MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

Environmental Statement

Volume 3, Annex 5.4: Geoarchaeological desk based assessment report

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Glossary

Term	Meaning
Chronostratigraphy	The application of time to sequences of rock layers to understand their ages.
Development Consent Order	An order made under the Planning Act 2008 granting development consent.
Ecotonal	Pertaining to a transitional area bridging two or more distinct ecological zones/environments.
Environmental Impact Assessment	The process of identifying and assessing the significant effects likely to arise from a project. This requires consideration of the likely changes to the environment, where these arise as a consequence of a project, through comparison with the existing and projected future baseline conditions.
Environmental Statement	The document presenting the results of the Environmental Impact Assessment process.
Facies	The distinguishable characteristics of a rock, including its chemical, physical and biological features.
Glacio-eustatic	Sea-level change resulting from changes in the volume of terrestrial glacial ice.
Glacio-isostatic	The reactionary movement of land masses following the removal of glacial ice burden.
Geoarchaeological Character Zone	Landscape parcels broadly defined by their geoarchaeological potential.
Historic Landscape Classification	A technique used to classify and present the overarching historic aspects of broadly defined landscape parcels.
Interstadial	A period of slightly warmer climate during a glacial period, associated with reduced ice volumes and the retreat of glaciers.
Intertidal area	The area between Mean High Water Springs and Mean Low Water Springs.
Kettle hole	A depression formed by the melting of a sediment-locked block of isolated ice left behind by a retreating glacier.
Lacustrine	Of or pertaining to lakes.
Littoral	Relating to, or situated on, the shore of a sea or lake.
Marine transgression	A period of rising sea levels in which previously dry land is inundated by seawater and perimarine environments (e.g., saltmarsh) are driven further inland.
Morecambe Offshore Windfarm: Transmission Assets	The offshore export cables, landfall and onshore infrastructure required to connect the Morecambe Offshore Windfarm to the National Grid.

Term	Meaning
Morgan and Morecambe Offshore Wind Farms: Transmission Assets	The offshore and onshore infrastructure connecting the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm to the national grid. This includes the offshore export cables, landfall site, onshore export cables, onshore substations, 400 kV grid connection cables and associated grid connection infrastructure such as circuit breaker compounds. Also referred to in this report as the Transmission Assets, for ease of reading.
Morgan Offshore Wind Project: Transmission Assets	The offshore export cables, landfall and onshore infrastructure required to connect the Morgan Offshore Wind Project to the National Grid.
Ombrotrophic	Peatland surfaces supplied by precipitation rather than groundwater.
Onshore Order Limits	See Transmission Assets Order Limits: Onshore (below).
Palaeoenvironment	Environmental conditions at a given period in the past.
Palaeotopography	Surface relief at a given period in the past.
Palustrine	Of or pertaining to freshwater wetland dominated by vegetation (i.e., swamps, marshes, bogs, etc).
Perimarine	Of or pertaining to terrestrial areas near a marine interface, often experiencing partial and/or periodic inundation, e.g., saltmarshes.
Stadial	A period of cold climate during a glacial period, associated with ice accumulation and the advance of glaciers.
Transmission Assets	See Morgan and Morecambe Offshore Wind Farms: Transmission Assets (above).
Transmission Assets Order Limits: Onshore	The area within which all components of the Transmission Assets landward of Mean High Water Springs will be located, including areas required on a temporary basis during construction and/or decommissioning (such as construction compounds). Also referred to in this report as the Onshore Order Limits, for ease of reading.

Acronyms

Acronym	Meaning
BGS	British Geological Survey
BP	Before Present
bp	bp Alternative Energy investments Ltd.
cal BP/BCE	calibrated years Before Present/Before Common Era (used in radiocarbon dating)
CE/BCE	Common Era/Before Common Era
DBA	Desk-Based Assessment
ES	Environmental Statement
GCZ	Geoarchaeological Character Zone

Acronym	Meaning
GI	Geotechnical/Ground Investigations
HNDR	Holistic Network Design Review
NWWS	North West Wetlands Survey
OA	Oxford Archaeology
OD	Ordnance Datum
OS	Ordnance Survey
OWL	Offshore Wind Limited
PEIR	Preliminary Environmental Information Report
UK	United Kingdom

Units

Unit	Description
ha	Hectare
km	Kilometres
km^2	Kilometres squared
m	Metre
ma	Million years ago
mbgl	Metres below ground level
nm	Nautical mile

1 Geoarchaeological desk based assessment report

1.1 Introduction

1.1.1.1 This document forms Volume 3, Annex 5.4 of the Environmental Statement (ES) prepared for the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (referred to hereafter as 'the Transmission Assets'). The ES presents the findings of the Environmental Impact Assessment process for the Transmission Assets. This document provides a high-level geoarchaeological desk based assessment (DBA) for the Transmission Assets.

1.1.2 The Morgan and Morecambe offshore wind farms

1.1.2.1 Morgan Offshore Wind Limited (Morgan OWL), a joint venture between bp Alternative Energy investments Ltd. (bp) and Energie Baden-Württemberg AG (EnBW), is developing the Morgan Offshore Wind Project. The Morgan Offshore Wind Project is a proposed wind farm in the east Irish Sea.

1.1.2.2 Morecambe Offshore Windfarm Limited (Morecambe OWL), a joint venture between Zero-E Offshore Wind S.L.U. (Spain) (a Cobra group company) (Cobra) and Flotation Energy Ltd., is developing the Morecambe Offshore Windfarm. The Morecambe Offshore Windfarm is also located in the east Irish Sea.

1.1.2.3 Both the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm have been awarded licences during the Crown Estate's Offshore Wind Leasing Round 4 process.

1.1.3 Project details

1.1.3.1 This report has been prepared by Oxford Archaeology (OA) on behalf of the Applicants, in relation to the Transmission Assets. Further background and details on the Transmission Assets are included within Volume 1, Chapter 3: Project description of the ES.

1.1.3.2 The report sets out a high-level geoarchaeological DBA for the Transmission Assets and should be read in conjunction with Volume 3, Chapter 5: Historic environment of the ES.

1.1.3.3 The Applicants provided an initial brief to undertake a geoarchaeological DBA as part of the Preliminary Environmental Information Report (PEIR), principally due to the potential for encountering waterlogged organic/peat deposits along the route of the Transmission Assets (e.g., at Lytham Moss), along with deep sediment sequences and associated edge environments along the Ribble Estuary. For the purposes of the ES, the initial geoarchaeological DBA presented in the PEIR has subsequently been updated to reflect the defined extent of the Transmission Assets Order Limits: Onshore (hereafter 'Onshore Order Limits') along with recent information derived from project specific geotechnical borehole data. The more extensive area previously assessed, however, has been retained along with its constituent Geoarchaeological Character Zones (GCZs) as it provides important contextual information, and is referred to hereafter as the 'wider study area'.

1.1.3.4 A Written Scheme of Investigation was first prepared to outline how this assessment would be carried out (OA, 2023a), to which this report subsequently conforms. All work for this geoarchaeological DBA has been undertaken in accordance with the Chartered Institute for Archaeologists' *Code of Conduct: Professional Ethics in Archaeology* (CIfA, 2022) and relevant *Standards and Guidance* (CIfA, 2020), Historic England's *Management of Research Projects in the Historic Environment: The MoRPHE Project Managers' Guide* (Historic England, 2015a), and guidance specific to geoarchaeology (Historic England, 2015b; 2020).

1.1.4 Location

1.1.4.1 The Transmission Assets are located on the south west coastal plain of the Fylde peninsula, Lancashire (see **Figure 1.1**). The Onshore Order Limits are located within the local authority areas of Fylde Council, Blackpool Council, South Ribble Borough Council, Preston City Council and Lancashire County Council. The Onshore Order Limits and wider study area (see **paragraph 1.1.3.3**) are shown on **Figure 1.1**.

1.1.4.2 The Onshore Order Limits of the Transmission Assets follow a broadly linear route beginning at the coastline at Starr Hills dunes immediately south of Blackpool and north of Lytham St Annes, before heading eastward through the site of Blackpool Airport and across mixed agricultural land towards High Ballam. Thereafter, the route continues south of Moss Side Station and on to the east above Warton and Freckleton. The Onshore Order Limits then broaden to the north east to encompass land lying between Freckleton and Kirkham to the east of Kirkham Road. The eastern portion of the Onshore Order Limits follows the north side of the inner Ribble estuary, crossing to the south side of the river towards Hutton, although the wider study area extends across most of the inner Ribble estuary east of Freckleton Naze and the confluence of the River Douglas, up to the western fringe of Preston itself.

1.1.4.3 The eastern portion of the Onshore Order Limits also incorporates areas of higher ground surrounding the Ribble estuary, on the north bank between the wider estuary and the course of the Savick Brook, and on the south bank near Penwortham and Howick Cross, including the National Grid substation at Penwortham itself.

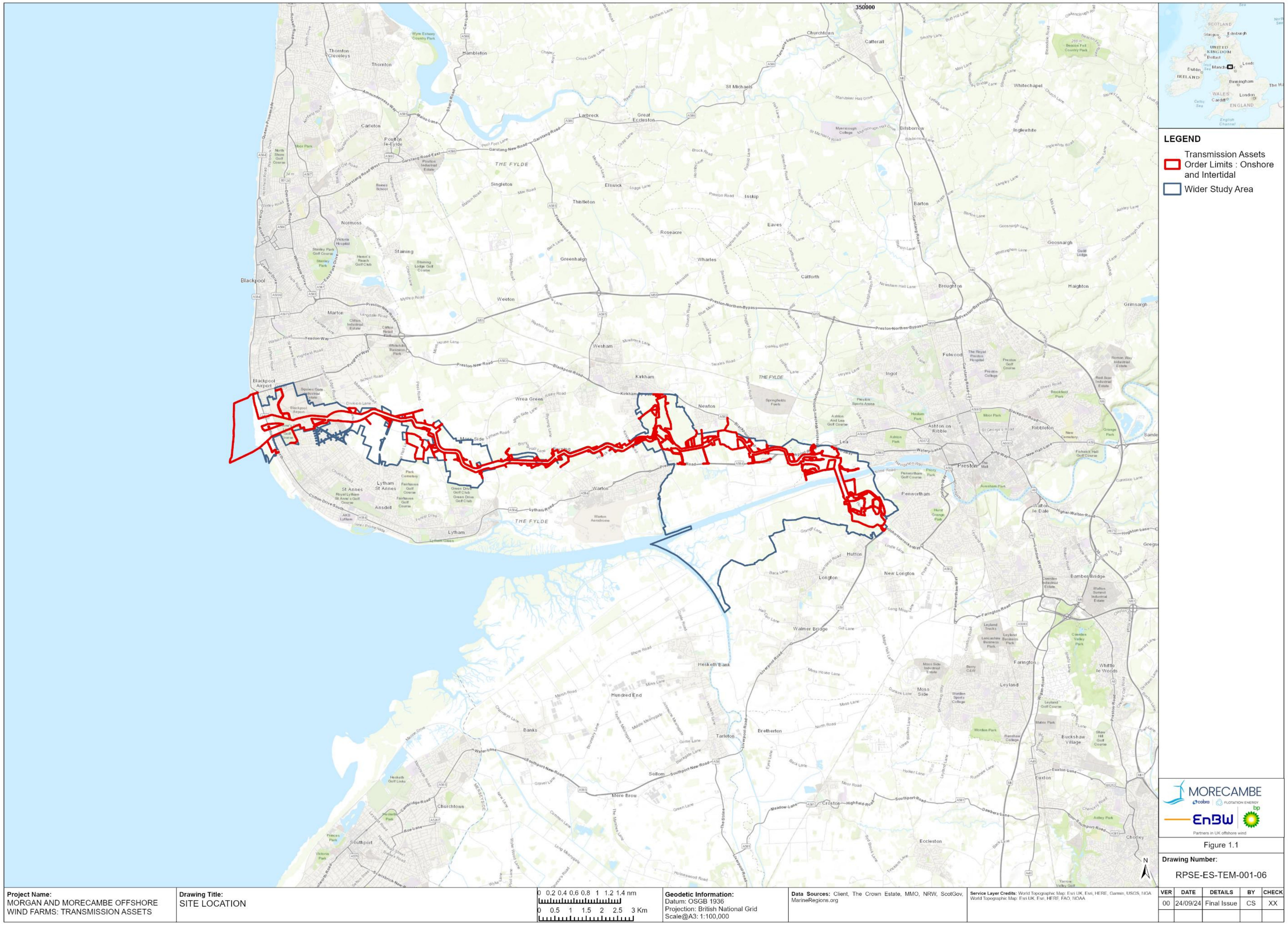

Figure 1.1: Site location

1.1.5 Geoarchaeological background

1.1.5.1 A separate overarching archaeological and historical desk based assessment has been prepared for the Transmission Assets in Volume 3, Annex 5.1: Historic environment desk-based assessment of the ES. The following geoarchaeological background section does not seek to replicate that report, but provides a more regional overview regarding the general character and burial conditions to be anticipated, with a particular focus on palaeotopography and environments of deposition.

1.1.5.2 This geoarchaeological DBA, along with an intertidal walkover survey (OA, 2023b), has been incorporated into Volume 3, Chapter 5: Historic environment of the ES.

1.1.5.3 Several large archaeological landscape and palaeoenvironmental studies have previously been carried out in the vicinity of the Transmission Assets, which together provide key context for the wider region (**Figure 1.2**). Foremost amongst these are the North Lancashire components of the North West Wetlands Survey (Middleton *et al.,* 1995) and the Aggregates Levy Sustainability Fund Aggregate Extraction project in the Lower Ribble Valley conducted by Oxford Archaeology and the University of Liverpool (Quartermaine, 2007; 2008). Further developer-funded projects addressing geoarchaeological themes include the Preston Western Distributor and East/West Link Road (Rutherford, 2019). Additional background is provided by various British Geological Survey (BGS) publications (e.g., Cripps *et al.,* 2016), coastal surveys, and sea-level studies (e.g., Fitch and Gaffney, 2011, **Figure 1.3** and **Figure 1.4**).

1.1.5.4 A number of historic boreholes have also been sunk within 1 km of the Onshore Order Limits (*cf.* BGS, 2023). For example, a study of 25 boreholes arranged linearly from the high-water mark at Starr Hills dunes inland towards Hey Houses identified a sequence of biogenic (peat and organic clay) deposits intercalated between clays, silts and sands of marine and estuarine origin. Other boreholes sunk across an approximately 22 km^2 area north of Lytham St Annes similarly indicated a sequence of past marine transgressive episodes, all but one of which lay at -4 m Ordnance Datum (OD) or above, and which dated from the early Mesolithic to the medieval period (Tooley, 1974).

1.1.5.5 There is evidence to suggest that human communities were active across south central Lancashire throughout the Palaeolithic and Mesolithic periods. One of the most famous local finds is that of the ‘Poulton Elk’ near Poulton-le-Fylde, approximately 8.5 km to the north of the wider study area, which appears to have been injured and pursued by hunters before drowning beyond their reach whilst attempting to swim to safety some 15,500-13,500 years ago (Hallam *et al.* 1973; Jacobi *et al.,* 1986).

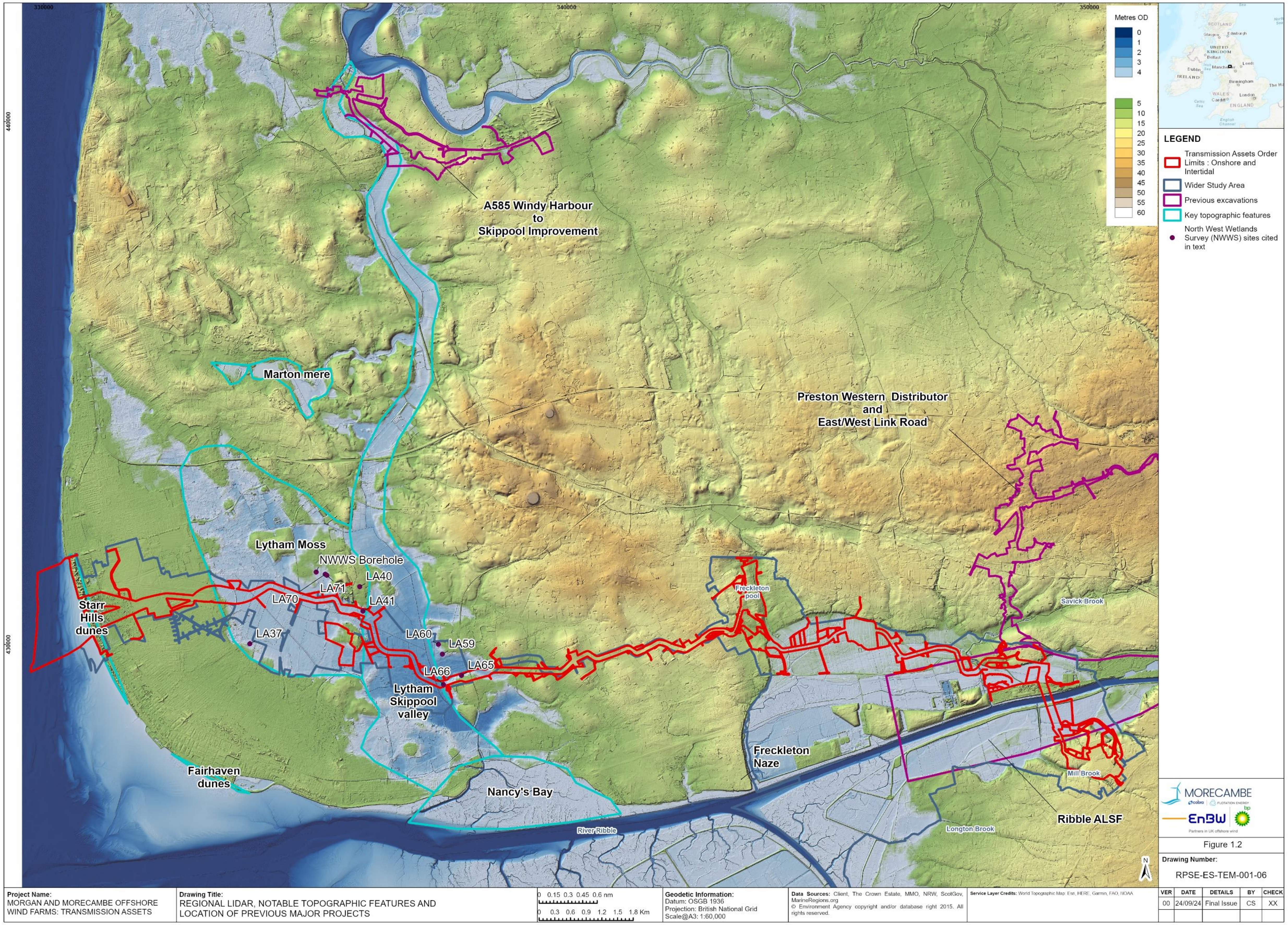

Figure 1.2: Regional LiDAR, notable topographic features and location of previous major projects

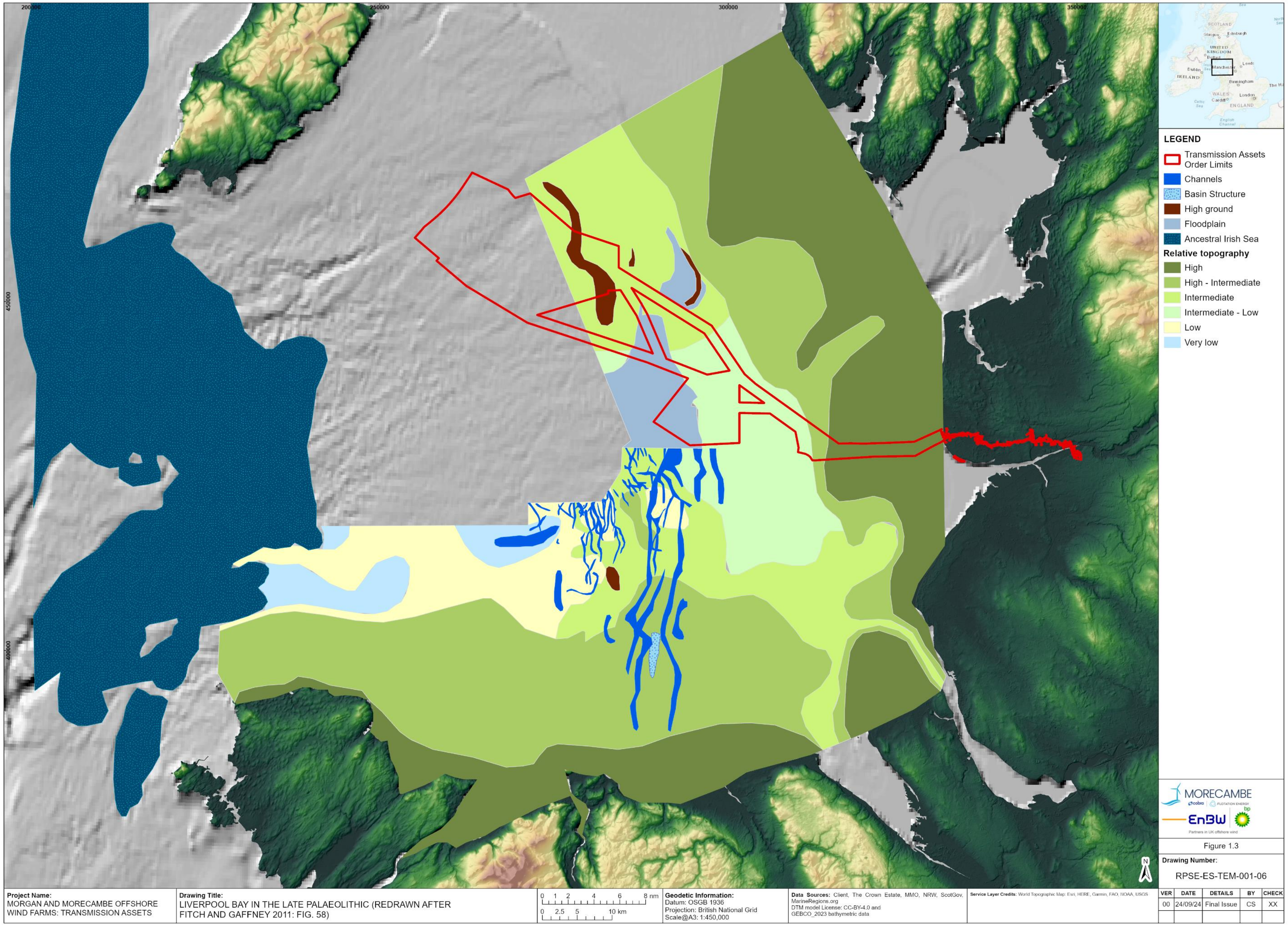

Figure 1.3: Liverpool Bay in the Late Palaeolithic (redrawn after Fitch and Gaffney 2011: Fig. 58)

