Land at Lower Hall Farm and Seed House Farm, Samlesbury, Lancashire

Geoarchaeological Desk-based Assessment Report

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Land at Lower Hall Farm and Seed House Farm, Samlesbury, Lancashire

Geoarchaeological Desk-based Assessment

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Summary

Existing geoarchaeological data for the Lower Ribble Valley have been subject to a desk-based assessment in order to evaluate the potential for similar geoarchaeology at a meander site near Samlesbury, Lancashire, between the Brockholes and Lower House meanders. Data from 20 new borehole sections were evaluated and integrated with the existing geoarchaeological deposit model produced by Oxford Archaeology and University of Liverpool in 2007. The new data show good general correlation and enable the model to be refined further. In addition, LiDAR data have revealed the presence of sand and gravel pits presently obscured by woodland and also palaeochannels adjacent to the river terraces, which may contain sediments suitable for palaeoenvironmental assessment and radiocarbon dating potential.

It is recommended that a series of boreholes is implemented to target deposits within these palaeochannels to establish the depth and chronology of terrace deposits and, therefore, to determine the areas with potential for underlying archaeological deposits.

1 INTRODUCTION

1.1 Scope of Work

1.1.1 Oxford Archaeology (OA) has been commissioned by Archaeology Collective on behalf of their client, Harleyford Aggregates Ltd, to undertake a geoarchaeological desk-based assessment for an area of land at Samlesbury, Lancashire, henceforth known as 'the Site'. The site is centred on NGR SD 58998 31513, and its location is shown on Figure 1.

1.1.2 The aims of this project are set out in four stages:

- ***Stage 1***: to provide an assessment of the geoarchaeology of the site through researching the documentary and published sources for the lower Ribble valley to establish, where possible, the distribution, height, thickness and age of river terraces and to assess the potential to extrapolate these data across the area of the Site;
- ***Stage 2***: use additional available borehole data provided by the client and any new data available from the British Geological Survey (BGS) open-access scheme to ground-truth the current depositional model, as interpreted from the 2007 Oxford Archaeology North and Liverpool University work. To use GIS to overlay the borehole data on the mapped terrace deposits;
- ***Stage 3:*** utilise available and potentially new data from LiDAR to check site-specific height and contour data; integration of these data with previous work to identify significant changes in the landscape of the site;
- ***Stage 4:*** integration of all datasets using a multi-media approach to produce a report, including recommendations for further work.

1.2 Location, topography and geology

1.2.1 The site (NGR DS 58998 31513) occupies approximately 53 hectares. It lies to the east of Ribbleton, Lancashire (Fig 1) and comprises enclosed flat farmland on the floodplain of the river Ribble and undulating, steep-sided wooded valleys and small fields used primarily for pasture (Archaeology Collective 2019).

1.2.2 Topographically, the site is located within a meander of the river Ribble, for the purposes of this work identified as the Bezza Meander (Fig 1). Towards the north-west, close to the meander loop, contours indicate an altitude above ordnance datum (OD) of just under 13.5m; further south-east, in the vicinity of the Bezza brook, the contours indicate altitudes of approximately 15m (OD). The topography of the site includes higher land rising from *c* 15m to 55m OD at the junction with the A59 to the south-east (Fig 2).

1.2.3 The bedrock underlying the site is mapped by the BGS as sandstones of the Sherwood Sandstone Group, sedimentary rocks that formed during the Triassic and Permian periods. The Recent or superficial geological deposits are recorded by the BGS as river terrace deposits of sand, gravel and alluvium. The area surrounding the Ribble Valley between Ribchester and Preston lay within the Devensian ice-cap and most of the landscape is covered by reddish/brown till. The present course of the river Ribble flows either directly on the bedrock surface or bedrock can lie at a depth of several metres. Of numerous valleys that join the Ribble, only the Bezza Brook has incised to bedrock (Chiti 2004).

1.3 Sources Consulted

1.3.1 The main source of geoarchaeological data for the project is a report and dataset deriving from a study into aggregate extraction in the lower Ribble valley, which was a joint project between Oxford Archaeology North and the University of Liverpool (hereafter, OA 2007); this included and integrated results from the work of Chiti (2004) on the Lower Ribble Valley and Gearey and Tetlow (2006) from a site at Lower Brockholes (further west). The work of Chiti (2004) and Gearey and Tetlow (2006) are also independently reviewed.

1.3.2 Extracts from borehole reports supplied by Archaeology Collective from Hydro (2016) and Richard Fox and Associates (2011, amended 2013) provide data on 21 interventions within the study area and are included in the geoarchaeological assessment (*Appendix B*). No original raw data are available for the boreholes apart from lithostratigraphic descriptions; however, approximate locations and generalised altitudinal height ranges, may be inferred from maps based on previously interpreted borehole data for 20 of the boreholes (Hydro 2016). Open-access data from the BGS provided few interventions within the study area (lithostratigraphic data for a borehole to the south-east SD53SE28 – the Houghton/Whittingham pipeline - are available but no altitude data are recorded). Additional borehole data are available within a 1km radius of the site; in particular, to the west of the site, originally concerned with the construction of the M6 motorway. These datasets (the BGS boreholes, as well as privately owned quarry company borehole logs for Brockholes Quarry) were reviewed and interpreted by Chiti (2004) and subsequently integrated by OA (2007) to construct a deposit model for a 7km stretch of the Lower Ribble Valley, within which the Bezza meander sits.

