type. The classes ' Defence', 'Domestic', 'Findspot', 'Monument (by form)', 'Gardens Parks and Urban Spaces' and 'Maritime' were all found to show a correlation with the river terraces:

- ***Defence:*** of the 22 occurrences of the defence NMR broadclass within the terraces 21 of them were found to be located on gravel terrace type 1; this is provisionally the oldest of the terraces and one of the highest threat potentials for extraction.
- ***Domestic:*** of the 36 occurrences of the domestic NMR broadclass within the terraces, 21 of them were found to be located on gravel terrace type 1; this is provisionally the oldest of the terraces and one of the highest threat potentials for extraction.
- ***Findspot:*** of the 30 occurrences of the findspot NMR broadclass within the terraces, 14 of them were found to be located on gravel terrace type 1; this is provisionally the oldest of the terraces and one of the highest threat potentials for extraction.
- ***Gardens Parks and Urban Spaces:*** of the 13 occurrences of the garden and parks NMR broadclass within the terraces, 5 of them were found to be located on gravel terrace type 3; this is provisionally one of the younger terraces and one of the lower threat potentials for extraction.
- ***Maritime:*** of the 16 occurrences of the NMR broadclass maritime within the terraces, 13 of them were found to be located on gravel terrace type 2, and is provisionally one of the older terraces and one of the higher threat potentials for extraction
- ***Monument (by form):*** of the 25 occurrences of the NMR broadclass (monument by form) within the terraces, 10 of them were found to be located on gravel terrace type 3, which is provisionally one of the younger terraces and one of the lower threat potentials for extraction.

3.1.9 The same archaeological data was also tested to see if there was a statistical correlation with simply being located on or not on any area of terracing. Within the Lancashire study area there were nine broadclasses of monument type which provided a statistical correlation with the areas of terracing:

- Commercial - not previously shown to correlate with any particular terrace type
- Defence- previously shown to correlate with terrace type 1
- Domestic- previously shown to correlate with terrace type 1
- Findspot- previously shown to correlate with terrace type 1
- Gardens Parks and Urban Spaces - previously shown to correlate with terrace type 3

- Industrial- not previously shown to correlate with any particular terrace type
- Monument (by form) - previously shown to correlate with terrace type 3
- Transport - not previously shown to correlate with any particular terrace type
- Water Supply and Drainage - not previously shown to correlate with any particular terrace type

(NB The Yorkshire area gave no correlations but again this is likely to be the result of the incomplete nature of the terrace mapping for the area).

3.1.11 The main anomaly within the data is the lack of any correlation for the broadclass 'Agriculture and Subsistence'. There are 235 sites in the records for the area (being 15.66% of the total records); however 57 of these are landscape features, such as ridge and furrow or field systems, yet they are represented as point data. This means that when creating a cell-based map of the distribution of the sites a false representation of the area that is actually occupied by the site is created. The solution to this is to digitise the extent of all the features and until this is done the combination will never truly represent the actual area occupied by a monument type.

3.2 THE LYNHER VALLEY PROJECT METHODOLOGY: ENCHANCING THE HER DATA

3.2.1 In order to create a sensible GIS based approach it was decided that the current HLC would provide the basis for attaching the findings of the work so far, this follows the model of the Lynher Valley Project. The Lynher Project had the disadvantage of having to digitise a non digital project, whereas the Lancashire data has provided a ready made framework of GIS polygons covering the study area and is capable of having almost any number of further data fields attached to them.

3.2.2 The data used was the HLC broad historic landscape character types as this was found to be the only complete data set for all the polygons within the study area. A map of raster cells was combined with each of the archaeology monument rasters and the following combinations were created:

For the Lancashire Study Area:

1) All HLC types were combined with each individual monument class for all the records in the database, producing 11 calculation maps and were then tested against the 'goodness of fit' model.

2) All HLC types were combined with each individual monument class for all the records in the database, producing 11 calculation maps and were then tested for relative significance and distribution according to the Lynher Valley Model.

3) All new records in the database, were broken down by their type and combined with each individual HLC type producing 14 calculation maps and then tested for relative significance and distribution according to the Lynher Valley Model.

4) All current (i.e. unenhanced as part of this survey) records in the database, were broken down by their type and combined with each individual HLC type producing 14 calculation maps and then tested for relative significance and distribution according to the Lynher Valley Model.

For the Yorkshire Study Area:

1) All HLC types combined with each individual monument class for all the records in the database, producing 7 calculation maps and then tested against the 'goodness of fit' model.

2) All HLC types combined with each individual monument class for all the records in the database, producing 7 calculation maps and then tested for relative significance and distribution according to the Lynher Valley Model.

3) All new records in the database, were broken down by their type and combined with each individual HLC type producing 10 calculation maps and then tested for relative significance and distribution according to the Lynher Valley Model.

4) All unenhanced records in the database, were broken down by their type and combined with each individual HLC type producing 10 calculation maps and then tested for relative significance and distribution according to the Lynher Valley Model.

3.2.3 The Lynher model calculates the relative significance of a site within the study area. This is achieved by taking the HLC type and calculating the percentage of the total study area that it occupies. Secondly the number of sites which fall within a HLC area are taken as a percentage of their own total data set. The relative significance is the Site types representative percentage divided by the HLC representative percentage. "A figure of 1 would be expected by chance; results greater than 1 indicate a tendency to fall within the predicted HLC types; results of 2 indicates twice as likely as chance, 8 indicates eight times more likely than chance, etc"(Herring and Tapper 2002).

3.2.5 The results of all the calculations performed were combined in an Excel table which allows checks to be made against each HLC broad type for both the goodness of fit test and the relative frequency. These results can be weighted in terms of 'High', 'Medium' and 'Low' archaeological potential and mapping produced (Fig1). These provisional results are to be refined and finalised during task 39.

4. COLLATION, ANALYSIS AND ENHANCEMENT OF THE HER DATA

4.1 SUMMARY

4.1.1 The study area falls within the plain of the Lower Ribble, which is a predominantly agricultural landscape, and the Long Preston Reaches, where the flat plain contrasts dramatically with the surrounding steep sided drumlins and hills that are typical of more upland scenery. The area is only a part of a wider river valley landscape that included the Hodder, and Calder, and, to the north of the Forest of Bowland the rivers Wenning and Lune. The Ribble Valley has been subject to considerable archaeological, historical and character based investigation and includes local government strategic projects such as the Countryside Character Assessment by the former Countryside Commission (Countryside Commission 1998), Historic Landscape Characterisation (Lancashire County Archaeology Service 2002, and Landscape Character Assessment (Lancashire County Council 2004).

4.2 COLLATION, ASSESSMENT AND ENHANCEMENT OF THE HER DATA (TASKS 33 AND 34)

4.2.1 Over the last two decades considerable work has been carried out by archaeological contractors throughout the study area and included over 100 reports by LUAU/OA North alone. These include excavation and evaluation, desk-based assessments and building recording. These have cumulated in professional publications such as the Excavation at Ribchester (Buxton and Howard-Davis 2000). Local History and heritage publications are plentiful and vary from the Roman period to the industrial archaeology of the valley (eg Rothwell 1990).

4.2.2 The initial comparison of the events data (191 records) showed that none of the HER events point data contained any reference to its bibliographic source. The events data polygons (81 records) refer to the event from which they are sourced, but again not to the bibliographic reference for the report. Table 1 summarises the numbers of different report types from the HER records for the study area. The table shows records for both study areas; however, the work for the Yorkshire area is not complete as this work will be undertaken as a single task, once the variation area is confirmed, and will be more time effective than repeating the procedure twice between the two areas (this is likely to be subject to revision).

Event report Type	**Number**	**Event report Type**	**Number**
Assessment	3	Geophysical survey	2
Building Survey	19	Photographic survey	1
Excavation	17	Site visit	2
Evaluation	2	Watching brief	35

Table1: Brief summary of report types referenced within the Lancashire study area

4.2.3 The compiled bibliography (created as part of Task 15) was cross-referenced to the sites in the events data and the corresponding bibliographic references were inputted to the project database allowing all bibliographic references to be accessed via the point data from within the GIS. Of the remaining records 78 were sites which had been visited by the Ribble Catchment Survey (LUAU 1997). The remaining records were those which were created as part of Task 15 and have now been fully referenced to their bibliographic records within the GIS. In addition to this work the additional literature collated in Task 15 which refer to sites and events within the wider study area have now been input into the project database.

4.3 GAZETTEER AND ARCHAEOLOGICAL RESEARCH (TASK 35)

4.3.1 ***Palaeoenvironmental Research:*** the environmental programme has been investigating the potential of the study area in close collaboration with the Liverpool team. This has resulted in the identification of archaeologically and palaeoenvironmentally important peat deposits which have the potential for establishing a vegetational history for the Ribble catchment. This will draw on the results of Bernardo Chiti at Upper Brockholes and the recent work of Mary Lakin at NAA at Lower Brockholes, which has produced a dated diagram. In this instance it has been agreed that we share our resources and provides an opportunity to benefit both projects and organisations. In addition to this two sites of considerable potential have been identified: the first is near the confluence of the Calder and the Ribble and the second is at Flashers Wood. These two sites, in conjunction with the work at Brockholes, have the potential to develop the vegetational history of the Lower Ribble and as a consequence a proposal has been submitted as a variation for undertaking detailed pollen analysis at a combination of both these sites.

4.3.2 The results of this work are crucial to the assessment of the palaeoenvironment of the valley and as a consequence the palaeoenvironmental gazetteer and summary results of the palaeoenvironmental work is incomplete.

4.3.3 The research into the archaeology of the valley has been undertaken and can be broadly divided into three areas:

Landscape Character: several studies have been commissioned which deal with the study area and its wider environment these have been consulted and used to draw together an understanding of the area within which the study area is contained.