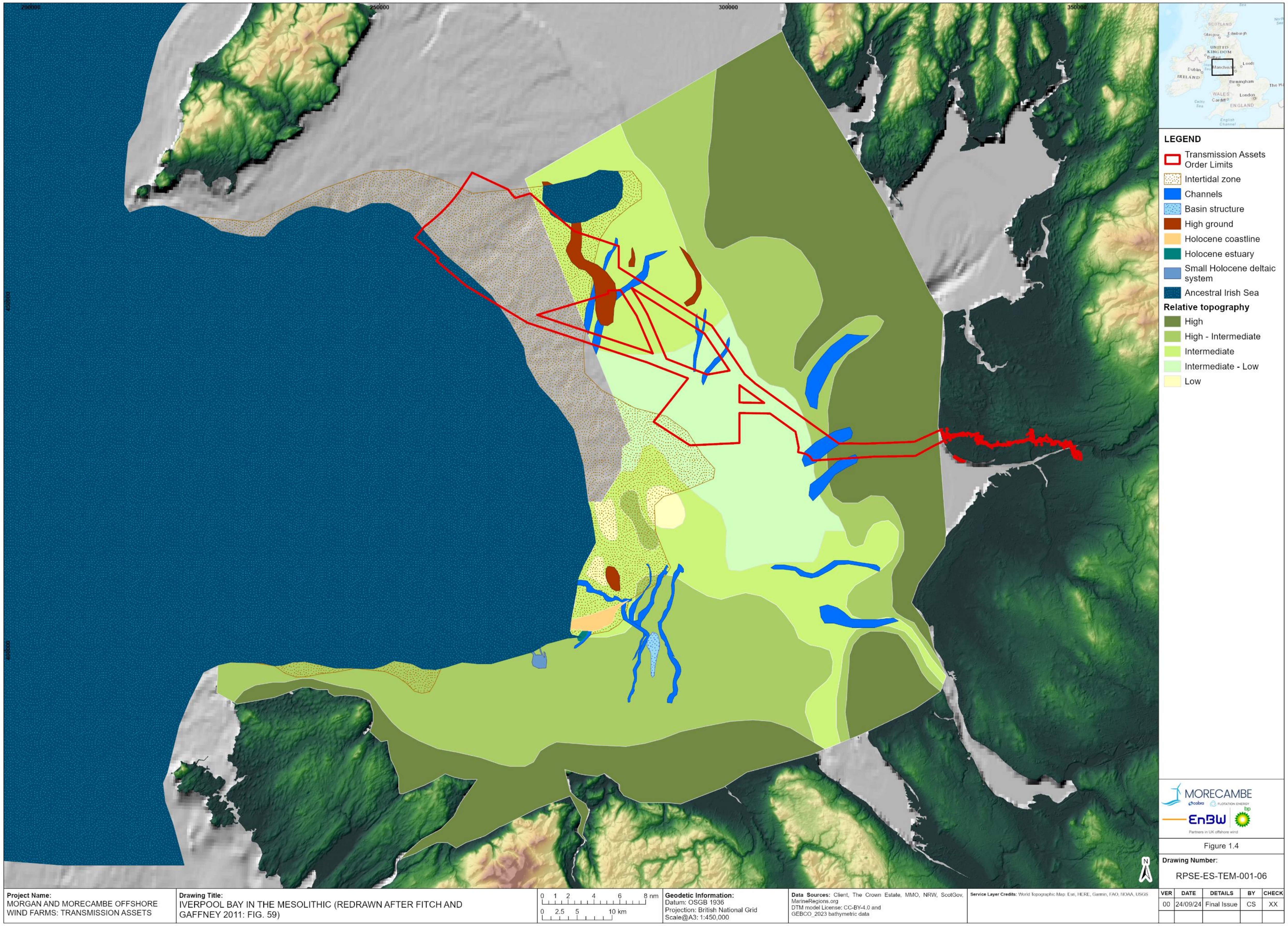

Figure 1.4: Liverpool Bay in the Mesolithic (redrawn after Fitch and Gaffney DTM model License: CC-BY-4.0 2011: Fig. 59)

1.1.5.6 Sites around Little Crosby near Liverpool, approximately 30 km south of the Transmission Assets, have also returned lithics dating from the late Upper Palaeolithic to late Mesolithic periods, in what was then a landscape transitioning from dune slack wetlands to freshwater swamps and fens (ARS, 2011). Mesolithic footprints (of both humans and other animals) have also been found preserved within former saltmarsh muds underlying contemporary beach sands at nearby Formby (Huddart *et al.,* 1999; Roberts, 2009). A Mesolithic antler mattock was also found on the bank of the River Ribble in 1992 (ARS, 2011; HER ref. MLA13244L).

1.1.5.7 Further evidence for human activity continues throughout the Neolithic period, Bronze Age and Iron Age, though Iron Age occupation of the Fylde peninsula itself appears relatively slight (*cf.* Chiti, 2004; Middleton *et al.,* 1995). The Ribble Valley is likely to have been an important communication route throughout those periods, providing access to a wide range of ecologies between the Pennine uplands and the low-lying wetlands of the Fylde. The Lytham-Skippool palaeo-valley forms a particularly notable feature within the regional landscape, connecting as it does the estuary of the River Ribble with the River Wyre to the north (**Figure 1.2**). Within the latter river valley, previous work by OA as part of the A585 Windy Harbour to Skippool Improvement scheme discovered well preserved Mesolithic and Neolithic archaeology within waterlogged peat deposits adjacent to the wetland edge (Highways England, 2018). Bronze Age dugout canoes were also retrieved from the Ribble during improvement works on Preston Docks (HER ref. PRN1410L), whilst other, as yet undated prehistoric logboats have been found within waterlogged deposits nearby (ARS, 2011; McGrail, 1978). There are also signs of more settled occupation occurring throughout later prehistory. For instance, a sand island at Lower Brockholes quarry, approximately 7 km to the east of the Onshore Order Limits, appeared to have been occupied during the Bronze Age, whilst the undated remains of several circular timber buildings (characteristic of indigenous architecture between the Bronze Age and Roman periods) have been identified at Preston East and Poulton-le-Fylde, respectively *c.* 6 km to the east and *c.* 8.5 km north of the Transmission Assets (S. Rowland pers. comm., 2023).

1.1.5.8 Roman activity is rather more apparent throughout south central Lancashire, though there is little firm evidence for extensive settlement in the immediate vicinity of the Ribble estuary itself. However, military forts were erected at Dowbridge (to the immediate north of the Onshore Order Limits, on the eastern edge of Kirkham) and Ribchester (some 16 km to the north east), whilst industrial activity has been identified at Walton-le-Dale (5.5 km to the east, to the immediate south east of Preston itself). Such installations were connected by an extensive transport network, including a major road between Kirkham and Ribchester. An extension of this road towards the Wyre beyond Poulton-le-Fylde has been posited, though its existence remains entirely conjectural at present (ARS, 2011; Chiti, 2004; Middleton *et al.,* 1995). However, nineteenth century reports of a short section of Roman road near Fleetwood at the mouth of the Wyre, alongside two other Fleetwood sites of possible Roman date, do suggest a Roman presence in the immediate area, albeit a relatively slight one (ARS, 2011; Watkin, 1883). A hoard of 120 Roman coins dating from 276-282 CE was also found near

Worden Hall (at Leyland, 8 km to the south west of the Transmission Assets) in 1850, and another from the peatlands of Longton Moss in 1819 (Middleton *et al.,* 2013).

1.1.5.9 Early medieval finds/sites across the south central Lancashire coastline are particularly sparse, though records attest to a growth in ecclesiastical establishments throughout the later medieval period. The largest of these was Tulketh Abbey, founded as a Savigniac monastery in 1124 CE within what is now Preston, with other priories and historic churches being dotted across the region. There was once also a motte-and-bailey castle at Tulketh Hall, whilst parts of Penwortham Castle still survive within St Mary's Churchyard, Preston (ARS, 2011). The remains of medieval field systems are also found across the Lancashire coastal plains (see Historic England, 2023). Whilst many medieval rural settlements continue to be inhabited today, there is one deserted village site located at Hightown, just north of Liverpool (ARS, 2011). Many of these settlements and field systems expanded in both complexity and spatial extent throughout the post-medieval period, with later ridge-and-furrow agricultural earthworks remaining evident across the modern landscape (ARS, 2011; Historic England, 2023).

1.2 Aims and methodology

1.2.1 Research context

1.2.1.1 This geoarchaeological DBA was commissioned to investigate the potential survival of below ground waterlogged deposits (including peat), as well as the palaeotopography, hydrology and edge environments associated with the Lytham-Skippool Valley, the lower Ribble, and its estuary (*cf.* OA, 2023a). The results of these investigations have the potential to contribute towards a number of research priorities identified by the North West Regional Research Framework (Research Frameworks, 2023), in particular the following Prehistory (PH) Research Questions:

- PH02: How effective has the North West Wetlands Survey been as a planning and research tool?
- PH04: How can we enhance existing datasets for prehistory in the region?
- PH17: How can a programme of sampling and investigation help to characterise landscape use of the wetlands during the prehistoric period?
- PH18: What can palaeoenvironmental analysis of buried soils tell us about prehistoric environments?
- PH19: How can we best capture data for the palaeoenvironment in prehistory?
- PH25: How can we better understand the distribution of prehistoric archaeology across the landscape?
- PH26: What was the changing nature of the relationships between people and their environment during the prehistoric period?

1.2.2 Aims of the geoarchaeological assessment

1.2.2.1 The principal objective of this geoarchaeological DBA is to provide high-level baseline data on the palaeotopography, sedimentary sequences and associated environments of deposition likely to be encountered across the Transmission Assets, and to discuss their geoarchaeological and palaeoenvironmental potential.

1.2.2.2 This geoarchaeological DBA is the first element of an iterative, multi-stage process, and as such has five basic aims:

- to contribute to a more detailed understanding, both locally and regionally, of extant sediment sequences, geomorphological features and their archaeological potential;
- to employ palaeotopographical inferences and associated data to identify specific areas considered to have high potential for the preservation of archaeological and palaeoecological remains within stratified sediment sequences (e.g. wetland ecotonal zones), and to consider the associated environments of deposition and their potential taphonomic conditions;
- to provide baseline data to contextualise any future quantitative deposit modelling based on project-specific Ground Investigations (GI) data and/or archaeological evaluation trenching;
- to provide baseline data that will feed into an integrated archaeological and palaeoenvironmental landscape model developed throughout the duration of the Transmission Assets, culminating in a more detailed understanding of cultural and natural landscape relationships across the proposed site; and
- in the longer term, to contribute to a better understanding of the value of geoarchaeological work within the regional planning process.

1.2.3 Methodology

1.2.3.1 The overarching project aims have been addressed within the parameters of this geoarchaeological DBA through the following tasks:

- the review of published geoarchaeological and palaeoenvironmental data relevant to the Transmission Assets;
- the collation of mapped geological and superficial data relevant to the Transmission Assets in order to characterise the sedimentary sequences contained within its bounds;
- the examination of topographical and LiDAR data to identify features such as palaeochannels and gravel islands;
- the assessment of historic BGS and project specific geotechnical borehole interventions that could be used to contribute to a future geoarchaeological deposit model of the Onshore Order Limits and/or select sub-areas, should this be required;
- the identification of specific zones or deposits of high geoarchaeological potential; and

- the identification of areas of uncertainty that currently lack sufficient lithostratigraphic and/or LiDAR data for adequate geoarchaeological assessment.

1.2.3.2 These tasks were undertaken by an experienced project team and in accordance with Historic England guidance documents (Historic England, 2015b, 2020).

1.2.3.3 The initial assessment for the PEIR divided the overall wider study area into a series of thirteen GCZs (**Figure 1.5**). Although three of these GCZs now fall beyond the extent of the defined Onshore Order Limits (GCZs 8, 12 and 13), they remain referenced in this report for contextual purposes. Working on the same principle of Historic Landscape Classification, the GCZs are largely defined on the basis of the surface geology (**Figure 1.5** to **Figure 1.13**), modern topography (**Figure 1.14** to **Figure 1.17**), and the likelihood for the preservation of buried land surfaces, archaeology and palaeoenvironmental data (**Figure 1.18**). Such preservation is likely to be highest where archaeological remains and associated land surfaces may lie buried beneath depths of sediment, particularly ecotonal areas adjacent to wetlands, on promontories, and/or at the confluence of watercourses. The assessment of these zones also encompasses the formation processes associated with the various deposit sequences and their likely palaeoenvironmental potential, particularly as related to the depth and spatial extent of peat deposits.

1.2.3.4 In order to formulate and summarise these GCZs, this geoarchaeological DBA has drawn on a number of open access data sources, including Ordnance Survey (OS) mapping, BGS mapping and Environment Agency Light Detection and Ranging Digital Terrain Model (LiDAR 1 m) data, along with relevant published and grey literature reports. Whilst insufficient project specific GI borehole data is currently available to produce a quantitative deposit model, an initial review of historical borehole data from the BGS website suggests the distribution is patchy and of moderate to poor quality. As such, a more qualitative review of select borehole data (both historic and project-specific) has been conducted as a part of the wider assessment of wetland/alluvial environments within the relevant GCZs.

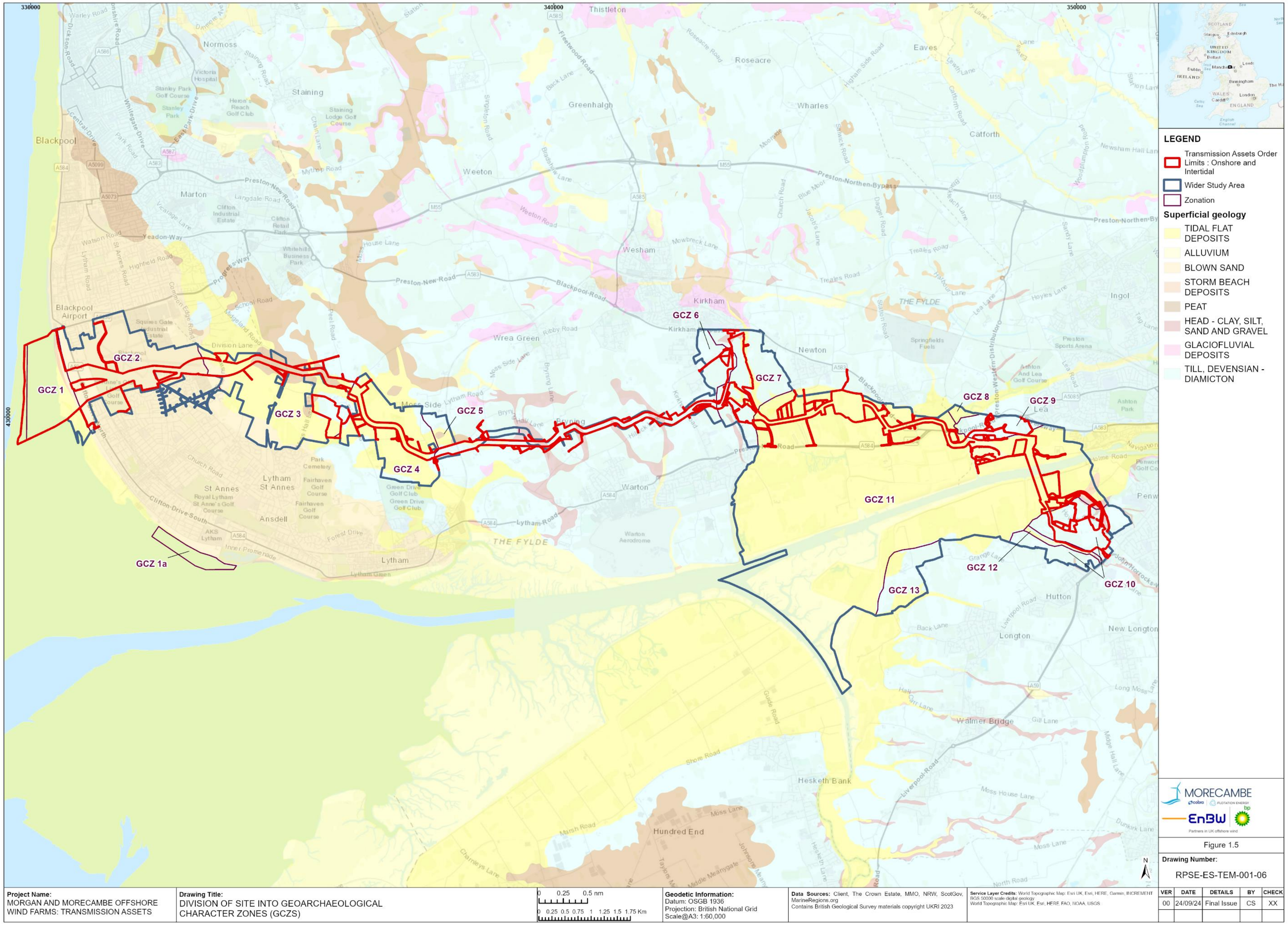

Figure 1.5: Division of site into Geoarchaeological Character Zones (GCZs)

