HyNet North West

ENVIRONMENTAL STATEMENT (VOLUME III)

Appendix 8.5 Geoarchaeological Deposit Model Report

HyNet Carbon Dioxide Pipeline DCO

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 – Regulations 5(2) (a)

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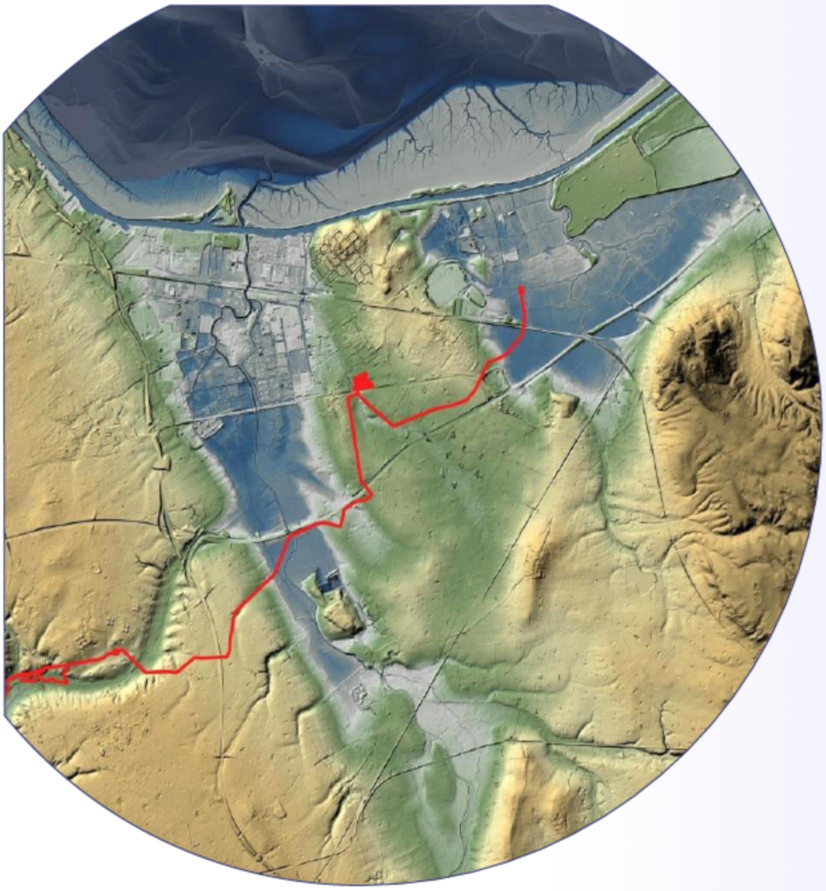

HyNet North West Carbon Dioxide Pipeline, Stanlow, Cheshire to Flint, Flintshire

Geoarchaeological Deposit Model Report

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HyNet North West Carbon Dioxide Pipeline, Stanlow, Cheshire to Flint, Flintshire

Geoarchaeological Deposit Model Report

by Mairead Rutherford with Elizabeth Stafford

With illustrations by Mark Tidmarsh and Anne Stewardson

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Summary

Oxford Archaeology (OA) North was commissioned by WSP UK Ltd to undertake a geoarchaeological deposit model at three localities along the route of the proposed HyNet North West Carbon Dioxide Pipeline, between Stanlow, Cheshire, and Flint, Flintshire.

The three study areas are located at points where the route traverses large tracts of tidal flat and peat deposits associated with the low-lying floodplains and marsh of the Rivers Mersey, Gowy, and Dee. The main aim of the work was to provide preliminary base-line data on the nature and depth of the sediment sequences and their geoarchaeological and palaeoenvironmental potential to inform the design of future evaluation and mitigation strategies.

Following an examination of 100 records derived from a recent geotechnical ground investigation, a total of 32 boreholes and test pits specific to the three study areas were included in the deposit modelling, alongside data from a selection of nine historical boreholes sourced from the British Geological Survey (BGS). The result of the modelling is broadly consistent with the BGS mapping of the areas, with superficial sedimentary sequences dominated by minerogenic sands, clays, and silts, likely laid down in intertidal/alluvial environments. The thickness of Holocene deposits overlying Pleistocene glacial deposits was recorded to a maximum of *c* 15m in Area 1 marginal to the River Mersey; *c* 7m in Area 2 on the Gowy floodplain; and *c* 18.5m in Area 3 on the Dee. Analysis of LiDAR DTM data has clearly identified the presence of tidal creek systems and palaeochannels, particularly across the floodplain of the River Dee (Area 3). Within the tidal deposits, the borehole data record multiple interbedded peat horizons which were particularly substantial in the north-eastern marshland in Area 1, and on the River Gowy floodplain in Area 2, the top of which occurred at, or within 1m of, current ground surface. Thin peats are recorded from parts of the Dee floodplain (Area 3), although the distribution here was found to be quite poor, with much of the data deriving from shallow test-pit interventions.

Overall, data distribution was generally sparce. Notably, close to the floodplain edge in Areas 1 and 2, ecotonal zones (the interface between dryland and wetland) may have provided a focus for past activity where evidence of occupation and relict landsurfaces may lie buried at relatively shallow depths in waterlogged conditions. The character and depth of the early Holocene topographic template, that is the interface of the Holocene and Glacial deposits, is thus difficult to predict at these locations.

The waterlogged burial conditions suggest good potential for preservation of organic remains which may include wooden structures and artefacts associated with wetland edge (seasonal) occupation, particularly adjacent to former watercourses. In addition, the presence of substantial peat and intertidal deposits suggests high potential for preservation of a range of

palaeoenvironmental remains for reconstruction of past vegetation (eg pollen, insects, and plant remains) and investigation of coastal evolution, sea-level change and palaeohydrology (eg diatoms, ostracods, and foraminifera), set within a robust chronological framework provided by radiocarbon and luminescence dating.

Dependent on scheme design and the depth and nature of direct and indirect construction impacts, further evaluation, deposit modelling, and sampling of the sites could be achieved through a combination of evaluation trenching across the shallower marginal zones combined with purposive boreholes to target the deeper sequences where the current distribution of data is sparse. The boreholes will also provide samples suitable for palaeoenvironmental assessment and scientific dating.

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The geoarchaeological (desk-based) research and data preparation was undertaken by Mairead Rutherford, who also prepared the main body of this report. The deposit modelling and LiDAR analysis were carried out by Elizabeth Stafford. The illustrations were completed by Mark Tidmarsh and Anne Stewardson. The project was managed for Oxford Archaeology by Stephen Rowland.

1 INTRODUCTION

1.1 Scope of work

1.1.1 Oxford Archaeology (OA) North was commissioned by WSP UK Ltd, to compile and interpret three deposit models across specific sections of the HyNet North West Carbon Dioxide Pipeline (henceforth, the DCO Proposed Development), that runs from Stanlow, Cheshire, in the east (NGR 346900 376156), west to Flintshire, Wales (NGR 325108 370789). The project is part of a wider Carbon Dioxide (CO2) pipeline transportation network.

1.1.2 The project is a nationally significant infrastructure project (NSIP) under Part 14(1)(f) of the Planning Act 2008. This deposit model report, for parts of the Stanlow-Flint route, is intended to support the planning application for the project.

1.2 Location

1.2.1 The Cheshire section comprises the eastern half of the DCO Proposed Development, which extends for 16km from the site of the proposed Above Ground Installation (AGI) terminus near Elton in the north-east, traversing south-west to the Welsh border. South of Elton and the Ince Marshes, the route runs in a broad south-westerly direction. The route crosses the Gowy floodplain, including the Mill Brook (a tributary of the River Gowy), before following a more south-westerly direction across the Dee estuary towards the English/Welsh border. The Flintshire pipeline section of the DCO Proposed Development extends for 18.9km, south-westwards from the River Dee floodplain, across the canalised channel of the River Dee near Sandycroft, following a west and northerly direction along the River Dee, to a proposed AGI at Flint (Figure 1).

1.3 Topography and Geology

1.3.1 Three main topographical areas across the route have been identified for compilation of localised deposit models (Figure 1):

- Area 1: Marshlands towards the north-east end of the DCO Proposed Development (Figure 3);
- Area 2: The River Gowy floodplain (Figure 3);
- Area 3: The River Dee floodplain (Figure 7).

1.3.2 The superficial and bedrock geological maps relevant to each area are presented on Figures 6a, 6b, 10a and 10b). The geology of the area is mapped by the British Geological Survey (BGS; online at [redacted]).

1.3.3 ***Area 1:*** Area 1, which trends north-east to south-west, is mapped as sandstone bedrock of the Kinnerton Formation (Fm) and the Chester Fm, both of Triassic age (formed approximately 252 to 247 million years ago). The bedrock geology is overlain by superficial deposits mapped as tidal flat deposits (to the north-east) and till (diamicton) to the south-west (Figures 6a and 6b).

1.3.4 ***Area 2:*** Area 2, which runs north-east to south-west, is underlain by sandstone bedrock of the Chester Fm. The superficial deposits include windblown sands in the north-eastern section with extensive deposits of peat occupying the central portion of

Area 2, with some till (diamicton) within the south-western section. The River Gowy cuts through the middle of Area 2; the Thornton Brook flows parallel to the River Gowy but further to the east, just outside the Area 2 boundary (Figures 6a and 6b).

1.3.5 ***Area 3:*** Area 3 runs south-west towards the floodplain of the River Dee, south across the Dee and then north towards Deeside. The south-western part, towards and across the Dee, is underlain by Triassic rocks of the Kinnerton Fm. Further west and north, the bedrock comprises red and purple mudstone of the Etruria Fm and the Pennine Middle Coal Measures Fm (of Westphalian, Carboniferous age, approximately 319-308 Ma BP (BGS). The superficial deposits which occupy the main, central portion of Area 3, are tidal flat deposits, with till (diamicton) recorded at either end (Figures 10a and 10b).

1.3.6 ***Routewide***: Outside Areas 1-3 and within Wales, the underlying bedrock is of Carboniferous age; the pipeline route traverses various formations, including the Pennine Lower and Middle Coal Measures, as well as formations comprising limestones, cherts, and sandstones (Figure 11b). The section of the pipeline route in Wales largely traverses ground mapped by the BGS as underlain by glacial deposits from the last (Devensian) glaciation. BGS mapping identifies glacial till as well as glaciofluvial deposits. There are also rare records of thin deposits of Head (clays, silts, sands, gravels) deposited subaerially at the bottom of slopes as a result of solifluction or gelifluction, although these may also include colluvium. Thin peat deposits are also present, for example, north of Ewloe near Shotton Lane (Figure 11a). Thin strips of alluvial deposits are mapped south of Babell, adjacent to a streamway of the Afon Pant-Gwyn. To the west of Flint, deposits of alluvium and associated undifferentiated river terrace deposits, are mapped adjacent to the Afon Nant-y-Flint (Figure 11a). To the west and north of Ewloe, further likely alluvial deposits are located adjacent to the Alltami Brook (Figure 11a) but these are undifferentiated by BGS mapping.

1.3.7 Across the River Dee and eastwards, the pipeline route is located within the northern part of the Cheshire Plain, to the west of the high ground of the Mid-Cheshire Ridge. The underlying geology largely comprises Triassic Sandstone, which outcrops as low ridges and hills, or is covered with extensive areas of drift deposits, including marine and freshwater clays and silts, as well as blown sand deposits. The whole of the Cheshire Plain was covered with thick ice sheets during the last (Devensian) glaciation with subsequent phases of erosion and deposition resulting in accumulations of glacial till, creating a landscape of low relief abutting the sandstone ridges (Cowell and Innes 1994). The Mersey Valley NCA (National Characterisation Area) covers the wide low-lying valley of the River Mersey, including the estuary with intertidal mudflats and saltmarshes, as well as tributaries, including the River Gowy.

1.3.8 Between Areas 1 and 2, the underlying superficial deposits comprise glacial till (Figure 6a), apart from deposits of alluvium associated with a tributary of the River Gowy. Between Areas 2 and 3, the superficial deposits are largely of glacial till, but there is a relatively thick strip of tidal flat deposits, with alluvial deposits associated with sands and gravels, in the area south of Chorlton and north of Caughall (Figure 6a).

1.4 Landscape Development and Previous Palaeoenvironmental Studies

1.4.1 Landscape development in this region is inextricably linked with sea level changes and coastal geomorphology. The Mersey Estuary in North West England occupies one of several Pleistocene river valleys cut into a basement of Carboniferous and Triassic rocks (Wilson 2004). Processes associated with the Devensian (last) glaciation would have left a series of deeply incised channels, large braided river systems, and kettle holes, which may have developed into major lakes. The data suggest that several of these river systems follow similar routes to modern rivers, such as the Rivers Mersey and Dee, which would have provided important navigation routes for prehistoric people. A detailed study, including 3D and 2D seismic data, bathymetric data, and borehole records, from Liverpool Bay, suggests that much of the area, though low-lying, was above water during the Late Palaeolithic period (Fitch and Gaffney 2011).

1.4.2 During the Holocene, rising sea-levels would have flooded the deep valleys in Merseyside created during the Pleistocene (Bell 2007). During the Early Mesolithic period, prior to inundation, the coastline lay to the west of the Wirral Peninsula and north of the Welsh coastline, so that a large area of land linked Wales and North West England. Climatic warming during the early Holocene would have created conditions suitable for growth of mixed deciduous woodland, replacing tundra-like conditions that developed during early Post-Glacial times. Subsequent sea-level rise during the latter part of the Early Mesolithic would, however, have shifted the coastline further into Liverpool Bay, the lowest areas developing into a wet landscape of fens, reedswamps, and salt marshes. Final inundation of the Liverpool Bay area would have proceeded relatively rapidly, during which an extensive inter-tidal zone developed, extending inland as far as Helsby (Fitch and Gaffney 2011; Wilson 2004).

1.4.3 Ince Banks, an extensive saltmarsh, is located on the southern shore of the inner Mersey Estuary, approximately 2km north-west of Area 1 (Figure 3). The BGS undertook a large investigation into the environmental evolution of the Mersey Estuary and cores were collected from Helsby Marsh and the more seaward Ince Marshes in 2000, with further cores collected by the BGS from Ince Banks in 2003 (Wilson 2004).

1.4.4 Several radiocarbon dates were obtained from peat sequences from these cores, which, in association with palaeoenvironmental analysis of pollen and diatoms, permitted the Holocene evolution of the area to be reconstructed. The results concluded that during the Early to mid-Holocene, the evolution of the inner Mersey Estuary was largely controlled by relative sea-level change (RSL), whereas the Late Holocene evolution was principally controlled by sediment supply.

1.4.5 Rising water-table levels coupled with ponding of riverine water may have developed as a response to rising RSL, resulting in deposition of freshwater peats. The peats have been dated at Helsby Marsh, to the early part of the late Mesolithic, at 7350+/- 60 ^{14}C yr BP (Wilson 2004). As sea level continued to rise, an expansion of sub-tidal and inter-tidal zones reached as far inland as Helsby Marsh, approximately 2km inland of the estuary, organic sediments from which have been dated from 6800+/-50 ^{14}C yr BP (Wilson 2004).

1.4.6 Marine conditions persisted at Helsby Marsh for 860 ^{14}C years, during which time RSL rose by approximately 1.13m. As the regional rate of sea-level rise slowed in the mid-Holocene, freshwater peat deposits expanded over former sub-tidal and intertidal surfaces, during the later Mesolithic, at 5940 +/- 40 ^{14}C yr BP. Terrestrial and semi-terrestrial conditions existed at Helsby Marsh for approximately 2700 ^{14}C yr BP. An increase in terrigenous influx to the estuary may have been triggered by catchment disturbance, from about 4000 ^{14}C yr BP. A greater availability of sediment, together with low rates of RSL rise, may have encouraged and maintained development of tidal flats from the later Bronze Age, around 3220+/- 40 ^{14}C yr BP (Wilson 2004).

1.4.7 OA North (2004; 2006) undertook archaeological assessment, including palaeoenvironmental analysis, along a pipeline running from Ellesmere Port to Mickle Trafford, Cheshire. The survey identified two palaeochannels at roughly right angles to the present course of the River Gowy, at Picton Lane, to the south of Area 2 (Figure 3). Although pollen preservation was variable, data were interpreted to support three clearance events, dated to the Early Neolithic (3100-2900 cal BC (4385±35 BP; SUERC-7285)), probable (undated) Bronze Age, and a major clearance event during the Late Iron Age to early Roman period (780-990 cal AD (1140±35 BP; SUERC-7284)), the latter clearance event interpreted as evidence of extensive arable and pastoral farming. Subsequently, tree regeneration and reduced agricultural activity was interpreted from the pollen diagram, followed by renewed clearance probably during the medieval period (OA North 2006). Chester Archaeology (1993) reported peat deposits from an excavation adjacent to Hapsford Services, close to the south-eastern boundary of Area 1, but the depth of peat was not ascertained nor were any dates obtained.

1.4.8 Two significant archaeological and palaeoenvironmental sites located to the north and west of the the DCO Proposed Development in North Wales, have been described from Prestatyn and Rhyl, both of which were protected by coastal sand dunes (Bell 2007). Archaeological finds associated with these sites inlcuded antler mattocks, flint tools, and shell-fish middens. The middens provided detailed palaeoenvironmental data, interpreted in terms of seasonal exploitation (Bell 2007).

1.4.9 Approximatey 12km west of the DCO Proposed Development, across the Flintshire/Denbighshire border, in a mire area to the south of Moel Llys-y-coed in the Clwydian Hills (NGR SJ 1471 6493), a palynological core from the mire contained peat dated from the early Mesolithic to post-medieval period (Grant 2009). The data were interpreted to indicate a transition from hazel-dominated woodland during the Mesolithic period to alder carr and grassland during later prehistory, followed by a transition to heather moorland. These changes reflect natural landscape evolution impacted upon by climate change and human activity.

2 AIMS AND METHODOLOGY

2.1 Aims

2.1.1 The project aims and objectives were as follows:

i. to utilise available borehole data to characterise the sub-surface deposits at three main areas across the scheme;
ii. to interpret the sub-surface stratigraphy in order to understand landscape development;
iii. to evaluate the data regarding the presence or absence of areas of potential archaeology, including identification of deposits likely to contain palaeoenvironmental evidence that could inform landscape development, potential landuse, and human impact on the landscape;
iv. to utilise the geoarchaeological data derived from the deposit model to inform locations for future interventions in order to build an improved deposit model;
v. to recommend particular locations suitable for collection of samples for palaeoenvironmental assessment to aid landscape reconstruction.

