West Burton Solar Project

Environmental Statement

Appendix 13.3: Geoarchaeological Assessment

Prepared by: Lanpro Services
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Contents

Issue Sheet

Report Prepared for: West Burton Solar Project Ltd.

Environmental Statement Appendix 13.3: Geoarchaeological Assessment

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1 Introduction

1.1.1 This document has been prepared by Lanpro Services Ltd on behalf of West Burton Solar Project Limited ('the Applicant'). It provides an overview of the methodology and the results of the geoarchaeological assessment undertaken across the whole of the West Burton Solar Project ('the Scheme') in support of an application for a Development Consent Order (DCO). The Scheme consists of three electricity generating stations each with a capacity of over 50 megawatts (MW) consisting of ground mounted solar arrays and 'Associated Development'; comprising of energy storage, grid connection infrastructure, cable routes and other infrastructure integral to the construction, operation and maintenance of the Scheme.

1.1.2 The results of the various environmental studies (including non-archaeological surveys) have been used to inform changes to the Scheme design including the removal of areas from the final redline boundary and adjustments to the proposed cable route. Redline boundaries provided for the geoarchaeological assessment report (Appendix 1) reflect the original redline boundaries used for the initial environmental scoping studies. The final redline boundary for the Scheme is shown in Figure 1.

2 Site Location

2.1.1 The location details for each of the West Burton sites and the Cable Route Corridors are tabulated below.

Phase	NGR	Parishes	Height above Ordnance Datum (aOD)	Appendix
West Burton 1 Solar Site	SK 91573 78470	Broxholme Scampton	7m – 8m aOD	1
West Burton 2 Solar Site	SK 89141 77406	Saxilby with Ingleby	5m – 18m aOD	2
West Burton 3 Solar Site	SK 85570 80353	Marton Brampton Stow	5m – 21m aOD	3
West Burton Cable Route Corridor (Lincolnshire section)	SK 89300 77080	Broxholme Saxilby with Ingleby Sturton by Stow	6m – 21m aOD	4

		Torksey Stow		
West Burton Cable Route Corridor (Nottingham Section)	SK 80685 82270	Cottam North Leverton with Habblesthorpe Sturton Le Steeple West Burton	3m – 22m aOD	4
Shared Cable Route Corridor	SK 82940 80916	Rampton and Woodbeck (Notts) Marton (Lincs) Brampton (Lincs)	3m – 23m aOD	5

West Burton 1 Solar Site

2.1.2 The West Burton 1 Solar Site comprises approximately 90ha of arable land to the east of Broxholme in the West Lindsey District of Lincolnshire.

2.1.3 Only minor adjustments were made to the redline boundary; no fields were removed from the scheme.

West Burton 2 Solar Site

2.1.4 The West Burton 2 Solar Site comprises approximately 305ha of agricultural land centred on the village of Ingleby in the West Lindsey District of Lincolnshire.

2.1.5 Fields N15 to N18 were removed from the redline boundary following the completion of the geoarchaeological assessment report.

West Burton 3 Solar Site

2.1.6 The West Burton 3 Solar Site comprises approximately 370ha of land to the south of Stow Park Road / Till Bridge Lane to the east of the villages of Marton and Brampton within the West Lindsey District of Lincolnshire.

2.1.7 Parts of Fields P1 and P4 were removed from the redline boundary following the completion of the geoarchaeological assessment report.

West Burton Cable Route Corridor

2.1.8 The West Burton Cable Route Corridor comprises c.120ha of agricultural land traversing parts of 138 fields in the West Lindsey district of Lincolnshire and Bassetlaw district of Nottinghamshire.

2.1.9 The Cable Route Corridor runs south-west from the north-west of West Burton 1 to the north-east of West Burton 2, crossing the River Till to the west of Carriers Farm. The cable route connects the eastern and western sections of West Burton 2 to the south of Ingleby Grange, following the course of Sturton Road. From the north-west of West Burton 2, it heads north towards Cowdale Lane. At which point it turns west and traverses fields adjacent to Cowdale Lane, before turning north and following the line of the Lincoln and Retford branch railway line, which borders the south-east of West Burton 3. The Cable Route Corridor enters West Burton 3 to the north of farm buildings belonging to Stow Park Farm. The Cable Route Corridor runs from the north-west of West Burton 3 at Poplar Farm, across fields to the south of Marton, towards the River Trent. It crosses the river to the south of Trent Port, after which it continues west toward Coates where it turns north-west and snakes towards West Burton Power Station, crossing Craikbank Lane, Northfield Road, Fenton Lane, Littleborough Road and Upper Ings Lane. The Cable Route Corridor turns west at Common Lane before heading north at North Street Farm towards the West Burton Power Station.

2.1.10 A fourth Solar Site option area (referred to as West Burton 4) was assessed during initial environmental scoping to the east of Clayworth and Gringley on the Hill in the Bassetlaw district of Nottinghamshire. Following the results of the various environmental assessments it was decided not to pursue this Site and it was removed from the scheme along with the associated cable route connecting it to the West Burton Power Station.

2.1.11 The West Burton Substation and Energy Storage site to the south-west of the West Burton Power Station was also removed from the scheme.

Shared Cable Corridor

2.1.12 The Shared Cable Corridor comprises 158.5ha in the Bassetlaw district of Nottinghamshire and the West Lindsey district of Lincolnshire. The Shared Cable Corridor is proposed to be used by up to three Schemes: the West Burton Solar Project, the Cottam Solar Project and the Gate Burton Solar Project.

2.1.13 Fields 106 to 117 are located within the West Burton Cable Route Corridor and total c.42 ha. The section of the shared cable corridor running between fields to the west of the River Trent to the Cottam Power Station is not located within the West Burton Cable Route Corridor and relate to works undertaken for the Cottam Solar Project and Gate Burton Solar Project.

2.1.14 The Cable Route Corridor crosses the River Trent to the south of Trent Port at Marton, following which the corridor runs north-west to the south of Marton towards Stow Park Road, intersecting the road to the west of Marton Grange.

3 Summary of Results (see Appendix 1)

West Burton 1 Solar Site

3.1.1 West Burton 1 is considered to have a medium geoarchaeological and paleoenvironmental potential in areas where alluvial deposits are located.

3.1.2 Flood alleviation of the Trent valley since the late-15th century has resulted in a mosaic of drainage channels and the loss of natural wetland environment. Alluvial deposits commonly occur along water courses such as the River Till, to the west of West Burton 1. Where present, alluvial soils have the potential to preserve environmental, historical and prehistoric archaeology and contain accumulations of dateable organics.

West Burton 2 Solar Site

3.1.3 The geoarchaeological assessment considered that West Burton 2 has a medium/high geoarchaeological and a medium paleoenvironmental potential in areas where alluvial deposits are located. There is a medium geoarchaeological and a low/medium paleoenvironmental potential in areas where river terrace deposits are located.

3.1.4 Alluvial deposits have been recorded within West Burton 2, adjacent to the course of the River Till, as well as superficial undifferentiated river terrace deposits and Holme Pierrepont Sand and Gravel Member.

3.1.5 Where present, alluvial soils have the potential to preserve environmental archaeology and contain accumulations of dateable organics. The date of undifferentiated sand and gravel deposits associated with river terraces is uncertain but assigned to a broad Quaternary (includes the Pleistocene and Holocene) age by the BGS. Pleistocene sands and gravels (such as Holme Pierrepont Sand and Gravel Member) have the potential to contain palaeolithic material.

West Burton 3 Solar Site

3.1.6 The geoarchaeological assessment identified that West Burton 3 is considered to have a medium/high geoarchaeological and paleoenvironmental potential in areas where Holme Pierrepont terrace deposits are located. There is a medium geoarchaeological and a medium/high paleoenvironmental potential in areas where alluvium / peat deposits are located.

3.1.7 The geological record becomes progressively older heading westwards across the Site. Extensive superficial deposits occur of Holme Pierrepont Sand and Gravel member (river terrace of the River Trent), glaciofluvial deposits are recorded in the north-west of the Site and a small area of peat deposits are mapped in the west.