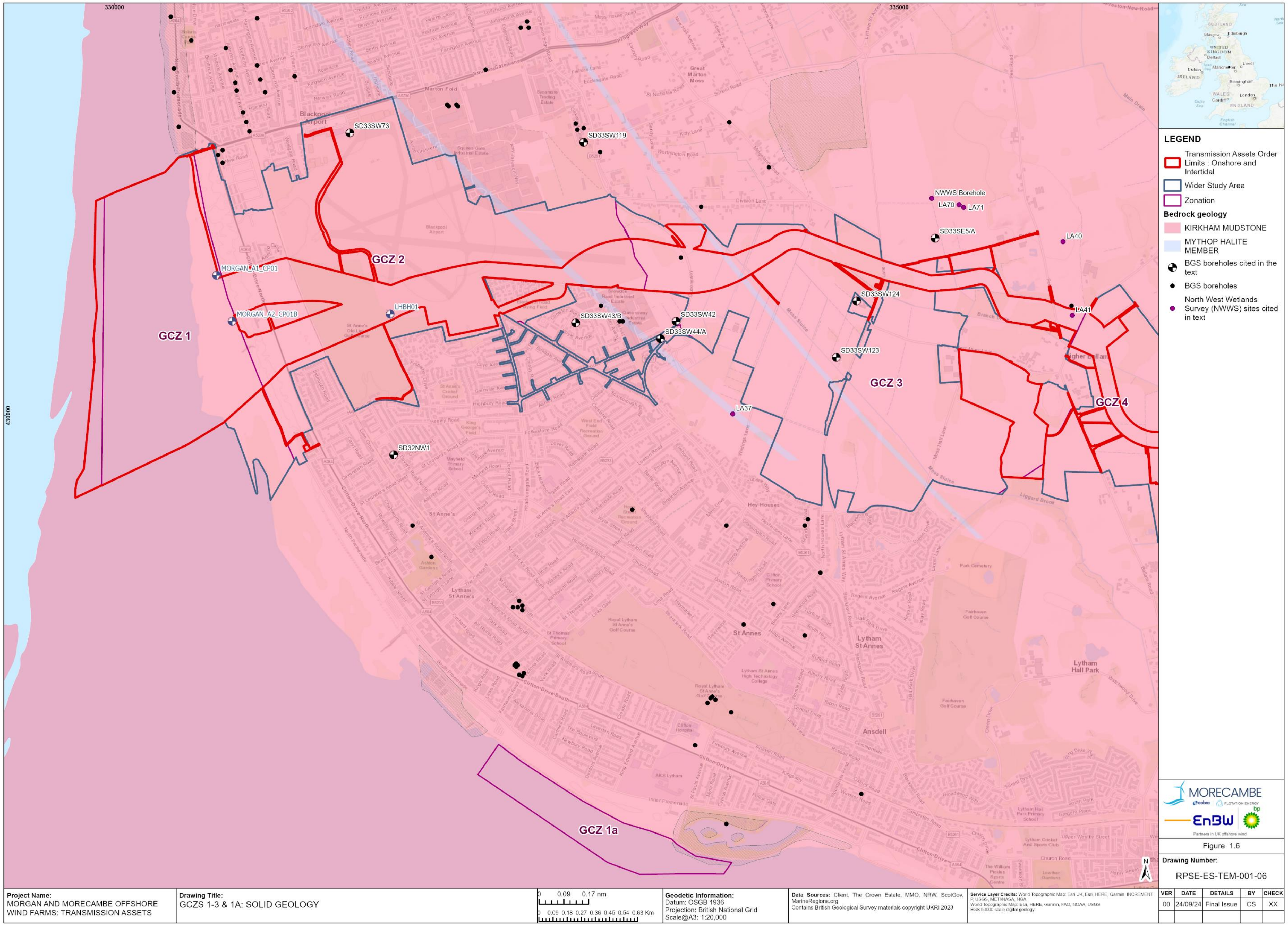

Figure 1.6: GCZs 1 to 3 and 1a - Solid geology

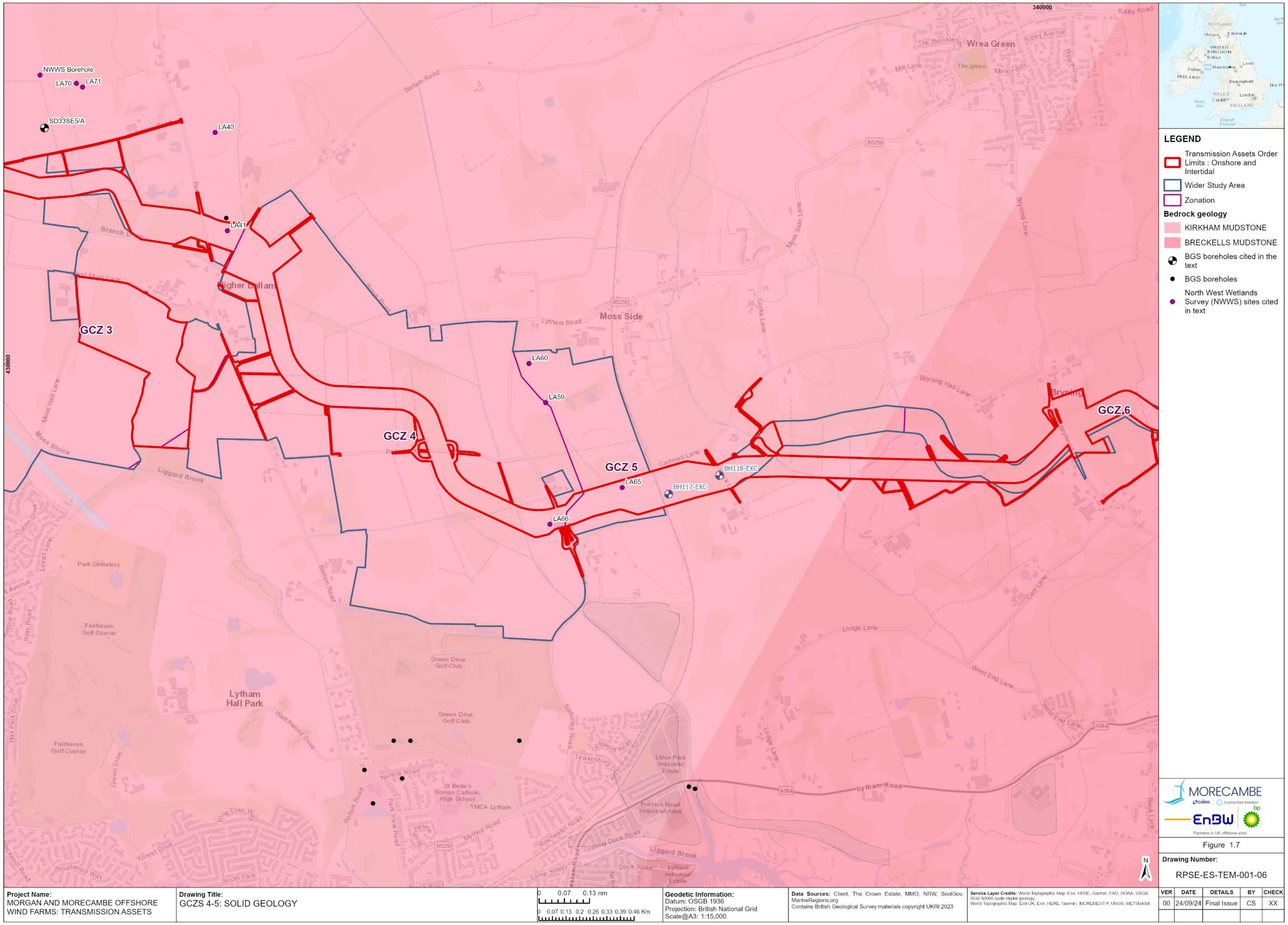

Figure 1.7: GCZs 4 to 5 - Solid geology

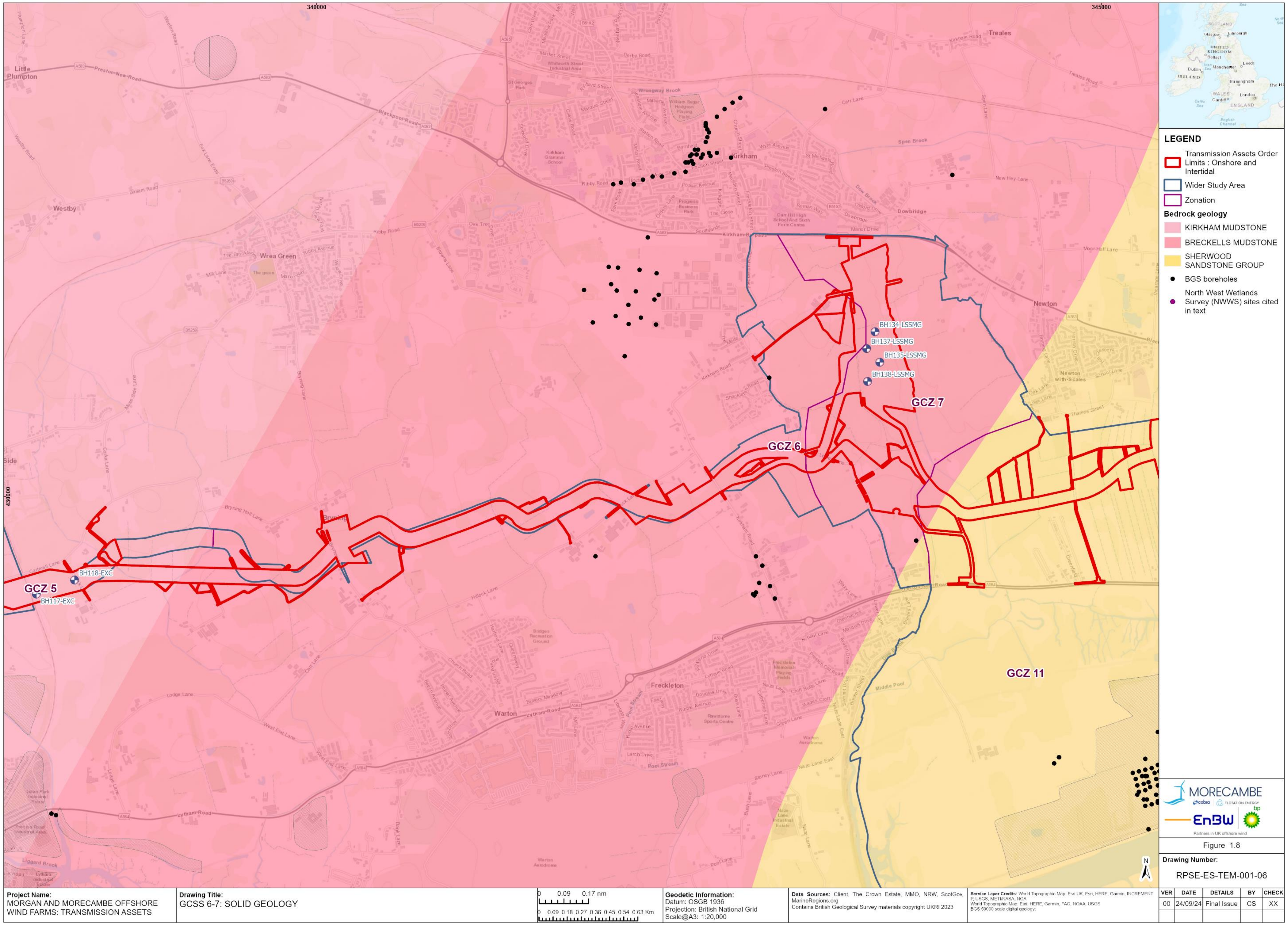

Figure 1.8: GCSs 6 to 7 - Solid geology

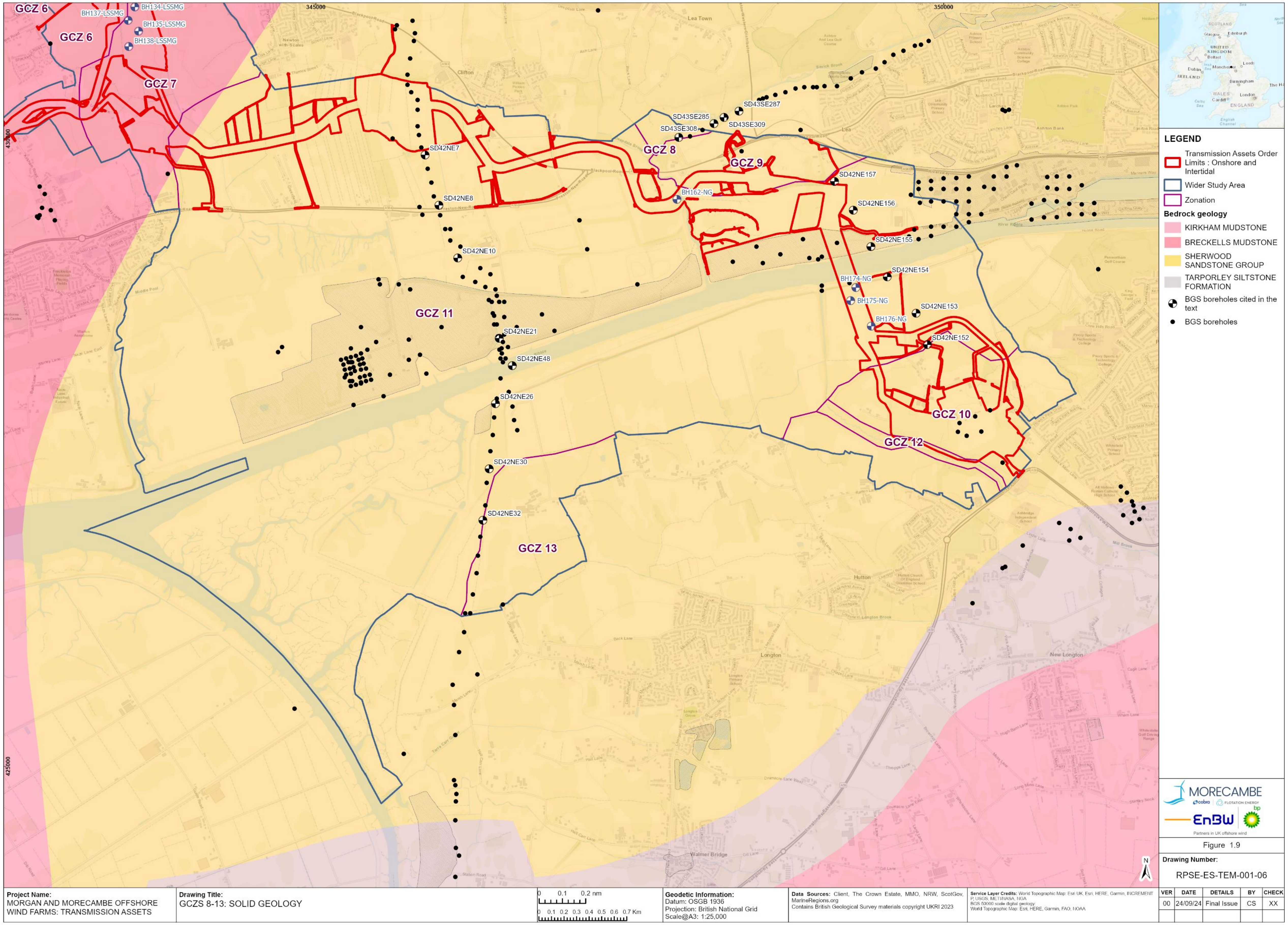

Figure 1.9: GCZs 8 to 13 - Solid geology

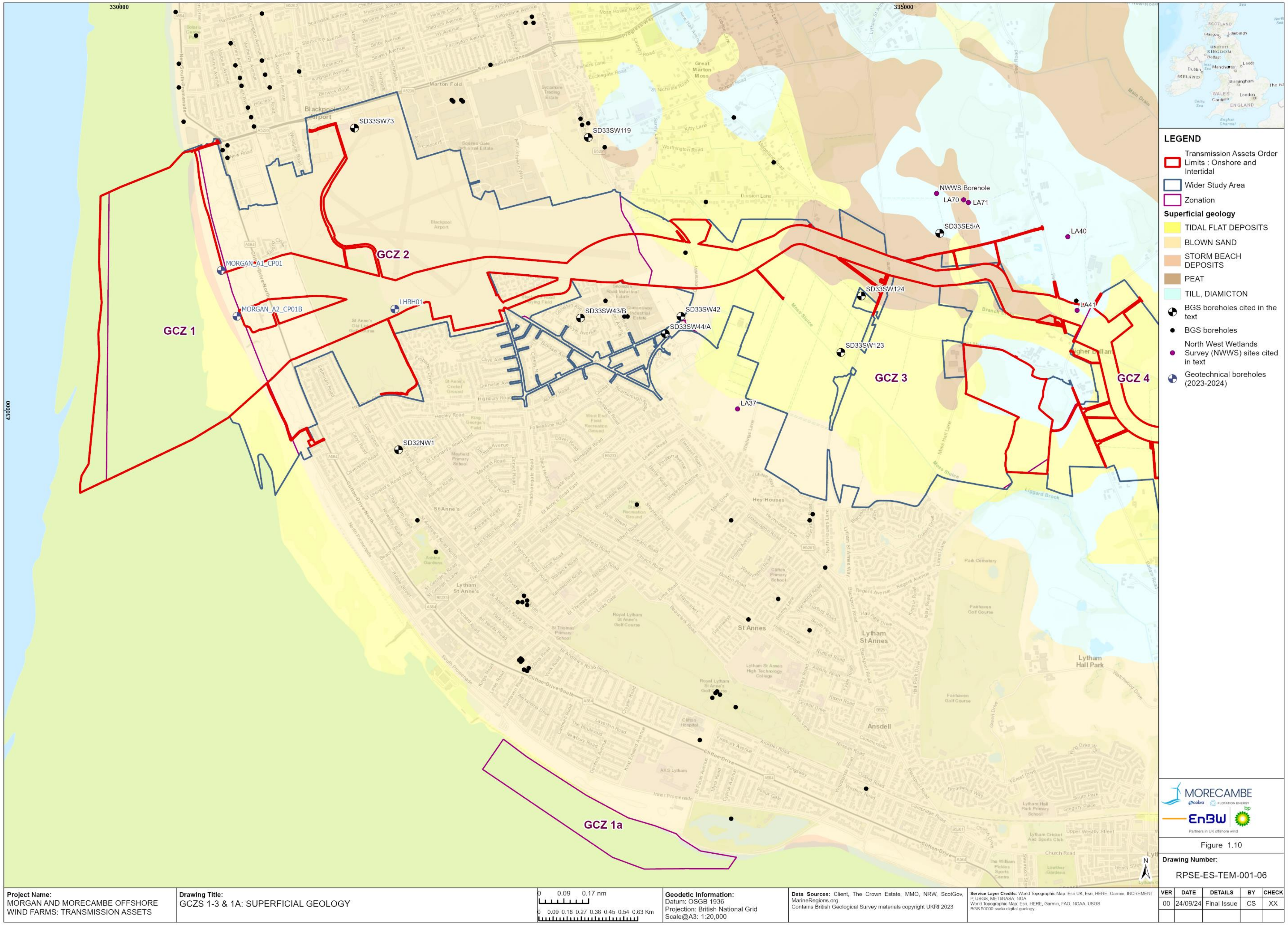

Figure 1.10: GCZs 1 to 3 and 1a - Superficial geology

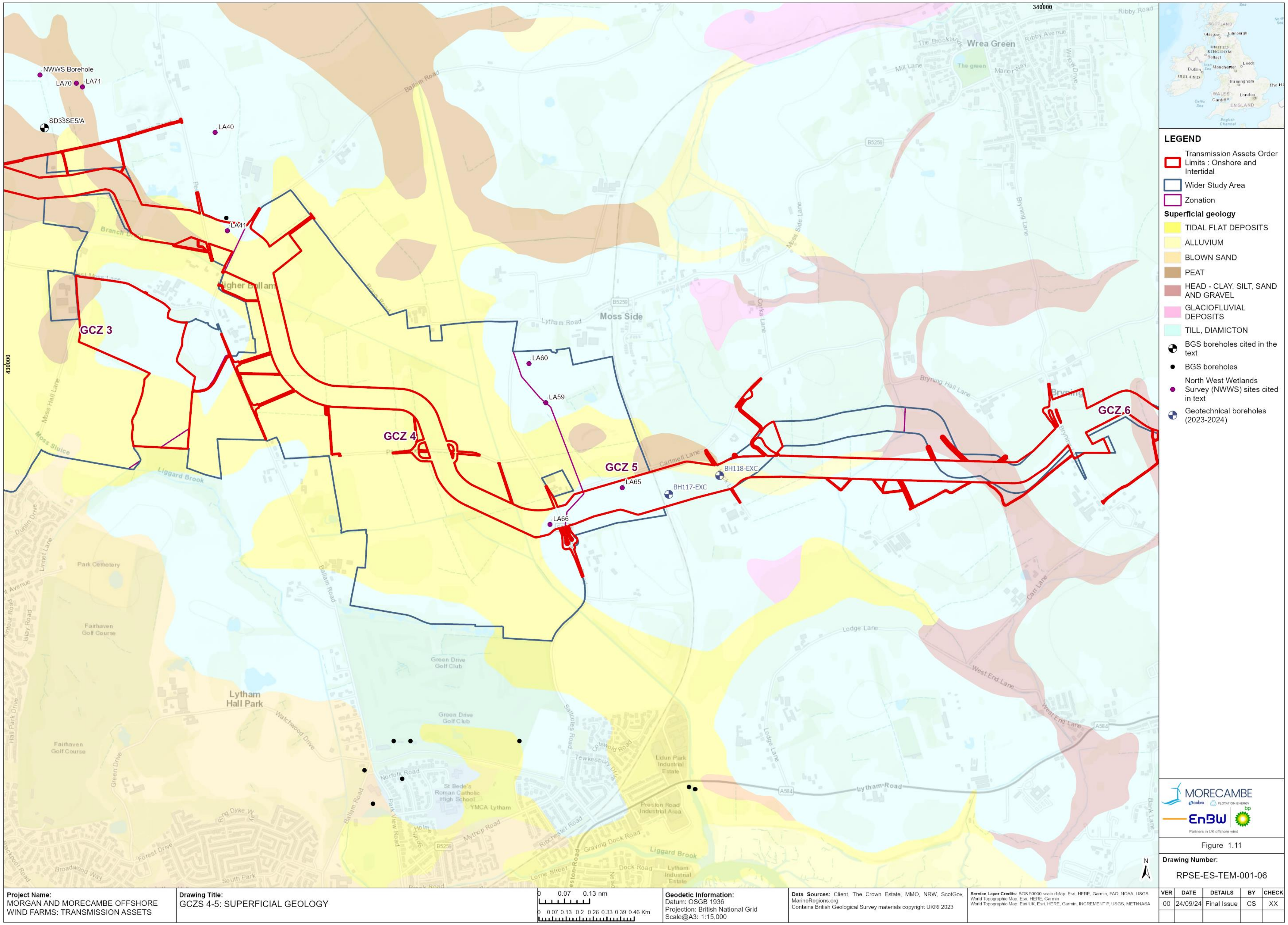

Figure 1.11: GCZs 4 to 5 - Superficial geology

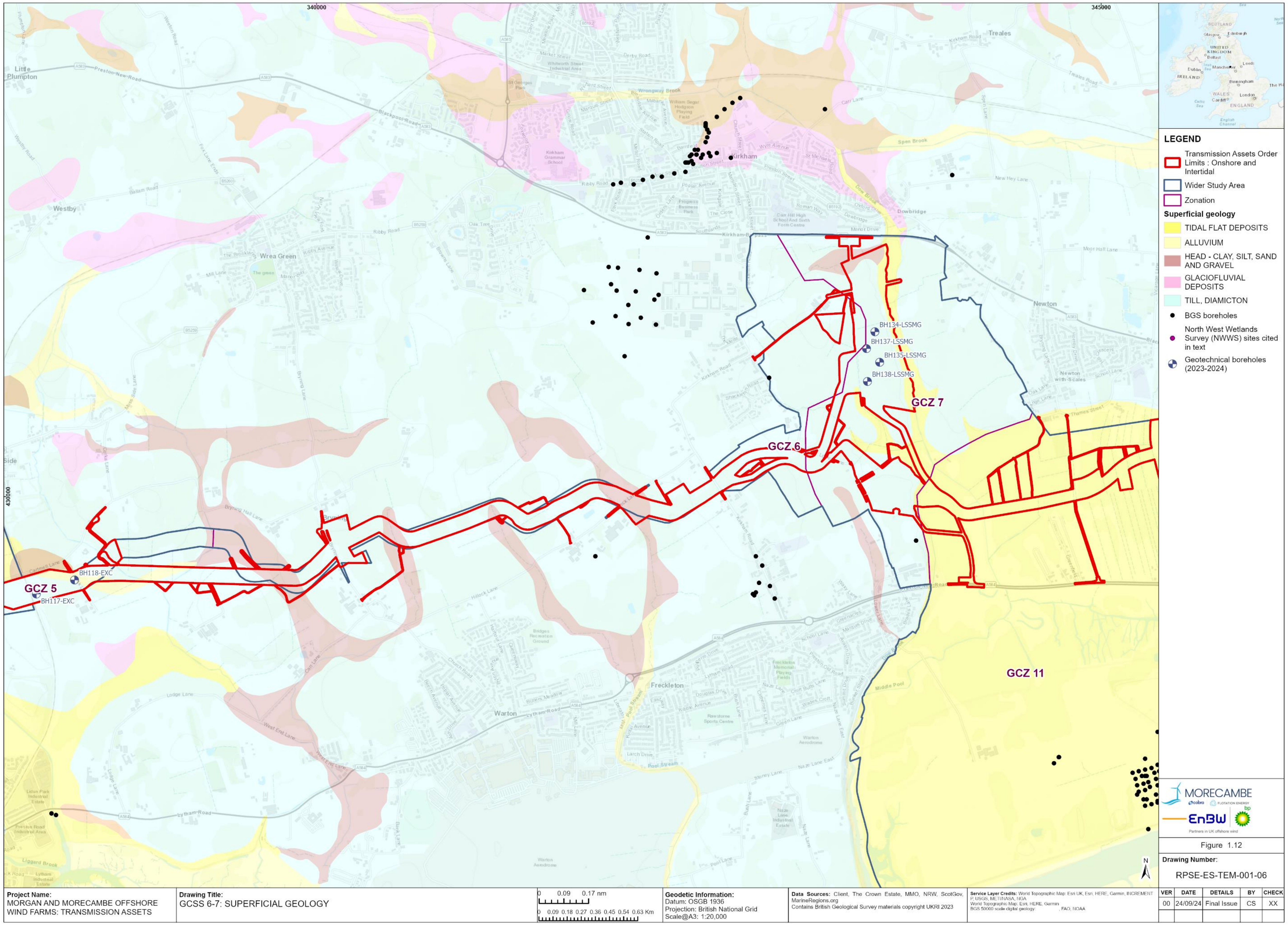

Figure 1.12: GCSs 6 to 7 - Superficial geology

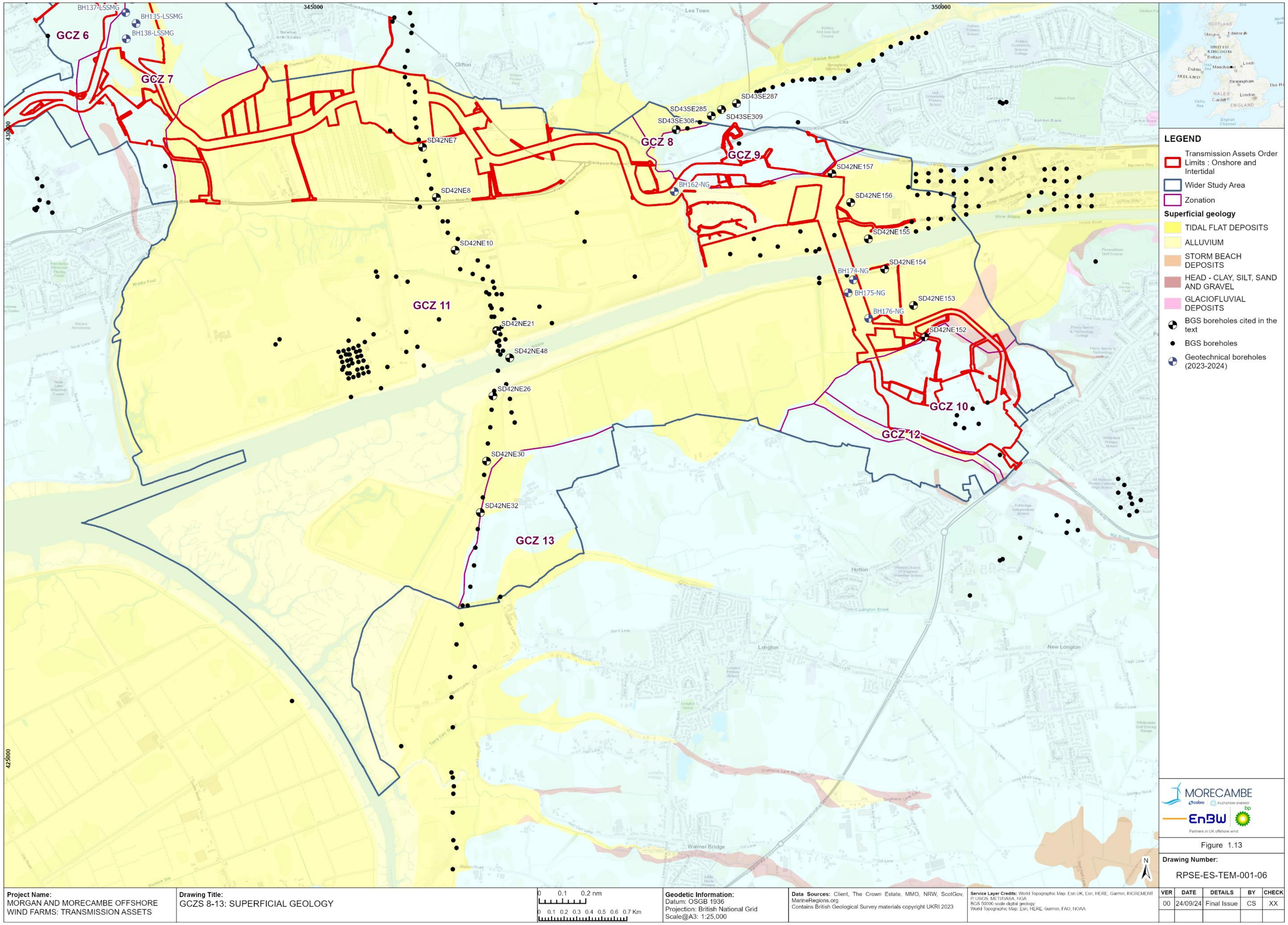

Figure 1.13: GCZs 8 to 13 - Superficial geology

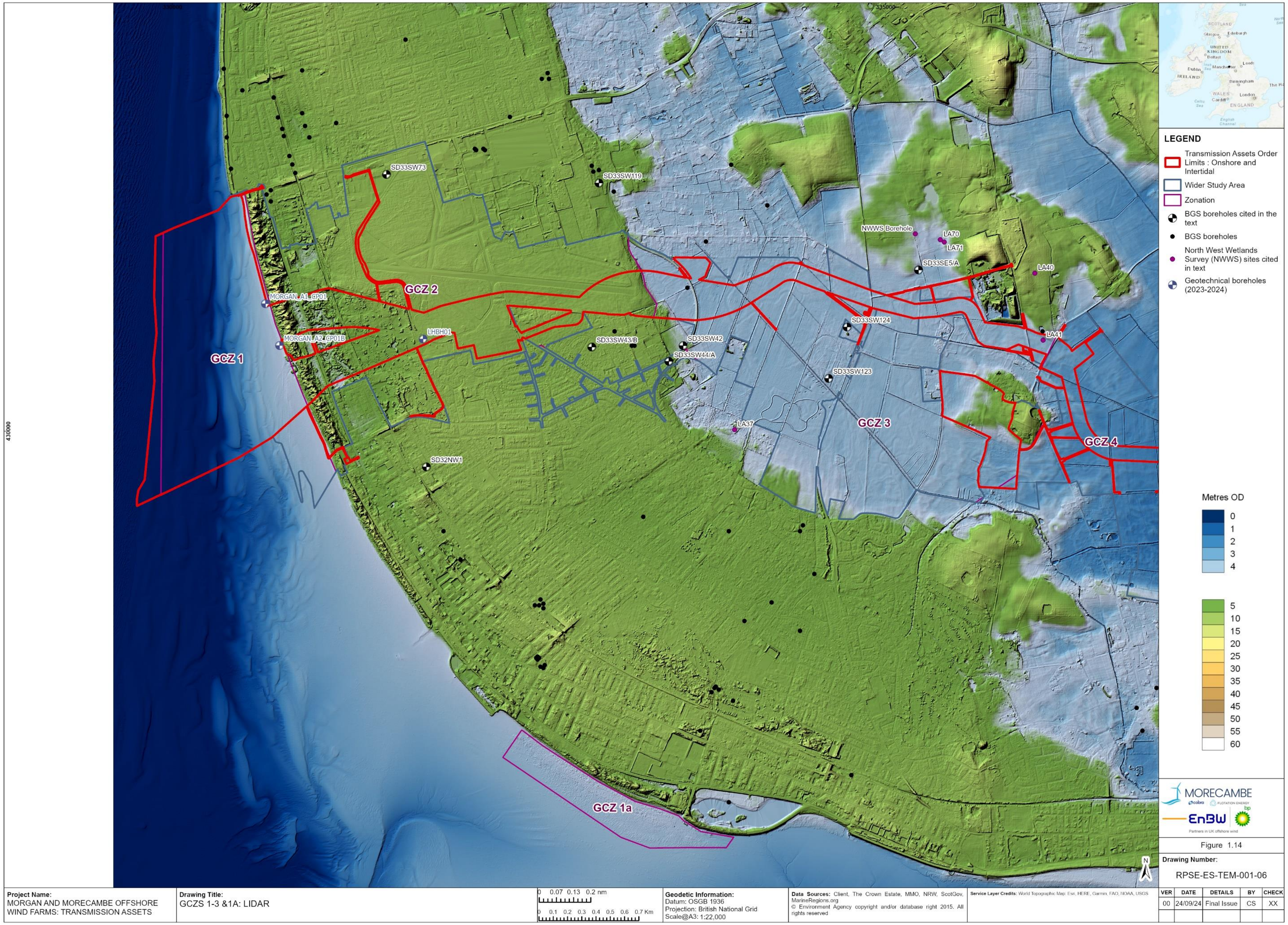

Figure 1.14: GCZs 1 to 3 and 1a - LiDAR

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Figure 1.15: GCZs 4 to 5 - LiDAR

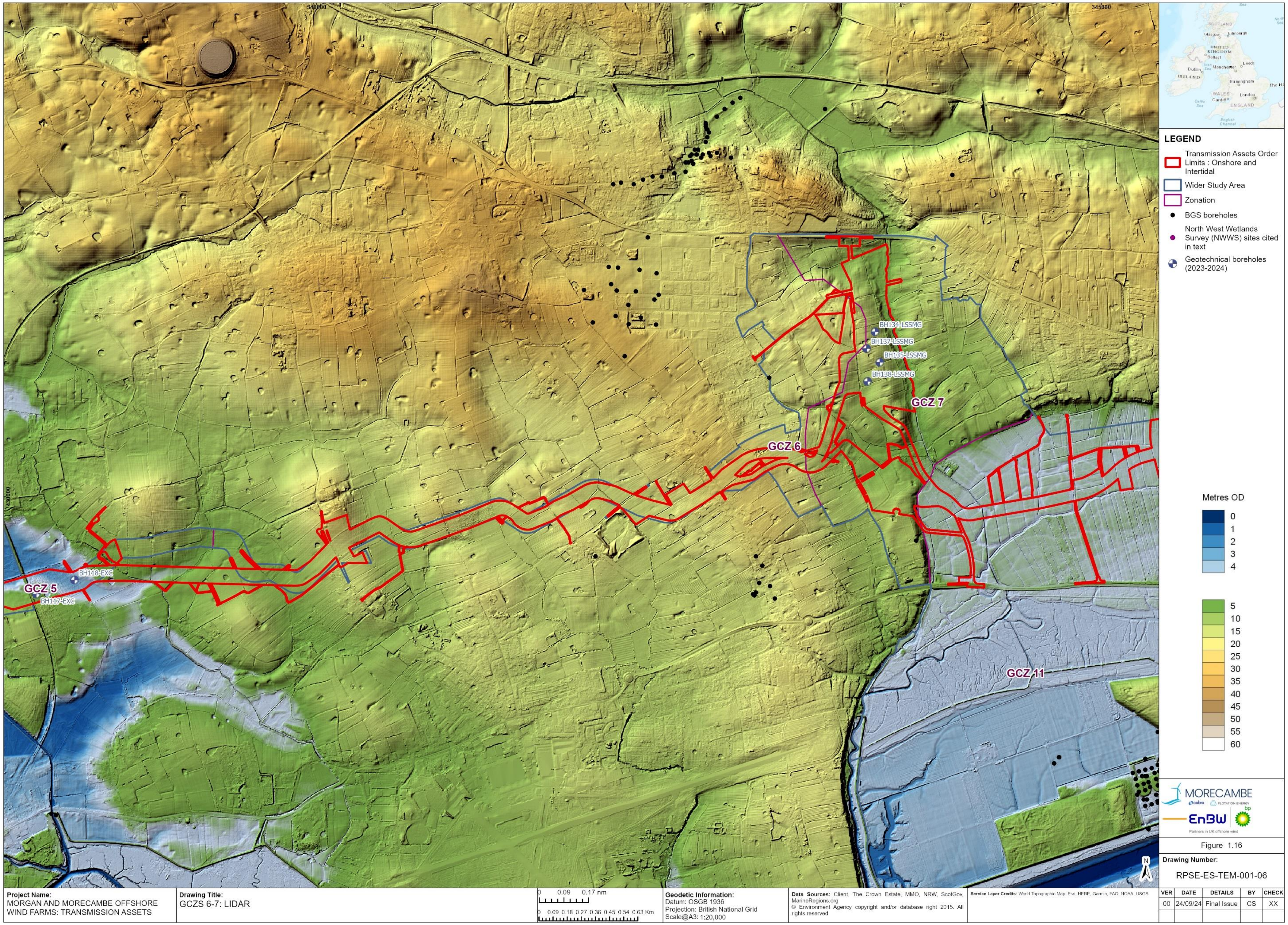

Figure 1.16: GCZs 6 to 7 - LiDAR

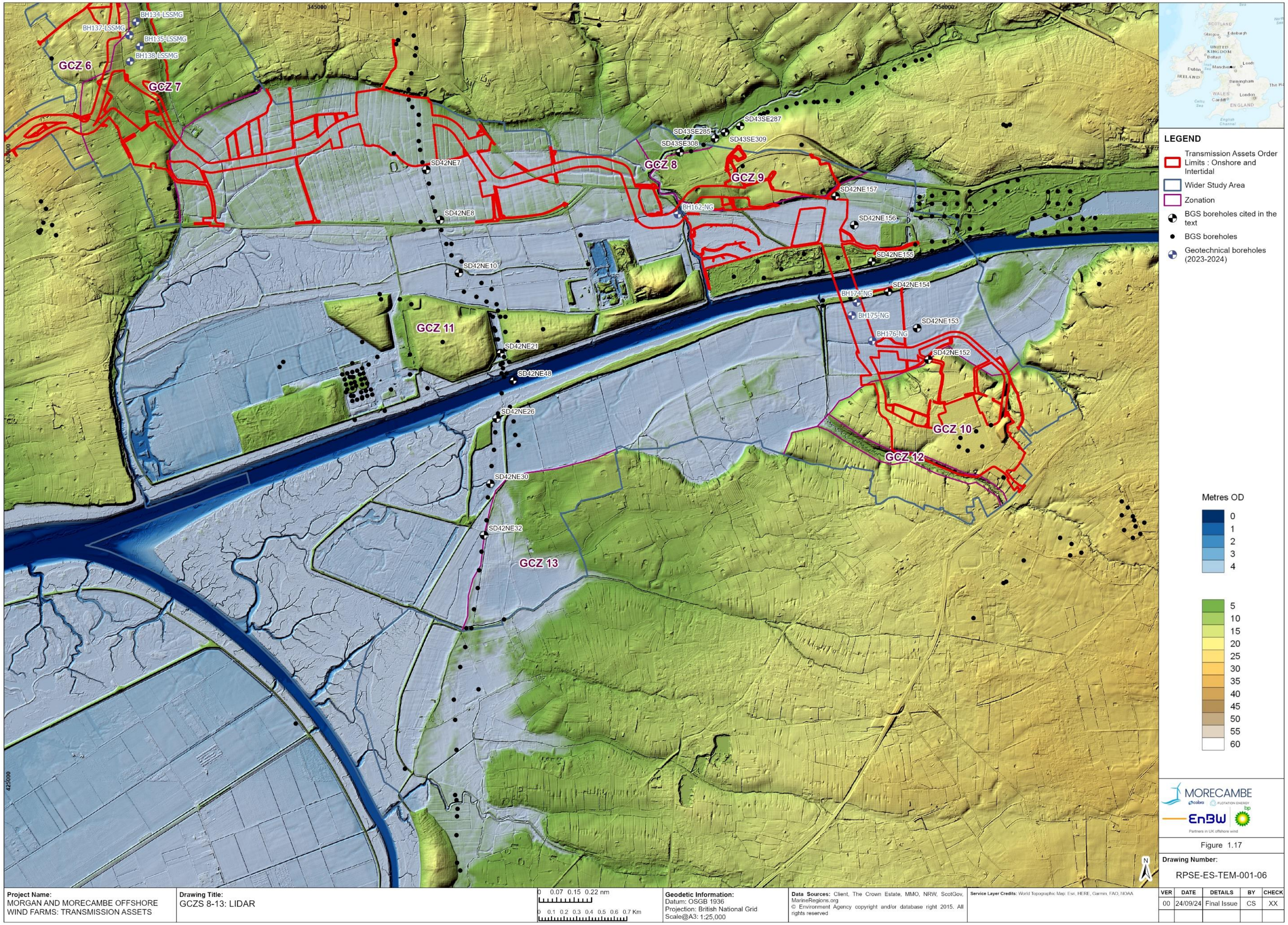

Figure 1.17: GCZs 8 to 13 - LiDAR

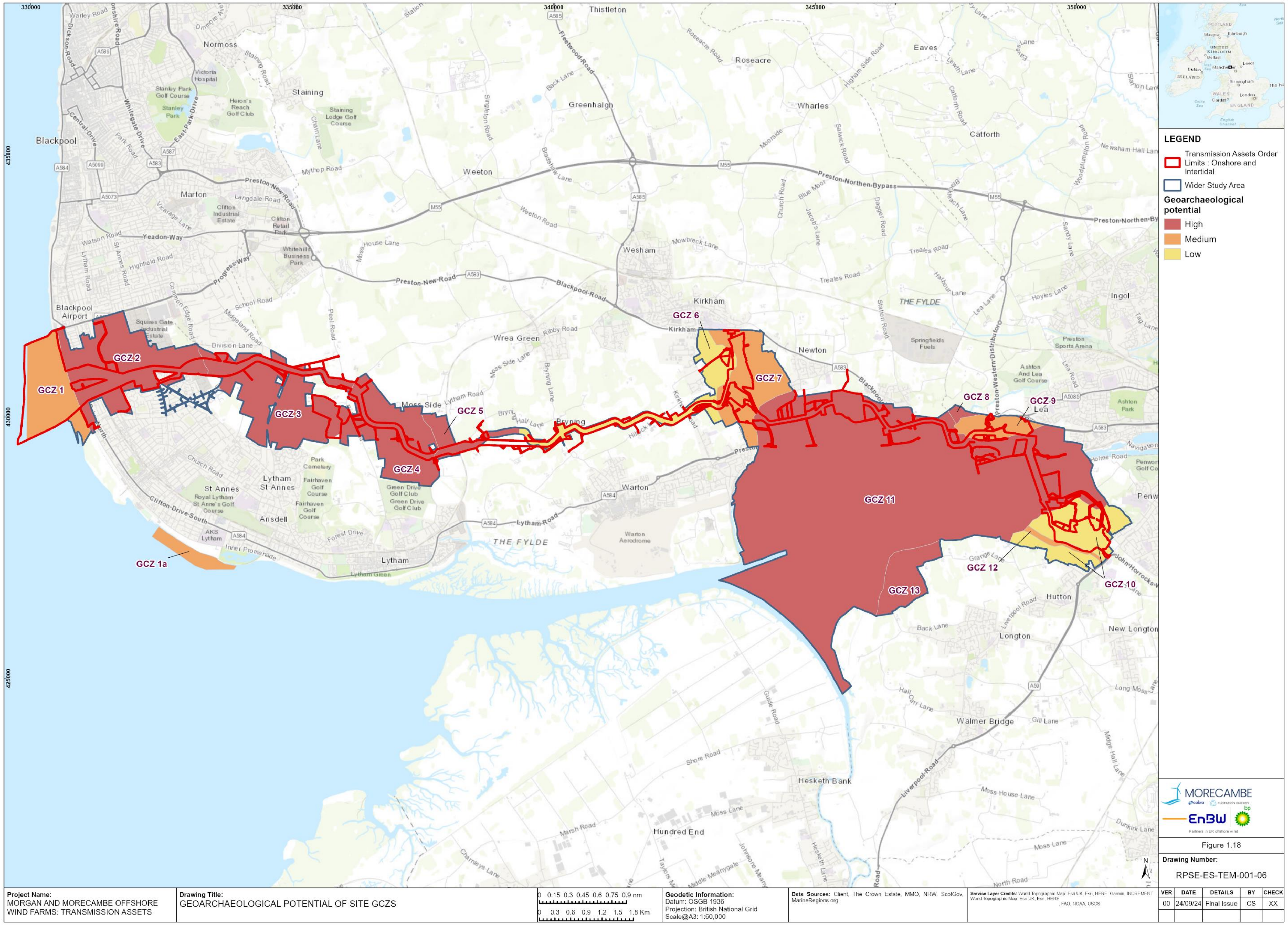

Figure 1.18: Geoarchaeological potential of site GCZs

1.3 Geological and chronostratigraphic framework

1.3.1 Solid geology