2.2 Methodology

2.2.1 The methodology employed in the study follows Historic England (2020) guidance for mapping buried deposits. In addition to recent geotechnical borehole and trial pit logs (Fugro 2022), the geoarchaeology study utilised historic borehole data from the BGS database ([redacted], accessed August 2022). The geotechnical interventions included boreholes drilled using a variety of methods, including cable percussion, rotary, and sonic-core drilling, as well as shallow trial pits (between 1.2m and 4.5m depth). No data interpreted from cone penetration methods have been used in creation of the deposit models, as in this instance these techniques are considered unreliable for recognition of soft sediments such as peat and are based on resistivity rather than visual assessment of sediments. Five borehole records within Area 2 (Gowy floodplain), originally suggested as suitable for production of a deposit model, were eliminated from the study as these were based on cone penetration records (LB_21_09_SCP, LB_21_10_ SCP, LB_21_118_ SCP, LB_21_119_ SCP, and LB_21_120_SCP).

2.2.2 Over 100 logs were accessed along the DCO Proposed Development and, of these, 41 interventions (inclusive of nine BGS historic borehole records) were selected for creation of deposit models relevant to Areas 1-3 (Figure 2). This report covers the stratigraphic sequence interpreted from the borehole lithological sequences.

Area	GI Works Interventions	BGS borehole data	Total interventions
Area 1	6	6	**12**
Area 2	10	3	**13**
Area 3	16	0	**16**
Total	**32**	**9**	**41**

Table 1: number of interventions per area

2.2.3 The lithological data from the geotechnical logs were entered into geological modelling software (Rockworks™ v2022) to allow correlation of broad stratigraphic units. Representative linear transects have been constructed to illustrate the distribution and extent of identified stratigraphic units across Areas 1-3 of the route (Figures 4, 5, 8, and 9).

2.2.4 It should be noted that all data derive from paper records following recent geotechnical fieldwork and as such, some of the data may still be at a preliminary stage of interpretation. The few BGS borehole records (relevant to Areas 1 and 2 only) are quite old but, nevertheless, provide valuable stratigraphic data. The problems associated with using geotechnical records in geoarchaeological deposit modelling have been outlined by Bates (1998) and reviewed for linear corridors in Carey *et al* (2018). However, the borehole data utilised have provided sufficient information to permit a preliminary, broad stratigraphic interpretation across the three areas of interest.

3 Results

3.1 Introduction and presentation of results

3.1.1 Deposit models across Areas 1-3 have been created from 41 interventions, presented as a series of stratigraphic transects (Figures 4, 5, 8, and 9). The associated data are presented as a series of maps, showing the transect locations, the superficial and bedrock geology, and DTM LiDAR plots (combined elevation and hillshade). The eastern part of the DCO Proposed Development (in North East Wales) was not subject to deposit modelling; however, a series of maps is also included for this region. *Appendix A* provides details of the geotechnical locations and *Appendix B* presents the interpreted stratigraphy for each intervention.

3.1.2 Each stratigraphical unit has been colour-coded in the transect figures, allowing broad correlation of units to be illustrated, each of which represents distinct depositional environments. The following stratigraphic sequence has been identified:

- Made Ground – dark grey;
- Topsoil – grey;
- Tidal Flat Deposits – blue;
- Peat – brown;
- Peaty Clay – light brown;
- Windblown Sand – yellow;
- Glacial Deposits – light blue;
- Bedrock – pink.

3.2 Stratigraphic sequence

3.2.1 ***Bedrock***: Bedrock geology in Area 1 (Figure 6b) is characterised by sandstones of the Kinnerton Fm, of Triassic age, recorded for example, from borehole LB_21_206_BH, as clayey fine sand with rare fine gravel of sandstone. The south-western end of Area 1 is underlain by Triassic sandstones of the Chester Fm.

3.2.2 Bedrock geology in Area 2 (Figure 6b) comprises reddish-brown sandstones of the Chester Fm, recovered for example, as reddish-brown sandy gravel and fine-coarse sand in borehole LB_21_08_BH.

3.2.3 The bedrock geology for Area 3 (Figure 10b) is more complex. South-west, towards and across the Dee, bedrock comprises Triassic rocks of the Kinnerton Fm. Further west and north, the bedrock comprises red and purple mudstone of the Etruria Fm and the Pennine Middle Coal Measures Fm (of Westphalian, Carboniferous age, approximately 319-308 Ma BP (BGS), eg LB_21_73_BH (west of Area 3).

3.2.4 Bedrock was deposited before humans evolved, and is devoid of archaeological potential.

3.2.5 ***Pleistocene deposits***: the surface of the Pleistocene deposits essentially defines the topography of the Early Holocene landscape. The shape of this surface would have affected sedimentation patterns throughout the Holocene and influenced the sedimentary sequence along the route of the DCO Proposed Development. By understanding the nature of this surface, it is possible to develop a better understanding of landscape evolution and archaeological potential.

3.2.6 Glacial deposits recorded from Areas 1-3 (Figures 6a and 10a) comprise largely till deposits and glaciofluvial outwash clays. Till deposits, created by the action of ice and meltwater, comprise largely unsorted sediment with gravel in a fine mud matrix. Although the tills themselves have limited geoarchaeological potential, they may very occasionally seal deeply stratified channel and interglacial deposits of archaeological and geoarchaeological potential.

3.2.7 Till deposits described from Area 1, for example, from LB_21_206_BH, comprise brown mottled grey to stiff reddish-brown sandy clay and clayey sand. Similarly, till deposits from Area 3 (LB_21_55_BH) comprise reddish_brown to firm brown gravelly clay and dense brown sands.

3.2.8 Glaciofluvial deposits may form features such as beds, channels, plains, and fans associated with meltwater. Across the route, these deposits are recorded east and west of Area 3, but none is present within Areas 1-3. Glaciofluvial sands and gravels have generally little geoarchaeological potential but may contain archaeology eroded and redeposited from Palaeolithic contexts. They may also seal stratified deposits of archaeological and palaeoenvironmental potential.

3.2.9 ***Head Deposits (Devensian and Holocene):*** Head is poorly sorted and poorly stratified angular rock debris and/or clayey hillwash and soil creep, mantling a hillslope and deposited by solifluction and gelifluction processes. Solifluction is the slow viscous downslope flow of waterlogged soil and other unsorted and unsaturated superficial deposits. The term gelifluction is restricted to the slow flow of fluidized superficial deposits during the thawing of seasonally frozen ground. The flow is initiated by meltwater from thawing ice lenses. Holocene slope deposits may form the upper part of the sequences in valley situations, deposited by erosional colluvial processes associated with deforestation and agricultural land-use, where present colluvium has the potential to bury land-surfaces and associated *in-situ* archaeological remains. Rarely occurring Head deposits are mapped across the western part of the DCO Proposed Development and none is recorded from Areas 1-3.

3.2.10 ***Windblown sand (Devensian and Holocene):*** blown sand is sand that has been transported by wind, or sand consisting predominantly of wind-borne particles. Windblown sand has low geoarchaeological potential but can bury land-surfaces and associated *in-situ* archaeological remains. Blown sand deposits are mapped by the BGS in Area 2 (Figure 6a) and described from borehole LB_21_08_BH as light-brown clayey sand.

3.2.11 ***Holocene Deposits:*** following the end of the Devensian glacial period, as the climate ameliorated, sea levels began to rise, depositing fine-grained sediment in low-lying areas, including sediments deposited under a mixed-energy regime (eg Tidal Flat deposits) as well as waterlogged (peat) deposits. Extensive areas of tidal flats infill the valleys of the Gowy and Dee rivers at low elevations, rising to higher elevations at the valley edges.

3.2.12 ***Tidal Flat Deposits (Holocene):*** Tidal flat sediments, including mudflats and sandflats, are deposited on marshy, low-lying land in the intertidal zone, that is alternately covered and uncovered by the rise and fall of the tide. They consist of unconsolidated sediments, which, in Area 1 (north-east marshlands; Figure 6a) and Area 3 (across the Dee floodplain; Figure 10a), comprise soft silty clay, with layers of sand, gravel, and peat, deposited under a mixed-energy regime, as described, for example, from borehole LB_21_44_BH. These deposits have the potential to seal waterlogged archaeological remains and palaeoenvironmental remains, including records of Holocene sea-level change. They may also seal former land surfaces, potentially dating to the Late- Glacial and early Post-Glacial periods.

3.2.13 ***Peat (Late Devensian/Holocene)***: peat deposits are key sites for the preservation of waterlogged archaeological and palaeoenvironmental remains. They may also seal former land surfaces and lake deposits dated to the Late Glacial and early Post-Glacial period. Lacustrine and palustrine in origin, they comprise organic material, forming beds and lenses within lagoons, bogs and swamps. Coastal marshes that contain accumulations of peat are present within or adjacent to the development area, for example, Helsby and Ince Marshes (Area 1; Figure 6a); peat is mapped at the surface directly beneath made ground across the Gowy floodplain (including the Mill Brook; Area 2; Figure 6a), and may be present within tidal flat sequences across the Dee floodplain (Area 3; Figure 10a). From Area 2, peat is described as dark brown, strongly decomposed, not particularly fibrous, and with few wood fragments, for example, from boreholes LB_21_11_BH and LB_21_12_BH.

3.2.14 ***Peaty Clay Deposits (Holocene):*** these deposits are present within Area 1, for example, LB_21_203_BH, LB_21_213_BH, and record peaty sediments occurring within broader tidal flat deposits. Intercalated deposits of peat and clay are grouped together as peaty clay deposits and have moderate to high potential to preserve waterlogged archaeological and palaeoenvironmental remains.

3.2.15 ***Alluvium (Holocene):*** described as clay, silt, sand, and gravel, with peat in places, these sedimentary deposits are fluvial in origin, and reflect the channels, floodplains, and levees of a river or estuaries. Floodplain deposits and palaeochannels (former river channels) are key contexts for the preservation of waterlogged archaeological and palaeoenvironmental remains, including, in coastal settings, records of Holocene sea-level change. Marginal areas adjacent to floodplains, and 'islands' of better-drained ground within floodplains and next to water courses (ecotonal zones) are known to be a foci for past activity. Whilst not occurring within Areas 1-3, deposits of alluvium are present across the DCO Proposed Development, for example, between Areas 1-2, east of Thornton le Moors, and between Areas 2-3 north of Caughall. Where rivers, brooks, or streams cross the route within Wales, deposits of alluvium are also recorded (eg west of Flint, where the Afon Nant-y-Flint crosses the route in several places; Figure 11a).

3.2.16 ***Topsoil (Holocene)***: across Areas 1-3, topsoil is described as dark-brown clayey silt to soft clay, or greyish-brown sandy, silty, clay with abundant rootlets (LB_21_213_BH; LB_21_08_BH; LB_21_54_BH). Topsoil is of low potential and significance for preservation of palaeoenvironmental and archaeological remains.

3.2.17 ***Made Ground (Holocene)***: particularly seen in Area 3, adjacent to the coalfields, for example, near Sandycroft, a thick sequence (*c* 4.5m) of Made Ground deposits comprises a mix of clay, sand, cobbles, slag, and ceramic (eg LB_21_109_BH). Made Ground is of low potential and significance for preservation of palaeoenvironmental and archaeological remains.

Area 1 – the north-eastern marshlands (Figures 3, 4, and 6a-c)

3.2.18 The transect (Figure 4) runs south-west to north-east and may be divided stratigraphically as well as altitudinally, into two parts. The borehole data at the north-eastern end (BGS_105 to LB_21_202_BH) show ground altitudes of less than 5m OD, whereas to the south-west, the elevations rise to between approximately 6-14m OD (BGS_23 to LB_21_205_TP). This corresponds with the geological changes from lower-lying Tidal Flat deposits in the north-east, to raised ground in the south-west, where the subsurface is underlain by glacial deposits overlying bedrock (LB_21_205_TP to LB_21_208_TP and BGS_23; Figure 6a). However, it should be noted, there is an absence of data from the interface (dryland/wetland) zone.

3.2.19 In two of the boreholes (LB_21_203_BH, LB_21_213_BH), thin peat is mapped directly overlying glacial deposits, whereas elsewhere, Tidal Flat deposits directly overly Till (eg LB_21_202_BH). A variably thick (*c* 1-4m) upper peat unit interbedded with variably thick (*c* 1-5m) Tidal Flat deposits, may be distinguished within all the borehole records from the north-eastern end of the transect. This package of deposits clearly reflects repeated estuarine/tidal action resulting from fluctuating sea levels. The sequence of peats may encompass freshwater peat accumulation prior to marine inundation, followed by deposition of mudflat/sandflat clays, silts, and sands, and saltmarsh peats, accumulating within the tidal range.

3.2.20 The deposits (between LB_21_202_BH and BGS_105) appear, from the deposit model, to represent a former channel fill. The presence of low-energy channel-edge environments, often a focus for activity in the past, offers some potential for the recovery of relatively *in situ* archaeological assemblages that could, for example, include timber structures, sealed beneath and within tidal flat deposits (eg Bell 2007). The channel fill has high potential for palaeoenvironmental remains.

3.2.21 The DTM LiDAR image (Figure 6c) clearly shows palaeochannels within the DCO Proposed Development and adjacent to the AGI installation point at Elton (for example, to the east and west of LB_21_202_BH at the very northern end of the scheme; Figure 6c). These may represent former tidal channels/creeks associated with tidal flats, the margins of which may preserve evidence of past activity.

3.2.22 From an archaeological perspective, deposits close to the coastline have potential to retain or conceal artefacts, as prehistoric people used coastal areas for access to resources and transport. An example of the undisputed presence of people in the intertidal zone may be inferred from footprints of people and hoof prints of aurochs and domesticated ox, preserved in marine silts interbedded with sands, from Formby Point, Lancashire (Huddart and Gonzalez 1999). Evidence suggests that mobile communities may have used coastal and wetland areas, perhaps using rich wetland sites for grazing domesticated animals, right up to the Bronze Age (Cowell and Innes 1994; Cowell 2000).

3.2.23 This area of tidal flat deposits appears confined to the north-eastern area in which the Grinsome Road AGI is to be located. This area is considered to be of medium-high archaeological and palaeoenvironmental potential and could contain artefacts relevant to prehistoric communities and should be investigated prior to installation of the AGI, as the construction would likely result in damage to the intertidal sediment sequence and any associated archaeological remains. The peats should be collected, dated, and subject to palaeoenvironmental assessment. Furthermore, these data would provide an opportunity to date sea-level index points, to correlate with, and perhaps enhance, the sea-level curve for the North West (Long and Roberts 1997).

Area 2 – the River Gowy floodplain (Figures 3, 5, and 6a-c)

3.2.24 This area has utilised borehole data made available from Fugro (2022) as well as historic data from BGS boreholes. Data from CPT interventions across the peat deposits within this area have not been used to construct the deposit model. It is understood that the ground conditions at the time of coring prevented rig stabilisation that would have enabled sediment cores to be collected from the peat (D Hooley *pers comm*).

3.2.25 The transect (Figure 5) clearly shows that, to the north-east, the sub-surface superficial deposits (as mapped by the BGS and confirmed by the GI work) record Till deposits overlying bedrock. Blown sand, mapped locally by the BGS, was also recorded within the GI works, although details emerging from both boreholes and trial pits suggest a possible thin sliver of Tidal Flat deposits (LB_21_114_TP, LB_21_115_TP) underlying blown sand and overlying Till. This may represent a former tidal channel, perhaps of the Thornton Brook, and is located to the east, just outside the boundary of Area 2 (Figure 6a). Slightly further west, windblown deposits directly overlying bedrock, are recorded in borehole LB_21_08_BH.

3.2.26 There were no useable records for approximately 700m from LB_21_08_BH westwards; thus no sediment profile east of the River Gowy. There is also a gap of *c* 1.3km between LB_21_11_BH and LB_21_12_BH, on the west side of the River Gowy, so the transect line has utilised available BGS data (outside the Area boundary) to contextualise the deposits. To the west of the River Gowy, interventions at ground altitudes of less than 5m OD show a consistent record of Till deposits overlain by Tidal Flat deposits, in turn overlain by peat accumulations in excess of 3m thickness (LB_21_11_BH and LB_21_12_BH). To the south-west, the ground level rises to approximately 17m OD and the GI data record Made Ground over bedrock.

3.2.27 DTM LiDAR images (Figure 6c) for the area to the west of the River Gowy and between the River Gowy and the Mill Brook, show development of palaeochannels, which, based on the borehole records, could contain peat packages useful for palaeoenvironmental data and radiocarbon dating, and which could also represent features within which archaeological artefacts may be concealed. The area has been heavily drained, and the preservation of peat, which may occur within 0.5m of the ground surface, may be compromised.

3.2.28 The area should be subject to archaeological survey and sample collection of peats. Previous data from palaeochannels adjacent to the River Gowy at Picton revealed pollen sequences suggesting some clearance activity during the Neolithic period and Bronze Age, with a major clearance event dated to the late Iron Age or early Roman period (OA North 2006).

Area 3 – the Dee floodplain (Figures 7, 8, 9; 10a-c)

3.2.29 The Area 3 transect stretches across a distance of approximately 7km and is divided into two sections, transects 3a and 3b (Figures 8 and 9). Transect 3a extends from the south-west to the north-east, across the Dee, crossing the Welsh/English border between interventions LB_21_40_TP and LB_21_39_TP (trial pits). Data from interventions LB_21_36_TP and LB_21_37_TP and from borehole LB_21_38_BH are not shown on the transect at the north-eastern end, as these contain records of Glacial Till deposits only, and are, therefore, of limited interest. Transect 3b runs in a north-west to south-east direction (entirely within Wales). At the north-western end, data from LB_21_109_BH is not shown, as the record is for 4.5m of Made Ground sitting on bedrock (Coal Measures). For continuity, both transects feature intervention LB_21_49_BH.

3.2.30 Lithological records for the north-eastern part of transect 3a are poor, being based on limited data from trial pits only; consequently, no data are available below a depth of about 3m. These data do, however, record Tidal Flat deposits, as indicated from BGS mapping of the superficial deposits (Figure 10a). The only deep records are available from borehole LB_21_44_BH, adjacent to the north-east bank of the Dee, and record a thick accumulation of approximately 18m of Tidal Flat deposits. The sediment profile for a length of approximately 2km to the north-east of the Dee (within the DCO Proposed Development) from LB_21_44_BH to LB_21_39_TP, is therefore very limited. This area could conceal deep sediment packages, including potential peat accumulation. Where available, the modelled data show the deep channel (*c* 18 m bgl; *c* -13m OD) of the River Dee, infilled with Tidal Flat clastic deposits, with a thin peat unit at *c* -12m OD) (eg LB_21_45_BH). South-west of the Dee, sediments recorded from boreholes LB_21_46_BH and LB_21_47_BH record thick deposits of Tidal Flat sediments whereas the record for borehole LB_21_49_BH reveals a thinner tidal flats package with two peat units, each less than 1m thick.