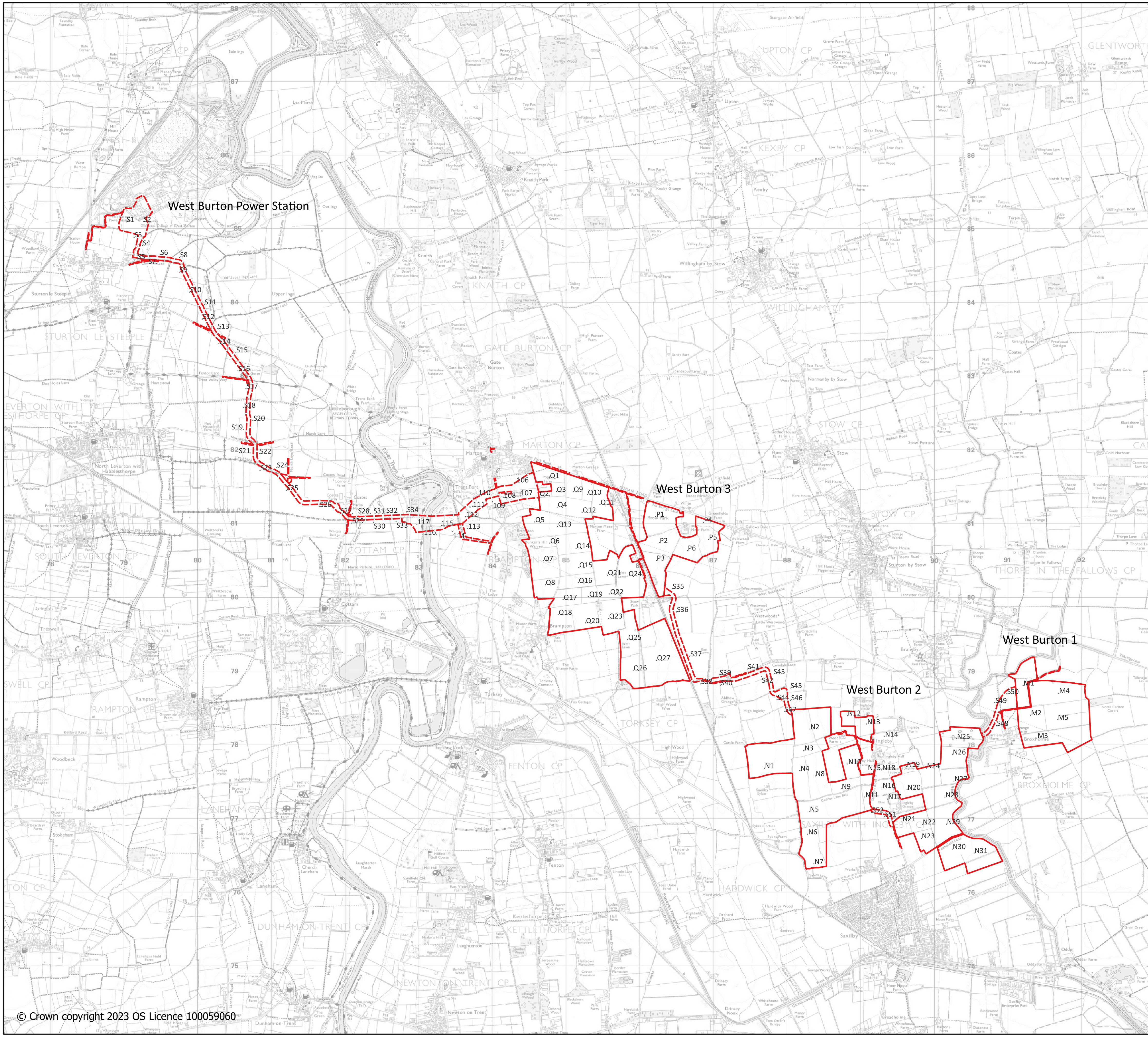
West Burton Cable Route Corridor

3.1.8 The geoarchaeological assessment identified the following geoarchaeological and paleoenvironmental potential along the West Burton Cable Route Corridor. These are recorded in the table below:

Section of Cable Route	Deposit	Geoarchaeological potential	Paleoenvironmental Potential
Between West Burton 1 and West Burton 2	Alluvial	High/Medium	Medium
Between West Burton 2 and West Burton 3	Unknown	-	-
Between West Burton 3 and West Burton Power Station	Alluvium/Peat deposits	High/Medium	High/Medium
	Holme Pierrepont terrace	High/Medium	High/Medium
	Unknown deposits	-	-

3.1.9 Where present, alluvial soils have the potential to preserve environmental archaeology and contain accumulations of dateable organics. The date of undifferentiated sand and gravel deposits associated with river terraces is uncertain but assigned to a broad Quaternary (includes the Pleistocene and Holocene) age by the BGS. Peat (or organic alluvium) form during periods of stabilisation or channel migration when vegetation accumulates in wetland environments and has a potential to contain prehistoric archaeology. Pleistocene sands and gravels (such as Holme Pierrepont Sand and Gravel Member) have the potential to contain palaeolithic material.

Figures



West Burton
SOLAR PROJECT

Proposed Solar Site

Proposed Cable Route Corridor

N

0 1 2 km

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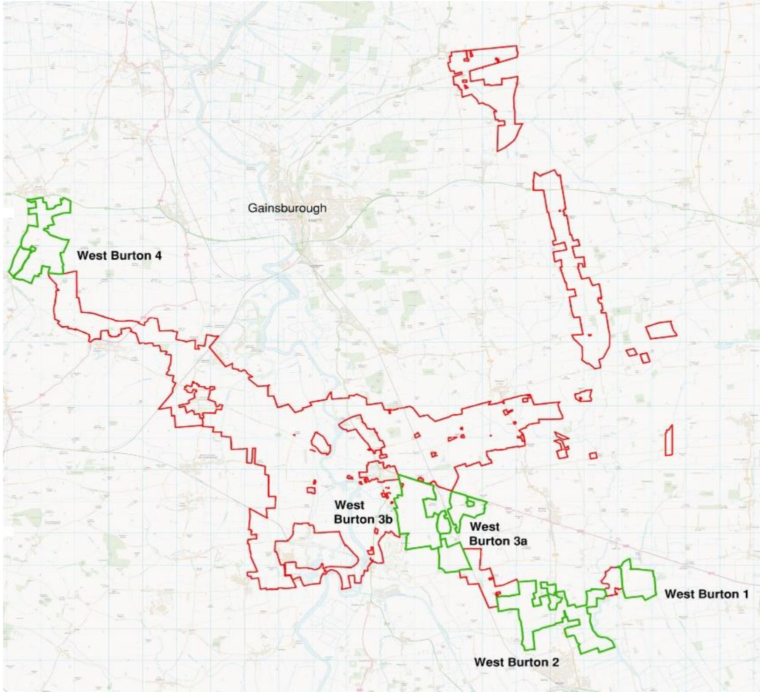
Figure App.13.3-1
Location of the West Burton Solar Scheme development sites

Appendix 1

West Burton 1 Solar Farm, Lincolnshire and Nottinghamshire: Geoarchaeological Assessment Report (OAN 2022)



West Burton Solar Farm, Lincolnshire and Nottinghamshire

Geoarchaeological Assessment Report

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West Burton Solar Farm Geoarchaeological Assessment Report

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With illustrations by Anne Stewardson

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Summary

The aim of this desk-based assessment is to investigate and characterise the geoarchaeological potential of the site of the proposed West Burton Solar Project and associated cable routes, to help identify areas of enhanced geoarchaeological interest.

The development lies within the wider Trent Valley, an area known for its rich floodplain archaeology, with evidence of fish traps, log boats, historical mills and bridges, all recovered from postglacial sand and gravel deposits, sealed beneath thick fine-grained alluvium. Low-lying broad river valleys provide access to riverine resources and have previously produced evidence of both ritual and settlement activity.

The geoarchaeological assessment report has shown that there is potential for features such as palaeochannels and gravel islands to exist within the development areas. Previous historic borehole data available across the sites are of little value, as the data lack specific criteria such as altitude records and do not discriminate superficial deposits where identified. Data for generation of a deposit model could, however, be obtained from future engineering interventions especially if consideration is given to positioning interventions in areas likely to yield geoarchaeological information.

Acknowledgements

The project was managed for Oxford Archaeology by Fraser Brown. The report was written by Mairead Rutherford. GIS support was provided by Hannah Leighton and the illustrations were completed by Anne Stewardson.

1 INTRODUCTION

1.1 Scope of work

1.1.1 Oxford Archaeology (OA) was commissioned by West Burton Solar Project Ltd to undertake a desk-based geoarchaeological assessment relating to the West Burton Solar Project, the sites of which are located on either side of the lower course of the River Trent, across the Lincolnshire/Nottinghamshire boundary.

1.2 Location

1.2.1 The solar farm sites, West Burton 1-3, lie to the east of the River Trent, in north-west Lincolnshire, and are clustered close together between Brampton to the west and Broxholme further east. The West Burton 4 solar farm and the West Burton Substation and Energy Storage site are in Nottinghamshire, respectively, just south of Gringley on the Hill and adjacent to the existing power station, just south of Bole (Fig 1). The four sites cover approximately 1073 hectares.

1.2.2 The sites are to be connected to each other via a cable corridor and to connection points at the West Burton power station. The exact route of the cable corridor is currently undetermined and these areas are therefore considered as search areas (Lanpro 2022). The zones of potential cable routes are included in the geoarchaeological assessment.

1.3 Topography and geomorphology

1.3.1 The low-lying landscape of the West Burton sites is characterised by extant river channels and palaeochannels bounded by Pleistocene river terraces and Holocene floodplains and is part of the wider Trent drainage basin. There are extensive areas covered by historical drainage systems.

1.3.2 The River Trent rises in Biddulph Moor, Staffordshire and drains into the Humber Estuary (after it has joined the Rive Ouse; Howard *et al* 2008). The middle reaches of the River Trent, between Weston and Gainsborough, are characterised by a medium energy, anastomosing and meandering system, within a developed floodplain. In contrast, downstream from Gainsborough, the floodplain is broad and dominated by fine-grained sedimentation, with the river channel showing lateral stability (Baker 2007). Traditionally, the fine silt (warp) load of the Trent in its lower reaches, has been used to improve the soils via warping (allowing water to enter fields through warping drains), for example, Morton Warping drain near Gainsborough.

1.3.3 The landscape surrounding West Burton sites 1-3 is mostly flat, and below the 20m OD contour, whereas the land within the development site at West Burton 4 rises northwards. To the east of the sites, a significant north/south escarpment ('Lincoln Cliff'), is located approximately 3km east of West Burton 1. The 'Lincoln Cliff' comprises Jurassic rocks and stands approximately 50m above the surrounding flat landscape. Closely following the escarpment is an ancient trackway, an extension of the Jurassic Way (B1398/Middle Street), linking Lincoln with the Humber.

1.3.4 The general distribution of soil types in the proposed sites reflect floodplain areas, indicative of wet meadows prone to flooding. Areas of peaty soils are present along the western edge of the West Burton 3 site.

1.4 Geology

1.4.1 The development site is situated on the Trent floodplain, bounded to the east by the Jurassic escarpment of Lincolnshire Edge and, further east and south, by the Lincolnshire Wolds escarpment of Cretaceous age, and to the west by older, low hills of Triassic age.

1.4.2 The bedrock at the West Burton sites 1-4 is of Triassic and early Jurassic age, comprising largely mudstones of the Scunthorpe Mudstone Fm, Penarth Group and Charmouth Mudstone Fm. The beds dip such that progressively younger strata are present further east (British Geological Survey (BGS) 2022).

1.5 LiDAR analysis

1.5.1 The LiDAR digital images for the development areas are interpreted to show a largely flat, slightly undulating topography, intersected with valley sequences of the River Till (West Burton 1, 2) and the River Trent (West Burton 3) and associated drainage networks. Higher ground is visible towards the northern part of the development site at West Burton 4.

1.6 Archaeology

1.6.1 The data covering the archaeological aspect of the project are documented in the Environmental Impact Assessment Scoping Report (Lanpro 2022). Of significance is the presence of the excavated Viking site at Torksey (Hadley and Richards 2016). This site is located adjacent to West Burton site 3, on a bluff in a bend of the River Trent but may potentially fall within or close to the cable route between West Burton 3 and the West Burton. Ancient trackways and Roman roads, for example the A1500 / Stow Park Road, are also present or adjacent to the development sites.

2 Aims and Methodology

2.1 Aims

2.1.1 The project aims and objectives are as follows:

i. To review published geoarchaeological and significant palaeoenvironmental data relevant to the sites.
ii. To provide mapped geological and mapped superficial data relevant to the site, to characterise the sediments.
iii. To examine topographical and LiDAR data to identify features such as palaeochannels and gravel islands.
iv. To assess availability of borehole / trial pit interventions that could be used to construct a geoarchaeological model for the site.
v. To consider how the superficial deposits at the sites may hold potential for recovery of archaeological artefacts and ecofacts, highlighting any significant geoarchaeologically significant zones and any areas of peat/coversands deposits.