1.3.1.1 BGS mapping (1:625,000 and 1:50,000) indicates a general east-west transition across the Transmission Assets from late Permian/Triassic mudstones to sandstones (**Figure 1.6** to **Figure 1.9**). GCZs 1 to 5 across the westernmost *c.* 9.5 km of the Transmission Assets are underlain by mudstones of the Kirkham Member, deposited during the Anisian-Ladinian Ages (247.1 to 237 ma BP) of the Triassic Period in lagoonal/shallow sea conditions where a hot, arid climate led to the frequent precipitation of evaporites (evidenced by linear bands of Mythop-Halite Member mudstones and halite-stones crossing the region from north west to south east). GCZs 6 to 7 to the immediate east are then predominantly underlain by younger mudstones of the Breckells Member, deposited during the Ladinian-Carnian Ages (241.5 to 228.4 ma BP) under similar conditions to the underlying Kirkham mudstones. The eastern *c.* 7.5 km of the Transmission Assets (from the eastern edge of GCZ 7 through GCZ 8 to GCZ 12) are conversely underlain by detrital sandstones of the Sherwood Sandstone Group. These sandstones were laid down during the Induan to Anisian Ages (252.2 to 241.5 ma BP), thus predating the Kirkham/Breckells mudstones, and formed under hot, arid conditions from the channel, floodplain and levee deposits of rivers and coastal estuaries.