2 GEOARCHAEOLOGY

2.1 Introduction

2.1.1 The current site is located between the Brockholes meander and the Lower House Farm meander of the Ribble and is here referred to as the Bezza meander (Fig 1). The river terraces from Brockholes in the west, across the Bezza meander as far as Lower House Farm to the east, and beyond to include the Osbaldeston meander, have been mapped by Chiti (2004) and, subsequently, revised and extended by OA North and Liverpool University (2007) to create an outline deposit model (Fig 2).

2.2 Geoarchaeological Data and Methodology

2.2.1 Floodplain formation was initiated in the Lower Ribble Valley following incision of the valley through glacial till after the Devensian Late glacial (*c* 11,500 years BP; Johnson 1985). This floodplain was then re-incised by a re-energised period of river flow, probably at the start of the Holocene and a new floodplain was deposited (Chiti 2004). The terrace sequences of the Lower Ribble Valley were formed through phases of deposition followed by incision, with a new depositional floodplain forming following each incision phase (Chiti 2004). The river terraces are developed on unconsolidated alluvial sediments and are easily destroyed by subsequent fluvial action – this means that a previous floodplain surface will only be preserved as individual terrace fragments at a higher level than subsequent floodplains (Lowe and Walker 1984); (Fig 3).

2.2.2 There are several difficulties associated with correlation and interpretation of terrace sequences within the study area. Chiti (2004) identified a series of local terrace sequences within individual river meanders and then joined the data together through altitudinal comparisons to create a regional model. This approach reflected the difficulty, during fieldwalking and mapping, of following individual terraces and could be attributed, in part, to anthropogenic impact which resulted in destruction or confusion of surface landforms through farming activities or construction. Furthermore, abandoned sand and gravel quarries would have removed most of the original ground, such as that which occupies most of the distal part of the Bezza meander (SD585318); this area is now densely wooded and seasonally flooded and may contain discarded agricultural waste (Chiti 2004). OA and the University of Liverpool (2007) built on the work of Chiti (2004) and employed additional methodologies (including LiDAR and GIS) to update the geoarchaeological model, including for the Brockholes meander and the Lower House meander, which sit to the west and east of the Bezza meander, respectively.

2.2.3 The terrace sequences identified and mapped within the Brockholes meander have been correlated across to the Bezza meander, largely based on altitudinal data (Chiti, 2004; OA 2007). This sequence has also been mapped across the Lower House and Osbaldeston meanders and provides the basis for the expected distribution of the terrace sequences within the Lower Ribble Valley.

2.2.4 The terrace sequence of the Lower Ribble Valley consists of four main surfaces, T1 (highest) to T4 (lowest); the modern floodplain is represented by T5 (OA 2007). The deposition of these terrace deposits reflects the response of the river system to impacts of base-level (sea-level) change and early Holocene landscape recovery following the last glaciation, as well as climate change during the Holocene and the impacts of people on the landscape /cultural change.

2.2.5 Historically, aggregate extraction in the Lower Ribble Valley has largely targeted the two highest river terraces. Previous borehole studies have confirmed that the lowest three terraces were primarily composed of alluvium with limited gravel (OA 2007; 3.4.8). Furthermore, the Lower Ribble Valley study of 2007 concluded that mapping, borehole data and the history of aggregate extraction show that it is Terraces T1 and T2 that provide good-quality sands and gravels with finer-grained alluvium typifying the lower terraces (OA 2007, section 7.2.3).

2.2.6 The locations of 20 of a possible 21 boreholes made available for this study (site topographic map, Fig 4, Hydro 2016) have been superimposed on the generalised OA (2007) deposit model for the lower Ribble terraces, which includes the Bezza meander (Fig 5). The altitudinal height for each borehole has been estimated from an altitudinal contour map (Fig 4). Unfortunately, the lack of both precise grid reference location points and altitudinal readings for the boreholes in the original log reports (Richard Fox and Associates (2011, amended 2013) precludes the use of these data to generate a separate deposit model for just the Bezza meander.

2.2.7 The approximate altitudinal height and position of each borehole on Terraces 1-5 (Fig 5) has illustrated the likely terrace assignment for each plotted borehole. By using the lithostratigraphic record for each borehole (derived from log reports; Richard Fox and Associates (2011, amended 2013)), combined with the altitude, it becomes possible to ground truth the 2007 deposit model.

2.2.8 ***Results:*** based on lithostratigraphy and altitude, it is estimated that the following range of altitudes characterise each terrace within the Bezza Meander:

- T1/ORANGE – *c* 14.5-15.5m OD
- T2/YELLOW – *c* 14m OD
- T3/GREEN – *c* 13.5m OD
- T4/PALE BLUE – *c* 12.5-13m

2.2.9 None of the boreholes penetrated the modern floodplain, T5.

2.2.10 ***Terrace T1/Orange:*** this is a late Devensian-stage surface (height *c* 10m above the modern Ribble) representing fluvial, probable cold stage multi-channel braided rivers, which deposited accumulations of inorganic sands and gravels. It post-dates deglaciation that resulted in the creation of 'lake Ribble'. Previous studies have shown that the sands proved unsuitable for dating with OSL (OA 2007). Mapping suggests that this terrace probably represents a late Pleistocene high terrace that aggraded until undated incision during the early Holocene (OA 2007).