2.2 Methodology

2.2.1 A review of geoarchaeological and palaeoenvironmental studies relevant to the West Burton Solar Project includes reference to published data and information sourced from academic studies (theses) and grey literature. Although the upper and middle Trent Valley floodplains have been the subject of years of research (e.g. Howard 2004; 2005; Howard *et al* 2008; 2011), the lower reaches of the floodplain have received less attention.

2.2.2 No geotechnical logs, from boreholes or trial pits for the West Burton sites, are available to use to generate a specific deposit model. The database for survey of the superficial and bedrock geology is therefore based on BGS (2022) mapping. Historic borehole data occur across the site, however, most of the data are denoted as confidential. A list of accessible borehole data, within and adjacent to the sites, is tabulated in Appendix A.

2.2.3 Scrutiny of topographical maps together with LiDAR images have been used to identify features that could mask or seal potentially important archaeology. Such features include identification of potential gravel islands (topographic highs) as well as palaeochannels.

3 RESULTS

3.1 Introduction and presentation of results

3.1.1 The results of the desk-based assessment are presented below, including an initial detailed review of geoarchaeological data and background palaeoenvironmental data. A series of maps for the study area accompany the text (Figs 2-7), showing geological, geomorphological topographical (LiDAR) data, presented by site. These data are then used to infer the likely geoarchaeological context for each of the sites.

3.2 Geoarchaeological background

3.2.1 A geoarchaeological study of the middle and lower Trent Valley has shown that OSL dating of glacio-fluvial deposits returned dates from between 212ka and 10.9ka, representing several glacial and inter-glacial phases (Schwenninger *et al* 2007). Deposits within the Bole Ings palaeochannel, in the lower Trent floodplain just south of Gainsborough, record Devensian sands and gravels, including the Holme Pierrepont Sand and Gravel Member (named River Terrace), overlain by a thick sequence of alluvial deposits (Dinnin and Brayshay 1999; Stein 2014). Further south and west, at Farndon Fields, Newark-on-Trent, coversands overlying the Holme Pierrepont Sand and Gravel Member have been dated by OSL to the Windermere Interstadial (Garton *et al* 2020) and were found to seal lithic scatters of late Upper Pleistocene age (Cooke and Mudd 2014; Garton *et al* 2020).

3.2.2 River confluences within the middle and lower Trent Valley, for example, the confluence of the Trent and Derwent (Krawiec 2012; Howard 2005), have also been subject to geoarchaeological research. These studies show the importance of identifying thick layers of alluvium, distributed across the floodplain areas, as these deposits, which may include accumulations of organic sediments, have the potential to preserve both cultural and environmental archaeology. Peat and organic deposits, where found within these deposits, allow for precise dating of specific pre-Holocene and Holocene palaeochannels (Stein 2014). Aston Bank, a palaeochannel of the River Trent, at Shardlow, Derbyshire, is one such example (Krawiec 2012). Palaeochannel mapping of the lower Trent north of Gainsborough has revealed very few surface-visible palaeochannels, as a consequence of thick deposits of alluvium masking the sub-surface topography (Baker 2007). However, the palaeochannel sequence from Bole Ings, was found to contain an important sedimentological and palaeoenvironmental record (Dinnin and Brayshay 1999). Boreholes from this site have indicated a maximum of *c* 9m of Holocene alluvium, including peaty silty-clay deposits.

3.2.3 During the early Holocene, a relatively open and unstable floodplain environment was also described by Dinnin (1992) from a palaeochannel sequence at Girton (approximately 25km upstream from Bole Ings). During this time, the floodplain was characterised by a dynamic, braided channel but by *c* 6000 BC, the Trent had evolved an anastomosing or single channel regime, leading to floodplain stabilisation.

3.2.4 The appearance of the lower Trent floodplain during the Bronze Age and Iron Age has been described by Knight and Howard (2004) as a rich wetland area with channels flowing across the valley floor. Continued clearance of woodland from the floodplain and gravel terraces, as well as adjacent upland areas, would have resulted in a more open landscape. This landscape would then have been prone to soil erosion and re-deposition of both colluvium and alluvium. The main channel would have remained active but minor streams and abandoned channels fringed by reed swamp would have accumulated under low-energy conditions.

3.2.5 There is sedimentological and palaeoenvironmental evidence that major channel shifting took place within the lower Trent Valley during the Iron Age. At Sturton le Steeple, the peat deposit that had formed in the Bronze Age, ended during the early Iron Age (Howard 2004). The deposits at Bole Ings show a change from woody peat and organic clays to silty alluvium during the middle to late Iron Age (Dinnin and Brayshay 1999). At Cottam, 4m of alluvium covers the Bronze Age peat deposits, which appear to have ended abruptly following a shift in the course of the Trent (Scaife and Allen 1999).

3.2.6 Sediment coring and radiocarbon dating of peat sequences east of the Viking Camp at Torksey, have revealed that a palaeochannel of the Trent existed at the site up until the Bronze Age (Hadley and Richards 2016). Siltation of the river further north resulted in the palaeochannel being cut off from the main channel, permitting peat to accumulate into the late medieval period and the surrounding lowland area east of the camp remained a wetland area. Sediment mapping to the north and south of the site recorded silt but no peat, suggesting that these areas remained open to the Trent, with the area to the north flooding regularly due to the tidal impact of the Trent (Hadley and Richards 2016).

3.2.7 Deforestation and intensified land use activity, which begun during the Iron age and continued during the Roman Period, lead to an increase in sediment load of regional river systems (the Don, Trent, Idle and Ancholme) and consequent deposition of thick deposits of fine-grained alluvium across the floodplain during the later part of the Roman Period (Tweddle 2001).

3.2.8 Deep alluvial deposits began to accumulate across the lower Trent floodplain during the Roman and post-Roman periods, for example, at Littleborough – situated on a gravel island to the west of the present course of the Trent (Stein 2014). Abandonment of land around Sturton le Steeple (which is also located on an island and terrace of sand and gravel, with peat of Late Bronze Age to Iron Age surrounding the gravel island) suggests the Iron Age/Romano-British field systems had become unusable even for grazing, due to flooding and alluvial infilling. A single wooden stake, radiocarbon dated to 790 to 1030 AD, was recovered from peat deposits infilling Roman features at Sturton le Steeple (Elliott 2004; Stein 2014).

3.2.9 On the eastern bank of the Trent, there is evidence for depsoition of aeolian sediments at this time, for example, at Torksey golf course (Stein 2014). The variation in deposit type between the west and east banks of the river is perhaps be due to channel structure and direction (Stein 2014).

3.2.10 Attempts at flood alleviation from around 1485 AD to the present day have resulted in a mosaic of drainage channels all across the lower Trent Valley, resulting in the loss of the natural wetland environment. Channel re-direction and building up of blankets of alluvium (warp) are clearly present at Cottam, North Leverton and Sturton le Steeple, while at West Buton and Bole, the channel was re-directed and straightened, with palaeochannels still clearly visible (Stein 2014).

3.2.11 A recent geoarchaeological study for an area of 280 hectares south of Newark-on-Trent (OA North 2022) for which a deposit model (based on borehole and trial trench interventions) was produced, identified potential terrace edge environments, sandy spurs, floodplain islands, river confluences and palaeochannels, that could have been a focus for human activity. The floodplain islands are separated from extensive deposits of Pleistocene gravel terraces mapped at the valley margins, by a series of alluvium-rich palaeochannels. The islands, gravel terraces and palaeochannel sequences have the potential to preserve archaeological and palaeoenvironmental remains.

3.3 Palaeoenvironmental background

3.3.1 A palaeoenvironmental record is available for an excavation site at Messingham (Carrott *et al* 1997), located north-east of Gainsborough. The pollen and plant remains from this site agree with an earlier beetle study from beneath coversands at Messingham (Buckland 1982) that described cold, typically late-glacial sedge-dominated fen conditions.

3.3.2 The most detailed palaeoenvironmental work from the lower Trent is from the Bole Ings palaeochannel, located to the west of the Trent, spanning the early to later Holocene period (Mesolithic to early Iron Age) (Dinnin and Brayshay, 1999). The data have been interpreted to suggest alder-dominated low energy floodplain/backswamp environments with wetland margins along the river bank and gravel islands/ridges on the floodplain, providing habitats for pine woods as well as mixed deciduous woodland. Disturbed habitats during the early Holocene are linked to hydrological changes (for example, waterlogging), possibly in response to rising sea level changes and floodplain aggradation (Dinnin and Brayshay, 1999).

3.3.3 The Elm Decline has been identified at Bole Ings (Dinnin and Brayshay 1999) and broadly correlated with that event at Cottam, with the presence of cereal pollen in post-Elm Decline assemblages recorded at Cottam (Scaife and Allen 1999). Evidence associated with possible tree clearance in the wider landscape, including a Bronze Age decline in lime (dated 2140-1740 cal BC (3579±70 BP; BETA-75271) has been associated with a peak in microcharcoal particles, and together have been interpreted to signify anthropogenic forest disturbance beyond the floodplain, with no evidence of disturbance to the dense alder carr occupying the floodplain (Dinnin and Brayshay 1999). Beetles from borehole sediments from Sturton le Steeple also support development of alder-rich fen carr woodlands on the lower Trent floodplain, with expansion of wetland areas throughout the early Bronze Age and into the Iron Age (Howard 2004).

3.3.4 Land beyond the floodplain was subject to arable and pastoral agricultural activity, dated 1120-540 cal BC (2690±100 BP; BETA-75270) at Bole Ings, and has been interpreted as evidence to support exploitation of areas such as the gravel terraces during the early Iron Age (Dinnin and Brayshay, 1999).

3.3.5 The evidence from peat accumulation at Torksey, suggests the area continued to exist as a wetland throughout the early medieval period, whereas the area north of this site would have been susceptible to the tidal influences of the lower Trent (Hadley and Richards 2016).

3.4 Geological, geomorphological and topographical data

West Burton 1

3.4.1 West Burton 1 is a relatively small site (*c* 90ha) north of Broxholme and east of the River Till (Fig 1). The western border of the site and connecting corridor is formed by the River Till, a tributary of which also clips the north of the site.