3.2.31 The data may be interpreted to represent Post-Glacial estuarine inundation of the Dee, resulting in a thick deposit of clays, silts, sands, and gravels, with deposition of a thin peat unit (LB_21_45_BH) indicative of an earlier saltmarsh or freshwater peat, deposited above the tidal range. This peat deposit may have been eroded or truncated by renewed tidal inundation.

3.2.32 Interventions at the south-eastern end of transect 3b record approximately 3m of Tidal Flat/peat intercalated deposits (LB_21_49_BH; LB_21_50_TP). DTM LiDAR images (Figure 10c) for this area show potential palaeochannels within the route boundary, probably associated with the Broughton Brook. Running north-north-west, the deposit model for interventions LB_21_52_BH to LB_21_56_BH appears to show a further channel fill of Tidal Flat/peat deposits, overlying Glacial Till. The data interpretation is hampered by a shallow record of *c* 3m of Tidal Flat deposits (LB_21_53_TP) and is mapped by the BGS on the border between Tidal Flats and Till; this trial pit finishes at *c* 3.5m (bgl), so deposits underneath this are currently unknown. The north-western extremity of transect 3b (LB_21_110_BH) records only topsoil directly on Glacial Till.

4 Discussion

4.1 Deposit Model

4.1.1 Overall, the deposit modelling has resulted in a broad characterisation of the nature and extent of the sub-surface stratigraphy for Areas 1-3. Table 2 presents a summary of the stratigraphic data for each area as presented in the geoarchaeological transects.

Area	Bore	Thick (m)	Presence			Base (m BGL)			Top (m BGL)
		MG	TD	Peat	WB	TS/MG	Holocene	Glacial	Bedrock
Area 1	BGS_105		Yes	Yes		0.3	8.05	18.05	
Area 1	BGS_119		Yes	Yes			7.68	20	
Area 1	BGS_141		Yes	Yes		0.15	12.55	14.7	
Area 1	BGS_142		Yes	Yes			12.3	19.5	
Area 1	BGS_143		Yes	Yes		0.1	11.8	15	
Area 1	BGS_23	0.4				0.4	0.4	15	
Area 1	LB_21_202_BH		Yes	Yes		0.2	14.8	17	
Area 1	LB_21_203_BH		Yes	Yes		0.2	8	15	
Area 1	LB_21_205_TP					0.3	0.3	2.4	
Area 1	LB_21_206_BH					0.3	0.3	14.6	14.6
Area 1	LB_21_208_TP					0.3	0.3	2.8	
Area 1	LB_21_213_BH		Yes	Yes		0.3	9.93	15.45	
Area 2	BGS_180		Yes	Yes		0.3	7	18	
Area 2	BGS_181		Yes	Yes		0.3	5.5	16	
Area 2	BGS_182			Yes		0.5	4.5	13	
Area 2	LB_21_05_BH					0.3	0.3	7.35	7.35
Area 2	LB_21_06_BH					0.3	0.3	7.9	7.9
Area 2	LB_21_07_BH	0.8			Yes	0.8	1.65	7.8	7.8
Area 2	LB_21_08_BH				Yes	0.35	1.8	na	1.8
Area 2	LB_21_11_BH		Yes	Yes		0.3	6.72	12.4	
Area 2	LB_21_114_BH				Yes		1.5	9	
Area 2	LB_21_115_TP		Yes	Yes	Yes	0.5	3.4	4.5	
Area 2	LB_21_12_BH		Yes	Yes		0.1	4.38	7.45	
Area 2	LB_21_13_BH					0.3	0.3	9.6	
Area 2	LB_21_14_TP					0.3	0.3	3	
Area 3a	LB_21_39_TP	0.3	Yes			0.3	0.9	4.5	
Area 3a	LB_21_40_TP		Yes			0.4	2		
Area 3a	LB_21_42_TP		Yes			0.3	3		
Area 3a	LB_21_43_TP		Yes			0.3	2		
Area 3a	LB_21_44_BH		Yes			0.3	18	30	
Area 3a	LB_21_45_BH		Yes	Yes		0.4	18.48	30	
Area 3a	LB_21_46_BH		Yes			0.5	13.95	19.5	
Area 3a	LB_21_47_BH	0.4	Yes			0.4	13.55	19.5	
Area 3a	LB_21_49_BH	0.8	Yes	Yes		0.8	4.3	9.45	
Area 3b	LB_21_110_BH					0.3	0.3	10.05	
Area 3b	LB_21_50_TP		Yes	Yes		0.3	3.6		
Area 3b	LB_21_52_BH		Yes			0.25	2.7	10.45	
Area 3b	LB_21_53_TP		Yes			0.3	3.4		
Area 3b	LB_21_54_BH		Yes			0.3	8.55	22.45	
Area 3b	LB_21_55_BH		Yes	Yes		0.2	5.2	25.45	
Area 3b	LB_21_56_BH	0.55	Yes	Yes		0.85	2.7	10	

Notes: MG = Mage Ground, TD = Tidal Deposits, WB = Windblown Sand (included in the Holocene sediment stack), TS = Topsoil, Shaded = base of stratigraphic unit not reached

Table 2: Summary of stratigraphy, Areas 1-3

4.1.2 The sediment sequences are relatively consistent with the BGS mapping of the area, although variations in detail may be observed (Area 2). A number of points are worthy of note regarding the reliability of the model.

4.1.3 The modelling for the site area relies on interpreted data from boreholes provided by Fugro (2022). Historical BGS records from previous ground investigations also provide some stratigraphic data and help to corroborate the lithostratigraphic descriptions recorded for the newer interventions. The deposit model is based on both the lithology and inferred stratigraphy interpreted from the borehole data and is a product of work by several agencies and individuals.

4.1.4 The distribution of interventions is variable. For Area 1 (the north-eastern marshes), stratigraphic data from a cluster of BGS boreholes support the stratigraphic interpretation from the new interventions. A data gap of 600m exists between LB_21_205_TP and LB_21_203_BH (although data from borehole BGS_105 is useful to narrow the gap). However, the record in BGS_105, whilst similar to LB_21_203_BH, is very different from that recorded further along the transect to the south-west. Further boreholes should be taken here for geoarchaeological purposes, to fully scope out the distribution of Tidal Flat/peat deposition.

4.1.5 For Area 1, the data and transects between BGS_105 and LB_21_202_BH show that Glacial Till deposits underlie the Holocene sequences which started to accumulate at -10 to -4m OD (Figure 4). Further west, Glacial Till deposits are recorded at surface or forming higher ground, at +4m OD to +14m OD.

4.1.6 The distribution of interventions for Area 2, the Gowy floodplain, is also variable. Only boreholes LB_21_11_BH and LB21_12_BH contribute new data, the rest of the data for the Gowy floodplain being provided from historic BGS boreholes (Figure 5). The base of the Holocene is placed at the top of Glacial Till deposits, at approximately +5m to +10m OD at the north-eastern end of the transect, but at 0 to -2m OD within the broader channel of the River Gowy, rising at the south-western end to between +9 to +12m OD. A series of boreholes to deliberately target the peat deposits which are present close to the surface or beneath *c* 1m of clay, on either side of the River Gowy and extending eastwards as well as along the length of the route paralleling the south-westerly course of the River Gowy, should be taken to fully investigate the geoarchaeology, palaeoenvironmental and radiocarbon dating potential.

4.1.7 For Area 3(a), the borehole data are quite far apart (Figure 8). Closer-spaced boreholes would be required for more detailed modelling and analysis of the evolution of the River Dee floodplain. The base of the Holocene is placed at -8m to -14m OD, across the south-western side of the channel of the River Dee, for which borehole data are available.

4.1.8 For Area 3(b), borehole and trial pit data are, again, too far apart to identify the shape of sub-surface peat/Tidal Flat deposits (Figure 9). The base of the Holocene is variable, occurring in the central area between *c* +2m to -4m OD, whereas at the far north-western end, glacial deposits are close to the surface, covered only with a thin layer of topsoil, at approximately 12m OD.

4.1.9 Within each of the three areas, fine-grained minerogenic sediments are present; these were probably deposited in a brackish water environment of tidal mud flat, creeks, and saltmarshes. Tidal Flat settings may reflect high-energy environments which can lead to channel instability and cycles of erosion and deposition. Localised channelling can result in mixing of fresh and marine sediments and the microfossils contained within. Peat deposits, which have the potential to seal buried landsurfaces, can be truncated by subsequent tidal transgression. Any archaeological remains associated with the Tidal Flat deposits (for example fish-traps or salt-making) may have been subject to reworking, but there is also potential for stabilisation surfaces to have occurred within these deposits.

4.1.10 Substantial deposits of waterlogged peats, up to 4m thick, which could include saltmarsh as well as freshwater peats, are recorded from Areas 1 and 2, with thinner peats recorded from the Dee Valley (although the data here are very sparse) as well as some localised peats, possibly associated with the Broughton Brook (Area 3; Figure 7). Peats accumulate in stable low-energy conditions and, therefore, any archaeological remains found in association are likely to be stratified and preserved *in-situ*. Peats within Tidal Flat sequences are likely to have been truncated once renewed flooding terminated peat accumulation. Nevertheless, where peats occur in these settings, they occupy an ecotonal zone at the interface between dry ground and wetland. Such areas may have provided a focus for activity in the past due to the abundance of natural resources available for exploitation.

4.1.11 Intercalated Tidal Flat clastic deposits and peat deposits have the potential to provide a high-resolution record of past vegetation and hydrological change, though assessment and analysis of pollen, diatoms, ostracods and foraminifera. The peat deposits have excellent potential for radiocarbon dating which can provide a chronological framework for palaeoenvironmental work and associated archaeological remains. The Tidal Flat deposits also offer potential for luminescence dating.

4.1.12 Due to the relatively thin cover of topsoil across GI interventions from Areas 1-3, it is likely that archaeological features and artefacts may have undergone some disturbance/truncation, depending on past land use and the effects of deep ploughing.

4.2 Potential Construction Impacts

4.2.1 The effects of development upon fragile subsurface deposits such as peat may be direct or indirect and could be of long- and short-term duration. Deposits such as peat, which may be present close to the surface (eg in Areas 1 and 2), could be adversely impacted from works associated with the DCO Proposed Development pipeline mainlay. Impacts, such as excavation and compaction (from heavy vehicle movement) could impact negatively on subsurface strata and the potential archaeological remains contained within.

4.2.2 Construction of AGIs and development of routeways to these AGIs could also have a direct impact, resulting in damage to, or loss of buried sediments. More deeply buried deposits may be affected locally at crossing points (rail, road, and watercourses) where directional drilling techniques are employed.

4.2.3 Dewatering could result in peat desiccation and consequent destruction. Any changes to drainage would affect the buried environments of waterlogged deposits. Waterlogged peat deposits considered to have high archaeological and palaeoenvironmental potential along the DCO Proposed Development should be assessed according to Historic England guidelines (2016) *Preserving archaeological remains, Appendix 3: Water environment assessment* techniques and possibly subject to a Tier 1 study.

5 RECOMMENDATIONS

Background

5.1.1 Wetlands, in both inland and coastal zones, are important archives of archaeological and palaeoenvironmental records – these are historic landscapes, that hold evidence for environmental and climate change, as well as providing environmental settings for human activities (Historic England 2021). Palaeochannels are also recognised as a potential focus for human activity.

5.1.2 The DCO Proposed Development is located to the south of the tidal estuary of the River Mersey and traverses westwards across the floodplain of the River Gowy, that joins the Mersey at Stanlow. Further west, in Wales, the route crosses the River Dee. These river floodplains accumulated thick deposits of Tidal Flat and peat sequences following inundation and flooding in response to sea-level rise, which began during the Early Holocene. Palaeoenvironmental and chronostratigraphic data are available for Ince and Helsby marshes, a few kilometres from the eastern end of the pipeline, but only limited, or no, data appear to be available for either the Gowy or Dee floodplains.

Recommendations

5.1.3 To improve the understanding of the evolution of these floodplains in relation to their potential archaeological significance, it is recommended that a series of boreholes should be located within Areas 1-3, to retrieve sediments for geoarchaeological and palaeoenvironmental purposes. Purposive boreholes will aim to fill gaps in the initial deposit models and specifically, to recover high-quality cores suitable for palaeoenvironmental assessment and radiocarbon dating. At shallower depths, test pitting or evaluation trenches may be appropriate techniques, as they provide more reliable methods of detecting stratified archaeological remains due to the greater visibility and access to section faces they provide.

5.1.4 If an AGI unit is to be built in Area 1, there is a risk that the intertidal sediment sequences preserved below the ground will be disturbed and/or destroyed; therefore, it is considered that this area should undergo intrusive investigation for the identification and recording of any archaeological remains that may be sealed beneath or within these deposits. Samples of any organic materials preserved beneath the subsurface should be taken with a view to palaeoenvironmental and chronostratigraphic (radiocarbon dating) work.

5.1.5 Outside of Areas 1-3, there are limited records for the presence at surface of Alluvium, peat, Head and River Terrace deposits. These could all be explored for archaeology, via shallow trench excavation, if they are at risk of being disturbed or removed for pipeline installation.

5.1.6 Boreholes targeting peat deposits should employ a coring technique that minimises compaction during drilling. Depending on the circumstances, this may employ the use of a hand-held Russian-type auger if peat deposits are at the surface, or a hydraulic rig where deposits are too deep, or too firm, to be accessed using a hand-held auger. Should sediments be excavated during test pitting or evaluation, a geoarchaeologist should attend site to record the sequences and to advise on sampling in line with Historic England guidelines (2015). Both borehole and trench stratigraphy should be integrated to allow the current deposit models to be updated as part of any forthcoming evaluation works.

5.1.7 The cores should be examined in detail by an experienced geoarchaeologist with a view to describing the lithologies and selecting appropriate sub-samples, including for pollen, plant macrofossil, beetle, diatom, foraminifera, and ostracod assessment, and radiocarbon AMS dating.

5.1.8 These data should be used to inform landscape evolution, correlation with previous work in the adjacent area, and to identify, where possible, any evidence of human impact on the environment. The data should also be used to update current knowledge regarding sea-level rise and fall during the Lateglacial – Holocene period and could, therefore, contribute to an updated model of sea-level change for the North West of Britain.

5.1.9 These palaeoenvironmental and sea-level data are important and, together with a programme of radiocarbon dating, have the potential to address research questions posed by regional research agendas for both England and Wales. The updated North West England Regional Research Framework ([redacted] accessed 22nd August 2022), outlines specific objectives, for example:

- ***PH12****: How can more widespread dating be applied to prehistoric sites?*
- ***PH17****: How can a programme of sampling and investigation help to characterise landscape use during the prehistoric period?*
- ***PH18****: What can palaeoenvironmental analysis of buried soils tell us about prehistoric environments?*
- ***PH19****: How can data be best captured for the palaeoenvironment in prehistory?*

5.1.10 The Research Framework for the Archaeology of Wales ([redacted] accessed 22nd August 2022) has outlined several relevant research objectives, including for example:

- *How were Welsh coastal and marsh inter-tidal areas exploited during early prehistory?*
- *What is the extent of the potential for survival of deposits containing archaeological and palaeoenvironmental evidence from Welsh coastal areas during early prehistory?*
- *How did marine transgression phases affect human activity, especially in prehistory?*
- *What were the environmental conditions associated with wetland sites?*

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APPENDIX A DEPOSIT MODEL DATASET – ALL GI LOCATIONS

Ground interventions used in deposit models in **BOLD**

Borehole	Easting	Northing	Elevation (OD)	Total Depth (m)
BGS_23	346146	374659	7.55	15
BGS_105	346822	375730	4.26	18.05
BGS_119	346810	375850	4.12	20
BGS_141	346895	375967	4.1	14.7
BGS_142	346944	375978	4.22	20
BGS_143	346895	376002	4.22	20
BGS_179	343580	343580	4.7	17
BGS_180	343680	372760	5.39	18
BGS_181	344000	372510	4.54	17
BGS_182	344120	372610	4.29	13
LB_21_01_BH	344571	374933	9	14.7
LB_21_02_BH	344513.1	374742.1	9.9	20
LB_21_05_BH	344662.2	373584.5	9.68	24.5
LB_21_06_BH	344721.8	373520.7	11.14	24.5
LB_21_07_BH	344734.7	373406.3	11.9	9.29
LB_21_08_BH	344331	373056.5	8.41	7.81
LB_21_11_BH	343612.4	372884.5	4.72	12.4
LB_21_12_BH	343441.8	372460.8	4.18	7.45
LB_21_13_BH	343185.5	372226.1	8.84	9.6
LB_21_16_BH	342790.3	371372.7	24.58	15
LB_21_18_BH	342259.6	371212	25.64	10.15
LB_21_19_BH	341454.4	371095.1	11.98	17.6
LB_21_20_BH	341513.6	371487.3	14.66	17.2
LB_21_21_BH	341133.6	371340.8	18.14	5.2
LB_21_27_BH	339241.9	371164.8	30.18	1.2
LB_21_30_BH	338673.4	371066.6	30.82	10.2
LB_21_32_BH	338282.8	370533.1	32.84	8
LB_21_33_BH	338180.3	370359.2	31.47	10.2
LB_21_38_BH	336712.6	369444	23.15	10.2
LB_21_44_BH	334879.8	367152.6	5.15	30
LB_21_45_BH	334680.7	367032.3	4.43	30
LB_21_46_BH	334533.2	366498.4	5.31	19.5
LB_21_47_BH	334468.8	366462.7	5.19	19.5
LB_21_49_BH	333804.5	366175.5	5.16	9.45
LB_21_51_BH	333226.3	3666120	5.08	10.05
LB_21_52_BH	332942.3	366933.5	4.91	10.45
LB_21_54_BH	332658.6	367326.4	5.02	22.45
LB_21_55_BH	332493.4	367494.1	5.11	25.45
LB_21_56_BH	332291.1	367527	5.36	10

