Rampion 2 Wind Farm

Category 6: Environmental Statement

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Executive Summary

This report outlines the findings resulting from a geoarchaeological and palaeoenvironmental desk-based assessment of the proposed onshore works associated with the Rampion 2 Offshore Wind Farm (Rampion 2) based on the proposed DCO Order Limits (the 'site'). The work was commissioned by WSP UK Limited and undertaken by Quaternary Scientific (University of Reading). This report considers the geoarchaeological and palaeoenvironmental potential and heritage significance of the site, which will help inform the need for any further mitigation measures. A range of documentary sources including geological mapping, satellite imagery and relevant Quaternary literature have been reviewed, enabling initial characterisation of the geography, topography, geology, geoarchaeological and palaeoenvironmental potential. The report concludes with a section summarising the potential and heritage significance of each major deposit type. The more significant archaeological and palaeoenvironmental remains likely to be encountered during the development of the Rampion 2 cable route are those underlying the floodplains of the principal rivers and those preserved in deposits occupying dry valleys on the Chalk in Landscape Zone 2.

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1. Introduction

1.1 Project background and context

1.1.1 This Appendix is a geoarchaeological and palaeoenvironmental desk-based assessment undertaken by Quaternary Scientific (University of Reading) for the onshore elements of Rampion 2.

1.1.2 Rampion Extension Development Limited (hereafter referred to as 'RED') is developing Rampion 2 (the 'Proposed Development') located adjacent to the existing Rampion Offshore Wind Farm (Rampion 1) located in the English Channel in the south of England.

1.1.1.1 Rampion 2 will be located between 13km and 26km from the Sussex Coast in the English Channel and will occupy an area of 160km^2.

1.1.1.2 The key offshore elements of the Proposed Development will be as follows:

- up to 90 offshore wind turbine generators (WTGs) and associated foundations;
- blade tip of the WTGs will be up to 325m above Lowest Astronomical Tide (LAT) and will have a 22m minimum air gap above Mean High Water Springs (MHWS);
- inter-array cables connecting the WTGs to up to three offshore substations;
- up to two offshore interconnector export cables between the offshore substations;
- up to four offshore export cables each in its own trench, will be buried under the seabed within the final cable corridor; and
- the export cable circuits will be High Voltage Alternating Current (HVAC), with a voltage of up to 275kV.

1.1.3 The key onshore elements of the Proposed Development will be as follows:

- a single landfall site near Climping, Arun District, connecting offshore and onshore cables using Horizontal Directional Drilling (HDD) installation techniques;
- buried onshore cables in a single corridor for the maximum route length of up to 38.8km using:
  - trenching and backfilling installation techniques; and
  - trenchless and open cut crossings.
- a new onshore substation, proposed near Cowfold, Horsham District, which will connect to an extension to the existing National Grid Bolney substation, Mid Sussex, via buried onshore cables; and

- extension to and additional infrastructure at the existing National Grid Bolney substation, Mid Sussex District to connect Rampion 2 to the national grid electrical network.

1.1.4 A full description of the Proposed Development is provided in **Chapter 4: The Proposed Development, Volume 2** (Document Reference: 6.2.4) of the Environmental Statement (ES).

1.1.5 This report considers the geoarchaeological and palaeoenvironmental potential and heritage significance of deposits across the onshore part of the DCO Order Limits (**Annex A**), which will inform the need for any further mitigation measures.

1.1.6 The onshore part of the DCO Order Limits of the Proposed Development consists of a linear area from Climping to Bolney, West Sussex (henceforth referred to as the 'site'), and encapsulates:

- the landfall at Climping;
- the onshore cable corridor with some local options;
- two onshore substation options;
- a number of options for temporary construction compounds adjacent to the onshore cable corridor; and
- likely temporary and permanent access requirements.

1.1.7 The Study Area referred to in this report comprises the Site and an area extending 1km from this boundary.

1.1.8 This work was commissioned by WSP UK Limited, on behalf of RED.

1.2 The Geology beneath the landscape

1.2.1 The Rampion 2 onshore route traverses a range of geography, topography and geology. The landscape varies in height and character across different bedrock geologies as the route climbs from the coastal plain over the South Downs to the Low Weald. This report focuses on the overlying superficial deposits that were laid down during the Pleistocene and Holocene periods. Understanding the buried sediments and soils across the site provides a framework for geoarchaeological potential: the potential for finding evidence of human occupation, exploitation and modification of the landscape (e.g., features and structures) and evidence for past environmental change (deeply stratified sediment sequences, ideally containing organics). A glossary of terms is provided in **Section 6**.