3.4.2 The underlying geology consists of lower Jurassic (Sinemurian – Pliensbachian) mudstones of the Charmouth Mudstone Formation (Fig 2). Historic borehole data from east of the River Till record deposits of clay and sand deposits overlying mudstones (bedrock), for example, SK97NW9 (BGS).

3.4.3 The superficial deposits are of Till (Diamicton), largely in the eastern part of the development site, with alluvial deposits adjacent to the watercourse, which forms part of the northern boundary of the site (Fig 3). Records of superficial deposits for the western part of the site are not available.

3.4.4 LiDAR and topographic data show the altitude of the development site is generally low, less than 10m OD (Fig 4). Features on the LiDAR image towards the northern part of the site may reference former channels of the River Till.

3.4.5 The cable route corridor between West Burton 1 and West Burton 2 crosses the River Till and associated alluvial deposits.

West Burton 2

3.4.6 West Burton 2 occupies an area of approximately 328ha and is located either side of the village of Ingleby, west of the River Till (Fig 1).

3.4.7 Bedrock comprises the younger Charmouth Mudstone Formation (lower Jurassic) to the east and the Scunthorpe Mudstone Formation (lowest Jurassic – early Triassic) to the west (Fig 2). There is little borehole coverage; available historic borehole data record clay overlying bedrock (BGS SK87NE27).

3.4.8 The superficial deposits comprise alluvial deposits along the course of the River Till, to the east. Localised deposits of undifferentiated river terrace deposits as well as the presence of the Holme Pierrepont Sand and Gravel Member (named River Terrace of the Trent), are recorded within the site. Elsewhere, the superficial geology has not been recorded (Fig 3).

3.4.9 The landscape is generally flat, undulating around 10m OD, with a gentle slope to the east towards the River Till. LiDAR from the area south-east of Ingleby (Fig 4) shows a palaeochannel of the River Till, situated on the east side of the river, between (but outside) the boundary of West Burton 1 and West Burton 2. The cable corridor between West Burton 2 and West Burton 3 crosses an area where superficial deposits have not been recorded (Fig 3).

West Burton 3

3.4.10 The site of West Burton 3, the largest of the West Burton Solar Project sites, at approximately 370ha, is located east of the River Trent, east of a line between Brampton to the south and Marton to the north, and is adjacent to the excavated Viking site to the north of Torksey (Fig 1). A Roman road (A1500/Stow Park Road) runs southwest from Marton to Sturton by Stow, delimiting the northern boundary of the site.

3.4.11 The geological record becomes progressively older the further west, with the Scunthorpe Formation giving way to mudstones of the Penarth Group. Available historic BGS borehole data record topsoil or clay directly resting on bedrock (e.g. SK88SW23) (Fig 2).

3.4.12 The superficial deposits determined by BGS (2022) mapping include relatively extensive deposits of the Holme Pierrepont Sand and Gravel Member (river terrace of the Trent), and the western margin of the site is coincident with a small area of mapped peat deposits (Fig 3). Glaciofluvial deposits are also recorded in the north-west corner of the development area, however, a significant proportion of superficial deposits across the site are unrecorded.

3.4.13 The LiDAR data (Fig 4) show that the landscape is generally of low relief of around 10m OD; the north-western part of West Burton 3 occupies a slightly raised area to the east of the Trent. An un-named tributary of the Trent cuts across the centre of the site.

3.4.14 The potential cable corridor between West Burton 3 and West Burton/Cottam power stations and beyond those to the West Burton 4 development site, covers a large area. This area contains extensive deposits of the Holme Pierrepont Sand and Gravel Member (river terrace named unit) as well as alluvium (which could contain localised peat deposits), especially to the west of the Trent. Further west, the superficial sediments are poorly recorded, with alluvium deposits along water courses and isolated deposits of Head (Table 1).

West Burton Substation and Energy Storage site

3.4.15 The West Burton Substation and Energy Storage Site, covering approximately 64ha, lies just over 1km south-west of Bole and immediately adjacent to the existing West Burton power station. The bedrock comprises the Mercia Mudstone Formation. The superficial geology of the site is not mapped by the BGS (2022), but an area of Till (diamicton) extends to the east and there are Head deposits to the west and alluvial deposits associated with the Wheatly Beck to the north (Fig 6).

3.4.16 This LiDAR and topographic data show the area is low lying, approximately 10m OD. There are BGS boreholes located to the east, but outside the site boundary. One BGS borehole is located within the southern tip of the site, SK78NE45, and records topsoil overlying just under 4m of red/brown firm marly clay which overlies bedrock. Outside the site boundary, the record for borehole SK78NE47, records topsoil underlain by silty clays, sands and gravels, which are underlain by red silty sand and then bedrock. The deposits are not interpreted but may, in part, represent either alluvial and/or till deposits.

West Burton 4

3.4.17 West Burton 4, covering approximately 247ha, is located to the west of the River Trent and the east of the River Idle, between the villages of Clayworth and Gringley on the Hill (Nottinghamshire). A Roman Road (Wiseton Road) runs from the north-east towards Clayworth.

3.4.18 The geology comprises bedrock of the Mercia Mudstone Formation (and Clarborough Member; Fig 5). Data from two historical boreholes confirm the presence of glacial sands and gravels overlying bedrock at Gringley on the Hill (BGS-SK79SW25) and record bedrock only at Clayworth (BGS-SK78NW75).

3.4.19 The superficial geology is largely unmapped; glacial Till is recorded to the north-west of the site, with glaciofluvial sands and gravels forming the higher ground at Gringley on the Hill. Deposits of alluvium have been mapped to the south of the site, along the Toft Dyke Drain (Fig 6).

3.4.20 The LiDAR image shows the altitudinal variation from north to south and the clearly elevated position of Gringley on the Hill, at approximately 65m OD, whereas the village of Clayworth sits alongside the Chesterfield Canal, at approximately 15m OD (Fig 7).

3.4.21 The cable corridor route from West Burton 4 towards West Burton power station crosses an area for which little data are available to indicate the superficial deposits.

3.5 Geoarchaeological deposits

3.5.1 Without further data it is not possible to construct a geoarchaeological deposit model for the superficial deposits to bedrock, for any of the West Burton sites. However, BGS (2022) mapped superficial and bedrock deposits for the four West Burton sites permits an interpretation of the likely sequence of stratigraphic succession (Table 1).

Stratigraphic Unit	Environment of Deposition	Archaeological Potential
Topsoil	Modern agricultural ploughsoil	Could contain redeposited pottery or lithic material brought to the surface through ploughing and sub-surface disturbance.
Warp	Modern flooding for soil improvement	Has the potential to seal *in-situ* historic and pre-historic archaeology.
Colluvium	Potential modern and ancient soil movement associated with agriculture and vegetation clearance.	Potential to contain re-deposited pottery and lithic material from historic and prehistoric activities on higher ground/slopes and to seal historic and pre-historic archaeology.
Alluvium/fluvial deposits	Holocene alluviation associated with overbank alluviation and migrating river channels associated with the	Has the potential to seal *in-situ* historic and pre-historic archaeology.

Stratigraphic Unit	Environment of Deposition	Archaeological Potential
	Rivers Trent, Till and Idle and associated tributaries.	
Peat/organic alluvium	Periods of stabilisation or channel migration that result in encroachment of vegetation.	Prehistoric potential.
Pleistocene sands	Aeolian coversands/riverine alluvial deposits overlying the Holme Pierrepont Sands and Gravels, on the floodplain of River Trent.	Palaeolithic potential.
Pleistocene sands and gravels	Undifferentiated Pleistocene terrace deposits – differentiation of which is largely based on altitude and mapping.	Palaeolithic potential.
Pleistocene head	Generally, sands formed from movement of waterlogged sediments through solifluction/hillwash.	Palaeolithic potential.
Pleistocene Till	Deposits of sands and gravels deposited by and underneath glaciers.	None.
Bedrock	Geological strata (dominantly mudstones of early Jurassic – late Triassic age.	None.

Table 1: Description of site stratigraphy

3.5.2 *Bedrock:* In the development areas, this comprises mudstones of Triassic to early Jurassic age, and where available, this is supported by BGS borehole data.

3.5.3 *Pleistocene deposits*: The Devensian (last) glaciation, which ended approximately 12.5ka BP covered east Lincolnshire to the Wolds, but the Trent Valley, south of the Isle of Axholme, was largely ice free during the Devensian. A reconstruction shows the maximum extent of the Devensian glaciation (red line) and the extent of glacial Lake Humber, which inundated the landscape south to Lincoln (Fig 8, after Baker *et al* 2013). In the Late Devensian (*c* 12,000ka BP), the lower Trent Valley was situated close to glacial Lake Humber, which was formed as a result of the North Sea Ice Lobe that caused the blocking up of the Humber Estuary and its tributaries (Howard 2001). The silting up and drainage of this large glacial body of water led to early accumulations of sediments along the Trent Valley (Howard, 2001). The draining of Lake Humber and other glacial and post-glacial run-off resulted in a very active alluvial channel, and the formation of the Trent Valley terrace sequence.

3.5.4 Howard *et al* (2011) used detailed multi-proxy environmental data to record the character of the Loch Lomond (Younger Dryas) Stadial floodplain conditions in the main valley floor of the River Trent, at Holme Pierrepont, Nottinghamshire. In this part of the valley, significant aggradation occurred during the cold conditions of the Stadial leading to deposition of the Holme Pierrepont Sand and Gravel Member, reflecting deposition within braided channels. Elsewhere in the catchment, deposition of the terrace may have occurred both before and after the main Dimlington Stadial (early part of the Late Devensian; Howard *et al* 2011). The braided channels contributed to the development of gravel islands, liable to shift while the braided channel was still active. These small gravel islands remained within the floodplain after the Devensian, creating small outcrops of slightly higher ground overlooking the lowland Trent Valley (Stein 2014). The gravel islands would have played an important role in prehistory, as they may have served as a focus for human settlement and activity on the otherwise low-lying Trent Valley.

3.5.5 The superficial sediments of much of northern Lincolnshire comprise, in part, cold-climate aeolian sands (coversands). The Lincolnshire coversands extend from the Humber in the north to beyond Gainsborough in the south (Bateman and Buckland 2001; Baker *et al* 2013; Fig 8). Most coversand deposition seems to have occurred between 13-11ka BP, (Bateman and Buckland 2001). The coversands can occur directly on bedrock or overlying the Holme Pierrepont Member (Stein 2014). Localised re-activation of these sediments has occurred during the Holocene and up to the present day (Bateman *et al* 2001). At Farndon Fields, near Newark-on-Trent, coversands overlying the Holme Pierrepont Sand and Gravel Member were found to seal buried landsurfaces and lithic assemblages of late Upper Pleistocene age (Cooke and Mudd 2014; Garton 2020).