Borehole	Easting	Northing	Elevation (OD)	Total Depth (m)
LB_21_59_BH	330930.6	366780	47.01	9.45
LB_21_60_BH	330683.5	366880.5	51.68	25.5
LB_21_63_BH	330166.8	366961.5	75.63	20
LB_21_64_BH	330026.9	366991	80.53	22.05
LB_21_65_BH	329899.8	367060.5	80.05	21.57
LB_21_73_BH	326874.3	367463.4	90.93	21
LB_21_74_BH	326729.1	367590.1	96.38	4.71
LB_21_77_BH	325676.1	368109.3	103.13	10.5
LB_21_78_BH	325620.4	368519.9	101.25	10.5
LB_21_81_BH	325247.5	369716.1	88.1	10.11
LB_21_85_BH	325143.7	370918.8	54.86	13.4
LB_21_88_BH	325184.9	370845.9	54.04	14
LB_21_95_BH	331118.7	366910.5	36.19	10.5
LB_21_99_BH	338175.1	370169.5	29.06	20.5
LB_21_103_BH	326001.6	367780.7	111.94	8
LB_21_109_BH	331482.3	367229.8	22.74	5.48
LB_21_110_BH	331712	367387	12.36	10.05
LB_21_112_BH	340601.8	371287.9	27.2	6.77
LB_21_114_BH	344521.9	373302.5	6.43	9
LB_21_121_BH	338859.5	370952.4	30.08	10
LB_21_160_BH	312212	384063	6.2	15
LB_21_202_BH	346935.7	376118.6	4.57	17
LB_21_203_BH	346963.7	375752.6	3.94	15
LB_21_206_BH	346289.2	375029.1	14.13	15.41
LB_21_210_BH	345112.3	374615.4	12.17	3.52
LB_21_213_BH	346952.4	375914.8	4.28	15.45
LB_21_03_TP	344502.3	374291.1	12.49	3.2
LB_21_04_TP	344588.5	373753.6	11.86	4.5
LB_21_14_TP	342848.7	371856.8	17.54	3
LB_21_20_TP	341510	371485.4	14.81	1.7
LB_21_22_TP	340832	371251.6	21.73	2.5
LB_21_26_TP	339263	371067.7	30.08	2.2
LB_21_31_TP	338302.4	370788.1	31.37	4.5
LB_21_35_TP	337806.9	369886.2	26.69	4.5
LB_21_36_TP	337389	369476.8	28.69	4.1
LB_21_37_TP	337031	369429.2	25.47	2.6
LB_21_39_TP	336414.6	369014	5.4	4.5
LB_21_40_TP	336177.3	368861.9	4.98	2
LB_21_42_TP	335290	368079.2	5.27	3
LB_21_43_TP	335163.8	367550.3	4.82	2
LB_21_50_TP	333500.8	366269.9	4.85	3.6
LB_21_53_TP	332642	366962.7	7.2	3.4

Borehole	Easting	Northing	Elevation (OD)	Total Depth (m)
LB_21_58_TP	331272.3	367099.1	27.84	3.3
LB_21_66_TP	329505.8	367101.5	83.96	4.5
LB_21_69_TP	328595.5	366458.1	87.13	3.5
LB_21_70_TP	328178.8	366812.2	90.5	4.5
LB_21_75_TP	326279.4	367651.6	92.02	4.5
LB_21_76_TP	325762.8	367902.4	105.84	4.5
LB_21_79_TP	325353.6	368983.4	87.9	2
LB_21_80_TP	325289.6	369290.1	98.88	4.5
LB_21_82_TP	325269.2	370034.3	89.75	2
LB_21_83B_TP	325084.9	370415.6	73.25	4.5
LB_21_84_TP	325090.8	370700.2	59.41	3
LB_21_87_TP	325130.3	370887.7	55.7	3.3
LB_21_89_TP	325217.3	370868.4	52.42	2.8
LB_21_91_TP	330976.2	366832.3	42.97	0.9
LB_21_92A_TP	331017.4	366900.1	39.03	4.5
LB_21_93_TP	331086.2	366952.6	35.38	0.8
LB_21_94_TP	331112.8	366931.1	35.64	4.5
LB_21_96_TP	338226.1	370352.9	31.72	1.5
LB_21_97_TP	338152.4	370286.7	30.53	2.5
LB_21_98_TP	338158.3	370192.1	29.49	2.7
LB_21_101_TP	341154.8	371330.9	17.46	2.8
LB_21_102_TP	341124.8	371319.3	17.95	2.5
LB_21_105_TP	325974.2	367805.1	112.83	1.3
LB_21_106_TP	326005	367894.6	117.13	1.9
LB_21_107_TP	326027.4	367953.5	119.26	1.5
LB_21_113_TP	341362.4	371423.3	17.67	1.4
LB_21_114_TP	344520.2	373308.5	6.35	2.5
LB_21_115_TP	344631.6	373338.1	9.56	4.5
LB_21_205_TP	346595.8	375363.2	5.76	2.4
LB_21_208_TP	346012.3	374727.6	12.76	2.8

APPENDIX B DEPOSIT MODEL DATASET – INTERPRETED STRATIGRAPHY

Ground interventions used in deposit models in **BOLD**

Borehole	Depth1 (below ground level)	Depth2 (below ground level)	Stratigraphy
BGS_23	0	0.4	Made Ground
BGS_23	0.4	15	Glacial Deposits
BGS_105	0	0.3	Topsoil
BGS_105	0.3	0.9	Tidal Flat Deposits
BGS_105	0.9	5.05	Peat
BGS_105	5.05	6.25	Tidal Flat Deposits
BGS_105	6.25	7.35	Peat
BGS_105	7.35	8.05	Tidal Flat Deposits
BGS_105	8.05	18.05	Glacial Deposits
BGS_119	0	0.79	Tidal Flat Deposits
BGS_119	0.79	5.05	Peat
BGS_119	5.05	6.77	Tidal Flat Deposits
BGS_119	6.77	7.68	Peat
BGS_119	7.68	20	Glacial Deposits
BGS_141	0	0.15	Topsoil
BGS_141	0.15	0.66	Tidal Flat Deposits
BGS_141	0.66	4.3	Peat
BGS_141	4.3	8.5	Tidal Flat Deposits
BGS_141	8.5	9.5	Peat
BGS_141	9.5	12.55	Tidal Flat Deposits
BGS_141	12.55	14.7	Glacial Deposits
BGS_142	0	1.3	Tidal Flat Deposits
BGS_142	1.3	2.6	Peat
BGS_142	2.6	7.7	Tidal Flat Deposits
BGS_142	7.7	10.5	Peat
BGS_142	10.5	12.3	Tidal Flat Deposits
BGS_142	12.3	19.5	Glacial Deposits
BGS_143	0	0.1	Topsoil
BGS_143	0.1	1.4	Tidal Flat Deposits
BGS_143	1.4	3.4	Peat
BGS_143	3.4	7.6	Tidal Flat Deposits
BGS_143	7.6	9.7	Peat
BGS_143	9.7	11.8	Tidal Flat Deposits
BGS_143	11.8	15	Glacial Deposits
BGS_179	0	0.3	Topsoil
BGS_179	0.3	1	Tidal Flat Deposits
BGS_179	1	4.2	Peat
BGS_179	4.2	5	Tidal Flat Deposits
BGS_179	5	17	Glacial Deposits
BGS_180	0	0.3	Topsoil

Borehole	Depth1 (below ground level)	Depth2 (below ground level)	Stratigraphy
BGS_180	0.3	1.5	Tidal Flat Deposits
BGS_180	1.5	5.5	Peat
BGS_180	5.5	7	Tidal Flat Deposits
BGS_180	7	18	Glacial Deposits
BGS_181	0	0.3	Topsoil
BGS_181	0.3	3.5	Peat
BGS_181	3.5	5.5	Tidal Flat Deposits
BGS_181	5.5	16	Glacial Deposits
BGS_182	0	0.5	Topsoil
BGS_182	0.5	4.5	Peat
BGS_182	4.5	13	Glacial Deposits
LB_21_01_BH	0	0.15	Made Ground
LB_21_01_BH	0.15	1.9	Tidal Flat Deposits
LB_21_01_BH	1.9	14.7	Bedrock
LB_21_02_BH	0	0.3	Topsoil
LB_21_02_BH	0.3	3.5	Glacial Deposits
LB_21_05_BH	0	0.3	Topsoil
LB_21_05_BH	0.3	7.35	Glacial Deposits
LB_21_05_BH	7.35	14.97	Bedrock
LB_21_06_BH	0	0.3	Topsoil
LB_21_06_BH	0.3	7.9	Glacial Deposits
LB_21_06_BH	7.9	10.8	Bedrock
LB_21_07_BH	0	0.8	Made Ground
LB_21_07_BH	0.8	1.65	Wind Blown Deposits
LB_21_07_BH	1.65	7.8	Glacial Deposits
LB_21_07_BH	7.8	9.29	Bedrock
LB_21_08_BH	0	0.35	Topsoil
LB_21_08_BH	0.35	1.8	Wind Blown Deposits
LB_21_08_BH	1.8	7.81	Bedrock
LB_21_11_BH	0	0.3	Topsoil
LB_21_11_BH	0.3	1.2	Tidal Flat Deposits
LB_21_11_BH	1.2	2.6	Peat
LB_21_11_BH	2.6	2.8	Tidal Flat Deposits
LB_21_11_BH	2.8	5.76	Peat
LB_21_11_BH	5.76	6.72	Tidal Flat Deposits
LB_21_11_BH	6.72	12.4	Glacial Deposits
LB_21_12_BH	0	0.1	Topsoil
LB_21_12_BH	0.1	0.4	Tidal Flat Deposits
LB_21_12_BH	0.4	3.62	Peat
LB_21_12_BH	3.62	4	Tidal Flat Deposits
LB_21_12_BH	4	4.38	Peat
LB_21_12_BH	4.38	7.45	Glacial Deposits
LB_21_13_BH	0	0.3	Topsoil

Borehole	Depth1 (below ground level)	Depth2 (below ground level)	Stratigraphy
LB_21_13_BH	0.3	9.6	Glacial Deposits
LB_21_16_BH	0	0.5	Topsoil
LB_21_16_BH	0.5	15	Glacial Deposits
LB_21_18_BH	0	0.4	Topsoil
LB_21_18_BH	0.4	10.15	Glacial Deposits
LB_21_19_BH	0	0.3	Topsoil
LB_21_19_BH	0.3	8.8	Glacial Deposits
LB_21_19_BH	8.8	17.6	Bedrock
LB_21_20_BH	0	0.3	Topsoil
LB_21_20_BH	0.3	17.2	Bedrock
LB_21_21_BH	0	1.5	Made Ground
LB_21_21_BH	1.5	5.2	Bedrock
LB_21_27_BH	0	0.3	Topsoil
LB_21_27_BH	0.3	1.2	Glacial Deposits
LB_21_30_BH	0	0.3	Topsoil
LB_21_30_BH	0.3	10.2	Glacial Deposits
LB_21_32_BH	0	0.3	Topsoil
LB_21_32_BH	0.3	8	Glacial Deposits
LB_21_33_BH	0	0.3	Topsoil
LB_21_33_BH	0.3	10.2	Glacial Deposits
LB_21_38_BH	0	0.4	Topsoil
LB_21_38_BH	0.4	10.2	Glacial Deposits
LB_21_44_BH	0	0.3	Topsoil
LB_21_44_BH	0.3	18	Tidal Flat Deposits
LB_21_44_BH	18	30	Glacial Deposits
LB_21_45_BH	0	0.4	Topsoil
LB_21_45_BH	0.4	16.43	Tidal Flat Deposits
LB_21_45_BH	16.43	16.7	Peat
LB_21_45_BH	16.7	18.48	Tidal Flat Deposits
LB_21_45_BH	18.48	30	Till
LB_21_46_BH	0	0.5	Topsoil
LB_21_46_BH	0.5	13.95	Tidal Flat Deposits
LB_21_46_BH	13.95	19.5	Glacial Deposits
LB_21_47_BH	0	0.4	Made Ground
LB_21_47_BH	0.4	13.55	Tidal Flat Deposits
LB_21_47_BH	13.55	19.5	Glacial Deposits
LB_21_49_BH	0	0.8	Made Ground
LB_21_49_BH	0.8	2.02	Tidal Flat Deposits
LB_21_49_BH	2.02	2.68	Peat
LB_21_49_BH	2.68	3	Tidal Flat Deposits
LB_21_49_BH	3	3.81	Peat
LB_21_49_BH	3.81	4.3	Tidal Flat Deposits
LB_21_49_BH	4.3	9.45	Glacial Deposits

Borehole	Depth1 (below ground level)	Depth2 (below ground level)	Stratigraphy
LB_21_51_BH	0	0.2	Topsoil
LB_21_51_BH	0.2	2.7	Tidal Flat Deposits
LB_21_51_BH	2.7	3.1	Peat
LB_21_51_BH	3.1	10.05	Glacial Deposits
LB_21_52_BH	0	0.25	Topsoil
LB_21_52_BH	0.25	2.7	Tidal Flat Deposits
LB_21_52_BH	2.7	10.45	Glacial Deposits
LB_21_54_BH	0	0.3	Topsoil
LB_21_54_BH	0.3	8.55	Tidal Flat Deposits
LB_21_54_BH	8.55	22.45	Glacial Deposits
LB_21_55_BH	0	0.2	Topsoil
LB_21_55_BH	0.2	2.55	Tidal Flat Deposits
LB_21_55_BH	2.55	3.9	Peat
LB_21_55_BH	3.9	5.2	Tidal Flat Deposits
LB_21_55_BH	5.2	25.45	Glacial Deposits
LB_21_56_BH	0	0.3	Topsoil
LB_21_56_BH	0.3	0.85	Made Ground
LB_21_56_BH	0.85	2.2	Tidal Flat Deposits
LB_21_56_BH	2.2	2.7	Peat
LB_21_56_BH	2.7	10	Glacial Deposits
LB_21_59_BH	0	0.3	Topsoil
LB_21_59_BH	0.3	9.45	Glacial Deposits
LB_21_60_BH	0	0.3	Topsoil
LB_21_60_BH	0.3	10.5	Glacial
LB_21_60_BH	10.5	25.5	Bedrock
LB_21_63_BH	0	2.8	Made Ground
LB_21_63_BH	2.8	12	Glacial Deposits
LB_21_63_BH	12	20	Bedrock
LB_21_64_BH	0	0.2	Topsoil
LB_21_64_BH	0.2	0.4	Made Ground
LB_21_64_BH	0.4	7.3	Glacial Deposits
LB_21_64_BH	7.3	22.05	Bedrock
LB_21_65_BH	0	0.3	Topsoil
LB_21_65_BH	0.3	21.57	Glacial Deposits
LB_21_73_BH	0	0.3	Topsoil
LB_21_73_BH	0.3	11.9	Glacial Deposits
LB_21_73_BH	11.9	21	Bedrock
LB_21_74_BH	0	0.2	Topsoil
LB_21_74_BH	0.2	2.7	Glacial Deposits
LB_21_74_BH	2.7	4.71	Bedrock
LB_21_77_BH	0	0.3	Topsoil
LB_21_77_BH	1.2	6.8	Glacial Deposits
LB_21_77_BH	6.8	10.5	Bedrock

Borehole	Depth1 (below ground level)	Depth2 (below ground level)	Stratigraphy
LB_21_78_BH	0	0.3	Topsoil
LB_21_78_BH	0.3	10.5	Glacial Deposits
LB_21_81_BH	0	0.3	Topsoil
LB_21_81_BH	0.3	10.11	Glacial Deposits
LB_21_85_BH	0	0.3	Topsoil
LB_21_85_BH	0.3	13.4	Glacial Deposits
LB_21_88_BH	0	0.2	Topsoil
LB_21_88_BH	0.2	14	Glacial Deposits
LB_21_95_BH	0	0.4	Topsoil
LB_21_95_BH	0.4	7.5	Glacial Deposits
LB_21_95_BH	7.5	10.5	Bedrock
LB_21_99_BH	0	0.3	Topsoil
LB_21_99_BH	0.3	20.5	Glacial Deposits
LB_21_103_BH	0	0.3	Topsoil
LB_21_103_BH	0.3	1.2	Glacial Deposits
LB_21_103_BH	1.2	8	Bedrock
LB_21_109_BH	0	0.25	Topsoil
LB_21_109_BH	0.25	4.5	Made Ground
LB_21_109_BH	4.5	5.48	Bedrock
LB_21_110_BH	0	0.3	Topsoil
LB_21_110_BH	0.3	10.05	Glacial Deposits
LB_21_112_BH	0	0.2	Topsoil
LB_21_112_BH	0.2	6.2	Glacial Deposits
LB_21_112_BH	6.2	6.77	Bedrock
LB_21_114_BH	0	1.5	Wind Blown Deposits
LB_21_114_BH	1.5	9	Glacial Deposits
LB_21_121_BH	0	0.3	Topsoil
LB_21_121_BH	0.3	10	Glacial Deposits
LB_21_160_BH	0	0.2	Topsoil
LB_21_160_BH	0.2	1.2	Made Ground
LB_21_160_BH	1.2	15	Tidal Flat Deposits
LB_21_202_BH	0	0.2	Topsoil
LB_21_202_BH	0.2	1.88	Tidal Flat Deposits
LB_21_202_BH	1.88	3	Peat
LB_21_202_BH	3	3.43	Tidal Flat Deposits
LB_21_202_BH	3.43	4.66	Peat
LB_21_202_BH	4.66	5.32	Tidal Flat Deposits
LB_21_202_BH	5.32	10	Peaty Clay
LB_21_202_BH	10	12	Peat
LB_21_202_BH	12	14.8	Tidal Flat Deposits
LB_21_202_BH	14.8	17	Glacial Deposits
LB_21_203_BH	0	0.2	Topsoil
LB_21_203_BH	0.2	0.5	Tidal Flat Deposits

Borehole	Depth1 (below ground level)	Depth2 (below ground level)	Stratigraphy
LB_21_203_BH	0.5	2.95	Peat
LB_21_203_BH	2.95	3.6	Tidal Flat Deposits
LB_21_203_BH	3.6	7.59	Peaty Clay
LB_21_203_BH	7.59	8	Peat
LB_21_203_BH	8	15	Glacial Deposits
LB_21_206_BH	0	0.3	Topsoil
LB_21_206_BH	0.3	14.6	Glacial Deposits
LB_21_206_BH	14.6	15.41	Bedrock
LB_21_210_BH	0	0.6	Topsoil
LB_21_210_BH	0.6	2.4	Glacial Deposits
LB_21_210_BH	2.4	3.52	Bedrock
LB_21_213_BH	0	0.3	Topsoil
LB_21_213_BH	0.3	1.2	Tidal Flat Deposits
LB_21_213_BH	1.2	4	Peat
LB_21_213_BH	4	4.3	Tidal Flat Deposits
LB_21_213_BH	4.3	5.9	Peat
LB_21_213_BH	5.9	9.34	Peaty Clay
LB_21_213_BH	9.34	9.93	Peat
LB_21_213_BH	9.93	15.45	Glacial Deposits
LB_21_03_TP	0	0.3	Topsoil
LB_21_03_TP	0.3	3.2	Glacial Deposits
LB_21_04_TP	0	0.4	Topsoil
LB_21_04_TP	0.4	4.5	Glacial Deposits
LB_21_14_TP	0	0.3	Topsoil
LB_21_14_TP	0.3	3	Glacial Deposits
LB_21_20_TP	0	0.3	Topsoil
LB_21_20_TP	0.3	1.7	Bedrock
LB_21_22_TP	0	0.3	Topsoil
LB_21_22_TP	0.3	2.5	Glacial Deposits
LB_21_26_TP	0	0.3	Topsoil
LB_21_26_TP	0.3	2.2	Glacial Deposits
LB_21_31_TP	0	0.3	Topsoil
LB_21_31_TP	0.3	4.5	Glacial Deposits
LB_21_35_TP	0	0.3	Topsoil
LB_21_35_TP	0.3	4.5	Glacial Deposits
LB_21_36_TP	0	0.3	Topsoil
LB_21_36_TP	0.3	4.1	Glacial Deposits
LB_21_37_TP	0	0.3	Topsoil
LB_21_37_TP	0.3	2.6	Glacial Deposits
LB_21_39_TP	0	0.3	Made Ground
LB_21_39_TP	0.3	0.9	Tidal Flat Deposits
LB_21_39_TP	0.9	4.5	Glacial Deposits
LB_21_40_TP	0	0.4	Topsoil