2.2.11 The borehole location data (Hydro 2016), supplied by the client, positions BH-2 within T1 on the deposit model (Fig 6), at an approximate altitude of 15.5m (OD). The borehole penetrated sediments to a depth of 6m, of which approximately 3m of sands and gravels was recorded, overlying deposits of slightly silty fine-medium red sand (2.8m thick); the borehole terminated in compacted red sand (Richard Fox and

Associates (2011, amended 2013)). The following boreholes, all south of the Bezza brook, also penetrate Terrace 1: BHs 18, 19, 21 and comprise thicknesses of approximately 2.5m of sands and gravels. These boreholes are positioned at altitudes of approximately 14.5-15.5m OD. This lithological record accords with that predicted by the geoarchaeological model for BHs 2, 18, 19 and 21. The lithological and altitudinal record for BH20 (altitude *c* 14.5m) suggests extending the presence of T1/Orange to the west. The lithological and altitudinal record for BHs 14-17 (altitudes 14.5-15m OD) also suggest an assignment to the T1/Orange terrace, also extending T1 further west. BH14 contains a very thick sequence of gravels, approximately 5m thick underlying a 2m thick sand deposit.

2.2.12 ***Terrace T2/Yellow:*** the height of this terrace is *c* 7-8m above the modern Ribble and is made up of mostly reddish sands and gravels, reworked from Permian bedrock. The terrace aggraded during the early Holocene, *c* 8000-4000 cal BC and dating from palaeochannel fill sediments suggests the channel and terrace abandonment probably occurred after *c* 7150-6750 cal BC. The late stage of T2 development involved a meandering channel regime. Subsequent incision is constrained to *c* 4000-1500 cal BC (OA 2007, section 5.4.2).

2.2.13 Borehole location data place boreholes 9, 12, 13, 3 and 4 within Terrace 2 (Fig 6). Lithological data for BH12 suggest a deposition of approximately 4m of sands and gravels overlying approximately 2m of red silts, firm brown clay and fine brown sand. These boreholes are located between approximately 13.5-14m OD. The positioning of BHs 12, 13, 9 and 3 within T2 corresponds with the geoarchaeological model predictions. The revised model supports an extension of T2 to the north and west, based on lithostratigraphic and altitudinal data from BH4.

2.2.14 ***Terrace T3/Green:*** the height of this terrace is *c* 5-6m above the modern Ribble and is characterised by meandering channels and deposits of fine-grained alluvium, locally overlying gravels at depth. This terrace aggraded around 1500-200 cal BC and may reflect input of sediment to the fluvial system, following cultural impacts on the landscape during the Bronze Age and Iron Age (OA 2007). The incision that followed T3 is broadly secured to the period 300 cal BC – cal AD 200 (OA 2007, section 5.4.2).

2.2.15 Mapped borehole data place BHs 5, 6 and 7 clearly within T3 (Fig 6). These boreholes are located at altitudes of between approximately 13-13.5m OD. The lithological data derived from the borehole sediments for BH7 comprise approximately 6m of fine-grained sands and silty sands overlying deposits of sand and gravel (*c* 1.5m thick), corresponding clearly with predictions based on the geoarchaeological model. This lithological package is very different from that described from the older terraces T1 and T2 (above) with thick sequences of predominantly fine-grained deposits overlying sands and gravels. The lithological and altitudinal data available for BH10 suggest assignment within the T3 terrace and therefore the revised model shows the occurrence of T3 to be present south of the main T2 terrace deposits.

2.2.16 ***Terrace T4/Pale Blue:*** the height of this terrace is approximately 4-5m above the modern Ribble. It is characterized by fine-grained alluvium and surface meandering channels. T4 aggraded *c* cal AD 200-100, corresponding with increased sediment input to the fluvial system following cultural impacts on the landscape during the Romano-

British period and into the medieval period. The incision that followed T4 is broadly secured to the period after cal AD 1460-1610 (OA 2007, section 5.4.2).

2.2.17 Mapping the position of BH11 shows that it is located close to T4 (Fig 6). The sediments recorded in BH11, at an altitude of 12.5m OD, comprise approximately 4.5m of very fine brown sand and silt overlying 1.5m of fine red sand with occasional gravel. This lithological succession accords with that predicted by the geoarchaeological model (OA 2007). The model is revised to include the extension of T4 further to the north-east, based on the lithostratigraphic and altitudinal data obtained from BH8.

2.2.18 ***Terrace T5/Dark Blue (Fig 4):*** this is the present-day floodplain, mostly visible and dated further east, with incision and aggradation occurring between c cal AD 1460-1610. There are no new borehole data located on T5.