3.5.6 *River terrace deposits*: Undifferentiated sand and gravel deposits associated with river terraces are mapped within the study area, for example, in the area of West Burton 1. The age of these deposits is uncertain and is assigned a broad Quaternary (includes the Pleistocene and Holocene) age by the BGS.

3.5.7 *Holocene alluvial and peat deposits*: During the early Holocene, as the sea level began to rise, thick swathes of alluvium were deposited within the floodplain of the lower Trent Valley (Howard *et al* 1999). The lower Trent is a wide, meandering valley, with low-energy and high-sediment load output, and the size of the channel allows for deep accumulation of alluvium across the valley (Stein 2014).

3.5.8 Alluvium and peat are currently actively accumulating throughout the lower Trent Valley (Stein 2014). Consolidation of drainage and alluvial channels has led to the accumulation of pockets of peat where alluviation has not eroded wetland sedimentation. Mapping by Challis (2002) determined that the lower Trent was covered in fine-grained alluvium with reworked gravels and sands. Records from boreholes have shown alluvial deposits ranging from 2.5m at Cottam to 5.7m overlying terrace sediments at Littleborough (Havelock *et al* 2002, 48).

3.5.9 Although Challis (2002) found little evidence for peat and organic sediments within the lower Trent Valley, excavations and coring have produced occasional organics, for example, peat was recovered from Sturton le Steeple (south of West Burton power station), within a Romano-British ditch on the present floodplain (Howard 2004; Knight 2000). The presence of late Holocene deposits such as this demonstrates that there may be other features such as abandoned palaeochannels that may hold palaeoenvironmental and dateable organics. Between Brampton (in the south) and Marton (further north), on the western edge of the West Burton 3 site and across the potential cable corridor, the BGS (2022) has mapped several small areas of peat deposits (Fig 3).

3.5.10 *Holocene colluvium deposits*: Colluvium deposits represent Holocene slope deposits associated with de-vegetation and agricultural practices. They have the potential to bury land surfaces and earlier deposits that could be associated with worked lithics.

3.5.11 *Warp*: The main area of warp deposition, mapped by the BGS (2022), occurs to the north of the development sites.

3.6 Summary table of potential

3.6.1 The geoarchaeological/palaeoenvironmental potential of features and deposits discussed above are presented by site below (Table 2). This is further differentiated into zones of high, medium or low potential, based on the extent and nature of the deposits found within the site area. It should be noted that this potential is often specific to discrete regions of these zones (eg palaeochannels, valley systems, mires etc), rather than the zone in its entirety.

3.6.2 Deposits of geoarchaeological potential reflect sediment accumulations that could be targeted for further work, for example, targeted ground investigation work or geoarchaeological survey across key sequences. Deposits of palaeoenvironmental potential are more likely to contain organic sediments that may hold prime data for establishing chronological and vegetational histories. The distinction between high, medium and low potential, is based on the extent and nature of the deposits found within the site area.

3.6.3 All these distinctions also take into consideration the potential for these zones to have acted as foci for past human activity and for the evidence of such activity to be preserved. Humans were often drawn to watercourses, springs and wetland-edge environments, as well as the valley slopes. Deposits can seal buried land surfaces associated with well-preserved archaeological features, structures or *in-situ* artefact assemblages, and areas of higher ground or islands could have been favoured for settlement. Much of the area covered by the sites of the study area, lies outside, and on the edges of, the main drainage pattern. Areas such as this were often used as communication routes between lower-lying and higher ground. Within them deposit sequences and archaeological sites could have been protected from the effects of fluvial erosion and well-preserved remains do not necessarily have to be buried at great depths to survive.

Table of Potential							
		Geoarchaeology			Palaeoenvironmental		
Site name	**Deposit**	**High**	**Medium**	**Low**	**High**	**Medium**	**Low**
West Burton 1	Alluvial		x			x	
West Burton 1	Till			x			x
West Burton 1-2 cable corridor	Alluvial	x	x			x	
West Burton 2	Alluvial	x	x			x	
West Burton 2	River terrace		x			x	x
West Burton 2-3 cable corridor	Unknown deposits						
West Burton 3	Holme Pierrepont terrace	x	x		x	x	
West Burton 3	Alluvium /Peat		x		x	x	
West Burton 4	Alluvium		x			x	
West Burton 4	Unknown						
West Burton 3-4 cable corridor	Alluvium /Peat deposits	x	x		x	x	
West Burton 3-4 cable corridor	Holme Pierrepont terrace	x	x		x	x	
West Burton 3-4 corridor	Unknown deposits						
West Burton substation and Energy Storage site	Unknown deposits						

Table 2: Summary of geoarchaeological/palaeoenvironmental potential

4 Discussion

4.1 Significance of deposits

4.1.1 A large geographical area, stretching from north of the Humber estuary to south of Newark, with Gainsborough roughly in the centre, represents the modelled extent of former glacial lake Humber (Bateman *et al* 2018; Baker *et al* 2013; Fig 8). The potential therefore exists for the survival of prehistoric remains at or near possible former water edge/wetland environments, but these are likely to be buried underneath thick deposits of alluvium.

4.1.2 River terrace deposits are present as undifferentiated deposits across the landscape of the West Burton Solar Project, but at West Burton 3 (Marton-Brampton and further east), these deposits are identified as the Holme Pierrepont Sand and Gravel Member. These deposits are indicative of braided channel sequences and possible development of sand islands, that may have been attractive to prehistoric people. These deposits may have been reworked through fluvial action and as such, may impact on the *in-situ* preservation of archaeological artefacts.

4.1.3 Superficial mapping by the BGS (2022) has recorded accumulations of alluvial sediments across the West Burton sites, representing (in part) low-energy environments depositing organic silts and clays, and in places, peat accumulation, suggesting potential wetland margin locations with vegetated palaeoenvironments. Alluvial deposits may represent channels or streams visited by people drawn to these sites for hunting, fishing, transport and other reasons. Organic alluvial deposits and, especially, peat deposits, have the potential to contain evidence of former environments and, importantly, to provide material suitable for radiocarbon dating, for chronological control.

4.1.4 BGS borehole data across all the sites are largely historic and of limited use in construction of a deposit model. The records often lack altitudinal data and have been sited to focus on bedrock geology rather than superficial deposits.

5 RECOMMENDATIONS

5.1 Further work

5.1.1 In order to groundtruth the findings of the geoarchaeological assessment, several survey methods could be employed:

- Identification of unmapped superficial deposits at the sites, to characterise the sediments and provide a more complete dataset for geoarchaeological modelling.

- Targeted borehole surveys through possible sediment sequences (including alluvial/peaty; colluvial and aeolian deposits) would potentially provide stratigraphic data and material for dating, provide chronological control and aid construction of a deposit model. The siting of any interventions for engineering works could also have a dual target of obtaining geoarchaeological data and it would probably be cost efficient to integrate geoarchaeological survey, of targeted higher-potential areas of deeper sediment packages, with engineering ground investigation surveys. Work there should be monitored by a geoarchaeologist, for deposit modelling purposes.

- Archaeological field evaluation is recommended to assess the archaeological potential of the different geomorphological zones within floodplain areas. This could be achieved using a combination of hand-dug test pits and mechanically excavated test pits/trenches and could be undertaken in parallel with other ground investigations and/or archaeological investigations.

- Integration of all datasets (new borehole data, superficial mapping and archaeological survey results) would result in production of deposit models to characterise areas of archaeological potential in greater detail.

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APPENDIX A BOREHOLE DATA

West Burton 1

Borehole Reference Number	Deposit
SK97NW9/H series – 56-65	Sand, clay and gravel overlying bedrock

Summary list of historic borehole data available within and near the site area of West Burton 1

West Burton 2

Borehole Reference Number	Deposit
SK87NE26-28 series	Clay overlying bedrock
SK97NW9 series	Sand and clay overlying bedrock
SK98NW12-13	*c* 2m topsoil/clay overlying bedrock

Summary list of historic borehole data available within and near the site area of West Burton 2

West Burton 3

Borehole Reference Number	Deposit
SK88SW23	Topsoil and clay to *c* 4m overlying bedrock
SK88SW24	Topsoil, sand and gravel
SK88SE14	Made ground, clay overlying limestone bedrock
SK87NE17	Clay overlying limestone bedrock

Summary list of historic borehole data available within and near the site area of West Burton 3

West Burton 4

Borehole Reference Number	Deposit
SK78NW75	Sand, clay and gravel overlying bedrock

Summary list of historic borehole data available within and near the site area of West Burton 4

West Burton Substation and Energy Storage unit

Borehole Reference Number	Deposit
SK78NE45	Topsoil, *c* 4m marly clay overlying bedrock
SK78NE46	Topsoil, *c* 3m marly clay overlying bedrock
SK78NE47	Topsoil, silty clay, sand and gravel, bedrock

Summary list of historic borehole data available within and near the site area of West Burton Substation and Energy Storage unit

APPENDIX B SITE SUMMARY DETAILS

Site name:	West Burton Solar Farm
Grid Reference	478658 386036
Type:	Desk-based Geoarchaeology Assessment
Area of Site	1009 hectares
Location of archive:	The archive is currently held at OA, Mill 3, Moor Lane Mills, Moor Lane, Lancaster, LA1 1QD.

Summary of Results:

The aim of this desk-based assessment is to investigate and characterise the geoarchaeological potential of the site of the proposed West Burton Solar Project and associated cable routes, to help identify areas of enhanced geoarchaeological interest.

The development lies within the wider Trent Valley, an area known for its rich floodplain archaeology, with evidence of fish traps, log boats, historical mills and bridges, all recovered from postglacial sand and gravel deposits, sealed beneath thick fine-grained alluvium. Low-lying broad river valleys provide access to riverine resources and have previously produced evidence of both ritual and settlement activity. These environments often offer excellent preservation potential for both significant archaeological and palaeoenvironmental remains.

The geoarchaeological assessment report has shown that there is potential for features such as palaeochannels and gravel islands to exist within the development areas. Previous historic borehole data available across the sites are of little value, as the data lack specific criteria such as altitude records and do not discriminate superficial deposits where identified. Data for generation of a deposit model could, however, be obtained from future engineering interventions especially if consideration is given to positioning interventions in areas likely to yield geoarchaeological information.