Borehole	Depth1 (below ground level)	Depth2 (below ground level)	Stratigraphy
LB_21_40_TP	0.4	2	Tidal Flat Deposits
LB_21_42_TP	0	0.3	Topsoil
LB_21_42_TP	0.3	3	Tidal Flat Deposits
LB_21_43_TP	0	0.3	Topsoil
LB_21_43_TP	0.3	2	Tidal Flat Deposits
LB_21_50_TP	0	0.3	Topsoil
LB_21_50_TP	0.3	1.6	Tidal Flat Deposits
LB_21_50_TP	1.6	2.1	Peat
LB_21_50_TP	2.1	3.6	Tidal Flat Deposits
LB_21_53_TP	0	0.3	Topsoil
LB_21_53_TP	0.3	3.4	Tidal Flat Deposits
LB_21_58_TP	0	0.3	Topsoil
LB_21_58_TP	0.3	0.6	Made Ground
LB_21_58_TP	0.6	3.3	Glacial Deposits
LB_21_66_TP	0	0.4	Topsoil
LB_21_66_TP	0.4	4.5	Glacial Deposits
LB_21_69_TP	0	1	Made Ground
LB_21_69_TP	1	2.2	Glacial Deposits
LB_21_69_TP	2.2	3.5	Bedrock
LB_21_70_TP	0	0.3	Topsoil
LB_21_70_TP	0.3	4.5	Glacial Deposits
LB_21_75_TP	0	0.3	Topsoil
LB_21_75_TP	0.3	4.5	Glacial Deposits
LB_21_76_TP	0	0.3	Topsoil
LB_21_76_TP	0.3	4.5	Glacial Deposits
LB_21_79_TP	0	0.3	Topsoil
LB_21_79_TP	0.3	2	Head
LB_21_80_TP	0	0.3	Topsoil
LB_21_80_TP	0.3	4.5	Glacial Deposits
LB_21_82_TP	0	2	Glacial Deposits
LB_21_83B_TP	0	0.3	Topsoil
LB_21_83B_TP	0.3	4.5	Glacial Deposits
LB_21_84_TP	0	0.3	Topsoil
LB_21_84_TP	0.3	3	Glacial Deposits
LB_21_87_TP	0	0.3	Topsoil
LB_21_87_TP	0.3	3.3	Glacial Deposits
LB_21_89_TP	0	0.3	Topsoil
LB_21_89_TP	0.3	2.8	Glacial Deposits
LB_21_91_TP	0	0.3	Topsoil
LB_21_91_TP	0.3	0.9	Glacial Deposits
LB_21_92A_TP	0	4.5	Glacial Deposits
LB_21_93_TP	0	0.3	Topsoil
LB_21_93_TP	0.3	0.8	Glacial Deposits

Borehole	Depth1 (below ground level)	Depth2 (below ground level)	Stratigraphy
LB_21_94_TP	0	0.3	Topsoil
LB_21_94_TP	0.3	4.5	Glacial Deposits
LB_21_96_TP	0	0.3	Topsoil
LB_21_96_TP	0.3	1.5	Glacial Deposits
LB_21_97_TP	0	0.3	Topsoil
LB_21_97_TP	0.3	2.5	Glacial Deposits
LB_21_98_TP	0	0.3	Topsoil
LB_21_98_TP	0.3	2.7	Glacial Deposits
LB_21_101_TP	0	0.4	Topsoil
LB_21_101_TP	0.4	2.5	Glacial Deposits
LB_21_101_TP	2.5	2.8	Bedrock
LB_21_102_TP	0	0.4	Topsoil
LB_21_102_TP	0.4	2.3	Glacial Deposits
LB_21_102_TP	2.3	2.5	Bedrock
LB_21_105_TP	0	0.3	Topsoil
LB_21_105_TP	0.3	1.3	Bedrock
LB_21_106_TP	0	0.4	Made Ground
LB_21_106_TP	0.4	0.9	Glacial Deposits
LB_21_106_TP	0.9	1.9	Bedrock
LB_21_107_TP	0	0.3	Topsoil
LB_21_107_TP	0.3	0.9	Glacial Deposits
LB_21_107_TP	0.9	1.5	Bedrock
LB_21_113_TP	0	0.3	Topsoil
LB_21_113_TP	0.3	0.8	Glacial Deposits
LB_21_113_TP	0.8	1.4	Bedrock
LB_21_114_TP	0	0.5	Topsoil
LB_21_114_TP	0.5	1.2	Wind Blown Deposits
LB_21_114_TP	1.2	1.3	Peat
LB_21_114_TP	1.3	2	Tidal Flat Deposits
LB_21_114_TP	2	2.5	Glacial Deposits
LB_21_115_TP	0	0.5	Topsoil
LB_21_115_TP	0.5	1.0	Wind Blown Deposits
LB_21_115_TP	1.0	3.4	Tidal Flat Deposits
LB_21_115_TP	3.4	4.5	Glacial Deposits
LB_21_205_TP	0	0.3	Topsoil
LB_21_205_TP	0.3	2.4	Glacial Deposits
LB_21_208_TP	0	0.3	Topsoil
LB_21_208_TP	0.3	2.8	Glacial Deposits

APPENDIX C SITE SUMMARY DETAILS

Site name:	Stanlow, Cheshire to Flint, *Flintshire*
Site code:	L11464
Grid Reference	NGR 312441, 384146
Type:	Geoarchaeology
Date and duration:	-
Area of Site	Approximately 34km linear corridor
Location of archive:	The archive is currently held at OA, Mill 3, Moor Lane Mills, Moor Lane, Lancaster, LA1 1QD.

Summary of Results:

Oxford Archaeology (OA) North was commissioned by WSP UK Ltd to undertake a geoarchaeological deposit model at three localities along the route of the proposed HyNet North West Carbon Dioxide Pipeline, between Stanlow, Cheshire, and Flint, Flintshire.

The three study areas are located at points where the route traverses' large tracts of tidal flat and peat deposits associated with the low-lying floodplains and marsh of the Rivers Mersey, Gowy, and Dee. The main aim of the work was to provide preliminary base-line data on the nature and depth of the sediment sequences and their geoarchaeological and palaeoenvironmental potential to inform the design of future evaluation and mitigation strategies.

Following an examination of 100 records derived from a recent geotechnical ground investigation, a total of 32 boreholes and test pits specific to the three study areas were included in the deposit modelling, alongside data from a selection of nine historical boreholes sourced from the British Geological Survey (BGS). The result of the modelling is broadly consistent with the BGS mapping of the areas, with superficial sedimentary sequences dominated by minerogenic sands, clays, and silts, likely laid down in intertidal/alluvial environments. The thickness of Holocene deposits overlying Pleistocene glacial deposits was recorded to a maximum of *c* 15m in Area 1 marginal to the River Mersey; *c* 7m in Area 2 on the Gowy floodplain; and *c* 18.5m in Area 3 on the Dee. Analysis of LiDAR DTM data has clearly identified the presence of tidal creek systems and palaeochannels, particularly across the floodplain of the River Dee (Area 3). Within the tidal deposits, the borehole data record multiple interbedded peat horizons which were particularly substantial in the north-eastern marshland in Area 1, and on the River Gowy floodplain in Area 2, the top of which occurred at, or within 1m of, current ground surface. Thin peats are recorded from parts of the Dee floodplain (Area 3), although the distribution here was found to be quite poor, with much of the data deriving from shallow test-pit interventions.

Overall, data distribution was generally sparce. Notably, close to the floodplain edge in Areas 1 and 2, ecotonal zones (the interface between dryland and wetland) may have provided a focus for past activity where evidence of occupation and relict landsurfaces may lie buried at relatively shallow depths in waterlogged conditions. The character and depth of the early Holocene topographic template, that is the interface of the Holocene and Glacial deposits, is thus difficult to predict at these locations.

The waterlogged burial conditions suggest good potential for preservation of organic remains which may include wooden structures and artefacts associated with wetland edge (seasonal) occupation, particularly adjacent to former watercourses. In addition, the presence of substantial peat and intertidal deposits suggests high potential for preservation of a range of palaeoenvironmental remains for reconstruction of past vegetation (eg pollen, insects, and plant remains) and investigation of coastal evolution, sea-level change and palaeohydrology (eg diatoms, ostracods, and foraminifera), set within a robust chronological framework provided by radiocarbon and luminescence dating.

Dependent on scheme design and the depth and nature of direct and indirect construction impacts, further evaluation, deposit modelling, and sampling of the sites could be achieved through a combination of evaluation trenching across the shallower marginal zones combined with purposive boreholes to target the deeper sequences where the current distribution of data is sparse. The boreholes will also provide samples suitable for palaeoenvironmental assessment and scientific dating.

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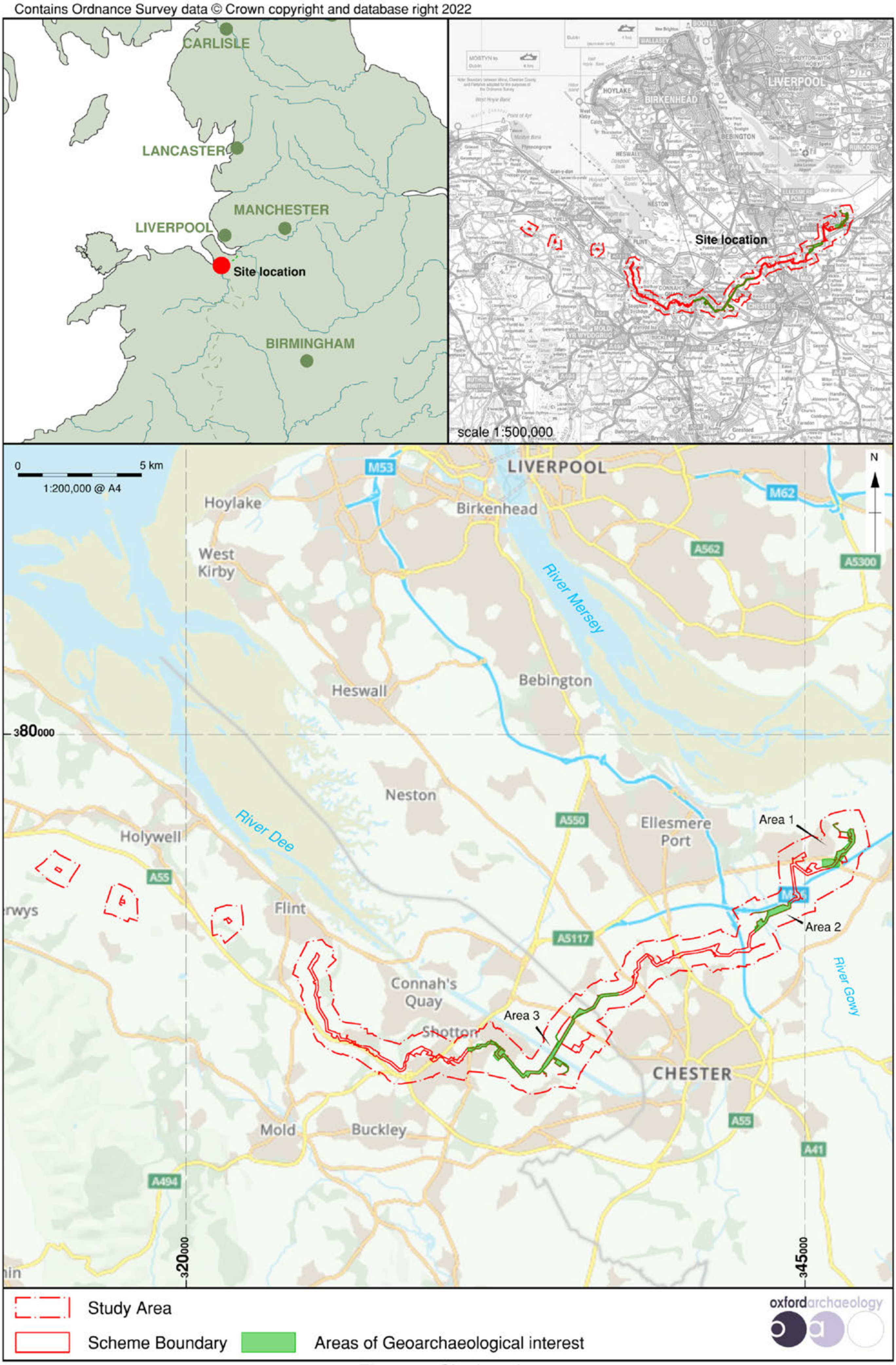

Figure 1: Site location

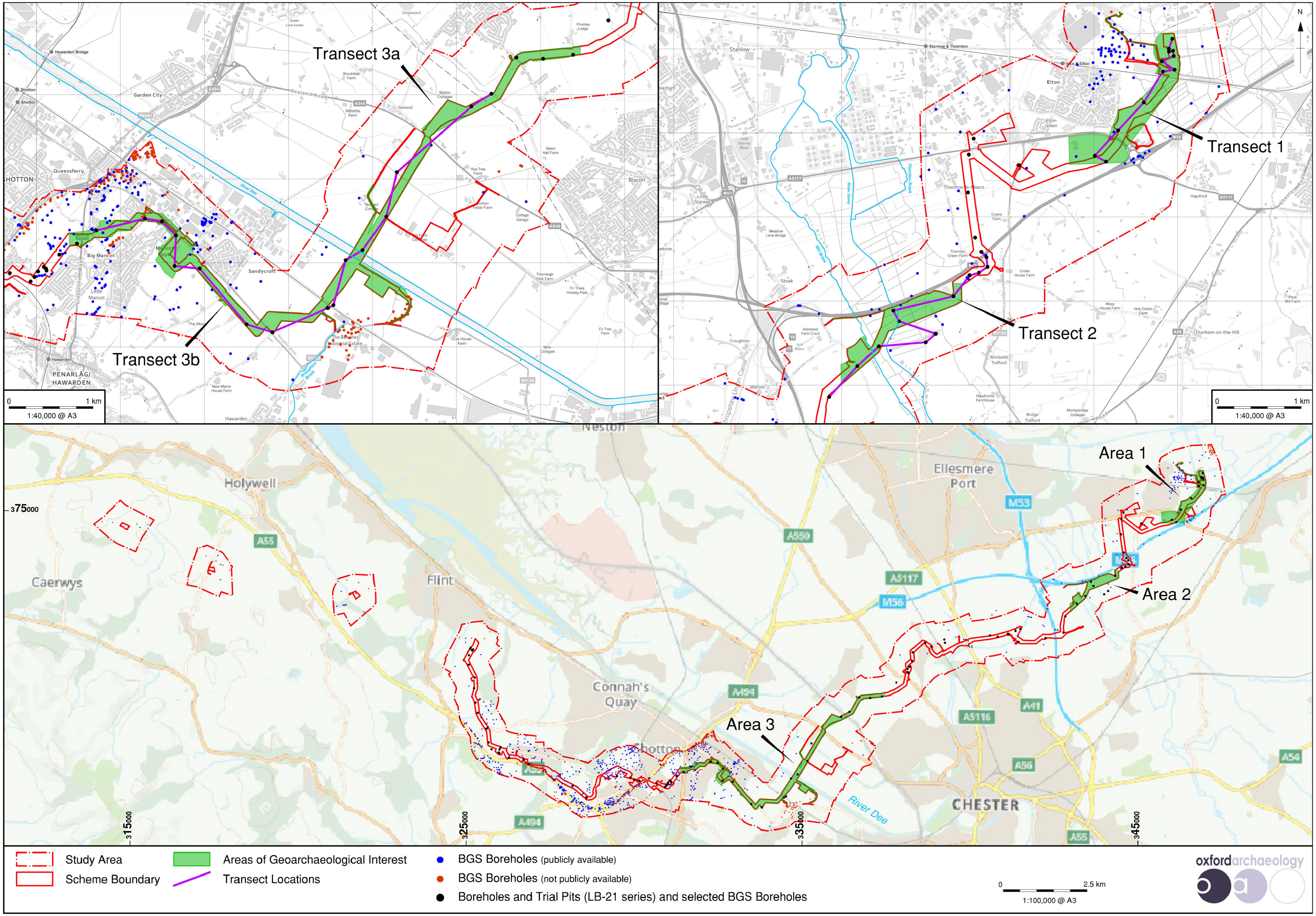

Figure 2: Route-wide distribution of BGS boreholes, geotechnical interventions and key zones of geoarchaeological interest subject to deposit modelling (Areas 1, 2 and 3)