2.2.19 ***Conclusion:*** in summary, valley filling probably occurred initially in the Late Devensian and was followed by a period of incision. Further aggradation then commenced in the early Holocene (T2) followed by a major incision and phase of abandonment after *c* 7150-6750 cal BC. Subsequently, a series of successive incision/aggradation cycles resulted in the formation of Terraces T3-T5. However, the chronology is not clear-cut as T2/T3 and T3/T4 transitions vary considerably across distances of *c* 4km (OA 2007, section 5.2.24).

2.2.20 New borehole data for the Bezza meander, overlain on the deposit model, show a good correlation between the predicted terrace distribution within the Bezza meander and the lithostratigraphic successions described from the boreholes. In summary, as the model predicted, Terraces 1-2 are characterised by coarser sand and gravel deposits whereas Terraces 3-5 are typified by accumulations of finer-grained clastic deposits. By using lithostratigraphic details for each borehole in combination with estimated altitudes, it has proved possible to revise the deposit model (Fig 6). A summary of borehole lithological records with height (m OD) and thickness of the mineral deposits, is tabulated in *Appendix B*.

2.3 Palaeoenvironmental Data

2.3.1 Alluvial deposits comprise sands and gravels, but also finer-grained sediments preserved within floodplains and palaeoechannels and may contain organic rich silts/clays and peats. These contexts can preserve artefacts and ecofacts indicative of palaeoenvironmental history and human activity and are therefore key contexts for interpreting the physical evolution of the landscape. These deposits could also provide plant macrofossils for radiocarbon dating, in order to improve the current chronostratigraphic framework.

2.3.2 Palaeoenvironmental data have been recovered from organic rich deposits (organic silty clay alluvium and peats) from palaeochannels associated with the Lower Ribble meanders. These data contribute to the chronology of the terraces, as well as providing an insight to local and perhaps regional vegetation change leading to interpretations of probable human impact on the former landscape.

2.3.3 There are no direct dating controls for the age of T1, but the first extensive alluvial plain of the Ribble must have been deposited following incision of the valley through glacial till after the Devensian Late glacial (Chiti 2004).

2.3.4 Sediments from two sites from the Brockholes meander, immediately west of the Bezza meander, have been analysed for pollen and provide chronological control for the age of T2 (Chiti 2004, 155-66; OA 2007; Gearey and Tetlow 2006). An organic fill of a palaeochannel was dated from 7572-7193 cal BC (8361±66 BP; AA-49828) to 2864-2473 cal BC (4067±51 BP; AA-49832) and provides a record of environmental change from the middle and later Mesolithic and the early Neolithic periods. During this time, the catchment of the Lower Ribble Valley was dominated by alder/elm/oak and hazel woodland. A little after 5208-4837 cal BC (6068±56 BP; AA-49829), there is evidence of a grass/sedge community developing at the site, which, together with increasing values of microcharcoal particles, may be indicative of woodland subject to burning. Chiti (2004, 164), suggests that this burning may have accelerated the development of an ox-bow lake. Open vegetation continued until sometime after 3960-3711 cal BC (5046±55 BP; AA-49831), followed by a re-generation of alder/oak and hazel woodland, which dominated the landscape until 2864-2473 cal BC (4067±51 BP; AA-49832), when the site re-flooded. A generally wooded environment with oak, hazel and alder, at 3331-2922 cal BC (4430±40 BP; Beta-213393) is also suggested from the pollen work of Gearey and Tetlow (2006) from another site at Brockholes.

2.3.5 Based on modelling of all the dates obtained from the Brockholes palaeochannel fill, the date at which the main channel probably became a backwater is estimated at 7150-6750 cal BC (8043±59 BP; AA-49826) but the channel probably remained active as a cut-off oxbow until perhaps as late as 3970-3780 cal BC (a combined date from AA-49830 and AA-49831; OA 2007). Peat accumulated within this oxbow / palaeo-meander loop, with flooding of the terrace continuing until 3002-2621 cal BC (4228±58 BP; AA-49833) and maybe until as late as 791-416 cal BC (2500±50 BP; BETA-213392) (OA 2007, section 5.2.7).

2.3.6 Palaeoenvironmental data and radiocarbon dating have also proved useful, although challenging to interpret, for determining the chronostratigraphy of terraces T3-T4, at the Lower House Meander (to the east of the Bezza meander, Fig. 2). For T3, modelled dates suggest that older channels appear to have been abandoned from about 2440-2140 cal BC prior to final abandonment by incision in either 310 cal BC – cal AD 280 or 2100-640 cal BC. The formation of T4 then followed by incision and subsequent aggradation. T4 was abandoned after cal AD 230-390 (OA 2007, section 5.2.15).

2.3.7 Further east again, at the Osbaldeston meander (Fig. 2), core samples were retrieved from two palaeochannels associated with T2, including a one from a peat deposit at Flashers Wood (SD 6438 3441). Dating of the peat suggests that it accumulated between cal AD 484 and 582, during the medieval period (OA 2007, section 5.3.1). Radiocarbon modelling has provided a date for the final abandonment of T2, of cal AD 290-480 and probably of cal AD 340-430. T3 was probably incised (abandoned) around cal AD 630-1460. The data also suggest that T4 was abandoned by cal AD 1460-1610 (*op cit*, sections 5.2.21-2).