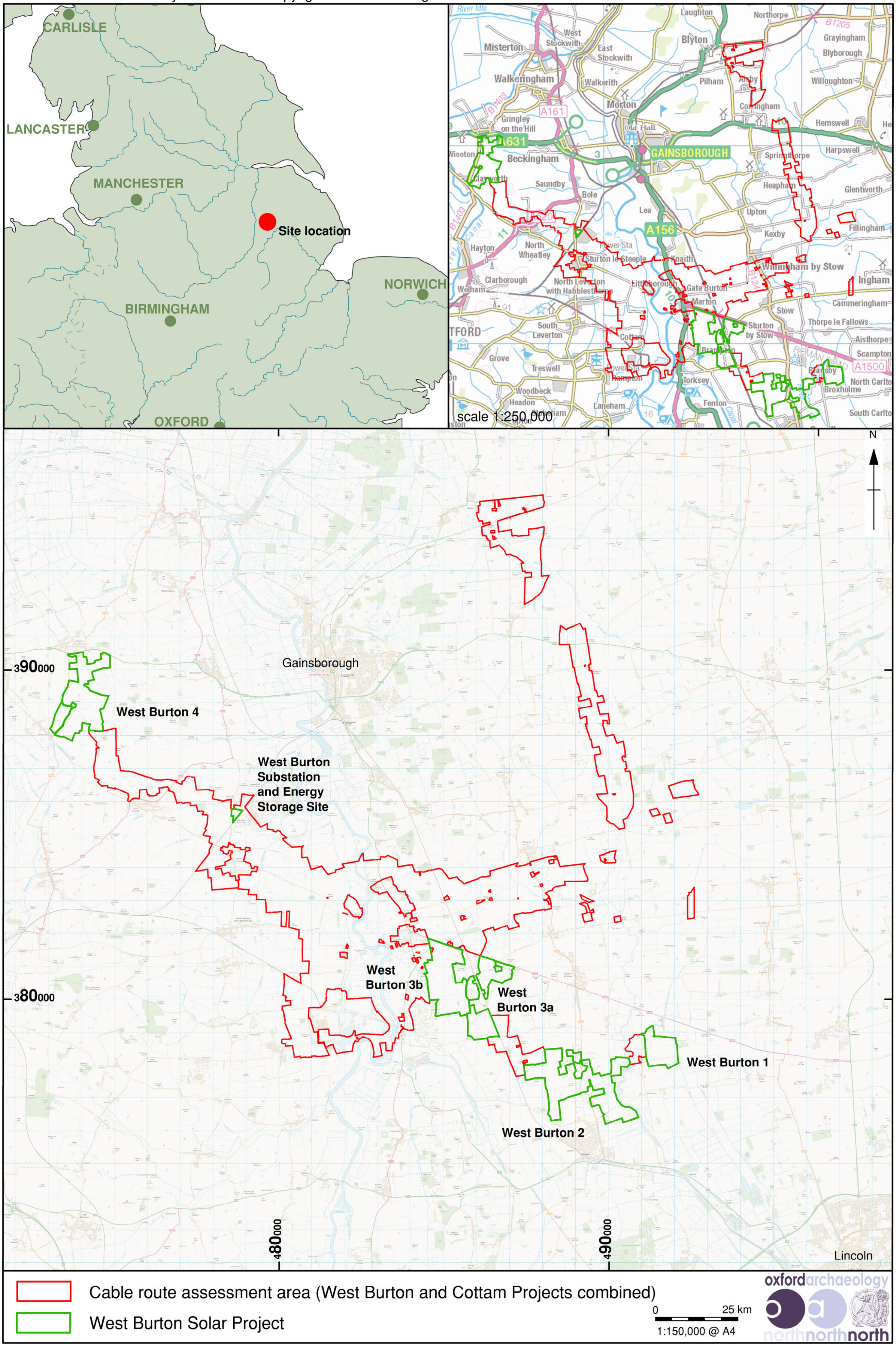

Figure 1: Site location map

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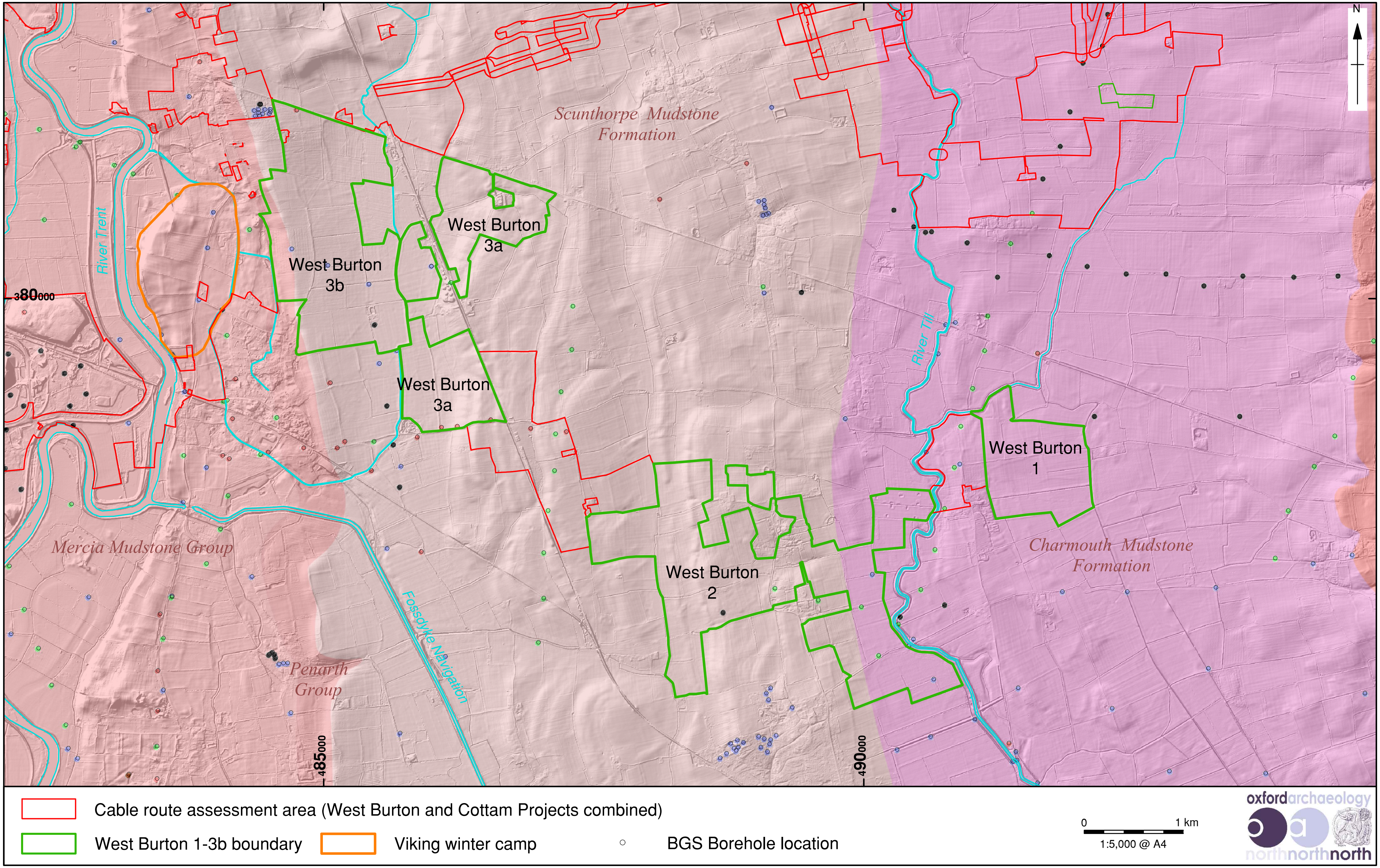

Figure 2: Baseline geology and BGS boreholes - West Burton 1-3

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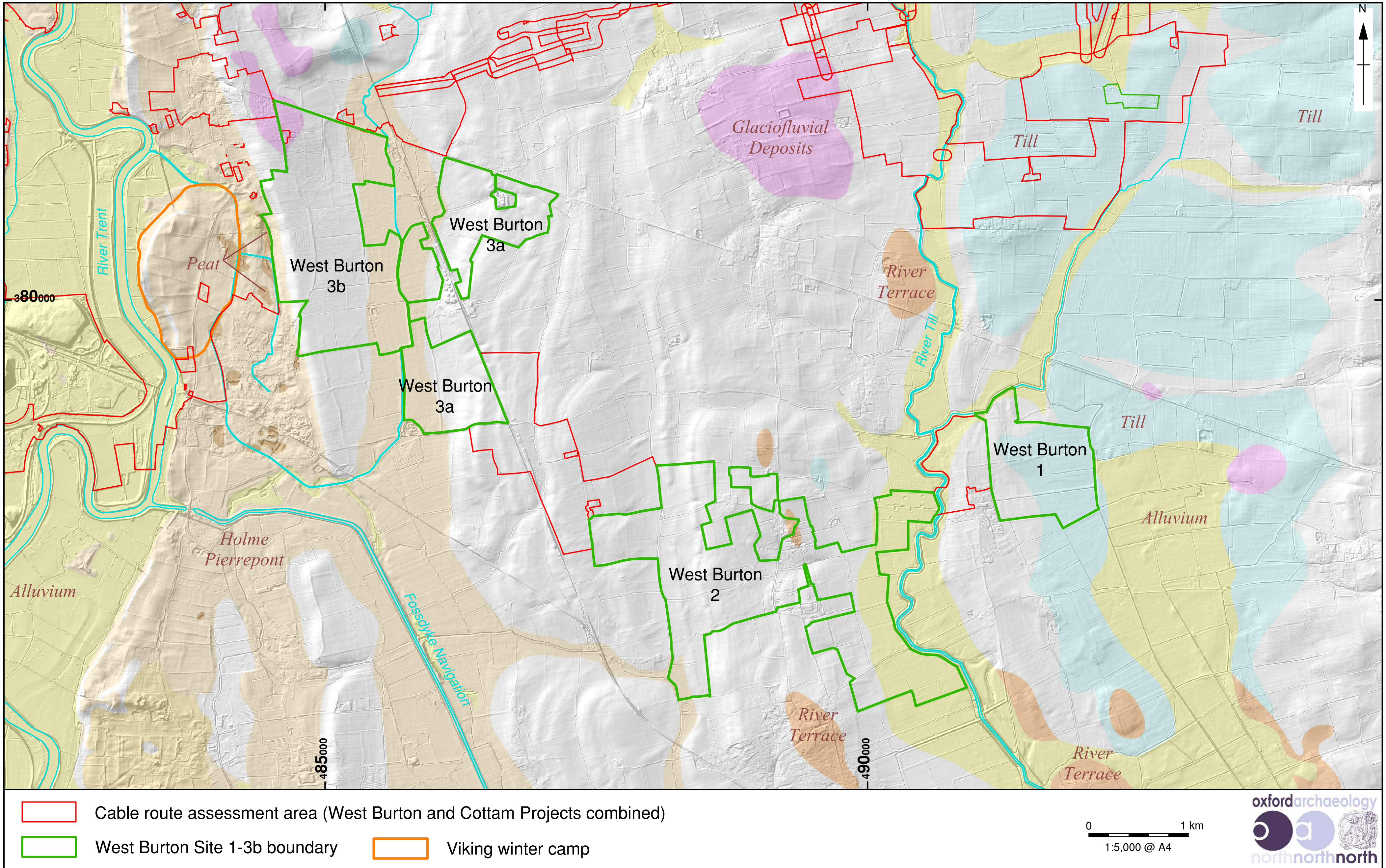