- Countryside Commission (1998) - Countryside Character Map of England, in particular the reports on the Bowland Fringe and Pendle Hill, Bowland Fells, and Lancashire valleys.
- Lancashire County Council - Landscape Strategy for Lancashire - Landscape Character Assessment
- Environment Agency - The Ribble Pilot Characterisation Report (commissioned as part of the Water Framework Directive).
- Lancashire County council - Historic Landscape Characterisation
- Lancashire County council - Historic Towns Survey

4.3.4 ***Landscape History:*** the above sources, as well as general archaeological historical texts for Lancashire, were used to research the historic character of the wider area and establish developmental patterns. The Ribble Valley itself exhibits similarities to the

Lune Valley, notably its use as a communication route, the presence of defended sites and later textile industry (Bagley 1982; Winstanley 2000). The linear earthworks and ponds which are often found along straight fast-flowing stretches of river, are remnants of the flax retting system of the Ribble valley are thought to be up to 800 years old (Higham 1998). A significant aspect of the later industrial development of the area was the quarrying and burning of lime; these extraction industries are relatively localised but have had a striking impact both visually and archaeologically on the landscape.

4.3.5 ***Current Archaeological Knowledge:*** the project data base and GIS was used as a research tool for this element of the project (which has allowed a preliminary 'trial' of its suitability so far). The wider data set provided by Lancashire County Council was examined on a broad period and type basis. The general pattern of land use is fairly well spread out, the prehistoric and medieval sites occupying a similar spatial distribution, though with fewer numbers of prehistoric sites (101 in comparison to 279 medieval). The Roman period has a very different type of pattern, and is one where activity is centred around the grid of documented Roman roads (Fig 2). Later periods see a concentration of industry around the water sources, making the remains of the earlier textile mills a high threat for potential aggregate extraction. A good example of this is at Grindleton where an important resource of potentially early flax ponds are set within the flood plain of the Ribble, located on Gravel Terrace 3 (Fig 3)

4.3.6 All these areas of work will be brought together as the final report and will be used to provide a context for the GIS record and data base. The results will help to define the research agenda for the Ribble Valley.

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FIGURES

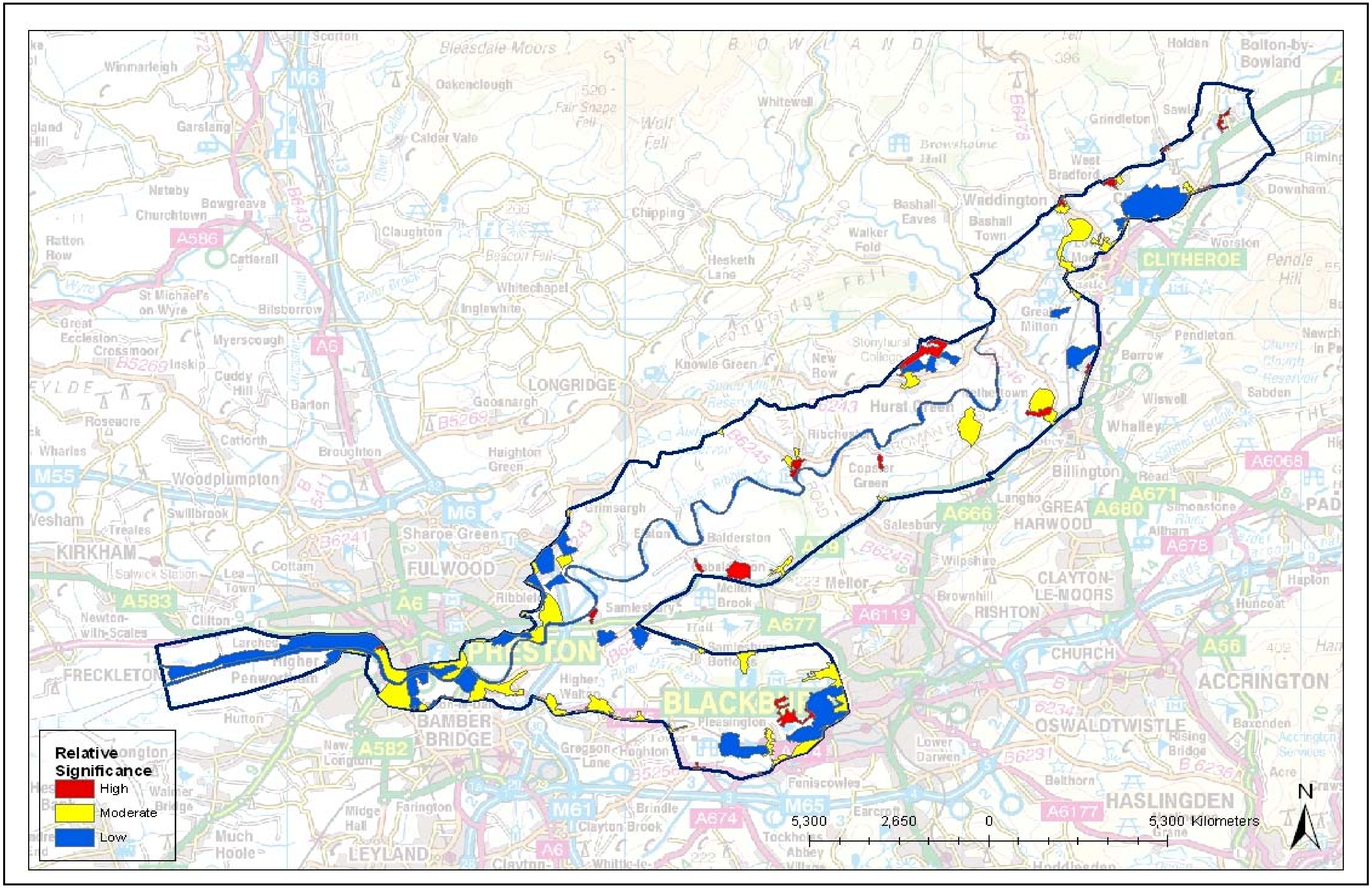
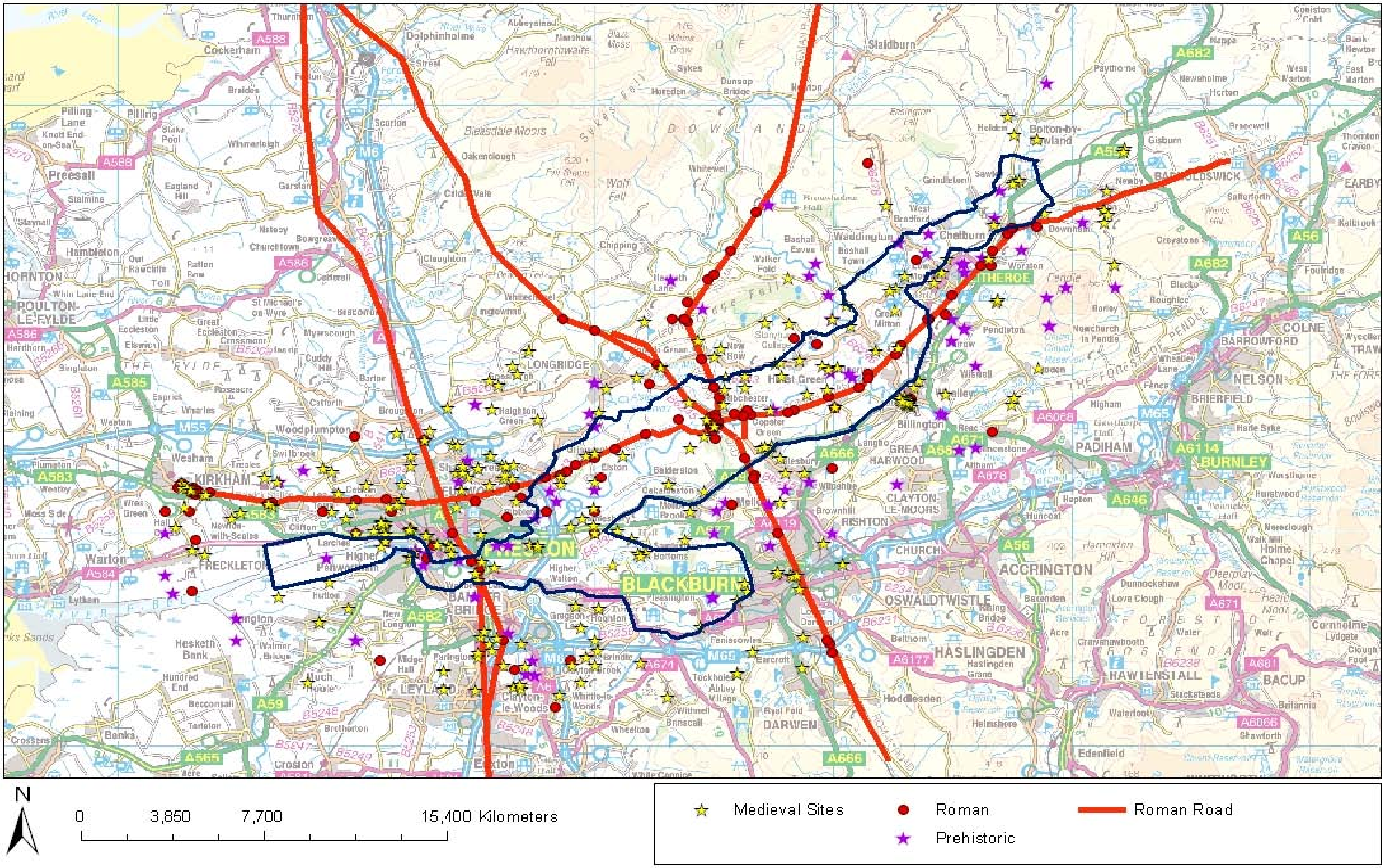