3 GIS AND LIDAR

3.1.1 Using GIS data, the positions of the new boreholes have been mapped onto the deposit model created by OA and the University of Liverpool (2007) (Fig. 5). This has permitted the lithostratigraphic data to be reviewed against predictions based on the deposit model (*op cit*, sections 4.2.5-15).

3.1.2 LiDAR data acquired for the Bezza meander have been analysed for both archaeological and geoarchaeological features. LiDAR is a powerful remote sensing technique that is able to record the ground surface beneath tree canopies. The westernmost tip of the meander is characterised by small areas of woodland, which, as evidenced by the LiDAR, are obscuring three areas of former sand and gravel extraction (Plate 1). One of these hollows, at the north-western tip of the meander, is now a water-filled pond, indicating that the underlying geology (clay or alluvial deposits) are not porous to water. The modern OS mapping shows these hollows as being 'sand and gravel pits (disused)' (Fig 1), but they are not shown on OS mapping of 1938 (OS 1938), so the extraction was evidently of relatively recent date. It is interesting to note that this part of the meander ridge comprises Terrace 3 deposits, which typically is a material that is not suitable for aggregate extraction, and raises the question as to why this area was used for this localised extraction when there were potentially better deposits to the east.

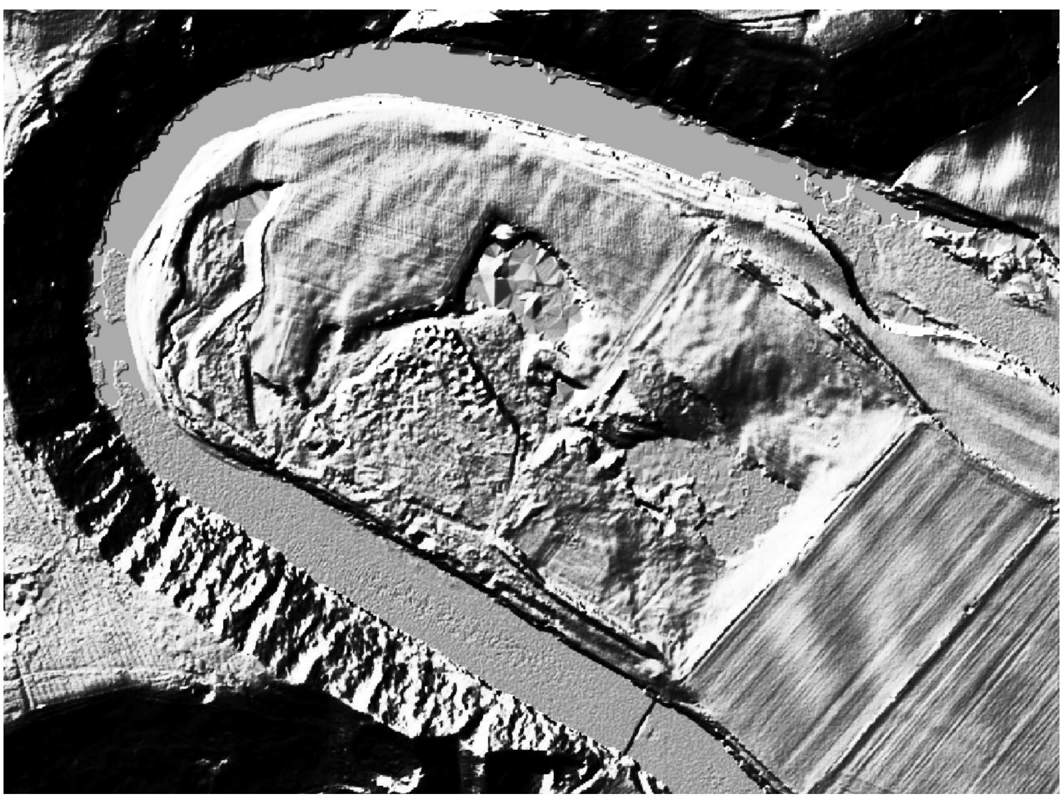

Plate 1: LiDAR hillshade view of the tip of the meander ridge showing sand and gravel pits

3.1.3 In the eastern part of the meander ridge is a substantial palaeochannel which has an erratic course from the area of Lower Hall Farm extending towards the western terminus of Bezza Brook (Plate 2). It cuts through the Terrace 2 deposits and has the potential to retain significant organic deposits; as such, it may warrant undertaking coring in this area. To the south of this palaeochannel and Lower Hall Farm there are also localised survivals of cultivation ridges shown on the LiDAR.