1.3.2 Chronostratigraphy and glaciations

1.3.2.1 The Pleistocene glacial history of the UK is complex, with the advance and retreat of several ice sheets occurring throughout the period as the climate oscillated between colder (glacial) and warmer (interglacial) stages. Comparatively warmer episodes occurring within glacial stages are then known as 'interstadials', and the intervening prevalence of severe cold conditions as 'stadials'. The last major glaciation across the UK is known as the Devensian, though the cycling of warmer and colder conditions within the stage vary at a regional scale. For instance, the north west of England incorporates the early Devensian 'Chelford Interstadial', characterised by organic-rich channel deposits exposed at Farm Wood and Oakwood Quarries near Chelford, Cheshire, and Uranium/Thorium dated to 86+/-26k BP (Worsely, 2015). Similarly, oxygen isotope evidence from the Irish Sea basin places the Last Glacial Maximum limit of the Dimlington Stadial at *c.* 38k BP, rather than the traditional date of 18k BP (Delaney, 2003; Chiverrell *et al.,* 2004). Detailed mapping of geological and lithostraphic data across lowland Lancashire by the BRITICE-CHRONO project has further indicated that deglaciation of the last ice sheet was regionally complete by 18.6-17.3k BP (Chiverrell *et al.,* 2016). **Table 1.1** below presents the generalised framework of this chronostratigraphic sequence, alongside the main archaeological periods recognised within the UK.

1.3.2.2 Although the solid geology within the Onshore Order Limits was initially formed during the late Permian and Triassic periods, much of the landscape seen today was moulded by events associated with the Devensian glaciation, which blanketed the whole of the Lancashire-Cheshire plain with thick ice sheets that scoured away much of the pre-existing bedrock (Chiverrell *et al.*, 2004; Innes and Tomlinson, 2008). Further erosional processes and the deposition of predominantly clayey Glacial Tills then formed the basis for all subsequent sedimentation, creating a local landscape comprised of undulating plains and low hills (Cowell and Innes, 1995).

Table 1.1: Generalised correlation of Mid-/Late Pleistocene and Holocene chronostratigraphy within the UK

Geological Epoch	Archaeological Period	Chronostratigraphy			
		Geological Stage		Age (years cal BP)	Marine Isotope Stage (MIS)
Holocene	Early Mesolithic to post-medieval	Flandrian Interglacial		11.7 k-present	1
Late Pleistocene	Upper Palaeolithic	Devensian Glaciation	Loch Lomond Stadial (Younger Dryas)	12.9 to11.7 k	2-5d
			Windermere Interstadial	15 to 12.9 k	
			Dimlington Stadial (Last Glacial Maximum)	26-15 k	
	Later Middle Palaeolithic		Upton Warren Interstadial	ca. 45 to 25 k	
			Mid-Devensian Stadial	ca. 61 to 45 k	
			Chelford Interstadial	ca. 95 to 61 k	
			Early Devensian Stadial	ca. 115 to 95 k	
		Ipswichian Interglacial		230 to 115 k	5e
Middle Pleistocene	Early Middle Palaeolithic	Wolstonian 'Complex'		374 to 230 k	6-10
		Hoxnian Interglacial		424 to 374 k	11
		Anglian Glaciation		478 to 424 k	12
	Lower Palaeolithic	Cromerian 'Complex'		750 to 478 k	13-19

1.3.3 Sea level change in the Liverpool Bay area

1.3.3.1 Detailed records of early Pleistocene sea-level change remain relatively few across the UK, largely due to successive glaciations obliterating earlier deposits (Long and Roberts, 1997). However, the marine deposits along the coast of historic Lancashire provide something of an exception, evidencing a series of successive glacio-eustatic and glacio-isostatic sea level shifts since the late Devensian, including the possible existence of a past land bridge between Great Britain and Ireland (Chiverrell *et al.,* 2004). Detailed studies of Liverpool Bay have incorporated seismic, bathymetric and borehole data to suggest that much of the area, though low-lying, lay above water during the Upper Palaeolithic (Fitch and Gaffney, 2011; **Figure 1.3**). As for present-day Lancashire, much of that now submerged landscape would have been shaped by geomorphic processes associated with the Devensian glaciation, creating a series of incised channels and kettle holes developing into larger lakes and braided river systems. The data suggest that several of these river systems followed similar routes to their modern counterparts, such as the Mersey and Dee, and would have provided important navigation routes for prehistoric people.

1.3.3.2 The early Mesolithic coastline would have lain well to the west of the current Lancashire coast. By approximately 11000 BP the sea level had risen to 37 m below modern OD (Research Frameworks, 2023; Usai, 2005), with concurrent climatic amelioration encouraging the spread of mixed deciduous woodland across the previously tundra-like landscape. Subsequent sea-level rise would have shifted this coastline further into Liverpool Bay, with the lowest-lying areas developing into a mosaic of fenland, reed-swamp and saltmarsh. Sea levels had risen considerably by approximately 9500 BP, though were still 18 m below current levels, exposing a wide shelf of now-submerged land between Wales and north west England. The final inundation of the Bay proceeded relatively rapidly, reaching -7 m OD by 7000 BP and more slowly thereafter (Chiverrell *et al.,* 2004; Tooley, 1978; Usai, 2005), during which time an extensive inter-tidal zone developed along the coastline (Fitch and Gaffney, 2011; **Figure 1.4**). Near-present sea levels were subsequently reached during the mid-Holocene high-stand *c.* 6050 BP (Peltier, 2002).

1.3.3.3 This broad narrative of rising sea levels also encompasses many local variances, both spatial and temporal. Work by Tooley (1978; 1982) to combine pollen and diatom cores with radiocarbon dates has established a series of twelve marine transgressions and regressive overlap tendencies throughout the Holocene, generally matching the broader regional trend for rapid sea level rise throughout the earlier part of the period. However, not all trans-/regression tendencies are evident across the full extent of the north west coastline, and localised variation appears to have been the norm (in contrast to the overarching Lytham I-X chronology previously proposed, *cf.* Tooley, 1982).

1.3.3.4 To the immediate north of the Ribble Estuary, marine conditions were encroaching within the Lytham-Skippool Valley by *c.* 5400 BCE, which would then have linked the Wyre and Ribble estuaries and made an island of the western Fylde and modern-day Blackpool. Maximum levels were then reached during the mid-Holocene high-stand, which pollen records indicate occurred in association with the widespread elm decline seen throughout the British Isles. Silty clays were deposited throughout the Lytham-Skippool Valley at that time, in which sporadic glacio-fluvial gravel islands would have stood above the level of the surrounding sea (Barlow and Shennan, 2011; Middleton *et al.,* 1995).

1.3.3.5 Sea levels then began to fall from this high-stand, with cores at Lytham Common and Heyhouses Lane recording no further marine influence after 3945-3663 cal BCE and 3942-3384 cal BCE respectively (Tooley, 1978). Biogenic sedimentation and peat formation within the Lytham-Skippool Valley further raised the level of previously littoral areas, such that the west and east Fylde remained united thereafter, initially by areas of saltmarsh and later by freshwater reed-swamps as the rate of sea level rise reduced (Barlow and Shennan, 2011; Middleton *et al.,* 1995). Sea levels then fluctuated throughout the mid- to late Holocene, mainly in accordance with localised conditions and events associated with the breaching, stabilisation and retreat of sand dunes and gravel bars established during the preceding high levels. A final transgressive episode is recorded in peats from the Starr Hills dunes dating to 1039-1298 CE (Barlow and Shennan, 2011), with dune material being sourced from an offshore sand bank that was likely already in existence by *c.* 4450 BCE (Innes and Tooley, 1993; Pye and Neal, 1993).

1.3.3.6 Low dune systems had begun to form along the Formby and Sefton coastlines to the south of the Ribble Estuary from approximately 2800 BCE (Innes and Tooley, 1993; Usai, 2005), with those of the south west Fylde likely forming somewhat later. During 1200 to 1400 CE, these dune systems were substantially reworked as climate instability associated with the so-called 'Little Ice Age' led to widespread coastal erosion and sand blowing. It was not until the nineteenth century that widespread stabilisation occurred as a result of the deliberate planting of marram grass (Barlow and Shennan, 2011; Pye and Neal, 1993).

1.3.3.7 Anthropogenic activity has in general had a particularly marked effect on the morphology of the Ribble Estuary over the past 150 years, with sedimentation rates increasing as embankment construction and reclamation efforts have reduced the size of the intertidal area and corresponding tidal prism (Van de Waal *et al.,* 2002). Estuarine infilling continues to this day, due partly to wider tendencies towards the onshore transport of material within Liverpool Bay, and partly to more localised anthropogenic activities such as reclamation training wall construction (from 1840-1937), dumping of dredge spoil in the estuary's in-draught, and the planting and subsequent spread of *Spartina* (Halcrow, 2013). Urban expansion has also led to the reduction and fossilisation of the once extensive dune systems to narrow strips along the present-day coastal frontage (Skelcher, 2008).

1.3.4 Superficial deposits

1.3.4.1 BGS mapping (1:625,000 and 1:50,000) indicates a variety of superficial deposits within the Onshore Order Limits (**Figure 1.5** and **Figure 1.10** to **Figure 1.13**). The key deposits are summarised below, along with any characteristics of particular geoarchaeological importance.

1.3.4.2 **Tidal Flat deposits** (Holocene): these sedimentary deposits are shallow marine in origin and generally detrital in character, forming beaches and bars in coastal settings. The tidal flats of the Ribble's outer estuary are predominantly sandy, with localised areas of gravel (including brecciated shell material) and muddy sand. Further into the estuary these deposits become increasingly dominated by silts, clays and fine sands, and where vegetated form extensive saltmarshes (Halcrow, 2013). Such deposits have the potential to seal waterlogged archaeology and palaeoenvironmental remains, including proxy data associated with Holocene climate and sea level change. Accounting for the rises in sea level discussed in S**ection 1.3.3** above, they may also seal former Late Pleistocene/early Holocene land surfaces.

1.3.4.3 **Storm beach deposits** (Holocene): these detrital sedimentary deposits are typically coarser grained than the Tidal Flat deposits discussed above, being deposited above the normal high-water mark by periodic high energy weather events in shallow marine environments. Though such events are usually erosive of underlying sediments, where storm beaches overlay Tidal Flat deposits, they may also seal archaeological remains and/or buried land surfaces.

1.3.4.4 **Alluvium** (Holocene): classified as a mix of clay, silt, sand and gravel, with peat in places, these sedimentary deposits are fluvial in origin and reflect the channels, floodplains and levees of rivers and smaller watercourses. They are often admixed with marine material under estuarine conditions (i.e., within tidal river and creek channels), and likewise throughout active saltmarsh environments. Floodplain deposits hold high potential for the preservation of waterlogged archaeology and palaeoenvironmental remains. A greater degree of in-channel erosion and reworking of material under high-energy conditions may be associated with palaeochannels (former watercourses). However, channel margins, cut-off meanders and sheltered backswamps associated with low-energy deposition and more stable conditions have higher potential to preserve in situ remains and accumulate organic sediments. As for the related Tidal Flat deposits discussed above, alluvium may also seal former late Pleistocene/early Holocene land surfaces. Marginal areas of adjacent higher ground, alongside 'islands' of better-drained ground within floodplains themselves, were often foci of past human activity.

1.3.4.5 **Blown Sand deposits** (Holocene): these aeolian sedimentary deposits are detrital in character, and largely composed of medium- to fine-grained sands. Across the south west Fylde, such deposits form an extensive dune system extending from south Blackpool to Lytham, though the majority of their extent has since been built over. A coastal dune system extends for 80 ha from Squire's Gate in the north to Lytham Green in the south (JBA Consulting, 2016), with the wider complex having expanded from the early thirteenth century onwards (Middleton *et al.,* 2014; Tooley, 1985). Lenses of exposed peat along the Lytham foreshore indicate these dunes seal earlier raised bog deposits associated with Lytham Moss (De Rance, 1875; 1877). Isolated finds of possible Neolithic/early Bronze Age flints on exposed buried land surfaces also suggest that there is substantial archaeological (in addition to palaeoecological) potential to the deposits underlying these dunes, though they are now buried under many metres of Blown Sand (Middleton *et al.,* 1995).

1.3.4.6 **Peat** (late Devensian/Holocene): peat deposits are key strata for the preservation of waterlogged archaeology and palaeoenvironmental remains and may also bury previous late Pleistocene/early Holocene land surfaces.

Lacustrine and palustrine in origin, they comprise accumulated organic material preserved under anaerobic conditions to form beds and lenses within larger lagoons, fens, bogs and swamps. In the north west of England, raised bogs are locally known as 'mosses', of which Lytham Moss and Marton Moss are both crossed by the western extent of the Transmission Assets. Functionally, these mosses comprise the same wetland complex (known together as Lytham Moss) extending across the neighbouring parishes of Lytham and Marton. This former wetland is now entirely reclaimed and sub-surface peat preservation is typically poor (Middleton *et al.,* 1995). However, potentially deeper and better-preserved peat deposits are contained within Weeton Moss and along the fringes of Marton Mere to the north, and within the lower reaches of the Lytham-Skippool Valley to the east. Small pockets of peat are also indicated by BGS mapping as existing within smaller riverine valleys cutting into the adjacent high ground.

1.3.4.7 **Head deposits** (late Devensian/Holocene): comprising unsorted detrital muds incorporating frequent sand and gravel clasts, these subaerial sediments typically form under periglacial conditions through processes of down-slope solifluction, soil creep and hill wash, often forming down-slope layers and fans of accumulated material. Within the Onshore Order Limits, these deposits typically infill the small valleys cut through the higher ground fringing the Ribble estuary (see below), and as such are essentially Glacial Till sediments redeposited during the immediately post-glacial conditions of the late Pleistocene/early Holocene. As for the surrounding *in situ* Till, these sediments themselves have limited geoarchaeological potential, though may seal deeply stratified deposits of greater archaeological and geoarchaeological interest.

1.3.4.8 **Glacial Till, Diamicton** (Devensian): these unsorted sediments are generally composed of gravels within a matrix of fine mud. They are glaciogenic in origin, created by the action of ice and meltwater, and can form a wide range of geomorphologies associated with past glacials and inter-glacials. Throughout the Onshore Order Limits, they typically form the higher ground surrounding the lower-lying Ribble estuary, Lytham-Skippool Valley and associated mosses. Although the Till has limited geoarchaeological potential, it may rarely seal deeply stratified deposits of greater archaeological and geoarchaeological interest.

1.3.4.9 **River terrace deposits** (Pleistocene/Holocene): river terrace deposits are key contexts for archaeological and geoarchaeological investigation. Comprising fluvial sediments (predominantly sands and gravels) deposited within the channels, floodplains and levees of past river systems, they often sit above the level of the present-day floodplain due to more recent downcutting following earlier periods of aggradation. Although most early-middle Pleistocene terrace deposits in north west England are likely to have been scoured out by the Devensian ice sheet, there is some potential for the recovery of late Pleistocene terraces and associated Upper Palaeolithic archaeological material (which until now has been largely restricted to finds from caves and rock-shelters; Research Frameworks, 2023). Research further inland has suggested the Ribble itself incorporates a sequence of four main terraces dating from the Pleistocene through to the late first millennium CE (Chiti, 2004). Within the Onshore Order Limits, BGS mapping only records a small area of relict undated terrace deposits within the inner estuary.

1.4 Geoarchaeological assessment

1.4.1 Introduction

1.4.1.1 To provide a framework with which to present the geoarchaeological potential of the Transmission Assets, the route has been divided into a series of GCZs based upon the wider study area (GCZ, **Figure 1.5**). Working on the same principle of Historic Landscape Classification, the GCZs are largely defined on the basis of the surface geology (**Figure 1.6** to **Figure 1.13**), modern topography (**Figure 1.14** to **Figure 1.17**), and the likelihood for the preservation of buried land surfaces, archaeology and palaeoenvironmental data (**Figure 1.18**). A broader assessment of the geoarchaeological potential prevalent across the Transmission Assets is provided in **section 1.5.4** following the more detailed assessment of each GCZ in the discussion below.

1.4.2 GCZ 1

1.4.2.1 GCZ 1 comprises the littoral zone at the westernmost end of the onshore part of the Transmission Assets (**Figure 1.5**). This zone encompasses the tidal foreshore of the south west Fylde peninsula, extending from the immediate west of the Starr Hills dune system out to the low-water mark, at which point the terrestrial portion of the Onshore Order Limits and the spatial remit of this DBA terminates. The superficial deposits of this zone are dominated by sandy Tidal Flat deposits, with portions of coarse-grained detrital storm beaches arrayed against the dune frontage to the east, all of which overlie basal mudstones of the Kirkham Member (**Figure 1.6** and **Figure 1.10**). In terms of recent heritage, the North West Rapid Coastal Zone Assessment Survey has logged Second World War beach defences along this stretch of beachfront, in the form of beach scaffolding and several pillboxes (Historic England, 2023).

1.4.2.2 Whilst no substantial archaeological remains or buried land surfaces from earlier periods have previously been recorded within this area, the presence of Mesolithic footprints preserved within the former saltmarsh muds underlying Formby Beach 24.5 km to the south provide an excellent case in point as to the infrequently realised archaeological potential of such environments (Huddart *et al.,* 1999; Roberts, 2009). Whilst a recent OA intertidal foreshore survey (OA, 2023b) did not encounter any such remains within the Onshore Order Limits, it remains the case that such features are usually only exposed when considerable beach material has been removed in the wake of storms (as at Formby, *cf.* Huddart *et al.,* 1999). The presence of buried peats and charcoal layers within the dune frontage to the immediate east (see GCZ 2 below) further suggests that important palaeotopographic/environmental features may still be preserved below the level of the present-day beach (in accordance with the locality's inland position during the late Palaeolithic and Mesolithic periods, *cf.* **Figure 1.3** and **Figure 1.4**). Accordingly, GCZ 1 is considered to be of medium geoarchaeological potential, pending any possible future investigation of the sub-surface deposits.

1.4.3 GCZ 1a

1.4.3.1 GCZ 1a (**Figure 1.5**) is essentially an isolated extension of GCZ 1, comprising the portion of tidal foreshore by Lytham St Annes contained within the Onshore Order Limits. As for GCZ 1, the superficial geology is composed of sandy Tidal Flat deposits, again overlying basal mudstones of the Kirkham Member (**Figure 1.6** and **Figure 1.10**). Isolated beach defences associated with the Second World War are arranged along its margins (Historic England, 2023), whilst its wider geoarchaeological potential is again identified as ‘medium’ in accordance with the rest of GCZ 1, as discussed above.

1.4.4 GCZ 2

1.4.4.1 GCZ 2 comprises the coastal sand dune complex immediately inland of the south west Fylde coastline (**Figure 1.5**). As for the adjacent beachfront, the zone is underlain by Kirkham Member mudstones (**Figure 1.6**), though with a superficial geology composed of Holocene Blown Sand deposits (**Figure 1.10**) forming a dune system tending towards transverse structures (JBA Consulting, 2016). This dune complex is believed to have begun forming in the early thirteenth century CE and expanded from its initial shoreline limits to cover much of the south west Fylde from Blackpool to Lytham (Middleton *et al.,* 2014; Tooley, 1985). Much of this dune system has been heavily urbanised in recent centuries, and the area of GCZ 2 is itself largely covered by the present-day extent of Blackpool Airport, itself a local heritage asset dating back to its roots as an early twentieth century airfield (Historic England, 2023). That said, the beach frontage of the Starr Hills dunes, the neighbouring Lytham St Annes Local Nature Reserve and St Anne’s Old Links Golf Club, and the area of the former Pontins site to the north under current redevelopment all demonstrate greater dune maturity, including evidence of star structures, blow-outs and localised dune slack formation (JBA Consulting, 2016).