Figure 1: Provisionally Weighted HLC polygons Displayed according to their relative significance for the archaeology broadclass 'Findspot' (*After the Lyner Valley Method*)



N
0
3,850
7,700
15,400 Kilometers
Medieval Sites
Roman
Prehistoric
Roman Road

Fig 2: General Distribution Pattern Of HER Data

Fig 3: Grindleton Detail Survey Data Now Geo Referenced Within The Project GIS, the Gravel terraces are shown as colour blocks and numbered by terrace sequence

ALSF AGGREGATE EXTRACTION IN THE RIBBLE VALLEY

Second Stage Two Preliminary Report

APPENDIX ONE

EXAMPLE REPORT: FLUVIAL EVOLUTION OF THE LOWER CALDER AT WHALLEY

Oxford Archaeology North

THE UNIVERSITY of LIVERPOOL

Department of Geography

March 2006

English Heritage

NGR: SD 586306

EXAMPLE REPORT: FLUVIAL EVOLUTION OF THE LOWER CALDER AT WHALLEY

1 Introduction

1.1 The River Calder is one of three major tributaries of the River Ribble. From a fluvial geomorphic perspective, understanding the evolution of the Calder is critical for improving understanding of the entire lower Ribble system. The surface geomorphology and sub–surface sedimentology of the Calder has been investigated at one site located at Whalley, some ~ 1 km upstream from the confluence. River terraces and palaeochannels were mapped using remotely sensed digital elevation model (DEM) interpretation and field mapping. Environment Agency LIDAR DEM data (spatial resolution 1 m, vertical accuracy 5–15 cm) was used to establish the distribution of terrace boundaries and palaeochannels (e.g. Figure 1). Field studies served as a check on the remote sensing. Information on sub–surface sedimentology was derived from 'Vibra' cores and bank exposures. Sediment sampling focused on securing organic material for 14C dating and minerogenic material for OSL dating, allowing a chronological framework of major fluvial system changes (i.e. terrace aggradation, channel abandonment, increase in flooding) to be established. It is anticipated that a complete fluvial chronology will be available by Summer/Autumn 2006. Additional samples were taken from all sediment units for physical and geochemical analysis (in progress). Where buried peat horizons were found, these were sampled contiguously for pollen analysis to reconstruct vegetation and environmental change.

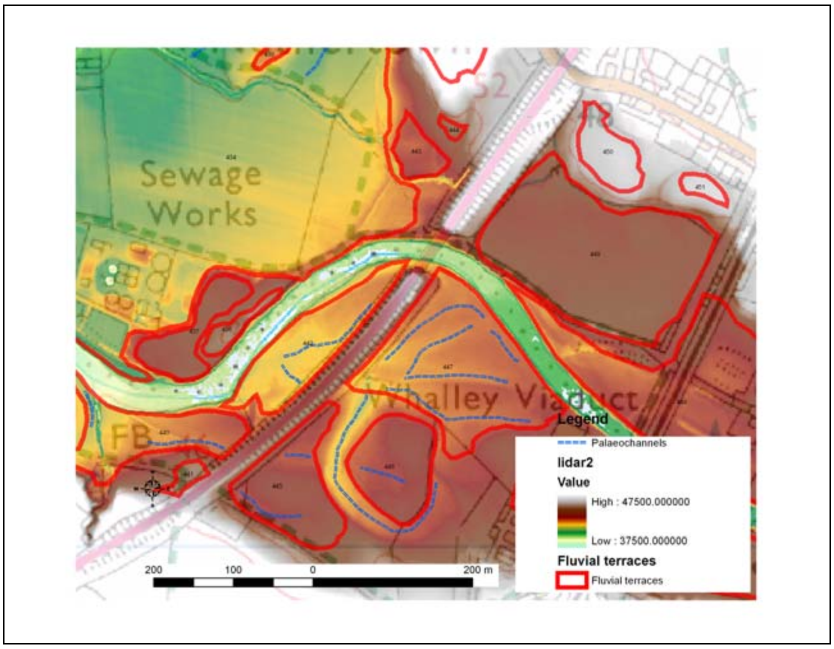


Figure 1: LIDAR map of the Lower Calder at Whalley, showing terrace boundaries and palaeochannels

1.2 The Geomorphology of the Lower Calder at Whalley

1.2.1 A total of four fluvial terraces are present within the Whalley study reach (Figure 2). Based on height range information (Figure 3), it is apparent that the study reach terraces are representative of the most extensive fluvial surfaces present along the lowermost ~ 5 km of the River Calder. However, Figure 3 also demonstrates that the overall terrace sequence becomes increasingly complex towards the confluence, where an additional two lower terraces appear to be present. Thus, potential correlations with the accepted four–stage model of Ribble fluvial terraces (Chiti, 2004) are not straightforward at this site.

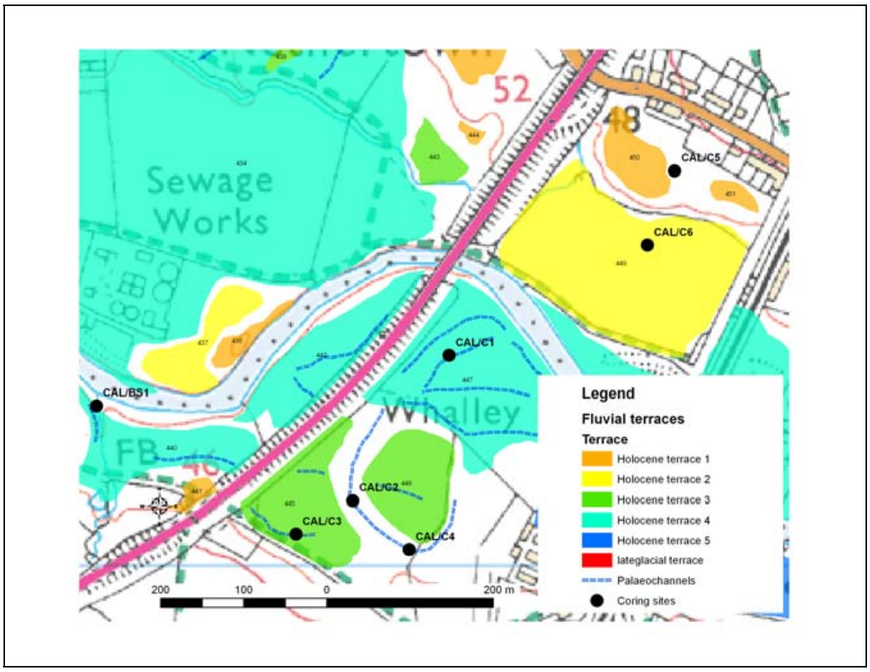


Figure 2: Geomorphological map of the lower Calder at Whalley, showing the location of coring sites and bank sections

1.2.2 In contrast with study sites located on the Lower Ribble, the Calder reach shows a general reduction in terrace preservation (i.e. spatial extent) with age. Thus, the highest and oldest terrace (T1) is only present in the form of isolated remnants located both on the outer edge and the central part of the valley–floor, while the flood plain is dominated by the lowest and youngest represented terrace (i.e. T4). This suggests that lateral channel reworking processes have played a greater role in the later stage of flood plain evolution (i.e. terrace stage T4) than vertical incision, a pattern that contrasts with evidence from the Lower Ribble, where the river and its flood plain have become progressively entrenched and confined (see Lower Ribble report).

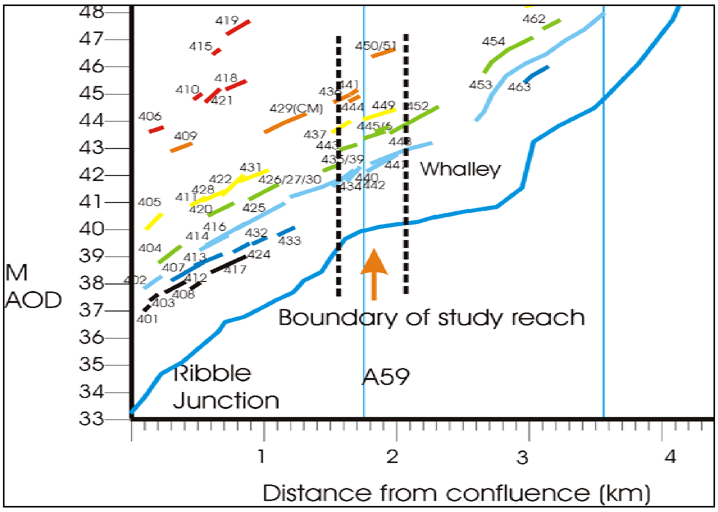


Figure 3: LIDAR – based height range diagram for the lower River Calder

1.2.3 High terraces T1 and T2 are devoid of surface palaeochannels in the study reach. However, 1 chronosequence of palaeochannels is present on the surfaces of terrace T3 and T4. The earliest of the T3 palaeochannels are present as relatively straight courses. Their geometrical form is in contrast with that of a later T3 channel represented by a very deeply incised (~ 2 m below T3 surface), tortuous meander loop (m1, Figure 2). Meander m1, and several others like it on T3 upstream and downstream of the study reach, was subsequently cut–off and abandoned at the time of terrace incision to terrace level T4. The evidence suggests that a tortuously meandering channel pattern was active and abandoned after the main phase of T3 aggradation, probably during a period of rapid incision prior to subsequent valley filling to the level of terrace T4. In this respect, the geometrical and vertical relationship between the earlier and later T3 palaeochannels is consistent with a reduction during the T3/T4 transition in flood magnitudes, sediment supply, or both. Additional evidence from a meander bend located ~ 500 m downstream from the main study reach supports the assertion that the late T3 stage involved significant changes within the fluvial system (Figure 4). Here, a series of palaeochannels and scroll bars (along transect AB) developed in tandem with fluvial incision to a depth of ~1.5 m.