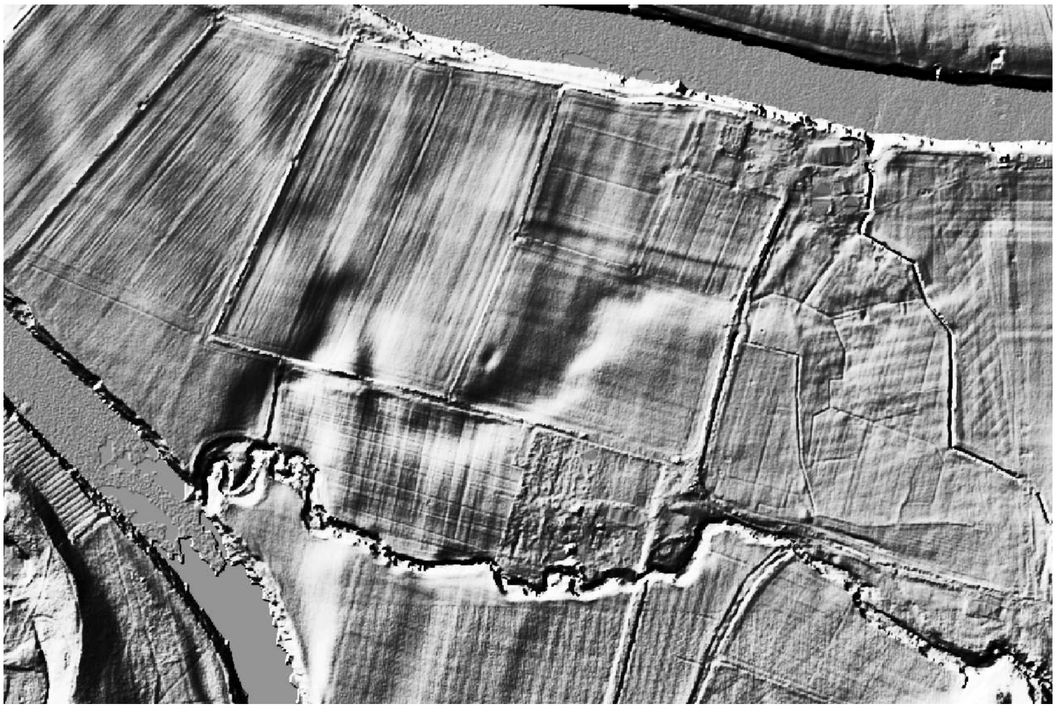

Plate 2: LiDAR hillshade view showing the lines of palaeochannels through the Terrace 2 deposits

4 ARCHAEOLOGICAL POTENTIAL

4.1 Potential for Archaeological Remains

4.1.1 Floodplain sediments may contain artefacts or seal buried land-surfaces containing archaeology. River terraces contain sand and gravel deposits that could yield *in-situ* archaeological artefacts or those that have been eroded and re-deposited from older contexts.

4.1.2 The Bezza meander that constitutes the site is situated between the Brockholes meander and the Lower House meander. Correlation of terrace deposits across these sites, together with new lithostratigraphic data from boreholes throughout the Bezza meander, indicate that there are substantial deposits of terrace sequences T1-T3 within the Bezza meander, with thinner presence of deposits of terrace sequences T4 and T5.

4.1.3 From an archaeological / palaeoenvironmental viewpoint, the River Ribble represents a natural boundary / routeway; the deposits within the valleys could contain evidence of multi-period occupation and landscape change. The established sequence of deposits suggests that there is potential for archaeology to exist, buried under the gravels and sediments (OA 2007, section 9.1.1).

4.1.4 The relative ages of the fluvial deposits have implications for the potential for archaeology, as follows:

- T1: as this is the oldest terracing, any archaeology is likely to overlie the fluvial deposits;
- T2: there is the potential for Mesolithic and Neolithic archaeology to be incorporated into the sands and gravels of Terrace 2, as well as being a feature of the overlying soil and colluvium;
- T3: there is the potential for Bronze Age and Iron Age archaeology to be incorporated into the largely finer-grained, alluvial deposits or for Bronze Age and earlier remains to be beneath these deposits;
- T4: there is the potential for post-Iron Age, Romano-British and medieval archaeology to be incorporated into the largely finer-grained alluvial deposits, or for Iron Age and earlier deposits beneath the terrace deposits.

4.1.5 As the processes involved in terrace formation are complicated, any *in-situ* archaeological remains may be buried by thick deposits of sands and gravels; in addition, artefacts may have been disturbed from their original location and re-deposited on later terraces.

4.1.6 The palaeoecological potential of the site is dependent on the location of palaeochannels associated with the terrace deposits. Organic sediments present within palaeochannels have the potential to contain significant palaeoecological pollen and plant remains and to provide material suitable for radiocarbon dating.

4.2 Limitations of the data

4.2.1 The lithostratigraphic and altitudinal data are derived from borehole records and maps supplied by the client and are taken as accurate representations of those data.

4.2.2 Altitudinal height (m OD) has been used to correlate the terrace sequences across the Lower Ribble meanders (Fig. 2) (Chiti 2004; OA 2007). Using altitudinal heights from new borehole data to place sedimentological records within a particular terrace could be inaccurate as a result of boundary overlaps, with altitudes perhaps straddling two terraces. A combination of lithostratigraphic data and altitude clearly permit recognition of T1/T2 and T3/T4, as the sediment packages for the older and younger terraces, respectively, may be differentiated using these criteria. However, the chronostratigraphy available for the Brockholes meander, for example, shows that the correlation between each valley incision and subsequent abandonment is not clear-cut, due to abandoned channels continuing to accumulate sediments in quiet backwaters or oxbows.

4.2.3 There is limited chronological control in the dating of the terraces. This may be due to a lack of dateable organic material or because dated material may be considered too young or too old (intrusive or residual).