1.4.4.2 Whilst the archaeological potential of these dune deposits are themselves relatively low, they are known to blanket older sites and landscapes. For instance, lenses of peat once exposed along the dune frontage at Lytham itself indicate that the overlying sand seals older raised bog deposits, effectively overprinting a westward extension of Lytham Moss (De Rance, 1875; 1877). W. Jackson also reported isolated finds of possible Neolithic/early Bronze Age flints on exposed buried land surfaces in the vicinity of Starr Hills during the 1920s, although the precise location of these findspots remains unknown (cf. Middleton *et al.,* 1995). Finally, Tooley (1978, Table 1) dated a charcoal lens underlying the Starr Hills dune complex to 7080-6800 cal BCE (Hv-4343) in the Mesolithic period, correlated with a pollen record indicative of previous tree cover declining in favour of hazel (*Corylus*) and other taxa associated with more open habitats. These finds suggest that there is considerable early prehistoric archaeological and palaeoecological potential to the deposits underlying these dunes, especially where they are intercalated with marine silts and clays from successive transgressive/regressive episodes (Middleton *et al.,* 1995).

1.4.4.3 BGS (2023) borehole records correlate with this assertion (*cf.* **Figure 1.6**, **Figure 1.10** and **Figure 1.14**). For instance, borehole SD33SW73 on the north side of Blackpool Airport recorded a layer of fibrous peat between 3.8-5.4 mbgl, underlain by marine clays to 5.7 m, with mixed sands and gravels below. Just outside the south east corner of the airport, borehole SD33SW43/B also encountered peat between 3-4.5 mbgl, with an underlying deposit of bluish grey silt interspersed with occasional peaty bands down to 7.6 m, suggestive of the repeated cycling of (peri)marine and more terrestrial conditions. Borehole SD33SW44/A to the east, on the edge of the mapped dune complex, likewise recorded peat at 3.7-4.2 mbgl, with greyish silts below. There is thus good evidence for the preservation of prehistoric peat below the dunes, though typically at a depth that may lie beyond the impact depth of the majority of groundworks associated with the Transmission Assets. That said, borehole SD33SW119, on the inland edge of the dunes to the north east of Blackpool Airport, did encounter much shallower peat deposits at 1.3-3.5 mbgl. Although this borehole lies outside the boundary of GCZ 2 itself, it demonstrates that not all peat deposits can be priorly assumed to be deeply buried. Conversely, borehole SD32NW1 in the vicinity of the Starr Hills frontage did not record any peat, only mixed sands and gravels to a depth of 16.46 mbgl, indicative of a higher energy environment where existing sediments have likely been extensively reworked by storm events.

1.4.4.4 Two recent project specific geotechnical boreholes (MORGAN_A1_CP01 and MORGAN_A2_CP01B) located across the dune frontage within the Onshore Order Limits (GCZs 1-2) similarly recorded predominantly sands and gravels to *c*. 15 mbgl, overlying stiff brown clay (likely weathered Kirkham Member mudstone). A single fragment of wood was recorded at *c*. 12.5 mbgl in MORGAN_A1_CP01). The drilling of geotechnical borehole LBH01, located further inland within GCZ 2, was monitored onsite by a geoarchaeologist. Here, deposits of dark greyish brown peaty sand and reddish brown fibrous peat were recorded beneath the dune sand at 3.5-5.2 mbgl. These organic deposits overlay further deposits of intercalated pale bluish grey silty clay and grey sandy silt to 17 mbgl, after which stiff reddish brown clay was encountered (again, most likely mudstone bedrock).

1.4.4.5 Lastly, aerial image analysis (Historic England, 2023) has revealed several instances of post-medieval ridge-and-furrow and associated field boundaries both within and surrounding the present-day bounds of Blackpool Airport. Where buried deposits are lacking, near-surface archaeological features may thus hold greater interpretive value for later periods, though their overall relevance for the Regional Research Framework remains relatively low (*cf.* Research Frameworks, 2023).

1.4.5 GCZ 3

1.4.5.1 GCZ 3 (**Figure 1.5**) comprises the former wetlands of Lytham and Marton Mosses, which though superficially separated by a parish boundary together form a single raised bog complex, referred to hereafter simply as ‘Lytham

Moss' (*cf.* Middleton *et al.,* 1995). The bedrock is again Kirkham Member mudstone (**Figure 1.6**), with overlying superficial deposits composed of Tidal Flats and Peat deposits, with Blown Sand fringing the juncture with the higher ground of GCZ 2 to the west, and Glacial Till in the vicinity of the hamlet of Higher Ballam to the east and along the edge of Peel 'island' to the north (**Figure 1.10**). This localised area of Till forms part of a low topographic ridge that extends south of the higher ground of Peel 'island', through Higher Ballam and south towards Lytham Hall Park. Though Lytham Moss and the adjacent lowlands of the Lytham-Skippool Valley were once likely blanketed by a single, contiguous wetland surface, this ridge seems to have effectively divided the two areas since at least the medieval period (Middleton *et al.,* 1995). The area encompassed by GCZ 3 lies wholly within the former raised bog of Lytham Moss, though this wetland has been progressively reclaimed since the early second millennium CE and is now largely devoted to mixed agricultural purposes.

1.4.5.2 As a result of more recent agricultural activity, the upper sediments are now dominated by organic-rich soils formed from degraded former peat deposits, with little preservation of intact peats across the central areas of the former wetland. For instance, BGS borehole SD33SW123, *c*. 490 m south of the Onshore Order Limits, encountered no surviving peat through 6.9 m of clays and silty sands, whilst borehole SD33SW124, *c*. 450 m to the north and right on the edge of the Onshore Order Limits, only recorded a very thin band of brown, amorphous peat directly capping Glacial Till deposits at 5.1-5.3 mbgl (*cf.* **Figure 1.10**). However, buried pockets of humified peat over a metre deep do survive to the east of Midgeland Road and along the west fringe of Peel 'island' near the B5410 (Middleton *et al.,* 1995). BGS mapping has similarly tracked larger peat deposits to the south and western of Peel 'island', and also indicates the presence of buried peat to the west of Higher Ballam (**Figure 1.10**), though these latter deposits were not documented by the North West Wetlands Survey in the 1990s. These sequences all overlie the blue-grey silty clays on which the Moss first developed, themselves deposited during successive phases of marine transgression (Middleton *et al.,* 1995).

1.4.5.3 A further sediment core extracted by the North West Wetlands Survey (NWWS) from approximately 500 m west of Peel (see **Figure 1.6**, **Figure 1.10** and **Figure 1.14**) aimed to better understand this general sequence, and uncovered 1.24 m of Neolithic to early Bronze Age peats overlying blue-grey, silty-clay marine deposits estimated to date from *ca.* 5570-4897 BP (Middleton *et al.,* 1995, 179-182; *cf.* Tooley, 1978). The lowermost peats (at 1.25-1.18 mbgl) returned a pollen assemblage indicating a gradual change from perimarine saltmarsh to reed-swamp ecologies as sea levels fell, with a brief return of marine conditions evidenced by a thin band of clay at 1.15-1.13 mbgl. Above this basal sequence, peats radiocarbon dated to the early Neolithic contained frequent micro- and macro-charcoal, interpreted as being indicative of both local and wider regional vegetation clearance by anthropogenic burning. The associated pollen shows a continued shift throughout this period from the preceding herbaceous vegetation to one associated with fen carr dominated by alder (*Alnus glutinosa*), holly (*Ilex aquifolium*), ivy (*Hedera helix*) and elder (*Sambucus nigra*). The presence of these species indicates the local presence of open woodland, whilst successive clearance episodes are evidenced by phased increases in charcoal and grass pollen alongside decreases in alder.

1.4.5.4 The mid-late Neolithic period then seems to have witnessed less anthropogenic disturbance, with arboreal pollen dominating above 0.78 mbgl. Much of this pollen was dominated by alder, presumably locally prevalent, whilst oak (*Quercus* sp.) input is more likely to have originated from nearby higher ground. From 0.55-0.6 mbgl, the pollen assemblage sees a proliferation of grasses, ruderals, cereal-type plants and royal fern spores (*Osmunda regalis),* alongside a reduction in both alder and oak and a general increase in charcoal. Radiocarbon dated to the early Bronze Age, these peats thus seem to have formed under renewed clearance conditions, with selective felling of surrounding woodland, and both arable cultivation and livestock pastorage being practiced in the surrounding area (Middleton *et al.,* 1995). A general narrative of phased prehistoric land clearance can thus be traced from the initiation of falling relative sea levels in the early Neolithic, though one that was far from uniform in its progression.

1.4.5.5 Similarly, BGS (2023) records show that borehole SD33SE5/A, located approximately 1 km north west of site LA41 (see below) and due south of the NWWS borehole, likewise reported the presence of peat extending from just beneath the shallow topsoil to a depth of 0.9 mbgl, with banded marls and sands continuing until a change to ‘strong clay’ (likely Glacial Till) at 5.4 m.

1.4.5.6 Importantly, these boreholes demonstrate the high value of even degraded peats where they are still preserved below the present-day land surface. This is especially true within a local landscape in which prehistoric archaeological recovery remains relatively slight. That said, the North West Wetlands Survey did record a number of flint scatter sites across Lytham Moss, the majority concentrated on the ecotonal zones fringing areas of higher ground (see **Figure 1.2**, **Figure 1.6**, **Figure 1.10** and **Figure 1.14**). The NWWS core discussed above was itself located close to a series of late Mesolithic to early Neolithic scatters on Peel ‘island’ to the immediate north of GCZ 3 (particularly sites LA70 and LA71, see **Figure 1.2**), whilst site LA37 to the south west lay near to what appears to have been the foreshore at that time. Flint scatters dated to the late Neolithic/early Bronze Age proved far more ubiquitous, with 17 securely identified sites and 30 possible others concentrated across the north east edge of the Moss around Peel ‘island’ and Higher Ballam. Most of these finds comprised waste products such as irregular scrapers, flakes and cores of locally available flint, with few finished implements (Middleton *et al.,* 1995).

1.4.5.7 Site LA40/LA41 (see **Figure 1.2**, **Figure 1.6**, **Figure 1.10** and **Figure 1.14**) at Peel Hall Farm proved particularly rich, evidencing one of the densest areas of Neolithic/Bronze Age activity in north west England with several locally unique finds, including arrowheads, serrated flakes and a bladed knife (Middleton *et al.,* 1995). Such sites indicate the repeated use of wetland-edge environments for tool manufacture, with finished implements presumably transported elsewhere for reuse (by way of comparison, see also the very similar site of LA605/LA606 (see **Figure 1.2**) recorded by the Wetlands Survey on the south bank of the Ribble at Far Banks; Middleton *et* *al.,* 2013). Most importantly, site LA41 and its associated palaeoecological sequences, both of high regional significance, lie just within the Onshore Order Limits in the north east corner of GCZ 3.

1.4.5.8 The prehistoric geoarchaeological potential of GCZ 3 is thus particularly high, with the areas of greatest potential lying around the edge of the small Glacial Till 'island' underlying Higher Ballam (see **Figure 1.10** and **Figure 1.14**), as well as that fringing the larger topographic feature of Peel 'island' to the immediate north. Ecotonal environments such as these have proved to be archaeologically rich across Lytham Moss, with mobile communities from the late Mesolithic to early Bronze Age repeatedly visiting favoured sites on the wetland edge as a part of their wider seasonal rounds (*cf.* Middleton *et al.,* 1995). The pollen assemblage from the NWWS peat core discussed above also indicates that later prehistoric periods were likely to have been characterised by increased settlement and agricultural activity. Indeed, it was hypothesised that site LA41 may also include possible barrow remains sealed below organic soils and/or relict peat (Middleton *et al.,* 1995), though present-day LiDAR data does not pick up such features (*cf.* **Figure 1.14**). Regardless, the spatial location of the wetland edge will have shifted over time in accordance with local variations in relative sea-level, sedimentation rates, vegetation cover and human land-use. It is therefore likely that lower deposits of higher archaeological potential will be masked by overlying sediments, and in some cases could incorporate well-preserved waterlogged remains. Likewise, though the presence of relict peat to the west of Higher Ballam remains to be verified by in-field prospection, the lower-lying areas of the former Moss are also of high potential for the recovery of paleoenvironmental data relating to the surrounding archaeology.

1.4.5.9 Needless-to-say, the former wetland of Lytham Moss is now in a highly degraded state after centuries of sustained drainage and reclamation. Documentary sources from the medieval monastic cell at Lytham record large areas of unreclaimed moss existing throughout the twelfth and thirteenth centuries, though little mention is made of the perceived value of the wetlands themselves. This changes in the sixteenth century, with local records making frequent mention of rush cutting for thatching and the economic importance of drainage ditches and areas of common pasturage. Sustained drainage then seems to have begun in earnest in the early eighteenth century, partly through deliberate drainage but also extensive peat cutting across the north west part of the Moss. This initial reclamation was complex, gradual and piecemeal, with large-scale, centrally engineered 'improvements' only being undertaken across the southern and eastern Moss by the local Clifton Estate from the early 1840s (Middleton *et al.,* 1995; *cf.* Rogers, 1981; 1986). The construction of the Main Drain in 1841 and the passing of the 1846 and 1850 Drainage Acts further escalated this process, eventually leading to the development of the present-day landscape.

1.4.5.10 The preservation potential of GCZ 3 is therefore comparatively low with regards to sub-surface deposits from historic periods, though numerous instances of post-medieval ridge-and-furrow, field boundaries and hollow ways are recorded from aerial imagery across the zone, as well as brick-earth pits within Higher Ballam itself (Historic England, 2023). Near-surface archaeological features may thus hold greater interpretive value, though as within GCZ 2 their overall relevance for the Regional Research Framework remains relatively low (*cf.* Research Frameworks, 2023). The possible exception concerns the ecotonal juncture with the sand dunes to the west. As noted above, this dune complex only developed across its present extent from the twelfth century CE onwards, overlying lower peat deposits as it spread eastward. For instance, BGS (2023) records of combined boreholes SD33SW42 (*cf.* **Figure 1.6**, **Figure 1.10** and **Figure 1.14**) show the presence of peats containing recognisable tree remains and intercalations of bluish clay from approximately 1.45-5.5 mbgl, overlain by thin deposits of Blown Sand. There is therefore greater potential for geoarchaeological recovery along the junction of GCZ 3 and GCZ 2 to the west, both in terms of lower deposits sealed beneath the dunes (see discussion of GCZ 2 above), and potential analyses of shifting medieval/post-medieval land-use across the dunes' advancing inland frontage.

1.4.6 GCZ 4

1.4.6.1 GCZ 4 comprises the lower lying wetlands of the Lytham-Skippool Valley that extend from Higher Ballam/Peel 'island' towards the higher ground to the east (**Figure 1.5**). It is again underlain by Kirkham Member mudstone bedrock (**Figure 1.7**), with the superficial geology mapped by the BGS as Tidal Flat deposits, edging onto Glacial Till towards the higher ground at its fringes (**Figure 1.11**). As discussed above, the Lytham-Skippool Valley is topographically demarcated from the raised bog of Lytham Moss to the west by a shallow ridgeline comprised predominantly of Glacial Till, though the extent to which this has always acted as an effective topographic division between the two areas of wetland remains somewhat moot (Middleton *et al.,* 1995). Nevertheless, though also artificially drained and mostly reclaimed for agricultural purposes in the modern era, the Valley is today lower-lying than the adjacent moss. It was also historically more affected by tidal processes through its south outfall at Nancy's Bay (see **Figure 1.2**), which until the construction of sea defences in the late eighteenth century was much more open to the Ribble estuary and extended approximately 1 km further inland (Middleton *et al.,* 1995). Although contemporary BGS mapping only records extensive Peat deposits through the more northerly parts of the Valley and the former basin of Marton Mere (see **Figure 1.11**), the area of GCZ 4 would once have been blanketed in flat, fen carr peat deposits, since degraded by drainage and other forms of historic land-use (Middleton *et al.,* 1995; *cf.* Usai, 2005).

1.4.6.2 The geoarchaeological potential for GCZ 4 is largely similar to that of GCZ 3, with the areas of highest potential skirting the higher ground around Higher Ballam, Peel 'island' and the juncture with GCZ 5 to the east. As for the area around Peel and Higher Ballam, the North West Wetlands Survey recorded two late Mesolithic/early Neolithic flint scatters on the fringes of the Valley to the north (Middleton *et al.,* 1995). Isolated late Neolithic/early Bronze Age perforated stone axes have also been recovered from across the moss edges and higher ground fringing the more northerly parts of the Valley, beyond the boundaries of the Transmission Assets. Bronze Age metal weaponry has also been recovered from the area of Marton Moss some 3 km to the north, with further metalwork and waterlogged coracles/canoes uncovered during the construction of the Main Dyke from Marton Mere towards Skippool Creek (Middleton *et al.,* 1995; *cf.* Thornber, 1837). As such, though the highest potential for preserved archaeological and palaeoenvironmental remains lies within these ecotonal zones, there remains the possibility for the occurrence of waterlogged deposits within the deeper sediments of the more central parts of the valley basin, should isolated peat deposits still be preserved at depth.

1.4.6.3 Similarly, the age and manner of the geomorphological formation of the Lytham-Skippool Valley is itself highly uncertain, though it has been posited to be glacial in its earliest origins and only later transformed into a fluvial/littoral system in accordance with progressive sea-level change (Tooley, 1978). In contrast to the raised mosses, there is also evidence of relict Palaeolithic land surfaces buried within its lowermost deposits, as attested to by the singular find of the 'Poulton Elk' to the north (Hallam *et al.,* 1973), currently dated to the Windermere interstadial at 13,500-11,500 cal CE (OxA-150) and posited to have inhabited a lightly wooded 'park tundra' landscape (Jacobi *et al.,* 1986). It is unlikely that such remains would be preserved in the immediate vicinity of GCZ 4 given the degree of later disturbance, but targeted borehole investigations could potentially help to clarify the Palaeolithic origins of the Valley from a purely sedimentary perspective, and thus add greater context to nearby finds such as the Poulton Elk.

1.4.6.4 The medieval and post-medieval reclamation of the Lytham-Skippool Valley largely mirrors that of Lytham Moss discussed above. In this vein, initial reclamation appears to have progressed in piecemeal fashion through the cutting of peat for fuel and the expansion of partially drained carr-land for the purposes of livestock pasturage. However, in contrast to the adjacent Moss, the continued presence of Marton Mere within the Valley catchment meant that by the mid-seventeenth century flooding was becoming increasingly problematic as peat extraction progressively lowered the land surface, so that water regularly overflowed into the cuttings. The Main Dyke was constructed to relieve this issue in 1731, draining Marton Mere into the now-canalised Skippool Creek/'flu' and greatly reducing the size of the Mere itself by 1786. This drainage programme was boosted in 1841 with the southern extension of the Main Drain into the Ribble estuary, and with the exception of Weeton Moss to the north all remaining wetland within the Valley was reclaimed for agricultural purposes by the mid-nineteenth century (Middleton *et al.,* 1995). In accordance with GCZs 2 and 3, the archaeological potential of this area with regard to later periods is thus largely restricted to near-surface features, of which aerial imagery has recorded several instances of post-medieval ridge-and-furrow/field boundaries along the western and southern portions of the zone (Historic England, 2023).

1.4.7 GCZ 5

1.4.7.1 GCZ 5 comprises a small, buried valley roughly following the contemporary line of Cartmell Lane, rising from the Lytham-Skippool Valley onto the higher ground to the east (**Figure 1.5**). In this regard, it forms one of several embayments cut into the Glacial Till overlying the Kirkham Member mudstones along the east side of the southern Lytham-Skippool Valley (*cf.* Middleton *et al.,* 1995). The present-day Wrea Brook runs roughly north-south through GCZ 5 and across the head of this small valley, perpendicular to its declination into the former wetlands to the west. The modern surface hydrology thus appears at odds with the base topography, with the BGS recording the presence of Alluvium within the base of the valley itself, transitioning into localised peat deposits before it meets the lower lying Tidal Flat deposits. The head of the valley near the juncture with GCZ 6 is conversely mapped as being filled with periglacial Head deposits (**Figure 1.11**). Accordingly, this small topographic feature may have formed by late glacial to early Holocene geomorphological processes, with a small watercourse flowing down from gravelly Head deposits deposited in depressions formed by ice scouring across the surface of the Glacial Till. Throughout the Holocene, this watercourse likely infilled with alluvial sediments, possibly exacerbated by the gradual blocking of its outfall by accumulating peat deposits. At some unknown point, this process evidently contributed towards the shifting of the watercourse, perhaps towards the alignment of the present-day course of the Wrea Brook and its eventual outfall into the saltmarsh of Nancy's Bay.

1.4.7.2 The North West Wetlands Survey recorded the locally rare presence of early Neolithic lithics at sites LA59/LA60 (Figure 1.2, Figure 1.7, Figure 1.11 and Figure 1.15) near Moss Side, on the higher ground to the north of the Onshore Order Limits. These lithics comprised a distinctive blade-based flint technology, including a flake from a polished stone axe, concentrated in a 50 x 40 m area itself located within a more diffuse scatter. Sites LA65 and LA66 on the south side of the valley (and within the Onshore Order Limits) also returned several waste and preparation flakes of unspecified prehistoric origin (Middleton *et al.,* 1995). The only other archaeological features of note within the immediate vicinity are some instances of post-medieval ridge-and-furrow to the south (Historic England, 2023). That said, much of this seeming sparsity of archaeological remains largely derives from the relatively minor scale of previous prospection. The valley overall comprises a discrete ecotonal catena running off the higher Glacial Till and down into the lower wetlands, within which both Alluvium and Peat may preserve waterlogged deposits of high archaeological and palaeoecological potential. In accordance with the discussion of wetland-edge ecotonal environments for GCZs 3 and 4 above, GCZ 5 thus comprises an area of high geoarchaeological potential.