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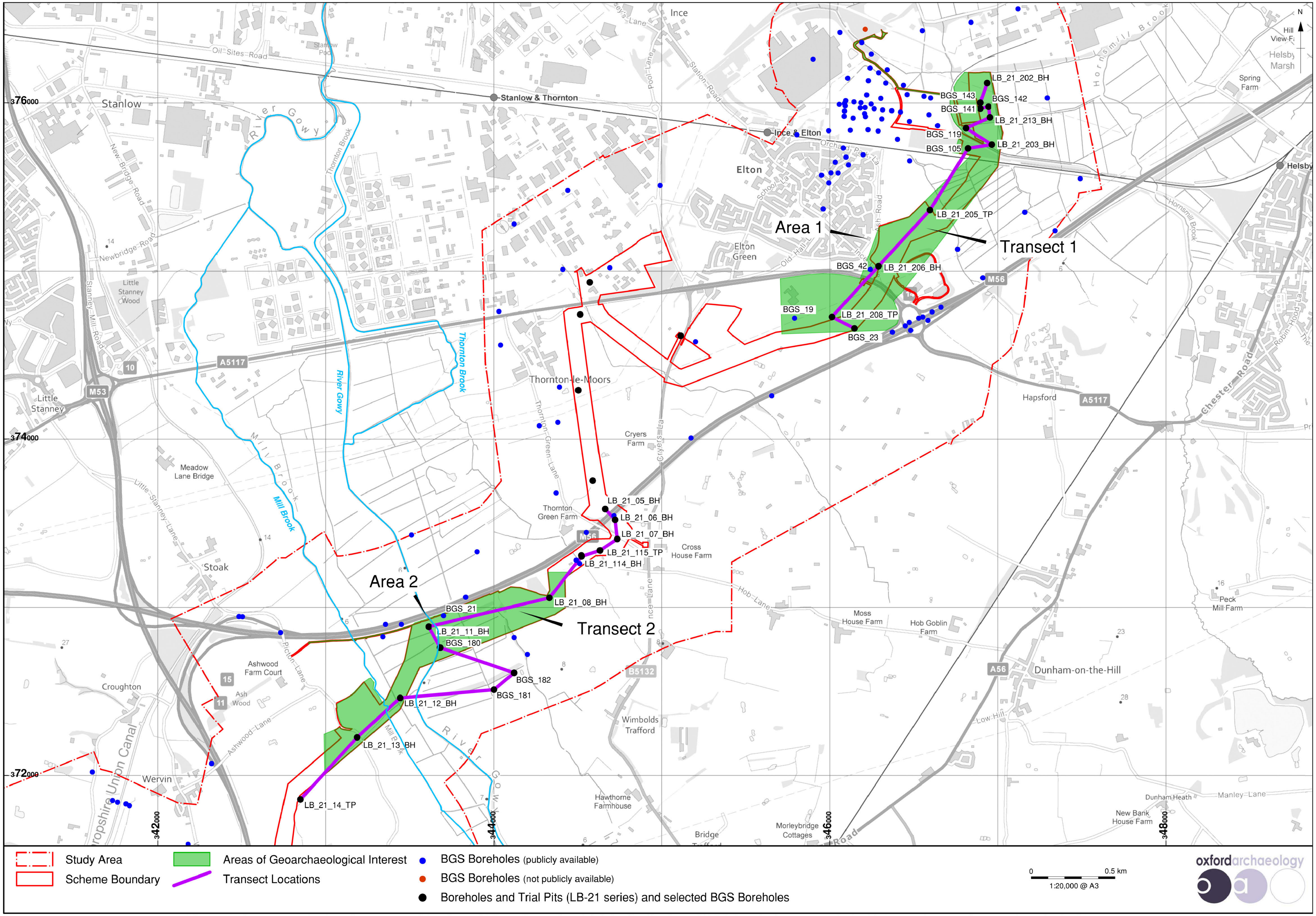

Figure 3: Areas 1 and 2 (north-east marshlands and River Gowy floodplain), distribution of BGS boreholes, geotechnical interventions and geoarchaeological transects

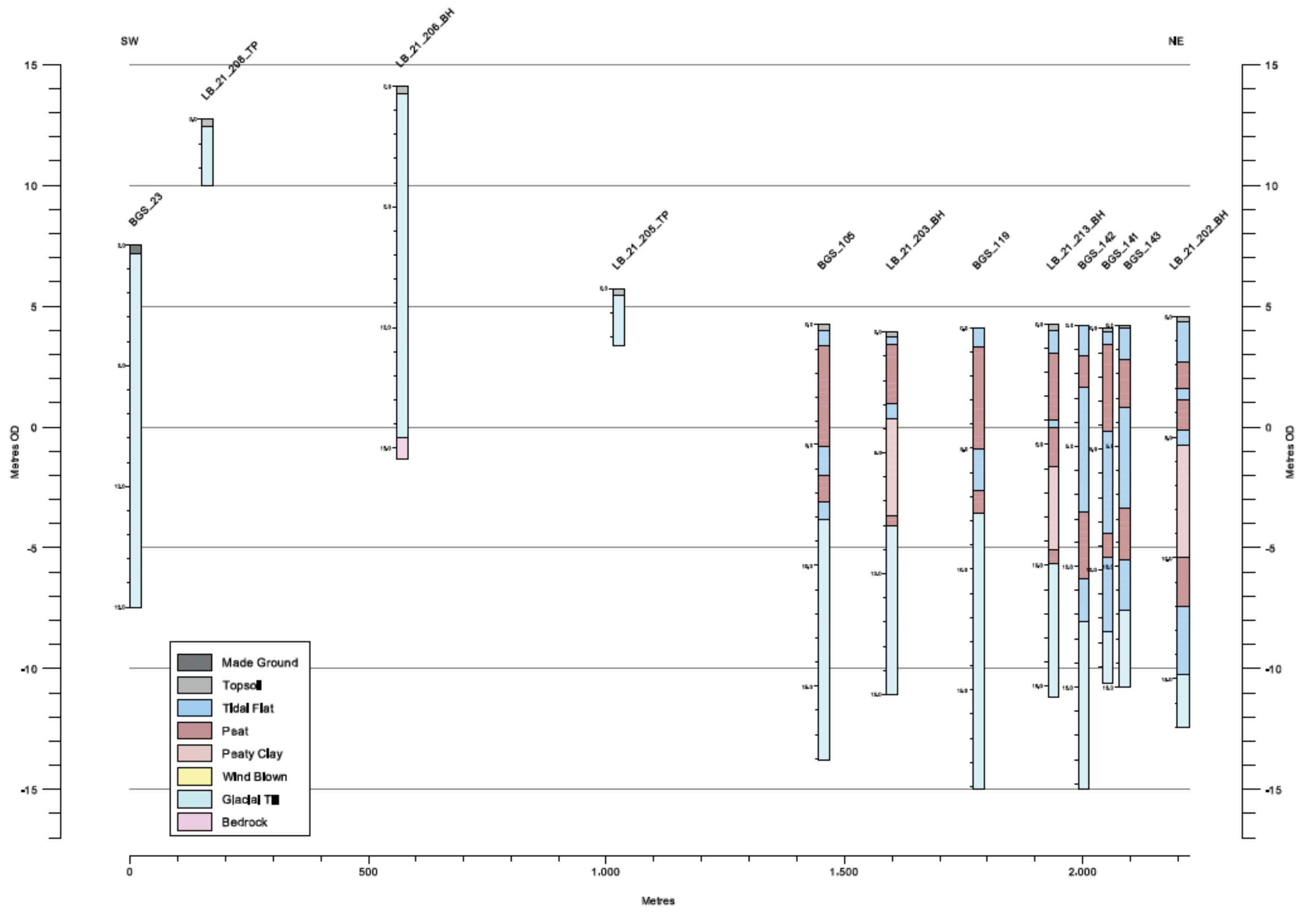

Figure 4: Geoarchaeological Transect 1, Area 1

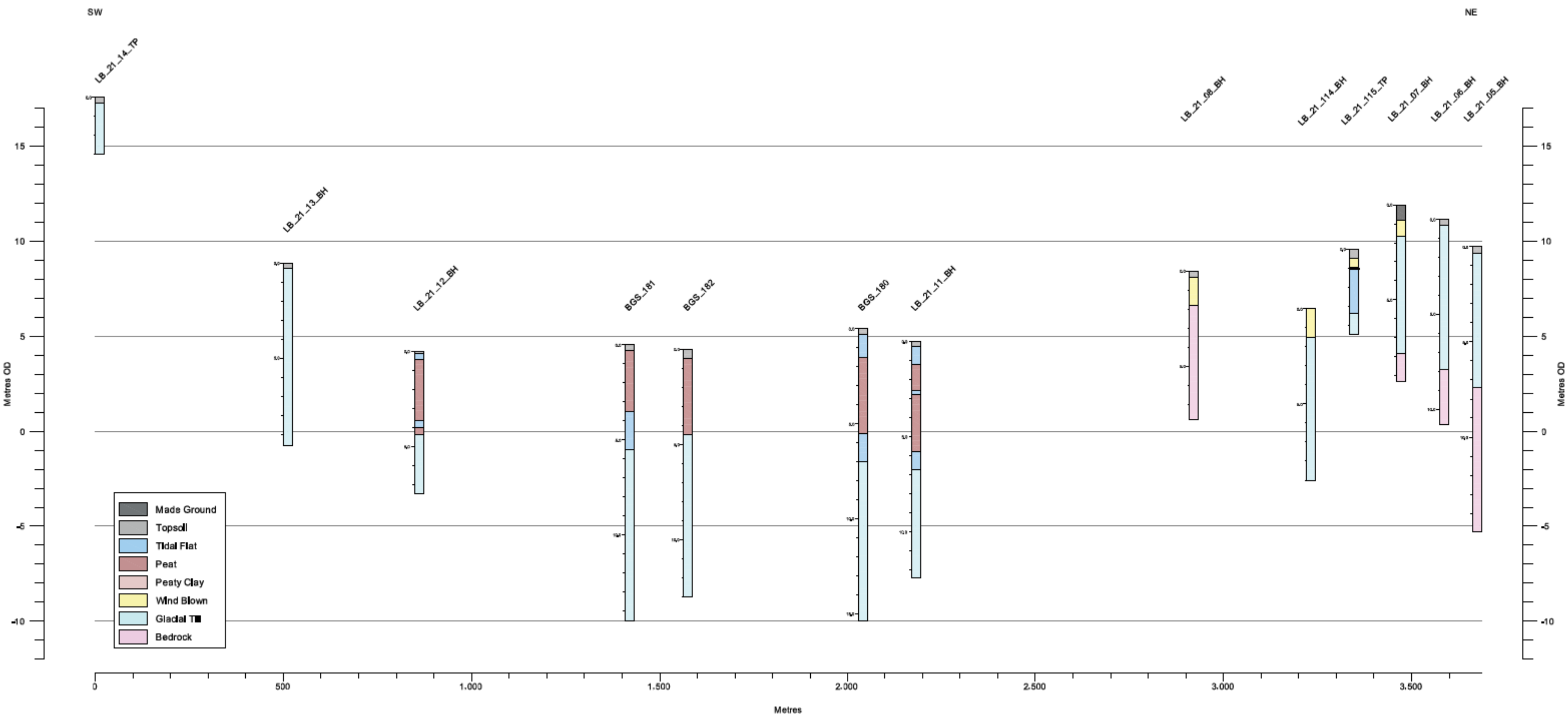

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Figure 5: Geoarchaeological Transect 2, Area 2

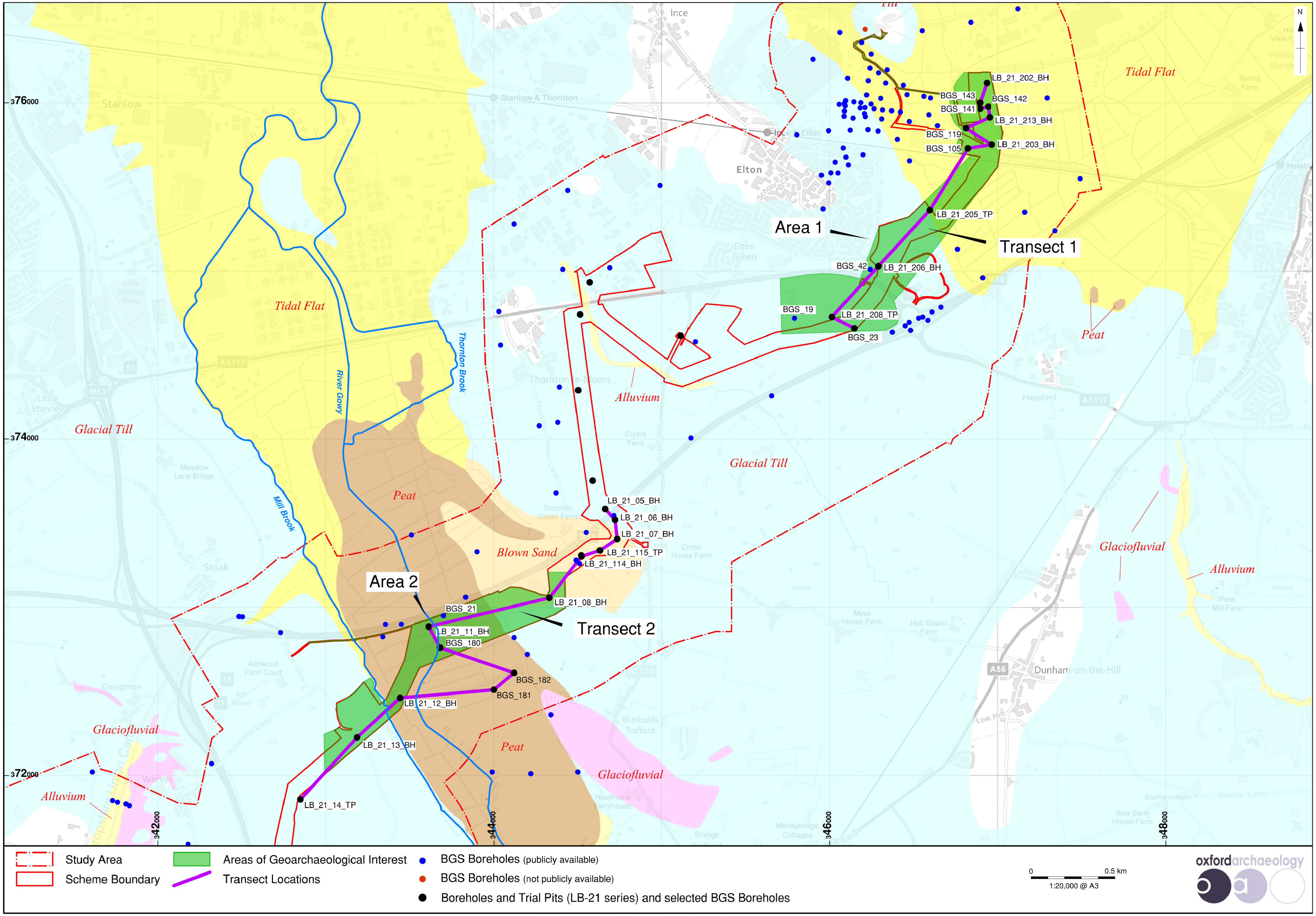


Figure 6a: Superficial geology, Areas 1, 2

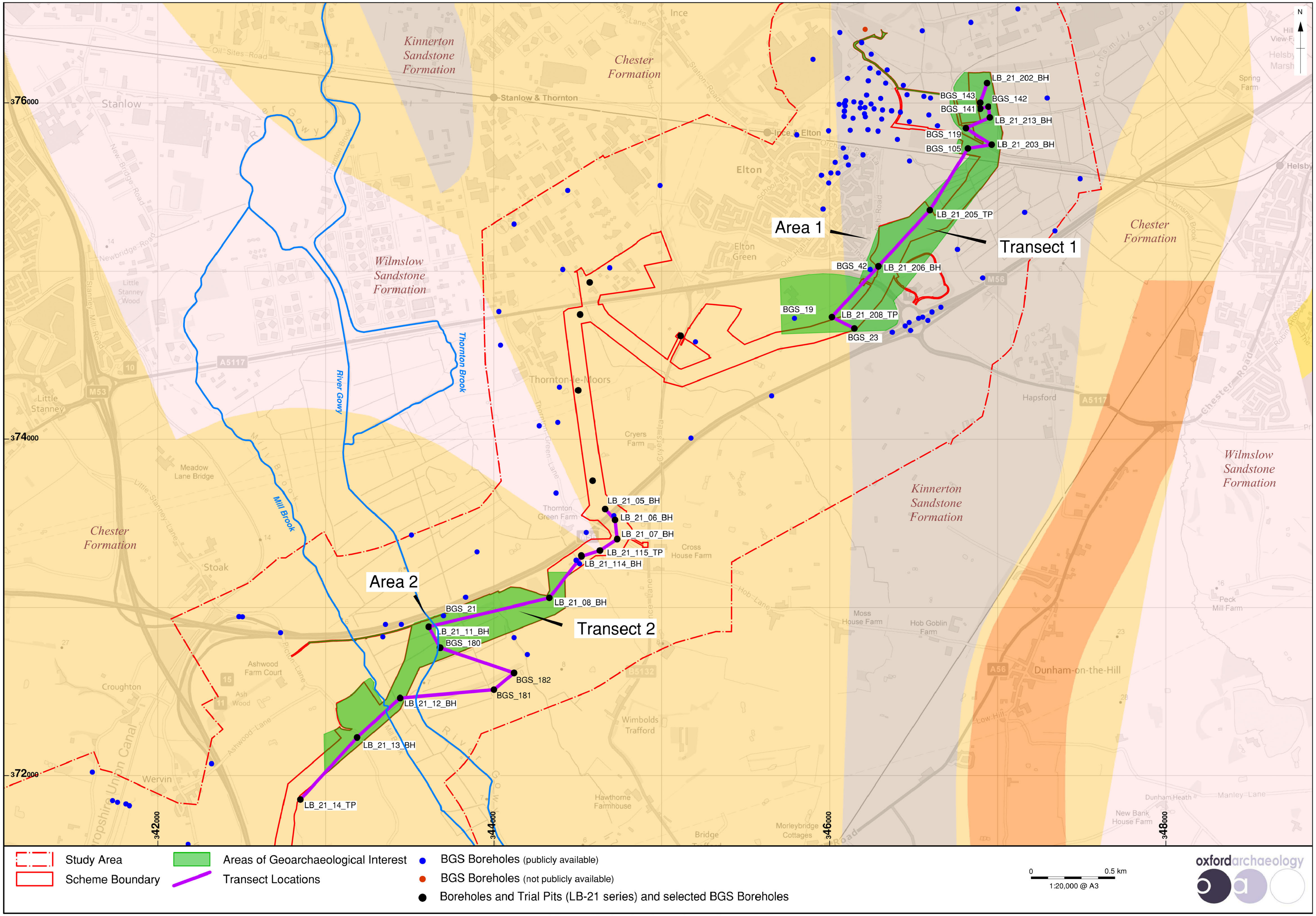
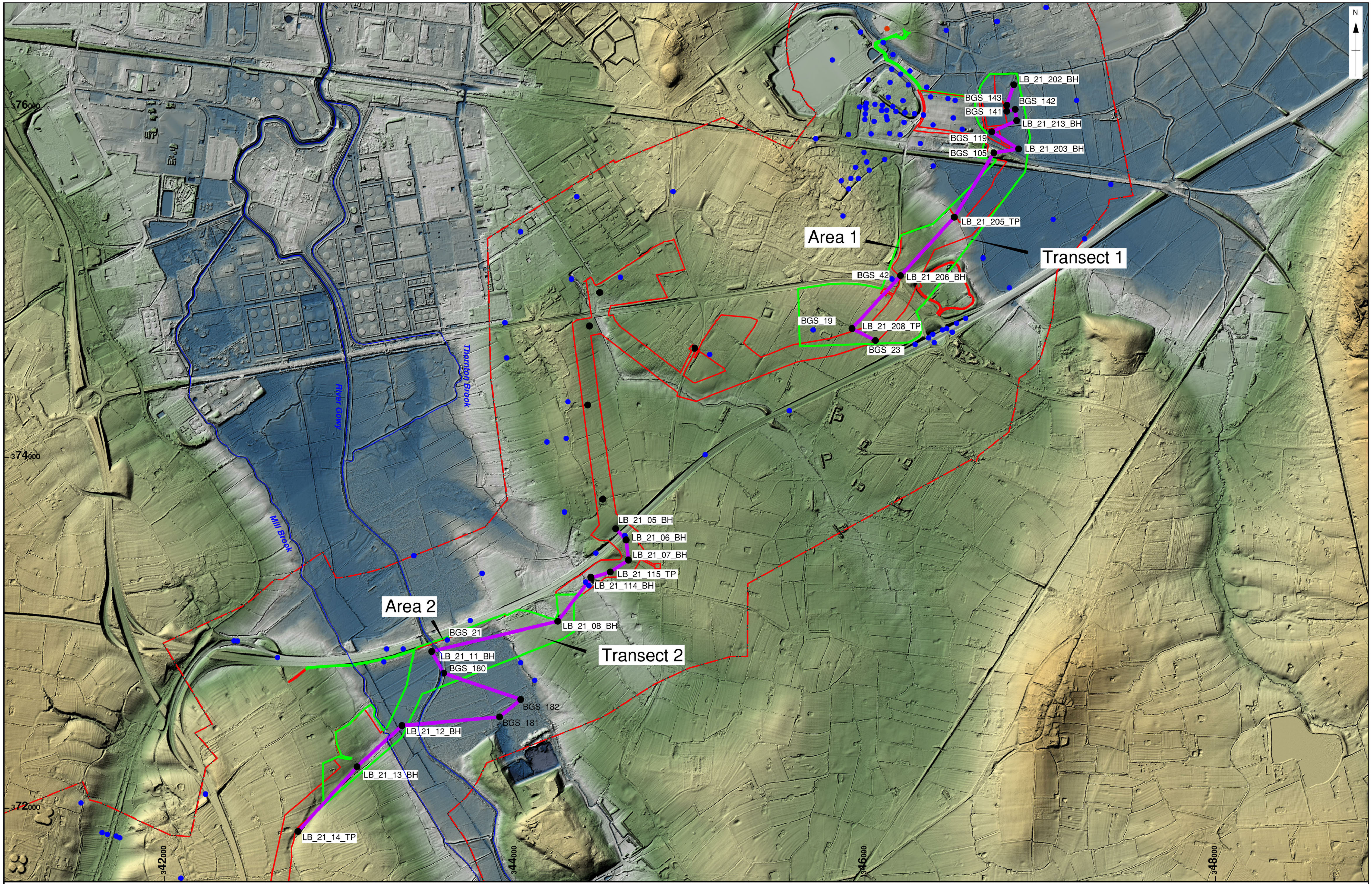