5 CONCLUSION

5.1.1 The regional research frameworks for NW England have identified that lowland landscapes, including lowland riverine settings, lack well-dated palaeoenvironmental and geoarchaeological data (Brennand 2007;https://researchframeworks.org/nwrf/). As river courses would have been attractive to prehistoric people, providing a focus for movement and perhaps settlement, they have a high archaeological potential. Raised river terraces adjacent to the River Ribble could have provided locations for settlement and could contain multi-period archaeological sites.

5.1.2 Factors including human impact, climate and flooding have undoubtedly impacted on fluvial systems. Better dated fluvial sequences, especially from areas of relatively poor data, such as north-west England, are needed to improve our understanding of these linkages (Foster *et al* 2007).

5.1.3 The updated north-west regional framework for archaeology (https://researchframeworks.org/nwrf/) identifies several important research questions:

- How can we identify previously unknown prehistoric sites; the agenda suggests greater scrutiny of methods and techniques in archaeological survey;
- How can we best capture data for the palaeoenvironment in prehistory; the agenda suggests targeting areas of high potential, including alluvial deposits;
- How can we enhance our understanding of, for example, the Mesolithic / Neolithic transition; the agenda suggests the application of scientific dating techniques is essential for providing a secure chronology and the basis for further work.

5.1.4 This work has detailed the results of previous desk-based geoarchaeological works (Stage 1) and used additional borehole date to ground-truth the deposit model (Stage 2) to improve understanding of the archaeological risk these deposits represent.

6 Recommendations for Further Work

6.1.1 The potential for the presence of archaeological remains within the Lower Ribble Valley could be significant.

6.1.2 Based on GIS / LiDAR mapping of palaeochannels associated with the river terraces, it is recommended that the archaeological potential of these features be assessed through a collection of a series of boreholes. Buried soils / stabilisation surfaces could hold important palaeobotanical data, interpretation of which could lead to vegetation reconstruction and former land-use data. Any suitable material recovered could be radiocarbon dated if sufficiently organic or be subject to OSL (Optical Stimulated Luminescence) dating, if appropriate.

6.1.3 Similarly, it is recommended that coring be undertaken through the terrace deposits in order to establish the depths and dating of aggradation and inception episodes of the key terrace deposits. As this would not be into organic-rich palaeochannels, the coring is unlikely to recover charcoal deposits suitable for radiocarbon dating purposes, and therefore dating will need to utilise OSL techniques.

6.1.4 During the aggregate extraction process, a programme of field monitoring could be undertaken in order to identify and retrieve potential archaeological remains. Identification of any visible archaeology could signal the potential for buried archaeology nearby. Continued episodic monitoring could be undertaken during each phase of quarry extraction. Geoarchaeological data from any new interventions could be incorporated into the present model to improve accuracy and reliability.

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APPENDIX A Table of Borehole data and Terrace sequences

Borehole Number	Terrace Number	Height (m OD) (approximate)	Thickness (m) of mineral deposit	Age of Terrace aggradation
1	T1- orange	Not available	3.1	Late Pleistocene
2	T1 - orange	> 15.5	3.1	Late Pleistocene
3	T2 - yellow	< 14	4.8	Early Holocene
4	T2 - yellow	< 14	4.7	Early Holocene
5	T3 - green	< 14	7	Bronze / Iron Age
6	T3 - green	c. 13.5	6	Bronze / Iron Age
7	T3 - green	< 13.5	7.5	Bronze / Iron Age
8	T4 – pale blue	< 13	4.1	Romano-British
9	T2 - yellow	> 13.5	3.1	Early Holocene
10	T3 - green	13.5	5.9	Early Holocene
11	T4 - pale blue	c. 12.5	6	Romano-British
12	T2 - yellow	> 13.5	3.8	Early Holocene
13	T2 - yellow	c. 14	5	Early Holocene
14	T1 - orange	15	7.25	Late Pleistocene
15	T1 - orange	> 14.5	4.1	Late Pleistocene
16	T1 - orange	c. 15	3.2	Late Pleistocene
17	T1 – orange	< 15	3	Late Pleistocene
18	T1 - orange	14.5-15	2.7	Late Pleistocene
19	T1 - orange	< 14.5	2.6	Late Pleistocene
20	T1 - orange	c. 14.5	2.5	Late Pleistocene
21	T1 - orange	> 15	2.5	Late Pleistocene

Table 1: Correlation of boreholes and terrace sequences

A.1.1 These data are based on lithostratigraphic descriptions of borehole sediments (Richard Fox & Associates Ltd 2011 (amended 2013) (Goff 2008) and interpreted altitudinal contour maps produced by Hydro (2013), integrated with the geoarchaeological deposit model of OA (2007), revised for the Bezza meander.