1.2.4 The partial re–filling of the valley to the T4 terrace level involved the re–establishment of a relatively low sinuosity channel geometry (Figure 2), which appears similar to that described for the early stage of T3. The presence of multiple palaeochannels and the large extent of the terrace suggest that the fluvial system was laterally dynamic during T4 times. Unlike the progressive lateral changes indicated for the late stage of terrace T3 evolution (c.f. Figure 4), the relationships between the T4 palaeochannels indicates that channel changes may have occurred by avulsion processes during flood events.

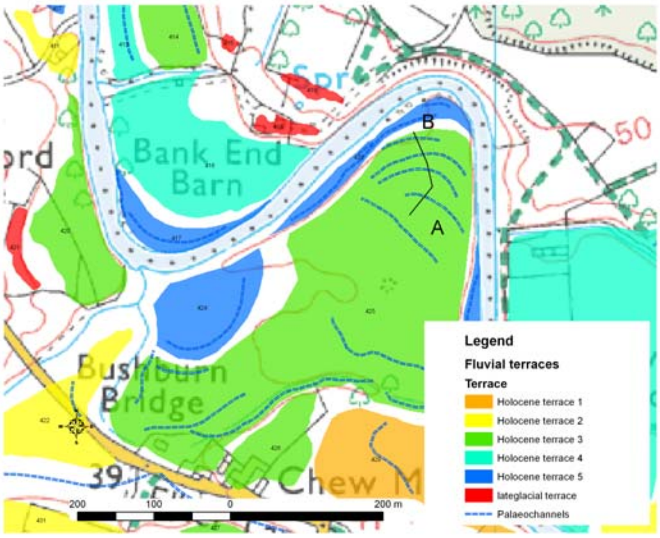


Figure 4: Example of lateral channel migration on terrace T3, ~ 500 m downstream from the main Calder study reach at Whalley

1.3 Fluvial Sedimentology of the Calder at Whalley

1.3.1 Unlike at the Lower Ribble Brockholes meander site (Chiverrell et al., 2006), no previous information is available regarding the fluvial sedimentology of the Calder terrace sequence. This section describes the results of sedimentological studies at the site from five palaeochannel 'vibra' cores and a single bank section site (Figure 2 for locations).

1.3.2 Cores extruded from the highest terraces – T1 and T2 – yielded a basal unit of dark grey, minerogenic, clayey rthythmite (Figures 5a–b), interpreted to have been laid down in a glacio–lacustrine environment during the Lateglacial deglaciation of the Ribble valley system. Subsequent Holocene stabilization of the valley–floor is indicated by a ~ 1.25 m thick accumulation of well–humified peat burying the rhythmite at T1. This stabilization may have taken place in response to a combination of factors: Holocene climatic improvement and vegetation development, reduced flood activity, reduced inundation of the site due to post–T1 fluvial incision. The upper part of the peat contains sandy flood beds and an increasing component of fluvial silts, signalling the first evidence for overbank river flood events affecting T1 during the Holocene. It is not clear whether the top of the peat on terrace T1 correlates with peaty alluvium present in the upper 1 m of the sequence on the lower T2 terrace. What is clear is that Holocene flood inundation and associated deposition was significantly greater on terrace T2, where > 2 m of flood bed sediments are recorded. The top of the T1 and T2 sequences comprise of laminated, bioturbated silty clays, representing a slowly accreting and vegetated surface subject to low energy fluvial deposition processes.

1.3.3 Sediment cores taken from terrace T3 and T4 palaeochannels yielded fining – up sediment sequences, marking the transition from active channel deposition (basal gravel) to the deposition of high energy flood sediments (fining up sand beds) and low energy fluvial sediments (laminated silty clays) after channel abandonment (Figures 5c to 5e). Each core includes a thin layer of highly organic peaty alluvium in the upper 1 m, pointing to a period (or periods) of relative stability due to reduced flood activity affecting the valley–floor during the Late(?) Holocene.

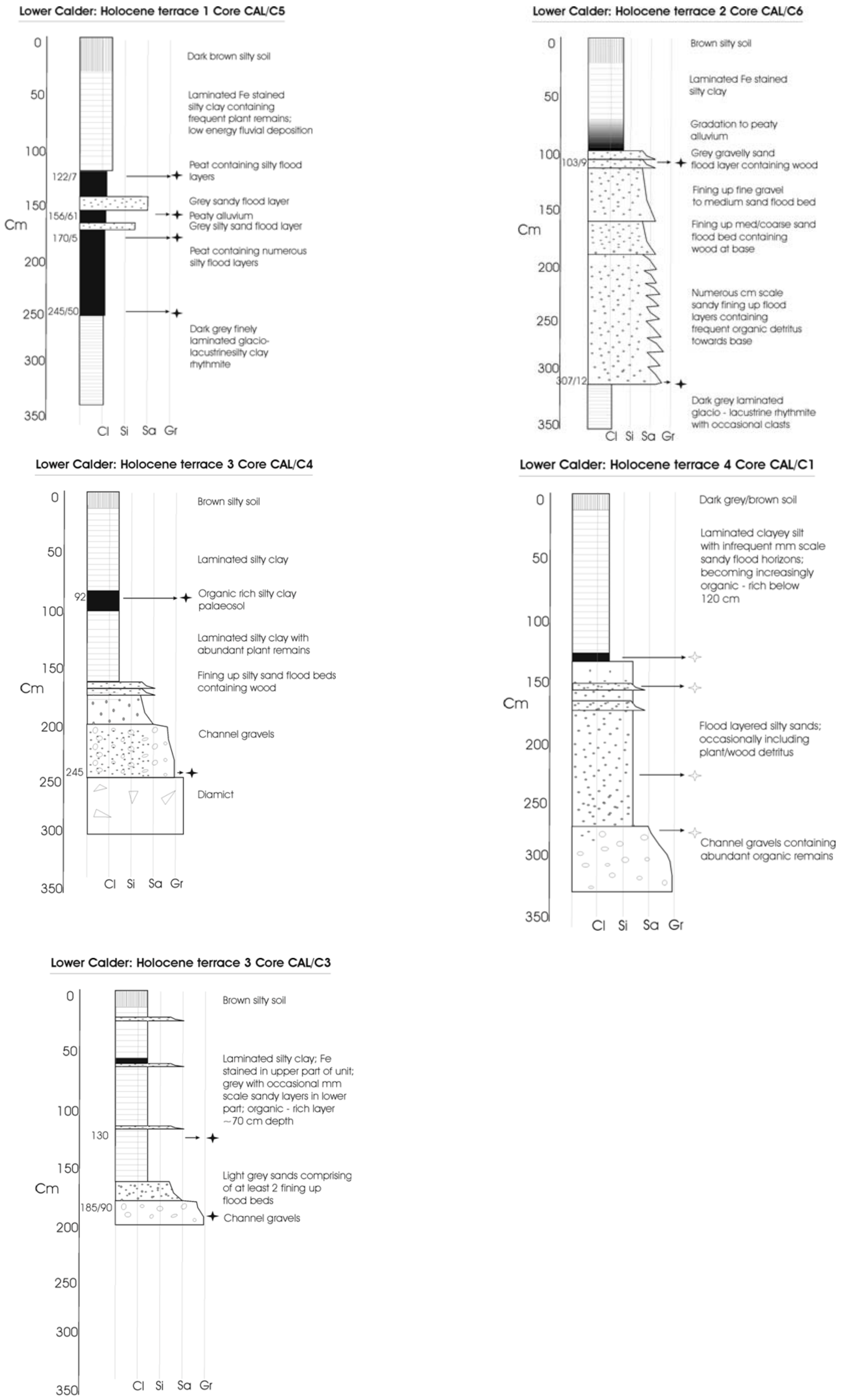


Figure 5: Core sedimentology in the Lower Calder at Whalley

ALSF AGGREGATE EXTRACTION IN THE RIBBLE VALLEY

Second Stage Two Preliminary Report

Appendix 2

Fluvial evolution of the lower Ribble: Brockholes

Oxford Archaeology North

THE UNIVERSITY of LIVERPOOL

Department of Geography

March 2006

English Heritage

NGR: SD 586306

APPENDIX 2

FLUVIAL EVOLUTION OF THE LOWER RIBBLE: BROCKHOLES

Richard Chiverrell, Geoffrey Thomas, Andreas Lang And Gez Foster

1.1 CONTEXT

1.1.1 The meander loop at Brockholes is unusual in the wider context of the lower Ribble, in that it has been the subject of previous research (Bernando Chiti, 2004). Attention has focused on the Brockhole location, because of the history of aggregate extraction and wealth of borehole information. The boreholes and exposure of sediment during aggregate extraction have allowed a more detailed understanding the glacial and fluvial geomorphology. Boreholes were undertaken associated with construction of the M6 motorway and subsequent lane expansions, for a pipeline to the east of the motorway and by aggregate companies prior to extraction at the Higher Brockholes quarry (run by Tilcon and latterly Tarmac). Lower Brockholes, to the west of the motorway, is currently the subject of planning application for further aggregate extraction. For the now worked out Higher Brockholes quarry and in preparation for the proposed new site at Lower Brockholes a series of shallow test pits have been excavated and describe further characterising the nature of both the sand and gravel deposit, as well any overlying archaeology or environmental deposits. Ben Geary and Emma Tetlow of Birmingham Archaeo-Environmental are currently undertaking palaeoenvironmental and geochronological research on two localities on the Lower Brockholes site.

1.1.2 Understanding the sequence of events at Brockholes is currently hampered by the scale of aggregate extraction. Fig 1 shows a southwards oblique aerial photography of the site prior to aggregate extraction, and much of the area to the left of the motorway has been affected by aggregate extraction. The British Geological Survey mapping (1960's) identifies an extensive area of sand and gravel highlighted on Fig 1 as the area between the two dotted lines labelled T1.