1.4.7.3 This situation is especially true given the lack of historic BGS borehole data from the immediate vicinity with which to gauge the potential depth and spatial extent of the Alluvium and Peat, and the likely date ranges of their initial deposition. However, two recently drilled project specific geotechnical boreholes are located in GCZ 5. Borehole BH117-EXC was located on the higher ground of the Glacial Till, whereas BH118-EXC was located on the margins of the southern side of the valley floor. The latter borehole recorded mottled grey/brown sandy clay from beneath the topsoil to 1.2 mbgl, which may represent alluvium, itself overlying light grey, slightly gravelly clay to 2.5 mbgl. The sediments recovered below this depth likely represent Glacial Till. Neither borehole recovered any notable organic deposits.

1.4.8 GCZ 6

1.4.8.1 GCZ 6 comprises the higher ground extending from the Lytham-Skippool Valley towards the area of the central Fylde near Kirkham (**Figure 1.5**), underlain across this geographic range by mudstone bedrock belonging to the Breckells Member **Figure 1.8**). The elevated topography is itself formed from deposits of Glacial Till, of which GCZ 6 crosses the south fringe of a larger formation extending to the north. Due to this peripheral location, much of the Till across GCZ 6 has been eroded through periglacial geomorphic processes, creating several small, shallow valleys filled with Head deposits (**Figure 1.12**) which now typically support small streams (often canalised into agricultural drainage ditches). The entire local landscape, especially the higher ground, is also sprinkled with kettle holes formed in the outwash plain of the last retreating glaciers (**Figure 1.16**).

1.4.8.2 There is generally very little archaeology recorded from within the vicinity of this zone, possibly as soils derived from Glacial Till are predominantly clayey and do not readily show cropmarks, whilst they can also limit the degree to which artefacts are brought to the surface by ploughing, which in areas of already low find density will lead to very low recovery rates during fieldwalking surveys (Middleton *et al.,* 1995). That said, post-medieval ridge-and-furrow has been mapped from aerial imagery to the south, around the environs of Warton and Freckleton. However, this reported distribution is principally the result of the heuristic boundaries of the North West Rapid Coastal Zone Assessment Survey (Historic England, 2023), so that similar features should be assumed to extend beyond those already logged within the Historic Environment Record. Historically, it has long been posited that the ‘lost’ Roman port of Portus Sentantiorum may have been located to the south at Freckleton Naze, on the north bank of the Ribble opposite its confluence with the River Douglas (*cf.* Whittaker, 1773). Though the mouth of the Wyre has also been suggested as an alternative location (Middleton *et al.,* 1995), a port location at Freckleton Naze would make logistical sense, as a relative sea-level minimum during the Roman period would have easily facilitated access to the north shore of the Ribble estuary by seafaring vessels (Chiti, 2004).

1.4.8.3 Overall, the geoarchaeological potential of GCZ 6 itself remains low. The areas of slightly higher potential are those lying immediately adjacent to GCZs 5 and 7, as in either case they represent the edges of higher ground overlooking the slopes down towards the Lytham-Skippool Valley and Freckleton Pool respectively, and thus are likely to have been attractive places for settlement throughout much of the past. Though of limited coverage, BGS (2023) records of boreholes to the north and south of the east end of GCZ 6 all show topsoil deposits of 0.3-0.4 m coming down directly onto weathered Till clays, such that any archaeological features are unlikely to be found below the upper 0.5 m of the sedimentary profile. However, there remains the possibility for locally buried land surfaces to lie sealed beneath the Head deposits discussed above.

1.4.9 GCZ 7

1.4.9.1 GCZ 7 comprises the valley of the Freckleton Pool stream and the immediately surrounding higher ground (**Figure 1.5**). This zone is also underlain by Breckells Member mudstones, with the transition to Sherwood Sandstone lying along its south east boundary **(Figure 1.8**). As for GCZ 6, the superficial geology is again dominated by Glacial Till marked with kettle holes across the higher ground, with pockets of Head deposits occurring in small valley depressions to the south and north

(**Figure 1.12** and **Figure 1.16**). A series of project specific geotechnical boreholes (BH134-LSSMG, BH135-LSSMG, BH137-LSSMG and BH138-LSSMG) were located across the central higher ground of GCZ 7, and all recorded simple sequences of modern top-/subsoil overlying Glacial Till. Conversely, the central valley of the Freckleton Pool is mapped by the BGS as being filled by Tidal Flat deposits (**Figure 1.12**), though the sloping elevation revealed by the LiDAR plot (**Figure 1.16**) would suggest that it is probably truer to say that these sediments are predominantly alluvial in composition, grading into tidal muds nearer the southern outfall of the Pool into the (now-reclaimed) Ribble estuary. It is also likely that Head and related Glacio-fluvial deposits are at least partly interdigitated with Alluvium across the more northerly reaches of the valley, though mostly beyond the limits of GCZ 7 itself (*cf.* **Figure 1.12**).

1.4.9.2 The only substantial archaeological remains recorded in the immediate vicinity are those of Dowbridge Roman fort, lying c. 170 m to the immediate north of GCZ 7 and east of Kirkham. This fort was initially one of a series of Agricolan marching camps later converted into a signal tower/fortlet in the late 1st century CE, before being remodelled in stone in the early second century. However, excavations have shown that it had fallen out of use by the mid-second century, whilst extramural activity seems to have been as small-scale and transient as that of the fort itself. It was linked to other Roman installations by a road running from the larger fort at Ribchester through Fulwood, Lea and Salwick, and possibly on to Fleetwood at the mouth of the River Wyre (Howard-Davis and Buxton, 2000; Middleton *et al.,* 1995). Aside from this small fort at Dowbridge, and the putative port at Freckleton Naze discussed above, Roman activity along the Ribble was concentrated further to the east, for instance at Ribchester and the settlement at Walton-le-Dale, and to have been focussed on the Ribble navigation itself rather than the surrounding dryland. The evidence for Iron Age-Roman occupation of the Fylde is thus very slight (Chiti, 2004; Middleton *et al.,* 1995), both within the immediate vicinity of GCZ 7 and in general.

1.4.9.3 The overall geoarchaeological potential of GCZ 7 may thus appear slight, but there are some specific caveats. The first of these concerns the alluvial/partially tidal sediments across the base of the narrow valley of the Freckleton Pool. No historic borehole data exists to currently assess how deep these deposits may be, though it is possible that they could seal either archaeological remains and/or waterlogged sediments of palaeoenvironmental value, especially towards the south end of the valley before its outfall into the Ribble estuary. On a related note, the whole south east boundary of GCZ 7 marks the juncture between the higher ground to the north and west, and the low-lying basin of the Ribble estuary to the south and east. This thus marks a distinctive ecotonal transition within the wider landscape, and it is likely that it would have been exploited as such by past communities. As discussed further below in relation to GCZ 11, there is medium-high potential for archaeological remains to be encountered across the upper part of this landscape boundary.

1.4.10 GCZ 8

1.4.10.1 GCZ 8 was delineated for the initial DBA but no longer falls within the Onshore Order Limits. It has been retained in this report for contextual purposes. The zone comprises the western most extent of the valley of the Savick Brook and its outfall into the inner Ribble estuary (**Figure 1.5**). The bedrock is Sherwood Sandstone, and whilst the base of the valley is mapped by the BGS as being filled by Tidal Flat deposits (**Figure 1.13**), these are more likely to comprise a sedimentary mélange of freshwater Alluvium deposited by the outwash of the Savick Brook itself and estuarine muds drawn eastward by the twice-daily flood tides. Perhaps more accurately, these are likely to have been the principal means of local sedimentary input prior to the reclamation of the saltmarshes lying beyond the Savick Brook's immediate outfall into the estuary beyond, a process which is estimated to have begun as early as the sixteenth century CE (Halcrow, 2013).

1.4.10.2 There is high potential for both archaeological and palaeoecological preservation across the valley floor of the Savick Brook. LiDAR imagery (**Figure 1.17**) shows several former meanders visible as palaeochannels in the fields to the immediate north east of GCZ 8, though their age remains unknown. In general, however, the intercalation of fine-grained alluvial and tidal sediments presents an environment where lower deposits could feasibly contain waterlogged organic material. This high potential is further supported by BGS (2023) borehole records, which extend in a linear transect upstream of the Brook's estuarine outfall (*cf.* **Figure 1.9**, **Figure 1.13** and **Figure 1.17**). Several boreholes (especially SD43SE285 and SD43SE309) record waterlogged sandy deposits at between approximately 2-3 mbgl, typically overlain by soft clayey Alluvium. However, the presence of Glacial Till at 1.5 to 3.5 mbgl in borehole SD43SE287 caps these lower saturated sands, indicating that they may be of Pleistocene date. Nevertheless, borehole SD43SE308 near the western end of GCZ 8 displays a clear sequence of alluvially lain silts down to 3 mbgl, with waterlogged sands and gravels overlying the basal Till from 3-3.5 m. Importantly, these lower sediments incorporated multiple inclusions of preserved wood, confirming that the best preservation conditions along the Savick Brook are likely to be found at/near its juncture with the wider Ribble estuary.

1.4.10.3 Recent works by OA as part of the Preston Western Distributor and East/West Link Road project have also recovered a 4 m deep peat core from the floor of the Savick Brook a few hundred metres upstream of the north east edge of GCZ 8. Preliminary assessment suggests that this peat sequence developed between the early Mesolithic period and the early Bronze Age and seems indicative of substantial palaeoecological potential relating to the early prehistoric environment of this area (OA, forthcoming).

The same investigation also uncovered evidence of late Mesolithic-early Neolithic nut processing and consumption within several tree throws situated on the north bank of the Brook, near the south west corner of Ashton and Lea Golf Club and approximately 860 m upstream of GCZ 8 itself (OA, forthcoming).

1.4.11 GCZ 9

1.4.11.1 GCZ 9 comprises the higher ground between the south side of the Savick Brook and the north east edge of the inner Ribble estuary (**Figure 1.5**). The bedrock is Sherwood Sandstone (**Figure 1.9**) capped across the higher ground by Glacial Till, itself marked by several kettle holes (**Figure 1.13** and **Figure 1.17**). The geoarchaeological potential of the Glacial Till is typically relatively low and any archaeological remains are likely to be buried at shallow depths. Recent investigations by OA as part of the Preston Western Distributor and East/West Link Road project encountered three early medieval pits on the higher ground to the south of the Savick Brook, approximately 200 m north of GCZ 9 (OA, forthcoming). Whilst this area of activity lies outside the current Onshore Order Limits, it is indicative of highly localised rural occupation rarely encountered across north west England, raising the overall potential of GCZ 9 from low to medium, in the recognition that further such features may yet be preserved within the Onshore Order Limits themselves.

1.4.11.2 Beyond its potential for early medieval occupation, the geoarchaeological potential of GCZ 9 is generally more limited. Aerial image surveys have only recorded post-medieval ridge-and-furrow within the zone, in addition to a small Second World War military camp in the woods to the north of the present-day Lea Gate Hotel (Historic England, 2023). That said, caveats to this broad statement do apply regarding the lower-lying western/south western parts of the zone where the higher slopes decline at relatively gentle gradients towards GCZs 8 and 11 (*cf.* **Figure 1.17**). In these areas, possible archaeological remains buried within edge deposits may extend into GCZ 9 itself. Conversely, project specific geotechnical borehole BS162-NG, located within GCZ 11 just off the southern boundary of GCZ 9 (**Figure 1.9**, **Figure 1.13** and **Figure 1.17),** suggests that the drop off into the adjacent estuarine basin is fairly sharp in this location. Here, a deep sequence of alluvial clays, sands and gravels extends to probable Till at 13.2 mbgl. Highly localised sub-surface topographic variation is thus likely to characterise the fringes of this zone.

1.4.12 GCZ 10

1.4.12.1 GCZ 10 (**Figure 1.5**) comprises the higher ground that fringes the south east edge of the inner Ribble estuary, situated on either flank of the Mill Brook (GCZ 12). The bedrock comprises Sherwood Sandstone, here overlain almost entirely by Glacial Till (**Figure 1.9** and **Figure 1.13**). At the eastern end of the zone several small valleys cut into the Till contain Head deposits. The high ground is again pockmarked by kettle holes, though they are less clearly pronounced than to the north of the Ribble (**Figure 1.17**). Aerial imagery again records extensive post-medieval ridge-and-furrow, with some instances of earlier medieval field systems just to the west of GCZ 10, immediately south of Bottom of Hutton (Historic England, 2023). In general, the geoarchaeological potential of the zone is considered relatively low. That said, the small valleys filled with Head deposits, running down to the estuary in the vicinity of the National Grid substation at Penwortham, do present some potential for locally buried archaeological remains, as discussed for GCZ 6.

1.4.13 GCZ 11

1.4.13.1 GCZ 11 (**Figure 1.5**) comprises an expanse of tidal flats and saltmarsh filling the inner basin of the Ribble estuary and its confluence with the River Douglas, now almost entirely reclaimed for agricultural or other purposes. BGS mapping shows the zone as being entirely underlain by Sherwood Sandstone, with the exception of its north west boundary with GCZ 7 which transitions into Breckells Member mudstones (**Figure 1.9**). The superficial deposits are likewise dominated by tidal silts, clays and sands, with tidal Alluvium filling the central navigation of the Ribble itself in addition to the estuarine outfall of the Savick Brook. Small protrusions of Glacial Till are also recorded across the southern edge of the zone as the higher ground of GCZ 13 slopes down north of Longton Brook. Finally, the small, incised valleys near Penwortham on the north east edge of GCZ 10 have exuded a small fan of Head deposits into the lower basin, from which a narrow bar of river terrace deposits extends out towards the current river course (**Figure 1.13**).

1.4.13.2 Broadly speaking, the morphological bounds of the inner estuary have likely remained more-or-less constant over the past 5000 years as sea-levels have likewise remained relatively stable (Halcrow, 2013). That said, recent research has tracked some major changes in channel distribution that have affected the outer estuary throughout the historic period (Van der Wal *et al.,* 2002). It is probable a degree of channel migration has also occurred within the inner estuary, with the potential for localised erosion and sediment mixing. Nonetheless, the inner estuary has broadly been subject to gradual infilling by both onshore and alongshore sediment transport throughout this period, exacerbated by pronounced tidal asymmetry within the estuary itself (Halcrow, 2013). It is likely as Tidal Flat deposits built up within the estuary, saltmarsh vegetation also expanded outwards from the edges of the basin. Subsequent land reclamation has since supplanted most of these former saltmarshes within the inner estuary, though more extensive areas do survive across the south west corner of GCZ 11, as well as the recent realignment works at Hesketh Out Marsh just outside the wider study area. LiDAR imagery (**Figure 1.17**) reveals the relict pattern of irregular, dendritic channels that underlies much of this reclaimed land, especially across the north west section of the zone.

1.4.13.3 This latter area also sits at a slightly higher elevation than the rest of the inner basin (excepting the modern instances of raised ground along the north bank of the modern-day Ribble, *cf.* **Figure 1.17**). It is likely that this area marks a relatively early phase of deliberate reclamation within the inner estuary, as is suggested by the presence of thin, sequentially arranged strip fields extending between the dryland to the north and the embankment along what is now Preston New Road to the south (see **Figure 1.17**). Although reclamations of estuarine marsh occurred from as early as the sixteenth century CE (Halcrow, 2013), it is likely this area was reclaimed in later centuries. Ordnance Survey certainly shows it to have been a well-established area of agricultural pasturage by the mid-nineteenth century (OS, 1846-1873). Post-medieval ridge-and-furrow is also recorded to the immediate east, just south of Clifton (Historic England, 2023). Large-scale reclamation in general occurred across both banks of the Ribble from 1850-1890, leading to a sizeable reduction in tidal volume. Training walls were also built within the inner estuary in 1840-1847 to constrain the central navigation, and were extended seaward in subsequent decades, eventually reaching Salter's Bank by 1932-1937. These walls in turn reduced the ebb flow of the main channel and created greater flood-dominant conditions to either side, further enhancing sediment import and necessitating frequent dredging until the close of the Port of Preston in 1981 (Halcrow, 2013).

1.4.13.4 In many respects this history of reclamation, canalisation, and even more recent realignment, is very much a part of the local heritage landscape, though of limited geoarchaeological value. The possible exception concerns the area of older reclaimed land south of Newton-with-Scales, where increased overburden may seal lower deposits that remain better preserved than elsewhere in the inner estuary, which in turn may prove of increased palaeoecological value and/or incorporate the archaeological remnants of prehistoric/early historic exploitation of saltmarsh resources. It is also worth noting the presence within GCZ 11 of several features dating to the Second World War. These include aircraft obstruction earthworks to the south west, a bombing decoy under what is now SUEZ's recycling and recovery plant on the north bank of the Ribble, a probable heavy anti-aircraft battery emplacement near Freckleton Naze, and several pillboxes and relict trenches on the outskirts of Preston to the east.

1.4.13.5 Of far greater geoarchaeological potential are the ecotonal environments skirting the edge of the estuary basin. As discussed above for the adjoining dryland zones, such transitional areas were often favoured by past communities, especially in terms of settlement on higher ground that was then well-placed to take advantage of adjoining wetland resources. Moreover, although the overall extent of the inner estuary is unlikely to have changed drastically over the past 5000 years, gradual infill sedimentation will have raised the level at which this ecotonal transition occurs. Former dry land is thus likely to have been buried as the estuary edge crept slowly upslope, potentially sealing relict land surfaces and archaeological sites in the process. Prior to reclamation, such habitats would also have presented resource-rich areas for human exploitation, for example through former saltmarshes and tidal mudflats. Though the material evidence for human presence within these landscapes is likely to be slight, the potential remains for the preservation of structures such as fish traps, weirs and raised walkways buried by later overburden (*cf.* OA, 2023b).

1.4.13.6 The northerly area of reclaimed land south of Newton-with-Scales (discussed above) holds particularly high potential in this regard. So too do the shallow slopes along the south edge of GCZ 11. LiDAR imagery (**Figure 1.17**) here indicates that a shallow shelf of former dry land extends under what are now reclaimed tidal flats. This is especially true for the flats directly adjacent to the embayment of Longton Brook within GCZ 13, the area of GCZ 11 to the north of Bottom of Hutton along the outfall of the Mill Brook, and that to the immediate north east of Penwortham substation. The potentially high value of the former two areas is further suggested by the encroachment of post-medieval ridge-and-furrow into the estuary itself (Historic England, 2023), indicating an earlier date of initial burial, and the presence of a buried paleochannel extending north west from the present-day outfall of the Mill Brook (*cf.* **Figure 1.17**). The slightly raised land surface of the latter area also seems to be at least partly conditioned by underlying river terrace deposits (*cf.* **Figure 1.13**). Though their date remains unknown, these deposits could themselves incorporate older, albeit reworked, Palaeolithic artefacts, whilst their surface may have been utilised by later communities as a drier 'island' within the surrounding tidal flats.

1.4.13.7 BGS (2023) borehole records within the inner estuary are more numerous than for the rest of the Onshore Order Limits, though in terms of relevant coverage are restricted to two broadly north-south transects across the basin, one near the east boundary of GCZ 11, and one near its western end (**Figure 1.9**, **Figure 1.13** and **Figure 1.17**). In the east, borehole SD42NE157 near the north shore and juncture with GCZ 9 records deposits of peat at 2-3 mbgl and 5.5-6.7 mbgl, intercalated with thick bands of silty clay, the lower 0.6 m of which were especially dark and likely organic-rich. Borehole SD42NE156 to the south did not contain any peat, but again encountered a thick deposit of organic silts containing preserved wood from 4.9 to 9.1 mbgl over lower sands and gravels. It would seem this northern bank of the innermost estuary thus offers particularly good potential for the preservation of organic remains. On either flank of the current river course, boreholes SD42NE155 and SD42NE154 both contained sequences of fluvial sands, as did borehole SD42NE153 to the south, with the noticeable exception of rotting fibrous wood encountered at 5.9 mbgl. Three project specific geotechnical boreholes (BH174-NG, BH175-NG and BH176-NG) produced broadly similar results. Finally, borehole SD42NE152 was located right on the transition between the tidal flats and southern dryland and encountered reworked Glacial Till deposits immediately below the 0.45 m thick topsoil. This seems to evidence a fairly sharp fall-off from the dryland into the estuary, contrary to the shallow 'shelf' to the immediate west hinted at by the LiDAR plot.

1.4.13.8 At the west end of GCZ 11, boreholes SD43SE26, SD42NE7 and SD42NE8 across the higher reclaimed land south of Newton-with-Scales all returned similar sequences of silty clays to a depth of 1.0-1.6 mbgl, overlying coarser sands and with gravelly clays occurring at approximately 6-8 m. Further south, the sequence of borehole SD42NE10 was initially similar, but with an additional deposit of silty sand containing organic matter at 5.5-7.0 mbgl. On the present north riverbank, borehole SD42NE21 then encountered mottled organic silty clays down to 1.25 mbgl, with fluvial sands beneath - a lower sequence mirrored by borehole SD42NE48 from within the navigation channel itself. The reclaimed land to the north thus appears to encompass substantial deposits associated with former saltmarsh, with that closest to the navigation channel encompassing near-surface organic sediments that likely result from more recent phases of overbank flooding and tidal wash. On the southern bank, borehole SD42NE26 likewise recovered black silty clay deposits from the upper 1.95 m, with coarser sands and gravels below. Heading towards the higher land of GCZ 10 to the south, boreholes SD42NE30 and SD42NE32 also encountered organic clays down to 1.1-1.2 m, with the latter retrieving particularly rich organic remains from 0.95-1.2 mbgl located directly adjacent to the shallow 'shelf' of the Longton Brook embayment (GCZ 13).