Figure 3: Baseline superficial deposits - West Burton 1-3

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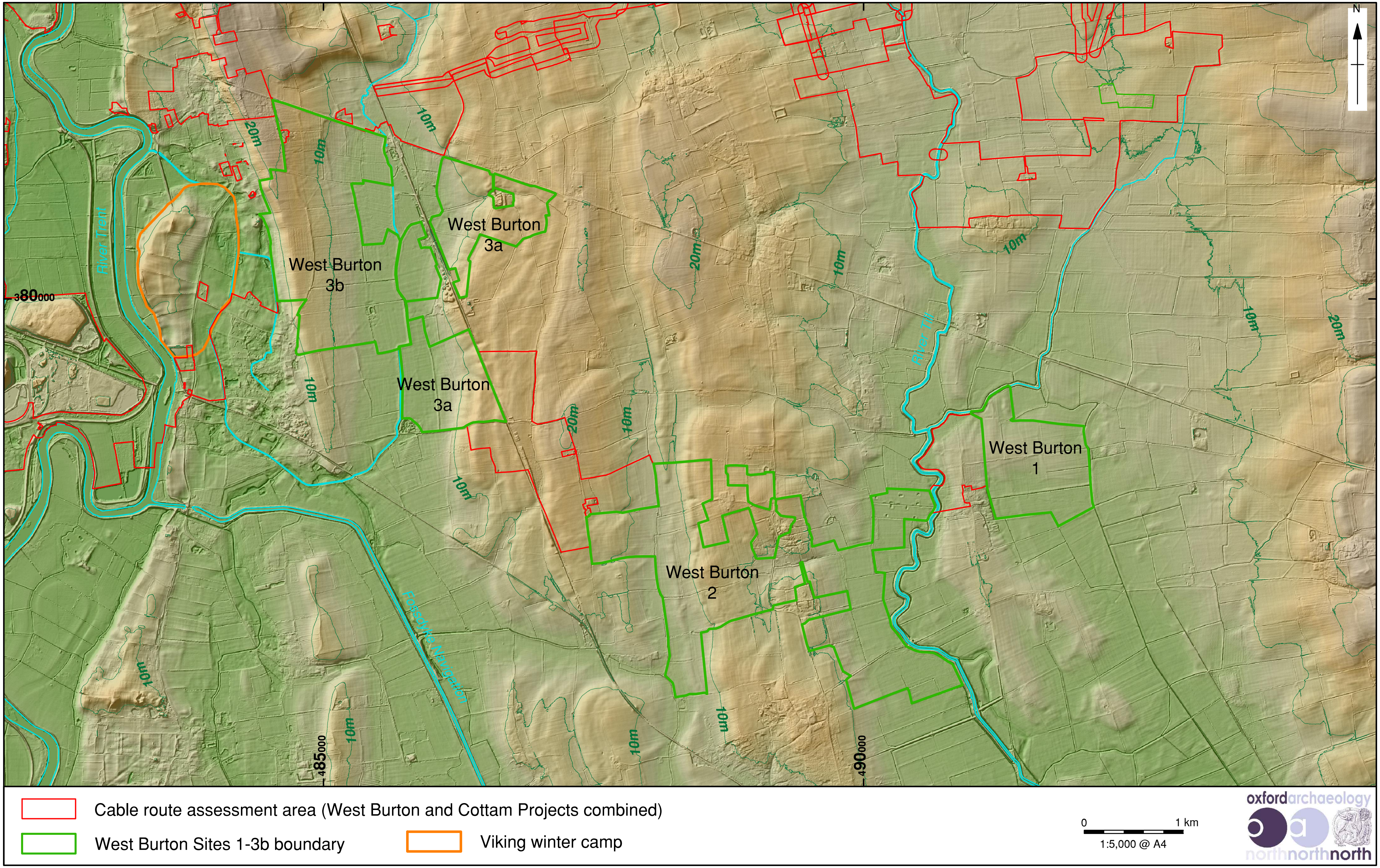

Figure 4: LiDAR image and contour topography - West Burton 1-3

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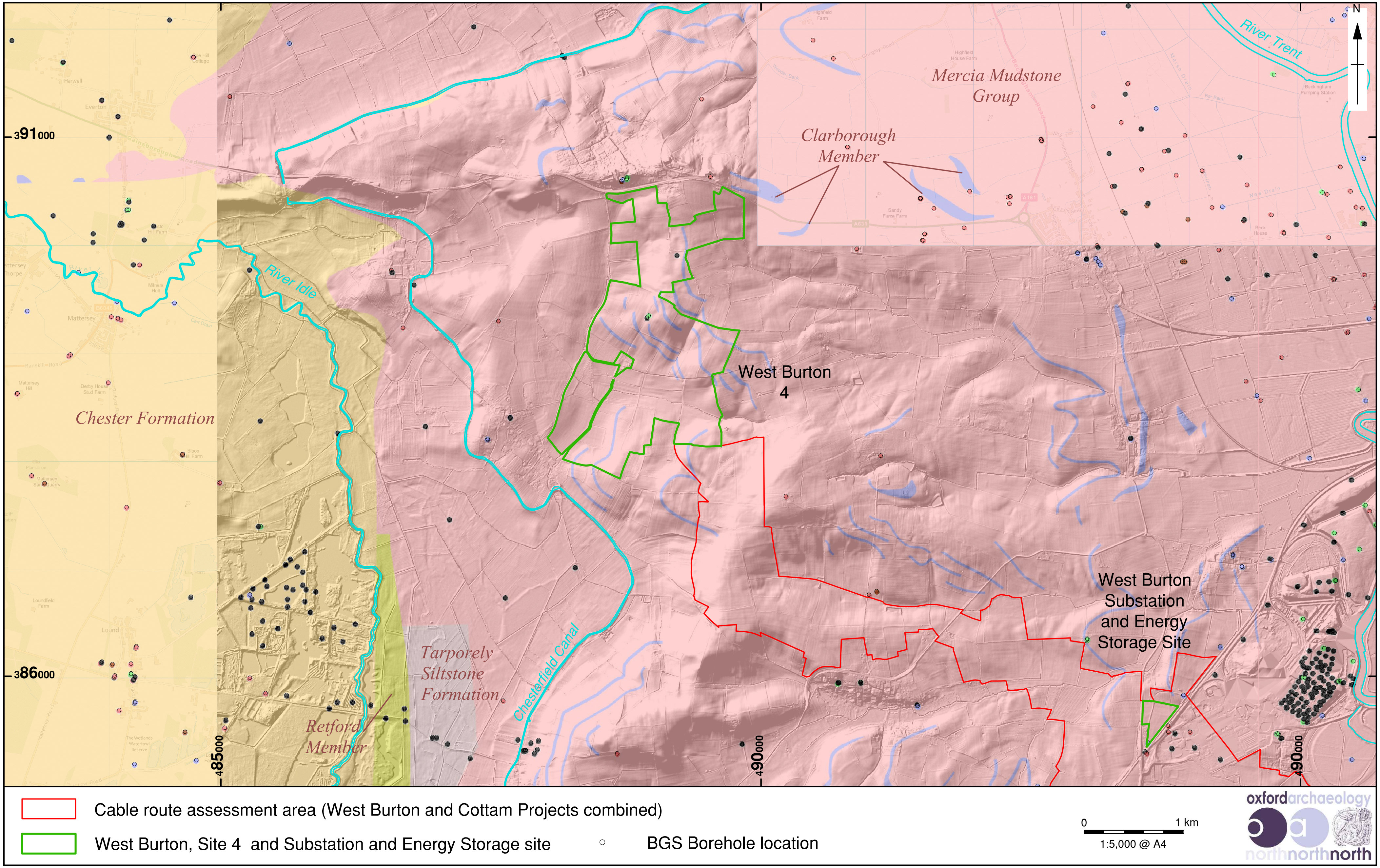

Figure 5: Baseline geology and BGS boreholes - West Burton 4, and Substation and Energy Storage Site