Figure 6b: Bedrock geology, Areas 1, 2



Study Area
Scheme Boundary
Areas of Geoarchaeological Interest
Transect Locations
BGS Boreholes (publicly available)
BGS Boreholes (not publicly available)
Boreholes and Trial Pits (LB-21 series) and selected BGS Boreholes

0 0.5 km
1:20,000 @ A3

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Figure 6c: LiDAR DTM Areas 1 and 2, illustrating elevation (yellow and brown are high ground, green and blue are low) and hillshade (altitude, 45 degrees; vertical exaggeration, x6; azimuth, 315 degrees)

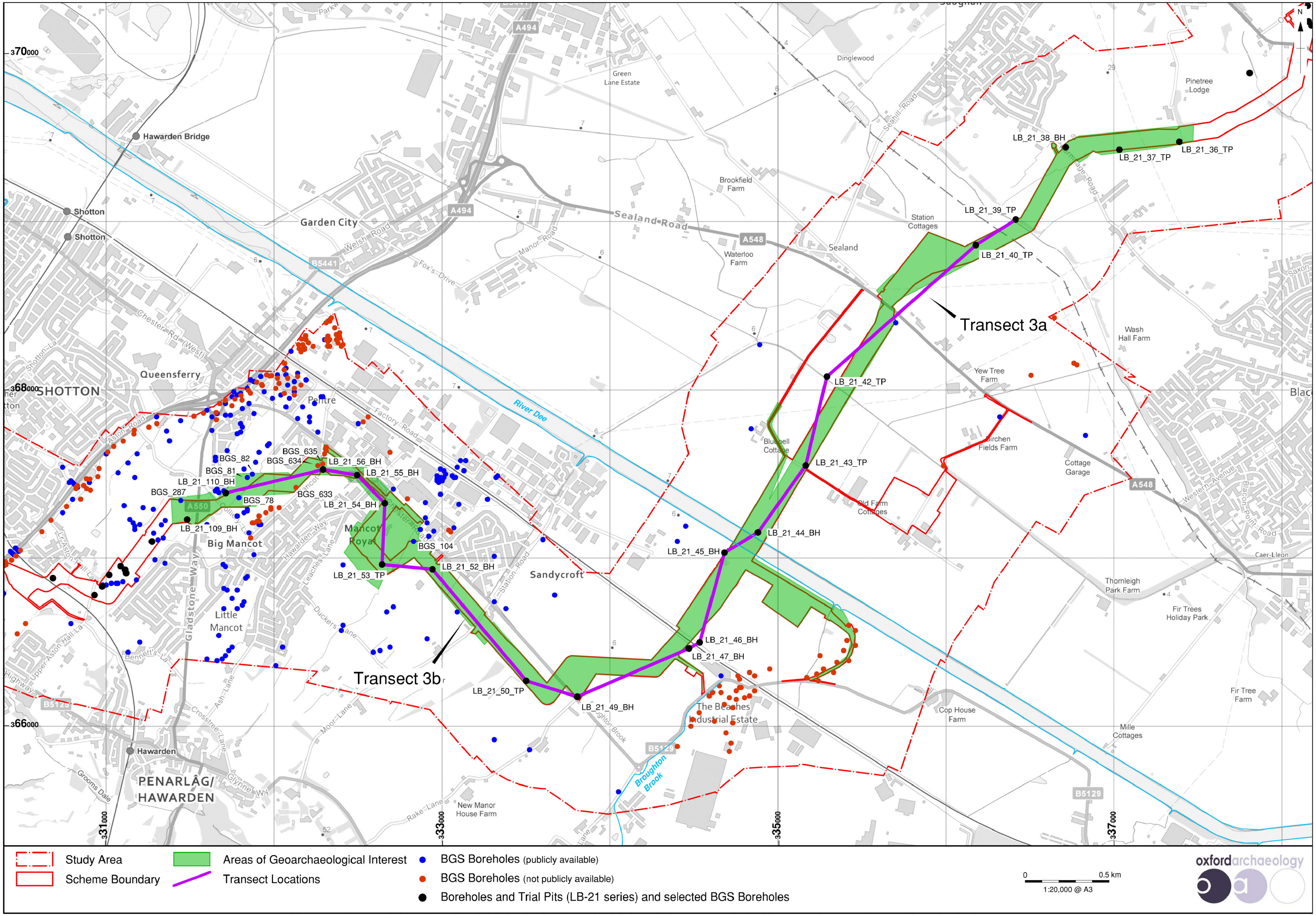

Figure 7: Area 3 (River Dee floodplain), distribution of BGS boreholes, geotechnical interventions and geoarchaeological transects

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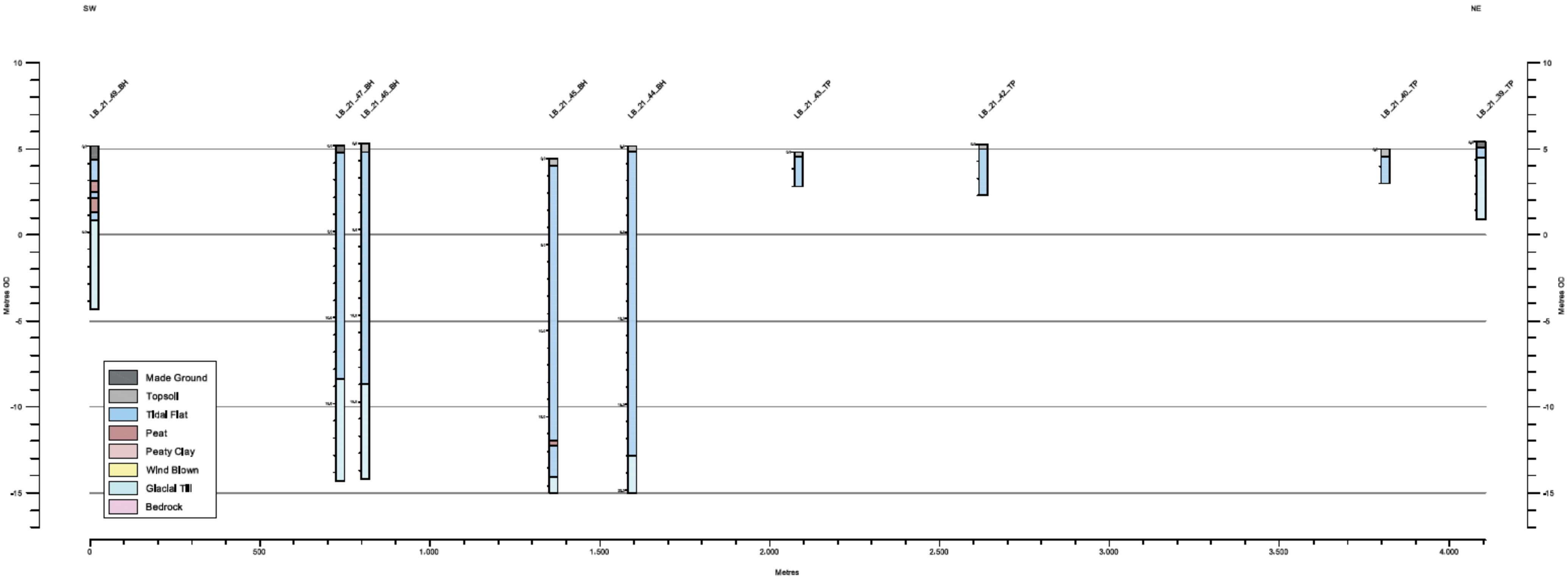

Figure 8: Geoarchaeological Transect 3a, Area 3

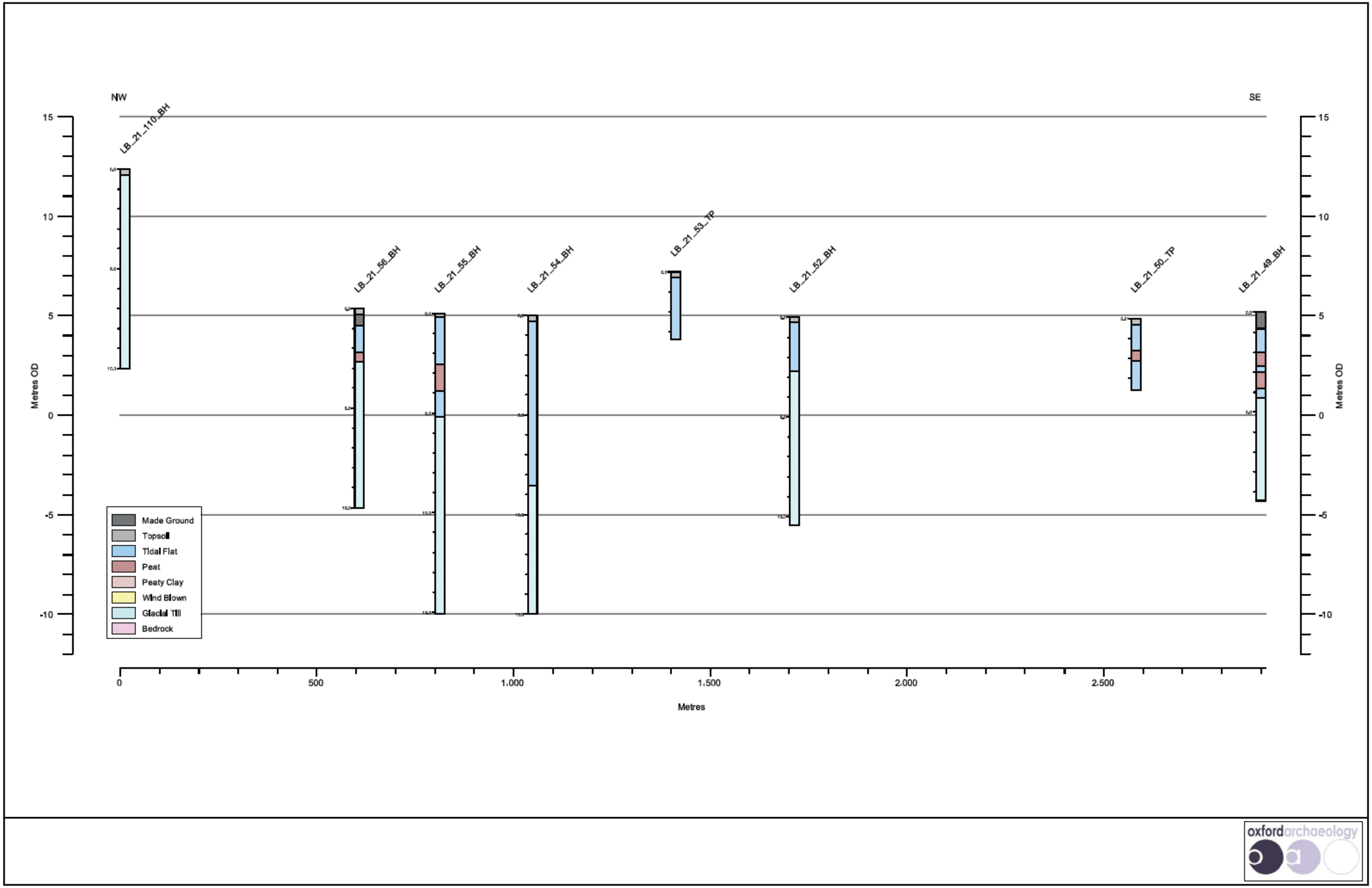

Figure 9: Geoarchaeological Transect 3b, Area 3

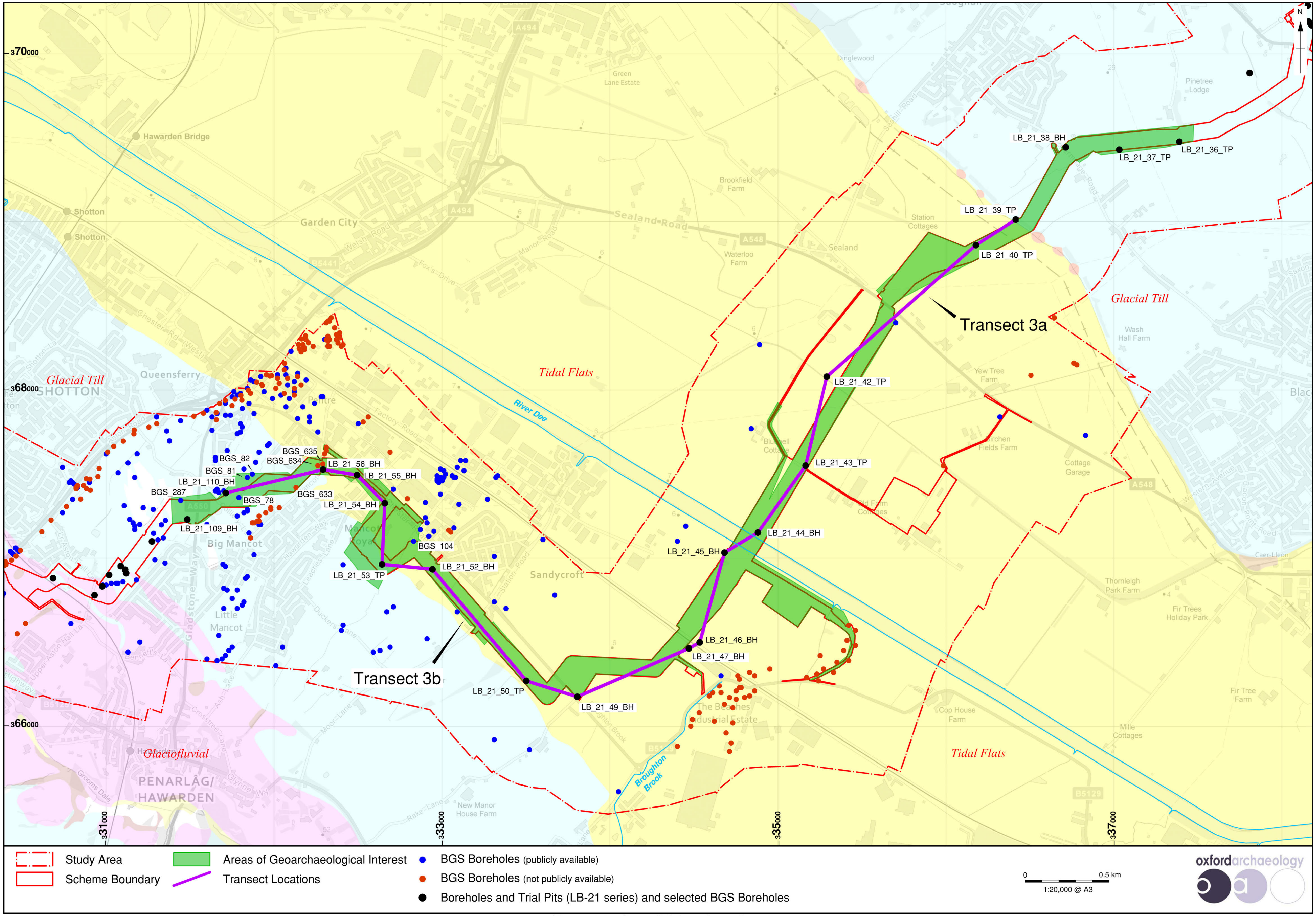

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Figure 10a: Superficial geology, Area 3