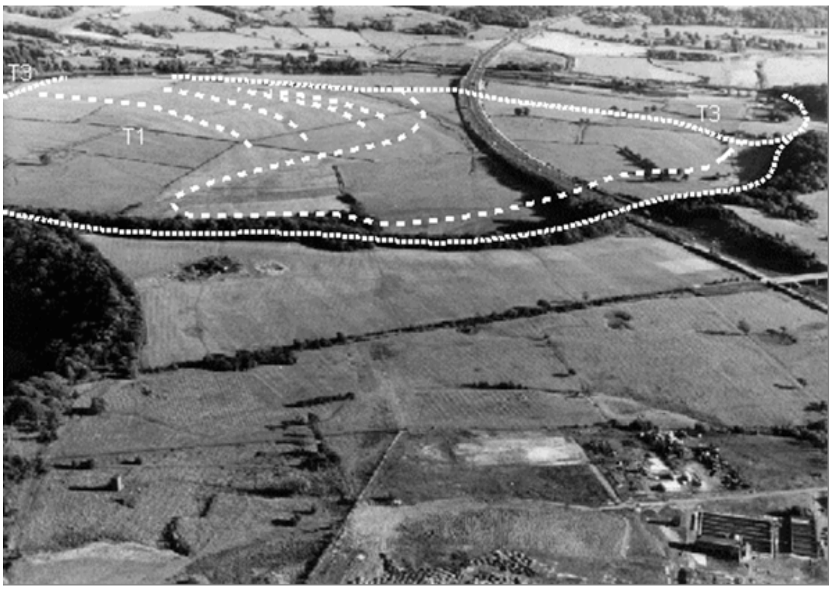


Figure 1:Oblique aerial photograph of the Brockholes meander loop (LRC N2511/PRN4503)

1.1.3 In addition the map describes the large dashed former channel loop which crosses the motorway as comprising alluvium. Chiti (2004) investigated the fluvial history of the lower Ribble and identified a sequence that comprises four river terraces. A broad chronological sequence of terrace development has been proposed by Chiti:

- Ribchester Terrace (Undated but Pleistocene age after 15 kyrs BP and before 9000 BP) Deposits comprise large quantities (4 m thickness) of sand and gravel, but with clay units.

- Brockholes Terrace (before 9000 cal. BP) Deposits comprise basal sandy gravels (3 m thickness) overlain by variable silty sandy gravel.

- Walton Terrace (After 4700 cal. BP and before 1900 BP) Deposits typically comprise 1-2 m gravel (possibly older), then an erosional cut and aggradation of fine grained silty-clays 2-3 m thick.

- Cuerdale Terrace (1400-1050 cal. BP) Aggradation of fine grained silty-clays.

1.1.5 The mapping of these river terraces at Brockholes was constrained by destruction of the geomorphology by aggregate extraction and the presence of the motorway (Chiti, 2004). However, the presence of unrivalled exposure in the quarry provided an opportunity to collect detailed sedimentological, palaeoecological and geochronological data. The mapping presented by Chiti (2004) reveals a relatively complicated geomorphology (Fig 2), with remnant fragments of the highest terrace (Ribchester), with the site dominated by the 2nd terrace (Brockholes) except for fragments of terrace 3 flanking the river. The mapping was based upon interpretation of 1940's aerial photography, alongside field mapping (Chiti, 2004).

1.1.4 This research project has re-evaluated the geomorphology and arrived at a different picture for the Brockholes site. We had the advantage of additional sources of information that were unavailable to Chiti (2004), and herein we define our methodological approach, sources and re-interpret the sedimentological, palaeonvironmental and geochronological data also collated by Chiti (2004) in the context of the revised geomorphology. The scale of extraction at Higher Brockholes renders the geomorphology impossible to discern, consequently we relied upon both oblique (Fig 1) and vertical aerial photography that pre-dated sand and gravel extraction, and EDM (total station) ground elevation surveys undertaken for Higher Brockholes before gravel extraction (for Tilcon in 1987) and for Lower Brockholes (Halletec Associates in 2005). Two forms of remotely-sensed digital elevation data (DEM) were also available: the NEXTMAP dataset with spatial resolution of 5 m and vertical accuracy of c. 50 cm (Fig 3); and the Environment Agency LIDAR DEM for Lower Brockholes with spatial resolution of 1-2 m and vertical accuracy of circa 5-15 cm (Fig 4).

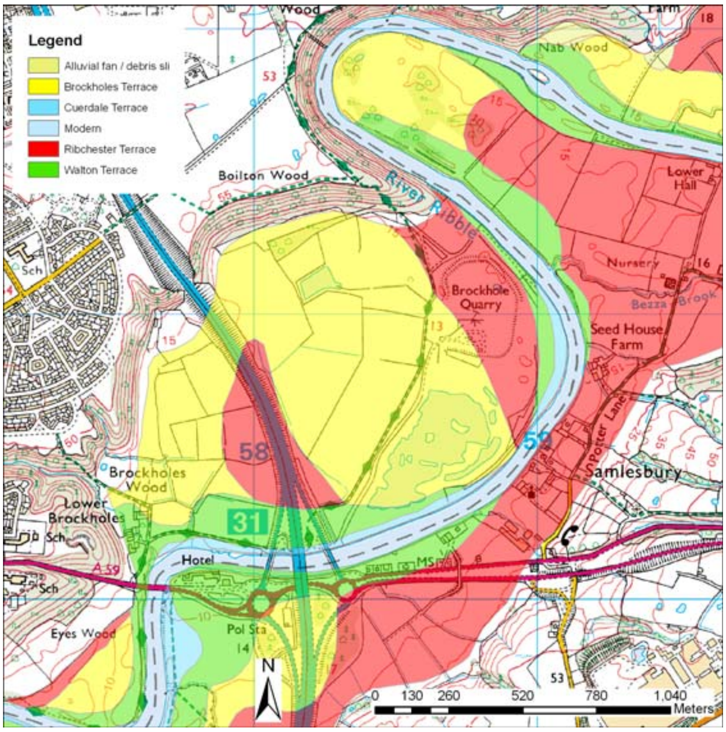


Figure 2:Geomorphological map of the Brockholes area after Chiti (2004).

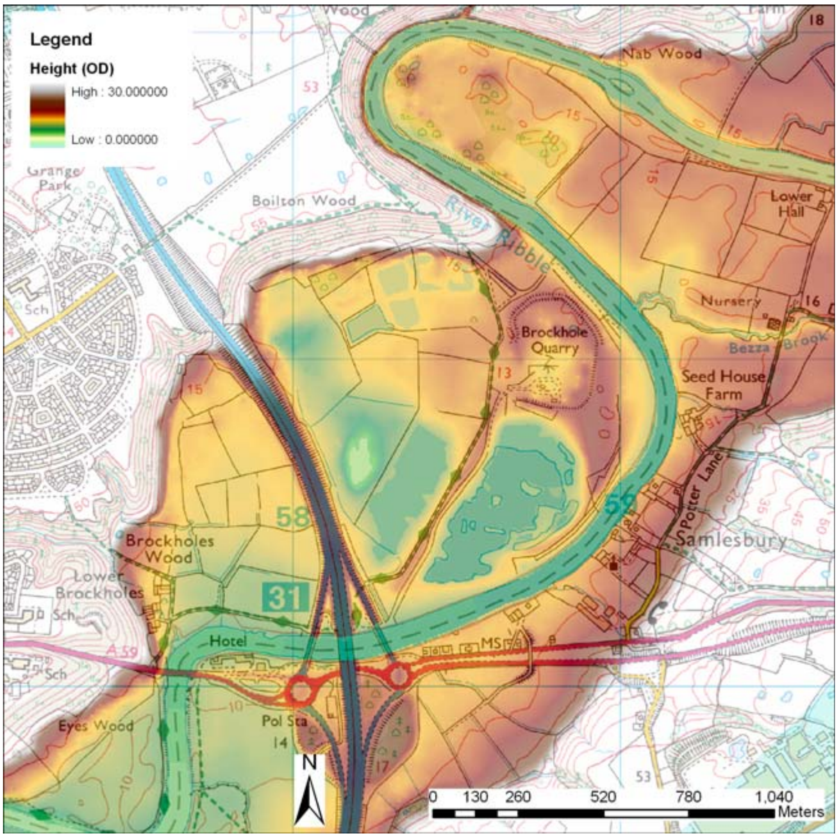


Figure 3: NEXTMAP™ digital evaluation data for the Brockholes area highlighting the impact of aggregate extraction.