1.4.14 GCZ 12

1.4.14.1 GCZ 12 (**Figure 1.5**), though included in the initial DBA, no longer falls within the Onshore Order Limits but has been retained in this report for contextual purposes. This zone comprises the narrow valley of the Mill Brook and the immediately adjacent higher ground, being surrounded on three sides by GCZ 10 and facing GCZ 11 to the north west as the Mill Brook outfalls into the estuary beyond. The valley itself is cut through the surrounding Glacial Till, and sits atop Sherwood Sandstone bedrock (**Figure 1.9** and **Figure 1.13**). It has been demarcated as a separate GCZ (as opposed to the Longton Brook within GCZ 10, for instance) on the lines that, although small, it appears more deeply incised within the surrounding high ground (*cf.* **Figure 1.17**) and contains a greater variety of sediment facies types. For instance, BGS mapping of the superficial deposits indicates its upper reaches are filled principally by Head, its middle section by Alluvium, and its estuary-adjacent lower reaches by Tidal Flat deposits (see **Figure 1.13**), though the actual boundaries between these sedimentary zones are unlikely to be so clearly defined. As for the valleys of the Freckleton Pool and Savick Brook on the northern shore of the estuary basin, the principal focus of geoarchaeological potential lies in the sealing of lower deposits by later Alluvium/Tidal sediments. However, as the valley is relatively sharply incised into the surrounding Till and is correspondingly very narrow, deep deposits may not have built up within it. Unfortunately, no historic boreholes are located within this zone to verify if this is the case, such that its geoarchaeological potential remains, at present, tentatively medium.

1.4.15 GCZ 13

1.4.15.1 GCZ 13 (**Figure 1.5**) again no longer falls within the Onshore Order Limits but has been retained in this report for contextual purposes. This zone comprises the higher ground flanking the southern edge of the inner Ribble estuary, to the immediate north of the present-day outfall of the Longton Brook as it runs west from the village of Longton itself. The bedrock is again Sherwood Sandstone (**Figure 1.9**), overlain in the most part by Glacial Till, but with pockets of Tidal Flat deposits across the lower ground fringing the estuary of GCZ 11 (**Figure 1.13**). This intercalation of superficial deposits appears to be largely conditioned by the shallow gradient of the sloping higher ground as it enters the estuary basin itself (**Figure 1.17**). As for the Savick Brook to the north east, the tidal flats mapped along the outfall of the Longton Brook are again most likely to comprise a mix of fluvial and more estuarine sedimentary material, with estuarine components increasing as it becomes increasingly tidal downstream to the west. LiDAR imagery (*cf.*

Figure 1.17) further reveals the presence of a buried palaeochannel running northward of the present-day course of the Longton Brook, suggesting that the wide embayment associated with its outfall has been formed through several episodes of channel avulsion throughout the past.

1.4.15.2 As mentioned above, borehole SD42NE32 to the immediate west recorded organic enriched sediments at 0.95-1.2 mbgl, presenting the possibility for a highly graduated and historically variable ecotonal transition from dryland to estuarine wetlands across the whole western interface of GCZs 13 and 11. That this area was important for more recent past communities is evidenced by the recording via aerial imagery of extensive post-medieval ridge-and-furrow across GCZ 13 to the west of Bottom of Hutton (Historic England, 2023). The continued presence of long, post-medieval strip fields running down to the estuary edge north of Marsh Lane to the immediate south of GCZ 13 (*cf.* **Figure 1.17**) further points to past land use practices focussed more on agricultural resource management than concerted settlement *per se*. In contrast to other areas of high ground fringing the estuary basin, GCZ 13 thus has high geoarchaeological potential due to its uniquely extensive ecotonal characteristics.

1.5 Geoarchaeological potential

1.5.1 Introduction

1.5.1.1 The Transmission Assets comprise a sizeable transect across a landscape that is relatively complex in its geomorphology, sediment history and geoarchaeological potential, encompassing as it does a range of sedimentary environments from sand dunes, to raised bog, to open estuary. The following section aims to integrate the data presented in the preceding GCZ descriptions to consider the overarching geoarchaeological potential contained within the Onshore Order Limits. That potential is expressed in terms of the following.

1. The possible presence of archaeological and well-preserved palaeoenvironmental organic remains that may lie sealed by, or within, sedimentary facies.
2. Areas with good stratigraphic sequences that could contribute to a deposit model (either in the case of existing BGS data, or where GI and/or purposive geoarchaeological works may be undertaken).

1.5.1.2 These data are considered first from a more general facies perspective (**Table 1.2**), followed by a more detailed breakdown of each of the GCZs encompassed within the Onshore Order Limits.

1.5.2 Potential of the sedimentary facies

1.5.2.1 This section summarises the broad potential for encountering archaeological remains within the various environments and sedimentological sequences throughout the Onshore Order Limits. The deposits are summarised in **Table 1.2**, followed by a more detailed commentary thereafter.

Table 1.2: Summary of sedimentary facies types and generalised geoarchaeological potential

Sediment unit	Environment of deposition	Geoarchaeological potential
Topsoil	Modern agricultural ploughsoil. Low to medium energy.	May contain redeposited pottery or lithic material brought to the surface through ploughing and sub-surface disturbance.
Colluvium	Potential downslope soil movement (both modern and more ancient) associated with agriculture and vegetation clearance. Also known as hillwash/ploughwash, accumulates through soil creep, slope/sheet wash, and rill/gully erosion. Low to medium energy.	Potential to contain redeposited pottery and lithic material from pre/historic activities on higher ground/slopes, and to seal buried land surfaces and pre/historic archaeology.
Tidal Flat Deposits	Holocene sedimentation of sands, silts and clays in coastal settings. Includes mudflats, sandflats, saltmarsh and tidal creeks. Low to medium energy.	Potential to seal *in situ* pre/historic archaeology in waterlogged conditions. May preserve evidence of former saltmarsh and creek systems, and earlier freshwater environments at depth (see below). Sites of seasonal activity (e.g. timber structures and fish traps, evidence of salt making). Localised erosion and reworking may have occurred proximal to larger channels.
Alluvium/Fluvial Deposits	Holocene alluviation associated with overbank flooding, migrating river/stream channels and backwater areas. Low to high energy.	Potential to seal *in situ* pre/historic archaeology (including former dryland) in waterlogged conditions, although reworking and erosion may be associated with coarser grained channel facies (sands and gravels). Timber structures may be preserved, particularly at marginal ecotonal zones adjacent to buried islands or at floodplain/channel edges.
Peat/Organic Alluvium	Periods of stabilisation or channel migration that result in encroachment of vegetation. True peats form from purely vegetative material under anoxic conditions, more fluvially-affected environments typically form organic-rich silts/silty clays. Low energy.	*In situ* prehistoric potential in waterlogged conditions, including preservation of organics such as timber structures and palaeoenvironmental remains.
Blown Sand Deposits	Aeolian coversands, typically forming semi-mobile dune systems. Low to medium energy.	Potential to seal *in situ* pre/historic archaeology, including under waterlogged conditions where buried land

Sediment unit	Environment of deposition	Geoarchaeological potential
		surfaces comprised wetland environments.
River Terrace Deposits	Undifferentiated Pleistocene sands and gravels. Medium to high energy.	Palaeolithic potential, largely reworked artefacts. Potential for later prehistoric archaeology across surface.
Storm Beach Deposits	Medium to coarse grained detrital sediments accumulated during specific weather events. High energy.	Low. May seal underlying land surfaces.
Head Deposits	Unsorted detrital muds incorporating sand and gravel, formed under periglacial conditions by down-slope solifluction and mass wastage. Low to high energy.	Rare potential for sealed Palaeolithic land surfaces.
Glacial Till, Diamicton	Deposits of clays, sands and gravels deposited by and underneath glaciers. Low to medium energy.	None. Very rarely masks underlying Palaeolithic archaeology.
Bedrock	Geological strata. Predominantly late Permian-Triassic mudstones in west, transitioning to sandstones in east. Low to medium energy.	None.

1.5.2.2 **Tidal Flat deposits**: BGS mapping of the regional superficial deposits has recorded considerable accumulations of Tidal Flat deposits along the Ribble estuary, including the lower reaches of its smaller tributaries such as the Freckleton Pool, Savick Brook, Mill Brook and Longton Brook, and the former coastal embayments of Lytham Moss and the lower Lytham-Skippool Valley. Where influenced by active freshwater fluvial systems, as alongside the central navigation channel of the River Ribble or the outfalls of the above-mentioned tributaries, these deposits are typically interleaved or admixed with accumulations of clays, silts and sands that often include an organic component. The lower reaches of valley systems such as the Ribble present complex sedimentary sequences in this regard, as both fluvial and estuarine dynamics typically influence the twin processes of erosion and deposition. The extensive former wetland environments of Lytham Moss and the adjacent Lytham-Skippool Valley are likely to be similarly complex, as in addition to perimarine influence they have also developed under fluvial input and *in situ* illuvial processes associated with the perched water tables of ombrotrophic wetlands. The sedimentary sequences from such environments are likely to reflect changes in Holocene relative sea level, and to have fluctuated throughout time in terms of their suitability for human exploitation. They thus have the potential to contain important archives for sea level and palaeoenvironmental reconstruction.

1.5.2.3 **Floodplain and river terrace deposits**: Due to the predominantly estuarine environs within the Onshore Order Limits, there are few environments that can be properly said to comprise floodplains as opposed to tidal flats. The exceptions constitute the mid- to higher reaches of the Freckleton Pool, Savick Brook, Mill Brook and Longton Brook before their outfall into the Ribble estuary's inner basin. Alluvial deposits along these watercourses have the potential for concealing and preserving both buried land surfaces and archaeology, including locally constrained waterlogged deposits. This is especially true given the propensity for such marginal areas to act as foci for human habitation. Furthermore, it is probable that alluvial sediments within these small valleys are interdigitated with colluvium that has washed down the valley sides, such that the resulting valley-floor deposits are likely composed of sediments from mixed fluvial and dryland sources, especially along their edges. River terrace deposits are scarce within the Onshore Order Limits, restricted to a small area mapped by the BGS near the inner neck of the Ribble estuary. Such terrace deposits may have been utilised by past communities as relative topographic 'highs' within the subdued topography of the surrounding estuary basin. Moreover, the previously dryland areas of such rises may now be buried beneath accumulated Alluvium or Tidal Flat deposits. Though highly localised and undated, there is a possibility these terrace deposits could also contain Upper Palaeolithic cultural material, albeit highly likely to be reworked.

1.5.2.4 **Peat deposits**: There are numerous portions of the Onshore Order Limits that infringe upon mapped peat deposits, particularly across the western half of the proposed route. These deposits are most notable along the northern fringes of the raised bog of Lytham Moss, and within a series of embayments on the eastern flank of the adjacent wetland of the lower Lytham-Skippool Valley. In both cases, these environments should be more properly termed 'former wetlands', as since the early eighteenth century they have been subjected to sustained artificial drainage and are now almost entirely reclaimed. Most of their former peat deposits have thus been severely degraded and are now evident only as organically enriched agricultural soils. Surviving peats are thus of particularly high palaeoenvironmental value, and their current mapped extent should very much be treated as a tentative rather than definitive expression of their sub-surface presence. This DBA has also highlighted the potential for the recovery of exposed archaeological sites on the periphery of former peatlands, and on previously elevated areas which now underly surviving peats. Having developed within glacial hollows, these deposits also have the potential to seal former land surfaces dated to the late Glacial and early post-Glacial period, even where relict peat is highly degraded, and to contain regionally important archives for sea level reconstruction.

1.5.2.5 The effects of development upon fragile subsurface deposits such as peat may be direct or indirect, and of both long- and short-term duration. Peat deposits close to the surface could be adversely impacted by works such as excavation and compaction (e.g. from heavy vehicle movement) which could impact negatively on subsurface strata and the potential archaeological remains contained therein. Dewatering could also result in extensive peat desiccation, even beyond areas directly subject to project works. Any changes to drainage would likewise affect the buried environments of waterlogged deposits.

1.5.2.6 **Blown Sand deposits**: The dunes extending along the shoreline between Blackpool and Lytham do not present a high value area for geoarchaeological potential in themselves, especially as they have already been largely developed within the site of Blackpool Airport. However, this DBA has shown that they do have potential in terms of sealing well-preserved buried peat deposits associated with the former westward extent of Lytham Moss. Although in many cases these deposits are likely to be buried below the probable impact reach of the Transmission Assets, borehole records from the immediate vicinity show that this may not always be the case, especially towards the landward side of the dunes where the depth of sand cover greatly decreases. The seaward side is conversely far less likely to preserve *in situ* buried wetland deposits across its exposed frontage, principally due to sedimentary reworking during the formation of supra-tidal storm beaches.

1.5.2.7 **Till and Head deposits**: Large areas of the Onshore Order Limits, especially where it crosses higher ground, are situated on Devensian Glacial Till. Although these superficial deposits are generally considered to have limited geoarchaeological potential, they may rarely contain deeply stratified archaeology sites and palaeoenvironmental sequences, and/or artefacts redeposited from Palaeolithic contexts.

1.5.2.8 **Ecotonal zones**: Human communities have often been drawn to watercourses, springs, and wetland-edge environments throughout the past, as these ‘ecotonal zones’ provide access to multiple resources whilst also offering the security of nearby dry land. Subsequent deposition can then seal land surfaces associated with well-preserved archaeological features, structures or *in situ* artefact assemblages along the fringes of such zones, whilst areas of higher ground (including ‘islands’) could have been favoured for settlement. There are many such locations throughout the Onshore Order Limits, often located at the juncture of one or more GCZs and thus also at key transitions between sedimentary facies types. These zones extend around most of the Ribble estuary’s inner basin, with areas of now buried shallowly declining ground holding the greatest potential for geoarchaeological recovery. The gently rising ground to the south of Higher Ballam and the small palaeo-valley of GCZ 5 similarly represent areas of particularly high potential associated with wetlands that were not always directly influenced by estuarine processes.

1.5.3 Existing BGS data

1.5.3.1 Existing BGS borehole data are largely inadequate for most of the areas highlighted as having high geoarchaeological potential. Many historical interventions are of poor quality due to their age and the recording standards of the time and are thus of limited use in the construction of deposit models. These records often also lack altitudinal data and have been sited to focus on bedrock geology rather than superficial deposits. Moreover, in many cases the spread of boreholes is too far apart to produce a quantitative model representative of subsurface deposits at a scale meaningful for archaeological enquiry.

1.5.3.2 The historic borehole data cited throughout this DBA (see **Table 1.3**) has thus been used in a qualitative manner, rather than as a means of precisely quantifying the presence/character of subsurface deposits of geoarchaeological importance. That said, there are several areas where BGS borehole coverage is reasonable enough and of high enough quality to support any new data acquired from project specific GI works and/or purposive geoarchaeological investigation. This is particularly the case for the inner Ribble estuary, where several north-south borehole transects are already in place.

Table 1.3: Referenced BGS boreholes

GCZ	BGS borehole ID	Easting	Northing
2	SD33SW73	331500	431800
	SD33SW43/B	332940	430590
	SD33SW44/A	333480	430490
	SD33SW119	332990	431740
	SD32NW1	331780	429750
3	SD33SW123	334600	430370
	SD33SW124	334730	430730
	SD33SE5/A	335230	431130
	SD33SW42	333580	430600
8	SD43SE285	348170	430120
	SD43SE309	348250	430170
	SD43SE287	348370	430220
	SD43SE308	347890	430010
11	SD42NE157	349130	429660
	SD42NE156	349280	429430
	SD42NE155	349420	429140
	SD42NE154	349550	428900
	SD42NE153	349780	428610
	SD42NE152	349870	428360
	SD43SE26	345760	345760
	SD42NE7	345870	429870
	SD42NE8	345980	429470
	SD42NE10	346130	429050
	SD42NE21	346460	428410
	SD42NE48	346564	428192
	SD42NE26	346430	427890
	SD42NE30	346380	427370
	SD42NE32	346330	426960

1.5.4 Summary of potential

1.5.4.1 The potential of the GCZs discussed in **Section 1.4** is summarised in **Table 1.4** below and illustrated in **Figure 1.18**, with each zone ascribed either high, medium, or low potential in accordance with the extent and nature of the deposits contained within it. It should be noted that this potential is often specific to discrete areas within the wider zones (e.g. palaeochannels, peatlands, etc), rather than the GCZ in its entirely, as is also noted within **Table 1.4** below.

1.5.4.2 Deposits of geoarchaeological potential represent sediment accumulations that could be considered for further investigation depending on the final scheme design, for instance via targeted GI or geoarchaeological survey across key sequences. Deposits of specific palaeoenvironmental potential are those most likely to contain organic sediments that may provide data for establishing regional chronologies and vegetational histories. The distinctions between high, medium and low potential are thus based on the probability that the deposits under consideration meet these criteria. These distinctions also consider the potential for these zones to have acted as foci for past human activity, and for the archaeological evidence of such activity to be preserved within the taphonomic environment/s particular to that zone. For example, early human activity is often associated with transitionary ecotones such as those along watercourses, fens, and wetland-edges, with areas of higher ground such as river levees, terraces and islands/promontories forming prime locations for habitation.

1.5.4.3 That is not to say that archaeological sites and artefacts will not be found elsewhere. For instance, areas of higher ground with thin soils may still preserve archaeological features, but they would typically be shallowly buried and have potentially suffered a degree of truncation. Conversely, the geoarchaeological emphasis on the geomorphology of past/present landscapes and their intersection with various forms of superficial deposits is made to identify the most likely locations where former land surfaces and substantial archaeological/palaeoenvironmental remains are likely to survive. On this basis, zones containing estuarine, river valley, moss (peat) and aeolian deposits will typically have high potential. Zones associated with geomorphological features that might have attracted former occupation, such as watersheds or palaeochannels, but with limited burial environments, are considered to have medium potential. Zones with neither of the above tend to comprise outcrops of Bedrock, Glacial Till or Glaciofluvial deposits with only limited depths of topsoil and are thus identified as having low potential.

Table 1.4: Summary of geoarchaeological potential by zonation

GCZ	Quality of extant BGS data	Superficial geology	Geoarchaeological potential	
GCZ 1	Poor	Tidal Flats, Storm Beach deposits.	Medium	Possibility for preserved land surfaces and palaeoenvironmental sequences below current beach level (*cf.* OA, 2023b).
GCZ 1a	Poor	Tidal Flats.	Medium	Possibility for preserved land surfaces and palaeoenvironmental sequences below current beach level (*cf.* OA, 2023b).
GCZ 2	Poor	Blown Sand deposits.	High	High potential for peats buried at depth, but may lie beyond impact depth of project works. Dune deposits themselves of relatively low potential.
GCZ 3	Poor	Tidal flats, Blown Sand deposits, Peat, Glacial Till.	High	Highest potential along edge of relative high ground associated with Higher Ballam and Peel 'islands', and for localised peat preservation west/north west of Higher Ballam and below dune sands along boundary to west/south. Peats/organic silts across rest of zone are likely to be highly degraded if present, and of relatively low potential, through the possibility remains for locally waterlogged conditions in specific areas. It is also important to note the presence of the North West Wetlands Survey's site LA41 within the north west corner of the zone near its juncture with GCZ 4.
GCZ 4	Poor	Tidal flats, Glacial Till.	High	Highest potential along edge of high ground associated with Higher Ballam and Peel 'islands', and adjoining GCZ 5 to the east. Peats/organic silts across rest of zone are likely to be highly degraded if present, and of relatively low potential, through the possibility remains for locally waterlogged conditions in specific areas.
GCZ 5	Poor	Peat, Alluvium, Tidal Flats, Head deposits, Glacial Till.	High	Highest potential for palaeoenvironmental preservation within tidal flats/peat/alluvium interface at mouth of palaeo-valley. Highest potential for archaeological recovery along edge of valley bottom and on adjoining slopes.
GCZ 6	Poor	Head deposits, Glacial Till.	Low	Slightly higher potential in/around Head-filled valley depressions.
GCZ 7	Poor	Tidal Flats, Alluvium, Head	Medium	Highest potential within alluvium/tidal flat deposits of Freckleton Pool, especially towards its southern outfall, and on

GCZ	Quality of extant BGS data	Superficial geology	Geoarchaeological potential	
		deposits, Glacial Till.		immediately adjacent slopes. Higher slopes of relatively low potential.
GCZ 8	Poor	Tidal Flats, Alluvium.	High	No longer falls within Order Limits. Highest potential for palaeoenvironmental preservation within tidal flats/alluvium interface at outfall of Savick Brook. Highest potential for archaeological recovery along edge of valley bottom.
GCZ 9	Good	Glacial Till, Tidal Flats, Alluvium.	Medium	Potential raised by presence of early medieval pits to immediate north, and across ecotonal lower slopes immediately adjacent to GCZs 8 and 11.
GCZ 10	Poor	Tidal Flats, Alluvium, Head deposits, Glacial Till.	Low	Slightly higher potential on lower slopes immediately adjoining GCZ 11.
GCZ 11	Fair	Tidal Flats, Alluvium, River Terrace deposits, Head deposits, Glacial Till.	Medium-High	Highest archaeological potential along ecotonal fringe below adjacent high ground, especially those adjacent to GCZ 13, and on river terrace deposits at eastern end of zone. Highest palaeoenvironmental potential within former tidal deposits under reclaimed land fringing outer shores of estuary, especially towards eastern and south western parts of zone where buried peats and organic silts have been encountered.
GCZ 12	Poor	Tidal Flats, Alluvium, Head deposits, Glacial Till.	Medium	No longer falls within Order Limits. Highest potential within tidal flats/alluvium towards outfall of Mill Brook and along edge of surrounding slopes. Potential decreases as valley progresses upslope.
GCZ 13	Poor	Glacial Till, Tidal Flats.	High	No longer falls within Order Limits. Highest potential across embayment associated with the outfall of the Longton Brook, and on lower slopes of high ground adjoining GCZ 11. Lower potential on higher ground to north east.

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