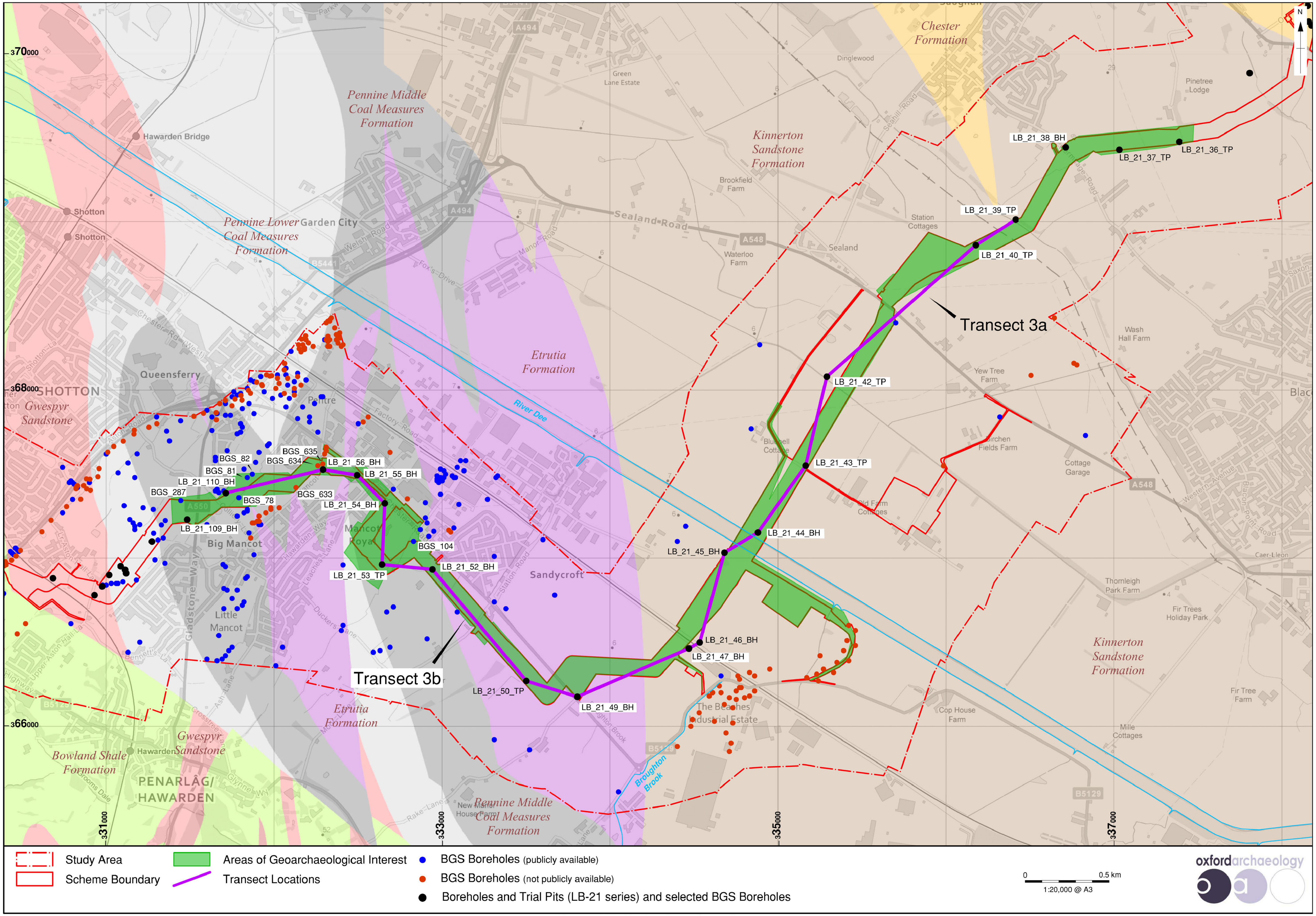

Figure 10b: Bedrock geology, Area 3

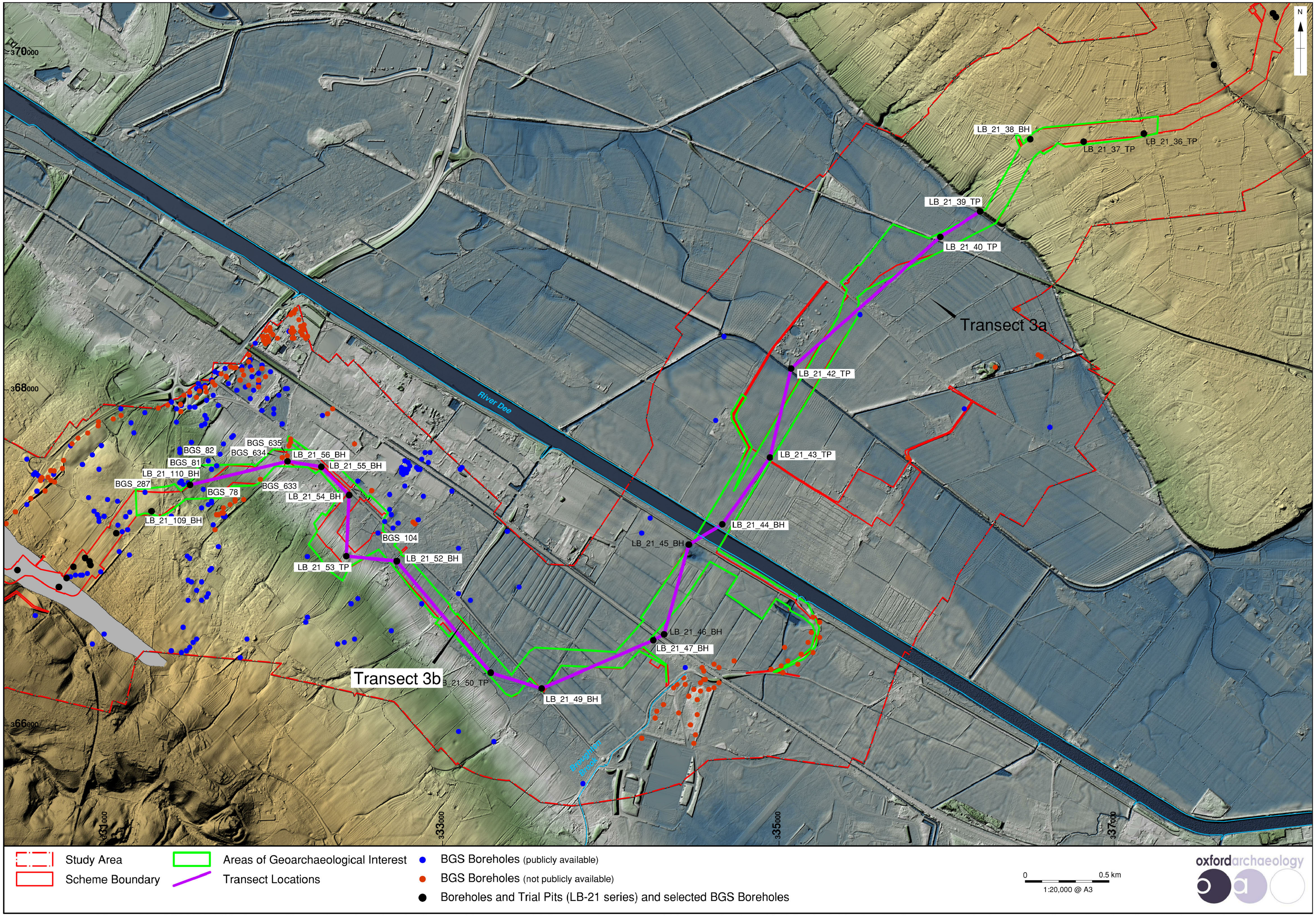

Figure 10c: LiDAR DTM, Area 3, illustrating elevation (yellow and brown are high ground, green and blue are low) and hillshade (altitude, 45 degrees; vertical exaggeration, x6; azimuth, 315 degrees)

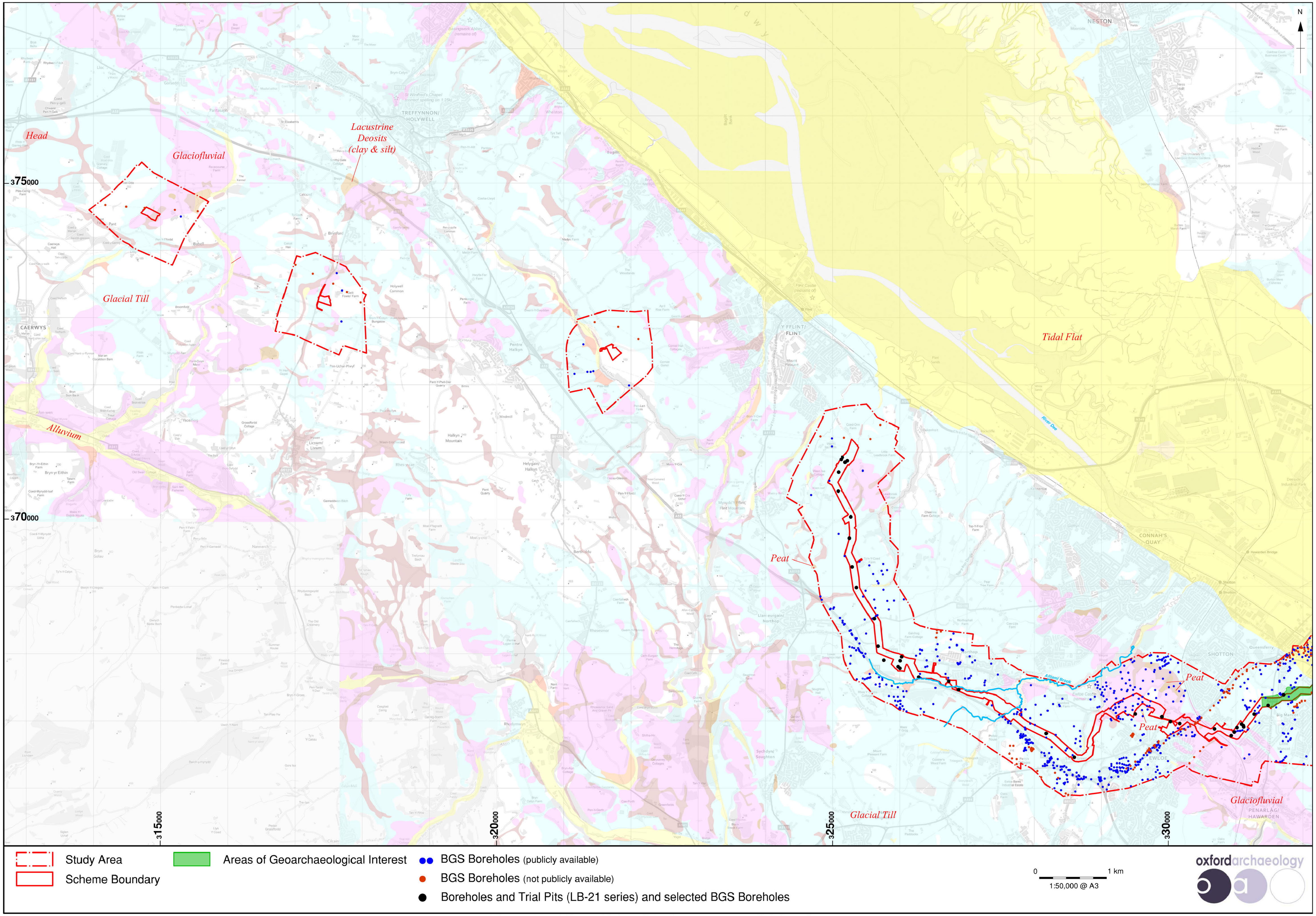

Figure 11a: Flint to Holywell to Caerwys, superficial geology

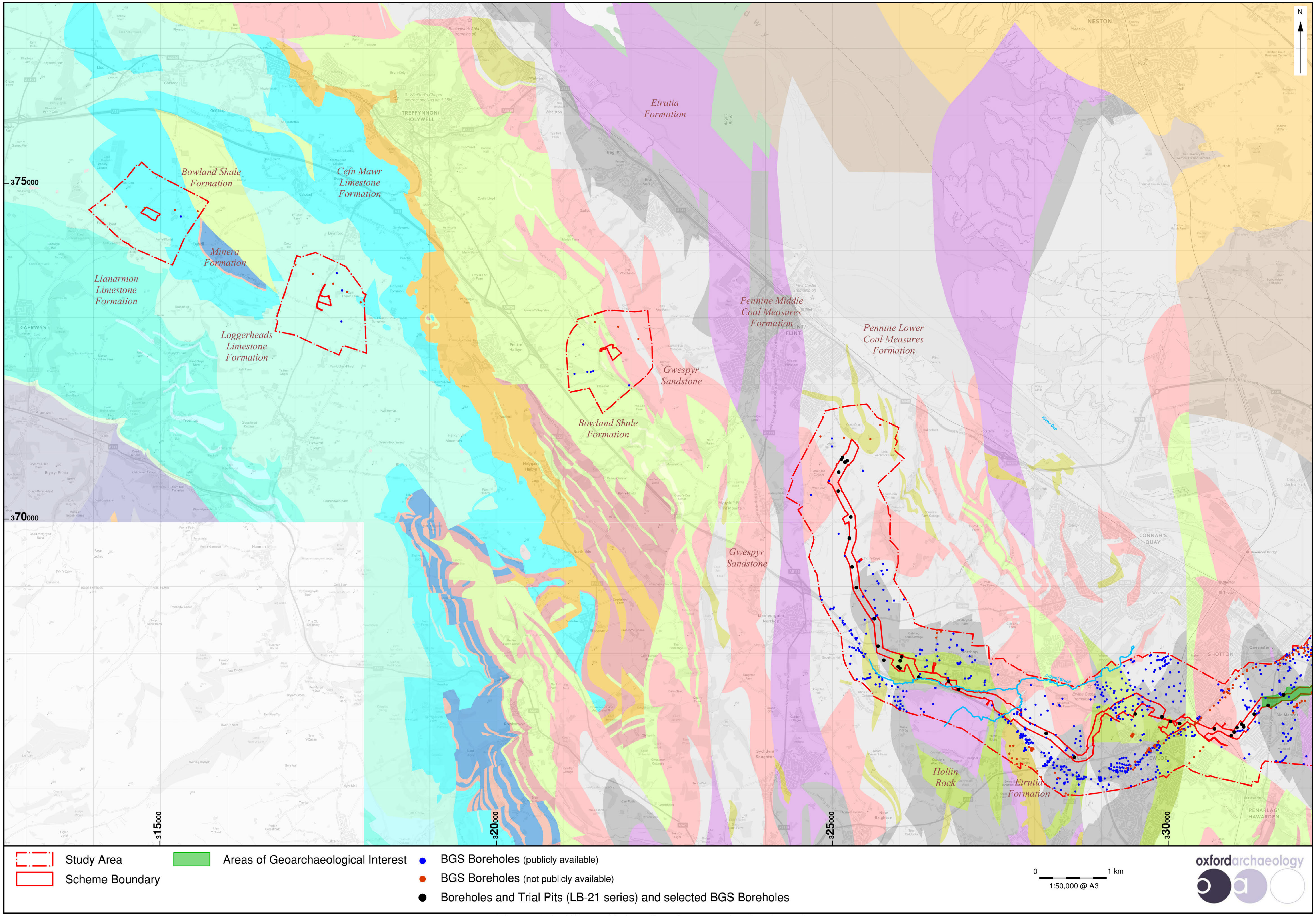

Figure 11b: Flint to Holywell to Caerwys, bedrock geology

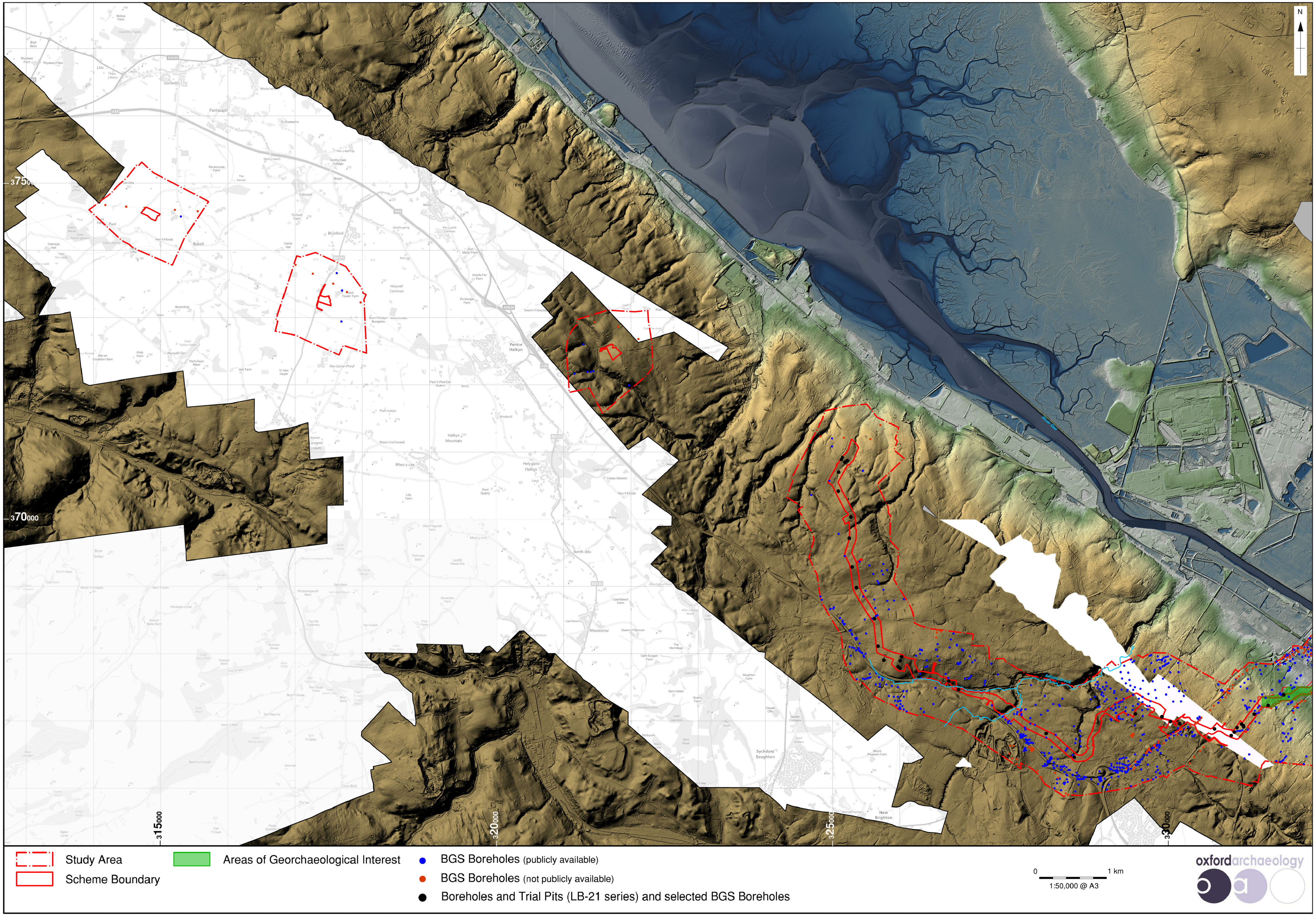

Figure 11c: LiDAR DTM, Flint to Holywell to Caerwys, illustrating elevation (yellow and brown are high ground, green and blue are low) and hillshade (altitude, 45 degrees; vertical exaggeration, x6; azimuth, 315 degrees)