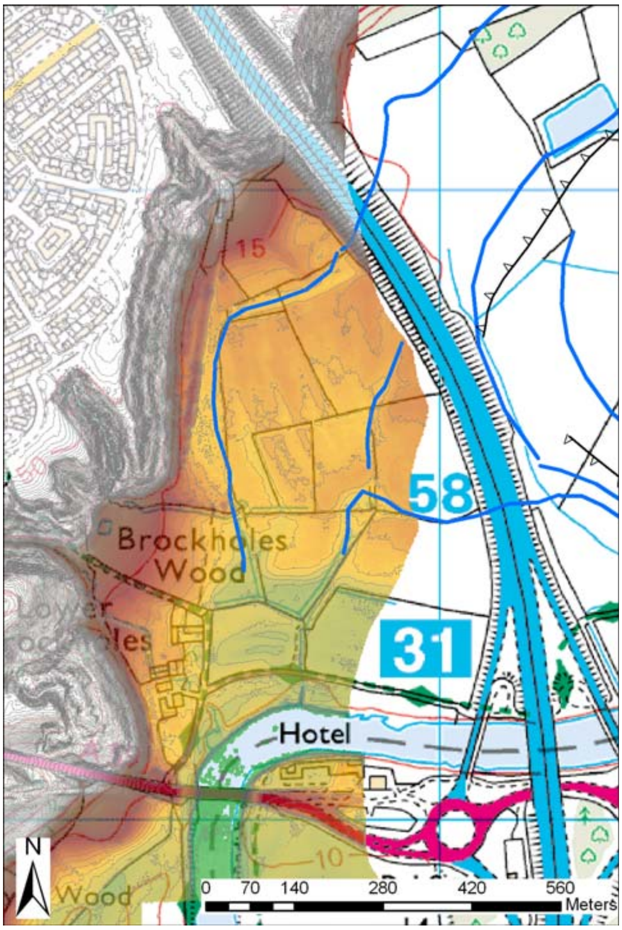


Figure 4: LIDAR digital evaluation data for the Lower Brockholes area, also identifying the main palaeochannels

1.2 GEOMORPHOLOGY OF BROCKHOLES

1.2.1 The main discrepancy between our interpretations of the geomorphology with Chiti (2004) is that we identify only two river terraces at Brockholes, which within our sequence are the highest terrace (T1) and the third terrace (T3). This interpretation is based on deriving a height range relationship for the terrace fragments from the LIDAR data and the Tilcon survey (1987) (Figure 5). The LIDAR data only cover the Lower Brockholes portion of this meander loop, but is more widely available downstream and upstream of Sunderland Hall. The LIDAR and NEXTMAP DEM datasets confirm Chiti's identification of four terraces within the lower Ribble.

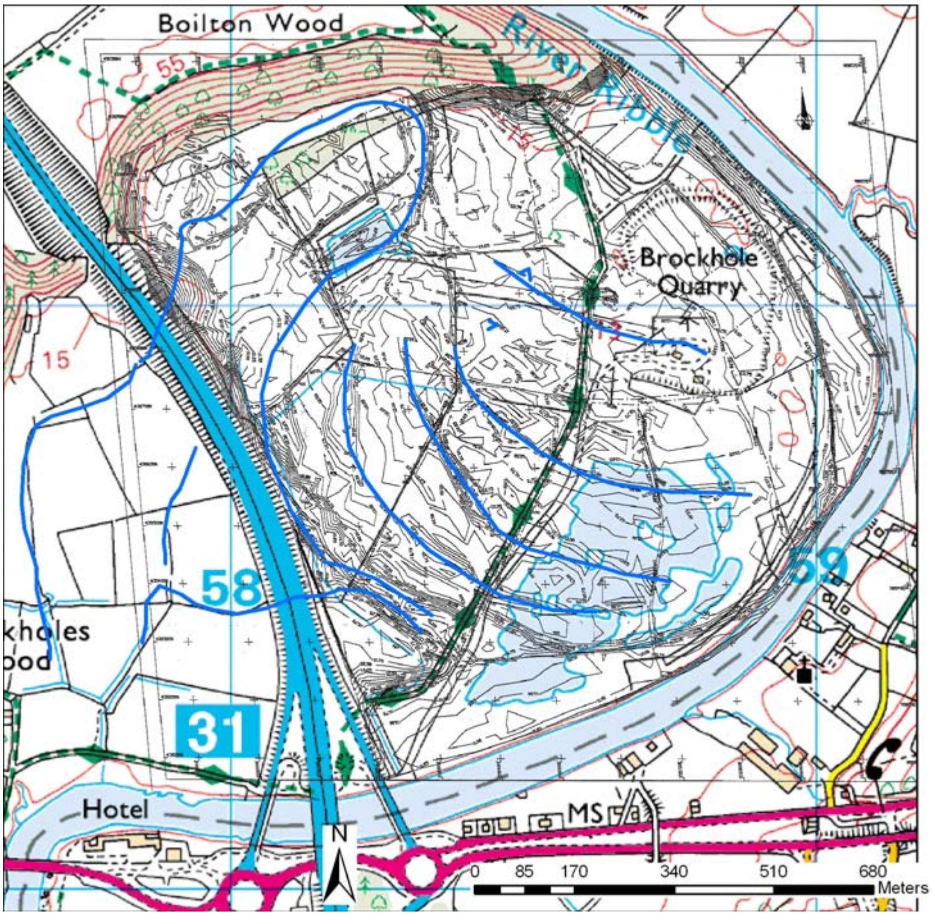


Figure 5:Contour map for the Brockholes quarry site survey before aggregate extraction commenced in 1987. Contours are at 25 cm intervals. Blue lines represent palaeochannels identified from the survey data.

1.2.2 The height range information shows that virtually the entire Brockholes meander loop is attitudinally part of the highest river terrace suite (T1), with exceptions the fragments of the third terrace (T3) which flank the river (Figure 6). These survey data also confirm the presence of a large palaeochannel meander loop that crosses the site, the planform of the palaeochannel matches the alluvium mapped by the BGS before construction of the motorway. The Tilcon survey also identified a series of scroll-bars and palaeochannels moving west to east upstream of the former meander loop. There is also a strong level of correspondence between our geomorphic interpretation of the aerial photography (Figure 1) and elevation data provided by the Tilcon survey (Figure 5) and remotely sensed datasets (Figure 3 and 4).

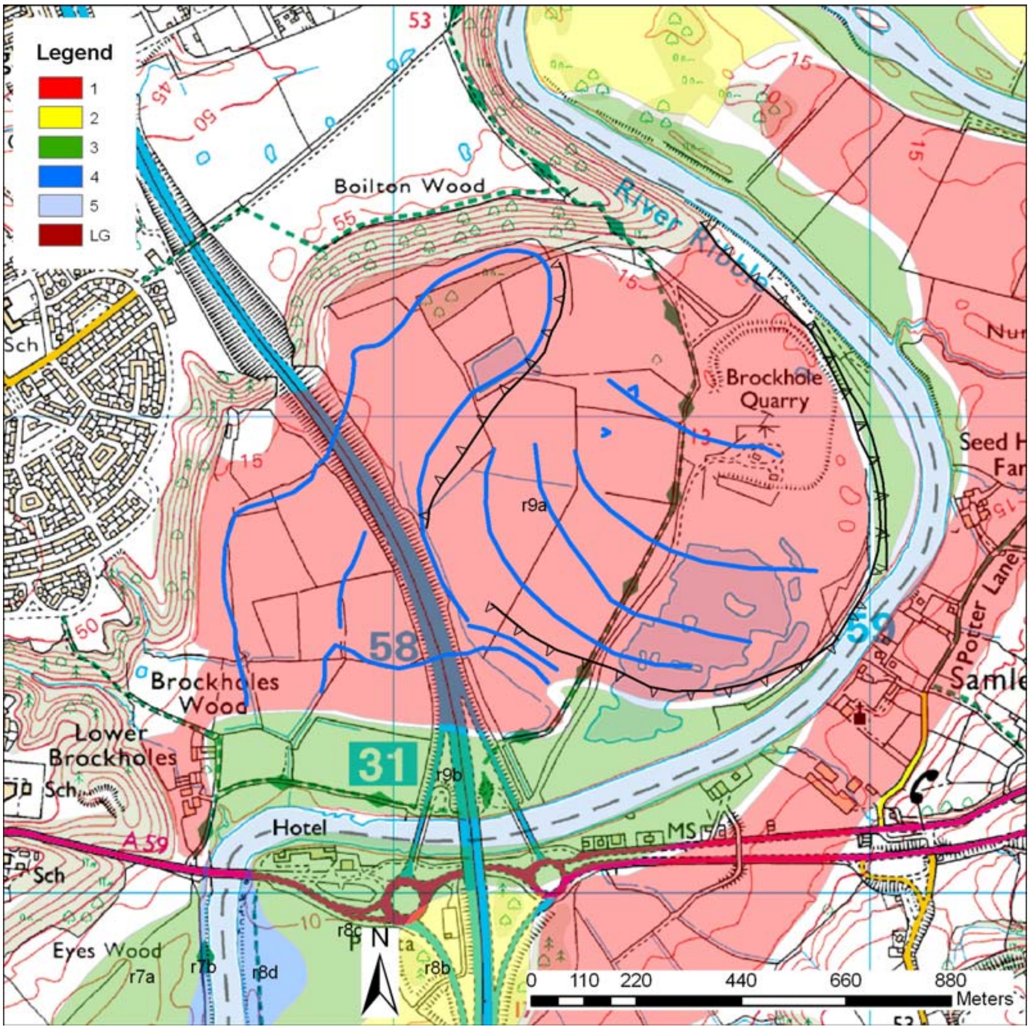


Figure 6: Revised geomorphology of the Brockholes meander loop

1.3 LATE PLEISTOCENE DEVELOPMENT OF THE LOWER RIBBLE: THE BOREHOLE EVIDENCE

(To be completed)

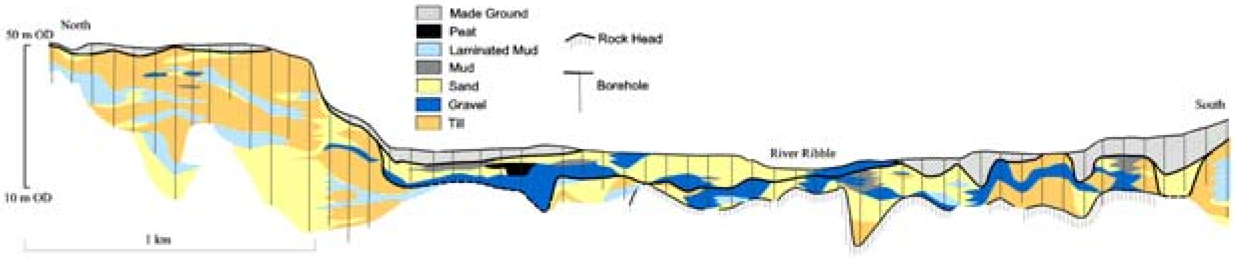


Figure 7: Schematic cross section derived from borehole evidence across the Ribble valley near the M6 motorway.