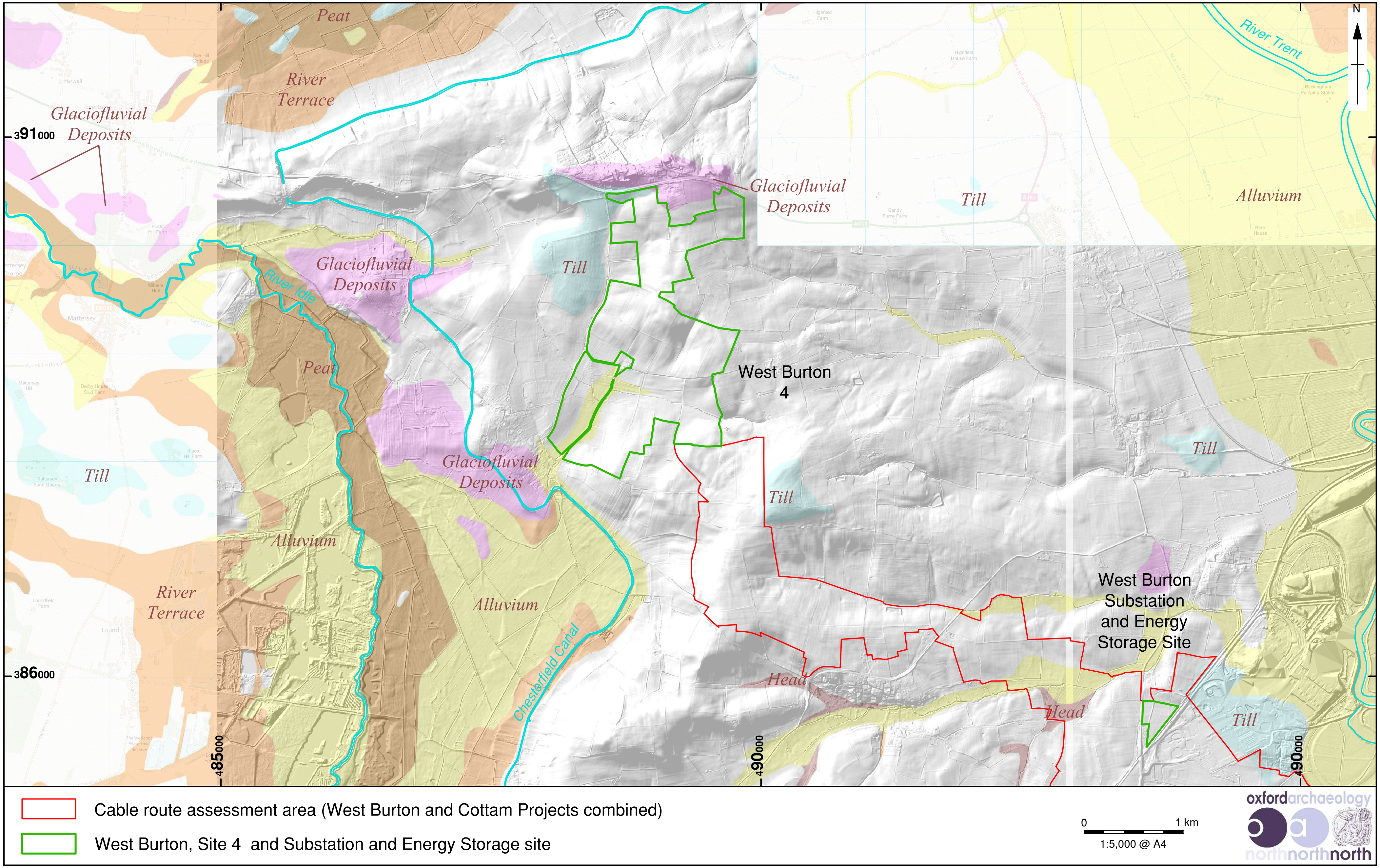

Figure 6: Baseline superficial deposits - West Burton 4, and Substation and Energy Storage Site

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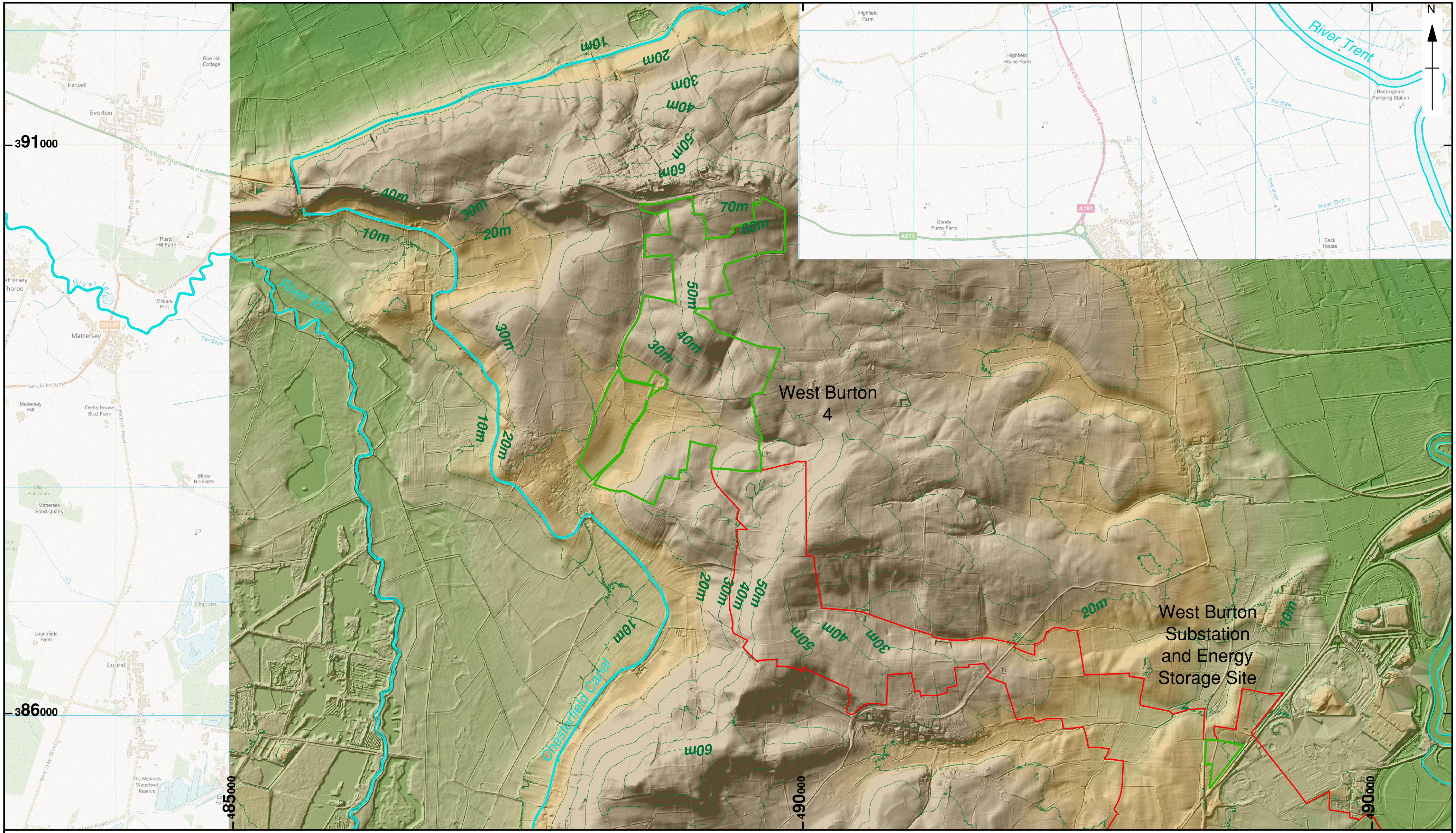

Cable route assessment area (West Burton and Cottam Projects combined)

West Burton, Site 4 and Substation and Energy Storage site

0 1 km

1:5,000 @ A4

oxfordarchaeology north

Figure 7: LiDAR image and contour topography - West Burton 4, and Substation and Energy Storage Site

FB*L11427*AMS*04052022

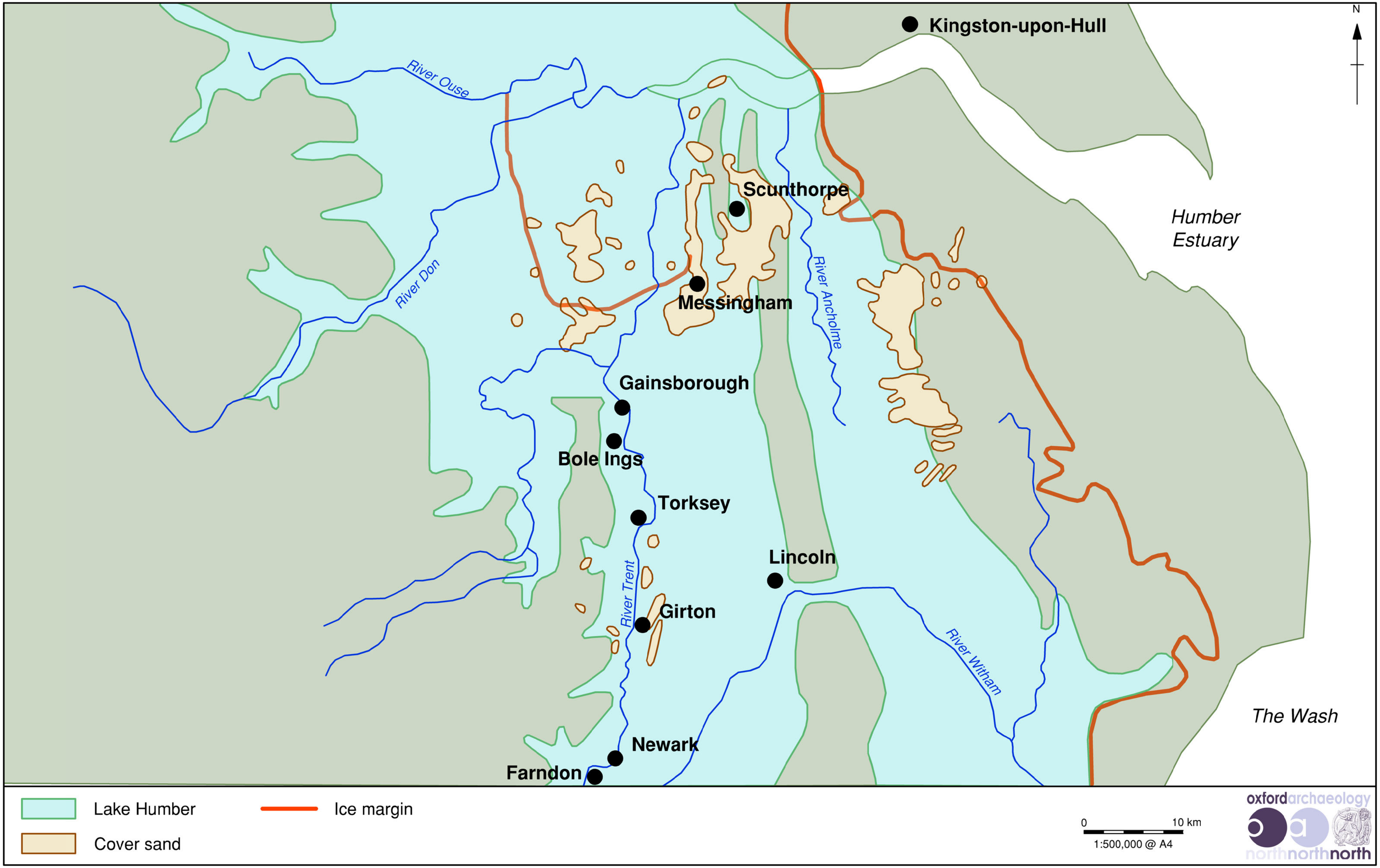

Figure 8: Extent of Lake Humber and Devensian ice margins

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