Terrace	Height (m OD) 2007 model	Height (m OD) Updated model 2021
T1 Orange	14.5-16	*c* 14.5-15.5
T2 Yellow	14.25-15	*c* 14
T3 Green	13.5-14	*c* 13.5
T4 Pale Blue	13	*c* 12.5-13m
T5 Dark Blue	12	N/A

Table 2: Correlation of terrace sequences and altitudinal bands derived from contour map (Fig 4)

Borehole Name	**Depth 1 (m)**	**Depth 2 (m)**	**Lithology**	**Comment**
BH1	0	1.9	Sand	Fine-grained sand, silt, clay
BH1	1.9	3.1	Sand	Sand and gravel, medium/fine (<100m)
BH1	3.1	7.3	Red Sand	Compacted red sand
BH2	0	0.2	Topsoil	
BH2	0.2	1.7	Sand	Very fine sand and clay
BH2	1.7	3.1	Sand	Sand and gravel (<50mm)
BH2	3.1	6	Red Sand	Compacted red sand
BH3	0	0.2	Topsoil	
BH3	0.2	1.6	Sand	Very fine brown sand, silt and clay
BH3	1.6	4.8	Sand	Coarse sand and gravel
BH3	4.8	6	Clay	Firm brown clay
BH4	0	0.2	Topsoil	
BH4	0.2	0.7	Sand	Very fine brown sand, silt and clay
BH4	0.7	4.7	Sand	Coarse and gravelly <100mm
BH4	4.7	5	Clay	Brown
BH4	5	7.5	Red Sand	
BH5	0	0.2	Topsoil	
BH5	0.2	1	Sand	Very fine silty sand
BH5	1	1.5	Clay	Brown silty
BH5	1.5	4	Sand	Very silty fine brown sand
BH5	4	7.1	Sand	Medium - coarse sand and gravel <100mm
BH5	7.1	7.5	Clay	Firm brown clay
BH6	0	4.9	Sand	Fine brown silty sand
BH6	4.9	6	Sand	Sand and gravel <100mm
BH7	0	0.2	Topsoil	
BH7	0.2	5.5	Sand	Very fine-grained silty sand
BH7	5.5	7.5	Sand	Sand and gravel
BH8	0	0.2	Topsoil	
BH8	0.2	3	Sand	Fine silty brown sand
BH8	3	4.5	Sand	Medium coarse gravelly sand
BH8	4.5	6	Red Sand	Compacted red sand

BH9	0	0.2	Topsoil	
BH9	0.2	0.7	Sand	Fine to medium silty brown sand
BH9	0.7	3.1	Sand	Gravelly sand and gravel (<75mm, <100mm)
BH9	3.1	6	Red Sand	
BH10	0	0.2	Topsoil	
BH10	0.2	2.8	Sand	Fine brown sand
BH10	2.8	5.9	Sand	Medium - coarse gravelly sand
BH10	5.9	6	Sand	Firm brown sand
BH11	0	0.2	Topsoil	
BH11	0.2	4.6	Sand	Fine brown sand
BH11	4.6	6	Red Sand	Fine red sand, occasional gravel
BH12	0	0.2	Topsoil	
BH12	0.2	1.3	Sand	Very fine brown sand and clay
BH12	1.3	4	Sand	Medium-coarse sand and gravel <44mm; <100mm
BH12	4	4.6	Clay	Red silt 4-4.1m and firm brown clay 4.1-4.6m
BH12	4.6	6	Brown Sand	
BH13	0	0.2	Topsoil	
BH13	0.2	1.9	Sand	Fine brown
BH13	1.9	5.1	Sand	Sand and gravel <100mm
BH13	5.1	6	Clay	Firm brown clay
BH14	0	0.2	Topsoil	
BH14	0.2	2	Sand	Fine brown sand, silt and clay
BH14	0.5	7.3	Sand	Sand and gravel, medium/coarse
BH14	7.3	7.5	Red Sand	Brown clay and fine red sand
BH15	0	0.2	Topsoil	
BH15	0.2	1.4	Sand	Fine brown sand
BH15	1.4	4.1	Sand	Sand and gravel, medium / coarse
BH15	4.1	4.5	Red Sand	Fine
BH16	0	0.2	Topsoil	
BH16	0.2	0.5	Sand	Fine brown sand, silt and clay
BH16	0.5	3.2	Sand	Gravelly brown sand and medium/coarse sand <75mm

BH16	3.2	6	Red Sand	Red/pink sand, compacted, occasional gravel
BH17	0	0.2	Topsoil	
BH17	0.2	1	Sand	Fine brown sand, silt and clay
BH17	1	2.8	Sand	Gravelly medium / coarse sand, silt, clay
BH17	2.8	4.5	Red Sand	Compacted fine red sand
BH18	0	0.2	Topsoil	
BH18	0.2	0.7	Sand	Fine brown sand, silt and clay
BH18	0.7	2.7	Sand	And gravel <100mm
BH18	2.7	3	Red Sand	Compacted
BH19	0	0.2	Topsoil	
BH19	0.2	1	Sand	Fine brown sand and silt
BH19	1	1.7	Clay	Brown
BH19	1.7	2.6	Sand	Gravel and clay
BH19	2.6	6	Red Sand	Compacted fine red sand
BH20	0	0.2	Topsoil	
BH20	0.2	1.2	Clay	Sandy, brown
BH20	1.2	2.5	Sand	Sand and gravel, medium coarse
BH20	2.5	3	Red Sand	Compacted fine red sand
BH21	0	0.2	Topsoil	
BH21	0.2	0.7	Clay	Fine brown clay
BH21	0.7	2.5	Sand	Sandy clay and gravel
BH21	2.5	3	Red Sand	Compacted fine red sand

Table 3: Lithostratigraphic descriptions from borehole logs

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