2. SEDIMENTOLOGY, GEOCHRONOLOGY AND PALAEOECOLOGY

2.1 INTRODUCTION

2.1.1 Description and laboratory analysis of the deposits at Brockholes has occurred in three stages: - completed pollen analyses and radiocarbon dates obtained by Chiti (2004) for Higher Brockholes, palaeoecology and radiocarbon dating for Lower Brockholes in progress by Ben Geary and Emma Tetlow of Birmingham Archaeo-Environmental; and Optically Stimulated Luminescence (OSL) dating and potential radiocarbon dating of the fluvial sands at Higher Brockholes in this project.

2.1.1 Chiti (2004) described a series of sections through peat-filled palaeochannels that typically overlie a basal sandy gravel unit that is widespread across the site and typically is some 2-3 m in thickness. This gravel unit is the sand and gravel exploited for aggregate. Overlying the gravel is a c. 1 m thick bedded fluvial sand unit with minor amounts of silt, which contains occasional organic materials. The organic-rich palaeochannel deposits occur in channels sunk into these sands. During Chiti's (2004) monitoring of the Higher Brockholes pit, sections exposing organic deposits occurred at three locations (Figure 8):- within the main large palaeo-meander immediately to the east of the motorway (Figure 9), and in two of the smaller palaeochannels that appear to reflect scroll-bar evolution upstream of the main palaeo-meander. Gearey and Tetlow (pers.comm.) in recent investigations (November-December, 2005) encountered further organic deposits in test-pits to the west of the motorway also from within the large palaeo-meander (Figure 8). There should be a strong correspondence between both the radiocarbon dating and palaeoecology investigations undertaken by Chiti (2004) and Gearey and Tetlow given that the materials were from the same palaeochannel.

2.1.2 During a recent visit to the Higher Brockholes quarry sections were available that exposed the top of the basal gravels, the bedded sands and overlying organic rich overbank and palaeochannel alluvium (Figure 8). Two OSL samples were taken from the bedded sands, and the site will be revisited to sample the palaeochannel deposits with co-operation of the Quarry Manager prior to restoration efforts in summer 2006. Access to the palaeochannel fill is currently unsafe owing to proximity to a small settling lagoon.

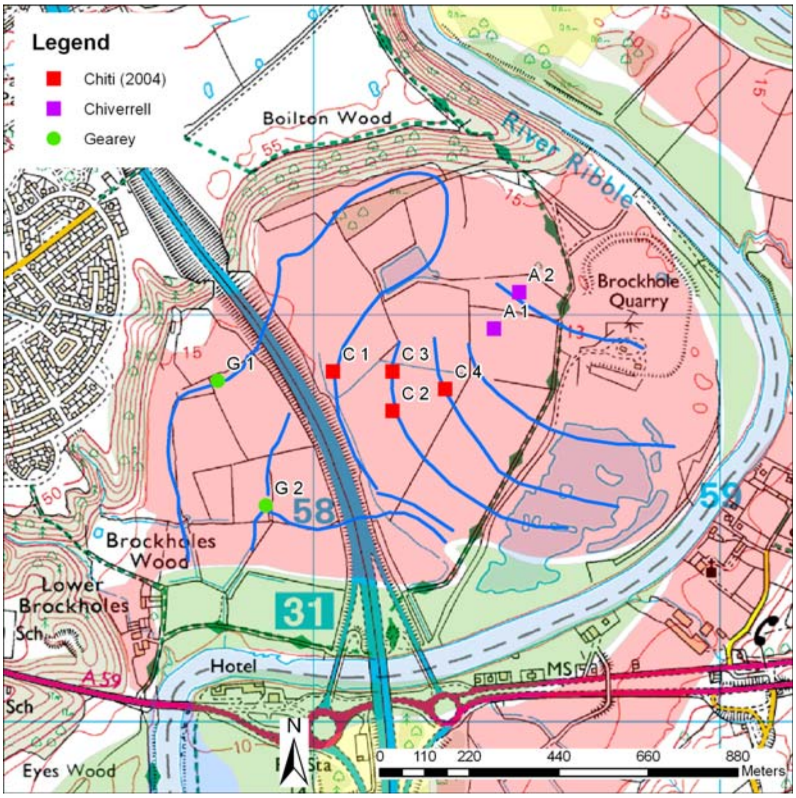


Figure 8: Sections with palaeoecological and geochronological data at Brockholes.

Figure 9: North-looking view of the saturated large palaeochannel loop prior to gravel extraction at Higher Brockholes, near the M6 (courtesy of Quarry Manager).

2.2 SEDIMENTOLOGY AND GEOCHRONOLOGY

2.2.1 Section C1 (Figure 8) through the large palaeo-meander described by Chiti (2004) encountered c. 1 m of gravel overlain by 0.75 m of bedded sands (Figure 10). The base of the gravels was not seen, but would not be greater than 2-3 m. The palaeochannel fill was c. 1 m in thickness, with a basal c. 0.4m flood- laminated sequence of organic rich plant detritus and silty-clays. This in turn was buried by c. 0.6 m thick terrestrial massive peat rich with wood and plant macrofossils (Figure 11). Overlying the peat is a greyish, iron-stained sequence of silty-clay alluvium of uncertain thickness owing to top-soil removal and disturbance during aggregate extraction.

2.2.2 The sequence is extremely useful for understanding the development and chronology for the T1 terrace, because the channel is the lowest ground on the terrace fragment and so would have been the most recently active palaeochannel. Radiocarbon dating the abundant organic materials within the basal sands and within the palaeochannel fill should secure the timing of terrace abandonment. Eight radiocarbon dates were obtained for the section (Chiti, 2004), and these form a broadly consistent younging up sequence. The basal date is from organic-rich silty-clay within the sands underlying the palaeochannel fill (8043±59BP: AA-49826), two dates come from within the organic rich silty-clay layers that form the base of the palaeochannel fill (8361±66BP: AA49828; and 7591±60 BP: AA-49827), and a date of 6068±59BP (AA-49829) from the middle of the same unit. The age of the overlying fibrous peat is secured by a basal date of 5046±55BP (AA-49831) and top date of 4067±51BP (AA-49832). There is one further date from within the overlying silty-clay alluvium of 4228±58BP (AA-49833). The quantity and broad agreement of the dating is encouraging, because considerable caution must be taken when interpreting radiocarbon dates obtained from fluvial depositional environments because the potential for reworking of materials.

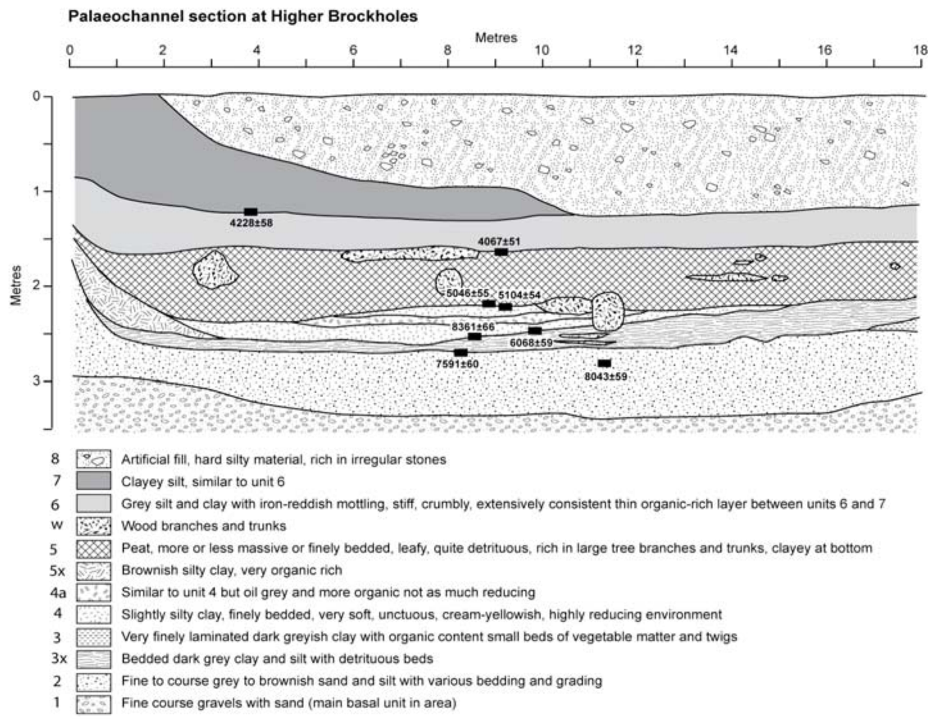


Figure 10: Peat and organic alluvium filled palaeochannel, section C1, described by Chiti (2004), identifying the radiocarbon control.

Figure 11; Organic-rich and peat filled palaeochannel at Higher Brockholes, near the M6 (courtesy of Quarry Manager).

2.2.3 A similar stratigraphic sequence was described by Gearey and Tatlow (pers. comm.) at locations G1 and G2, downstream within the same palaeochannel. Radiocarbon dates for the base and top of organic rich palaeochannel deposits are being obtained for sections at both G1 and G2, and will further secure the chronology of this large palaeo-meander form. Radiocarbon dating of the G1 peat yielded a date of 4330±40BP for wood at the top of the peat and a problematic, too young age for the basal peat of 4070±60BP. The G2 section yielded a date of 5330±70BP for wood at the base of the peat, and 2500±50BP for wood within alluvium towards the top of the organic-rich sequence.

2.2.4 Chiti (2004) also describes exposures within palaeochannels on the large scroll-bar, and these are interesting because they should be older features than the large palaeo-meander and offer the potential to secure earlier fluvial development at Brockholes. Chiti (2004) describes two sections within a palaeochannel on the scroll-bar at C2 and C3. Here the sequences (Figure 12) show basal gravels overlain by bedform bar-form silty-sands, fining up to a silty-clay alluvium channel fill deposit. A thin peat intercalated within the clayey-silt channel fill has been dated to 9163±40BP (AA-48975), which is older than ages derived from basal organic matter in the two flanking palaeochannels. Poorly exposed thicker peat deposits, not dated, occur beneath the section (Figure 12), but are probably within the silty-sand palaeochannel fill rather than the sandy gravel unit. The possibility of reworking and incorporation of older organic matter could account for this older assay.

2.2.5 The section (C4) exposed in the second channel on the scroll-bar was some 4.5m in thickness, and revealed 1-1.5m of leaf-rich peat buried by bedded silty-clay alluvium (Figure 13). The organic-rich deposits were within a channel form cut into sandy gravels. The outer bank of the palaeochannel reveals bedded sandy-gravel dipping in the direction of and reflects bar migration. Interbedded within the bar gravels are organic materials. Three dates were obtained from this setting: - leaf-rich peat deposits from the top (6149±70BP: AA-48974) and bottom (7819±58 BP: AA48973) of the organic rich palaeochannel fill; and from leaf and wood detritus towards the top of the sandy gravel bar deposits 6522±53 BP (AA-48972) (Chiti, 2004).

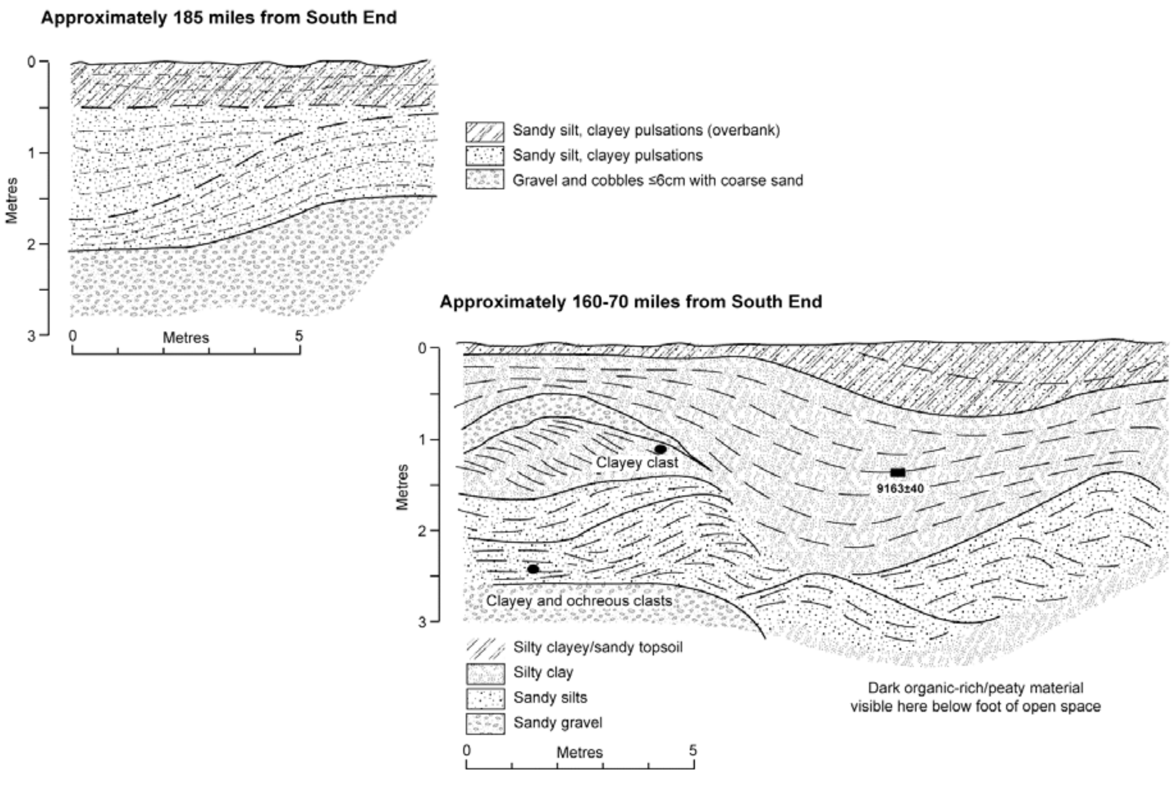


Figure 12: Peat and organic alluvium filled palaeochannel, section C2 and C3, described by Chiti (2004), identifying the radiocarbon dating.

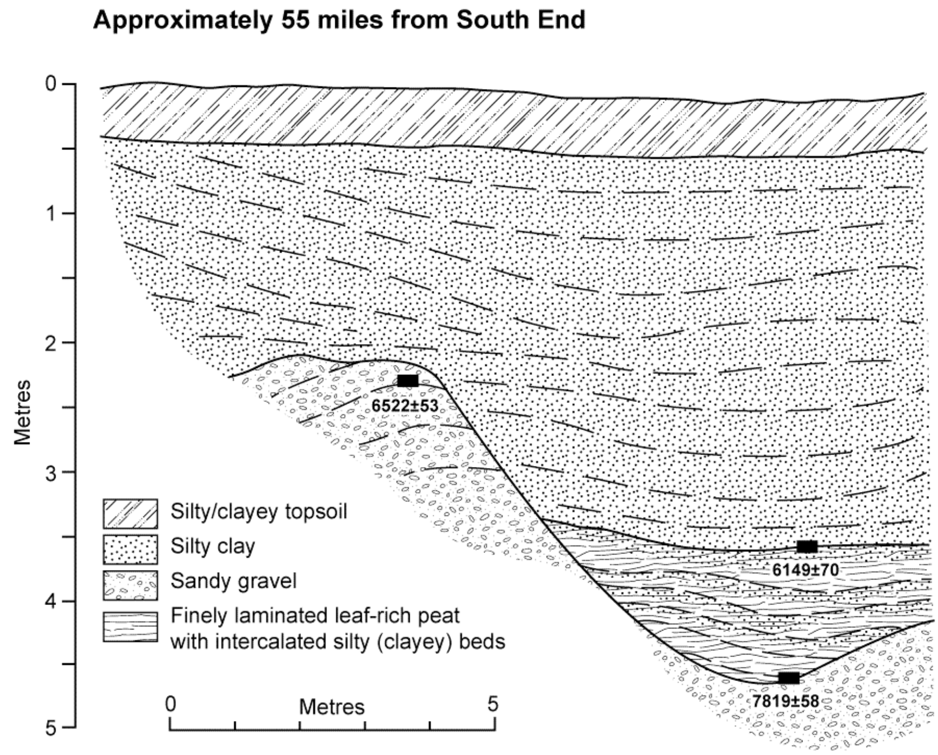


Figure 13: Peat and organic alluvium filled palaeochannel, section C4, described by Chiti (2004), identifying the radiocarbon dating.

2.3 PALAEOECOLOGY: SECTION C1 (CHITI, 2004)

2.3.1 Chiti (2004) undertook pollen analyses for the peat and organic silty-clay deposits exposed (C1) in the large palaeo-meander channel (Figures 10 and 11). These fourteen pollen analyses are secured by six radiocarbon dates and span the period c. 7500 to 4000 ^{14}C years BP. The pollen spectra (Figure show the sequence post-dates the expansion of *Alnus*, and is dominated by arboreal taxa. Alnus is the most abundant taxa with *Quercus* and *Corylus* also abundant but at lower frequencies. The broad pattern of change through the sequence is that *Alnus* increases in abundance up the profile and *Corylus* declines. The comparatively low frequencies of herbaceous taxa are dominated by Poaceae and Cypercaceae, which also are more abundant in the lower half of the profile and decline as *Alnus* increases. The pollen evidence signifies wet arboreal woodland dominated by *Alnus*, which is typical of what is expected of a lowland landscape in Lancashire before major woodland clearance during the early to mid-Holocene.

2.3.2 ***OSL sampling and analyse;*** two samples were sampled from section A1 and A2 to secure OSL dates for the sand unit that overlies the main extensive gravel deposits that form the basal Holocene (?) stratigraphy across the site (Figure 14 and 15).

Figure 14:Location OSL sampling site A2, the base of the section is gravel, and the inset shows the sample location.

Figure 15: Location OSL sampling site A1, the base of the section is gravel.

2.3.3: ***Holocene evolution of the Lower Ribble: Brockholes:*** The fluvial geomorphology at Brockholes comprises two river terraces, whose surface morphology is/was diversified by pronounced palaeochannels and in particular a large palaeo-meander. Altitudinal survey suggests that the terraces comprise the T1 highest and T3 third highest of the river terraces of the lower Ribble. Radiocarbon dating suggests a broad temporal equivalence between three locations located along the main palaeochannel, and so that there was little difference between the timing of the onset organic sedimentation between the main palaeochannel, and smaller and older palaeochannels on the meander scroll-bar. The radiocarbon chronology implies channel abandonment occurred c. 7591±60BP, which marked the beginning of organic matter and silty-clay flood laminae within the large palaeochannel. The cessation of active river flow is confirmed by the widespread inception of terrestrial peat deposits between c. 5500 and 4000 BP, which also constrains the fluvial incision and terrace abandonment to before 5500 BP and probably closer to c. 7600 BP. The comparatively late date for wood within alluvium at section G2, could reflect continued inundation of the channel closer the contemporary Ribble at c. 2500 BP. The inundation of the palaeochannel loop could also be a function of localised off-slope flow of water, particularly given the tendency of the site to episodically flood (Figure 9), although this would have been exacerbated by construction of the M6 motorway. Research to date at Brockholes has revealed little about the chronology and character of deposits related to the T3 terrace.