1.2.2 Chronologically, the superficial geology along the route covers the last 250 thousand years (ka) of geological time, extending across the Middle (781-126ka) and Late Pleistocene (126-11.5ka) through to the Holocene period (11.5ka-present). The Pleistocene and the Holocene together form the Quaternary, the period of Earth history characterised by high amplitude and frequency cold (glacial) to warm (interglacial) climate cycles (see **Table 1-1**).

The Pleistocene – the environmental setting of early human communities

1.2.3 The Pleistocene (2.6-1.7ka) is largely characterised by long glacial stages when the site was in a periglacial zone (at the ice margins) and the landscape shaped by water, wind and ice. Remnants of cold stage river gravel, Raised Beach, Head and Clay-with-flints representing the last two major onshore glaciations are present within the Study Area (the Devensian and the Wolstonian complex). These stages are punctuated by warm interglacials (the Ipswichian) and times of less significant climatic amelioration (the Aveley, Upton Warren and Windemere interstadials) (refer to **Table 1-1**). Sediments and their contained faunal and floral remains enable reconstruction of former environments occupied by Palaeolithic communities. Palaeolithic remains therefore form part of the Pleistocene record and include artefacts such as stone tools, faunal remains and the remains of early humans (hominins). Such remains are rare, but significant for understanding the early human occupation of Britain.

1.2.4 Pleistocene sediments and their subfossil content can be significant even in the absence of archaeology, as they enable the reconstruction of the landscape, climate, and environment of the Palaeolithic. In many cases, artefacts from geological units equivalent to those which may be encountered on Rampion 2 are held within museum collections. However, because of the way in which Palaeolithic artefacts were collected in the 19th and early 20th centuries, the environmental record that modern investigations of the deposits can supply is often missing. In addition, it is important to build up an understanding of the way in which the character and preservation of Pleistocene remains varies from place to place, even in the same geological unit. Recent advances in direct dating techniques, including optically stimulated luminescence (OSL), electron spin resonance (ESR), and amino acid racemization (AAR), have added further significance to Pleistocene remains, enabling more reliable dating, relevant both to artefacts and to an understanding of landscape evolution to be achieved.

The Holocene – from the Mesolithic to the present day

1.2.5 The Holocene encompasses the last 11.5ka and the archaeological periods from the Mesolithic to the present day. During this climatically warm and stable time, sediments were deposited by rivers, estuaries and on floodplains (alluvium including peat), on slopes (colluvium), by wind (aeolian) and within these sediments, soils formed. Variations in the elevation and thickness of these different deposits can be significant as they represent different environmental conditions that would have existed in a given location during the Holocene. For example:

1. the presence of peat or soil horizons represent former terrestrial or semi-terrestrial land-surfaces, and
2. the various alluvial units represent periods of changing fluvial conditions, possibly driven by hydrological variability (e.g. relative sea-level and/ or anthropogenic activity within the river catchment).

1.2.6 By studying the sub-surface stratigraphy in greater detail, it will be possible to build a more detailed understanding of the former landscapes and environmental changes that took place across space and time.

1.2.7 Fine grained alluvial and organic-rich sediments (in particular peat) also have high potential to provide detailed reconstructions of the past environment and may contain evidence of human occupation in the form of geoarchaeological remains. They provide an opportunity to increase knowledge and understanding of the interactions between hydrology, human activity, vegetation succession and climate during the Holocene. Such investigations are carried out through the assessment/analysis of palaeoecological remains (e.g. pollen, plant macrofossils and insects) and dating (e.g. radiocarbon, OSL).

Table 1-1 Chronological Table for the Late Quaternary

	Marine Isotope Stage (MIS)	Approximate date (thousands of years ago)	Epoch	Stage name				British archaeological period	Climate	
Late Quaternary	1	0.5	Holocene		Late		Historic	Post medieval	warm	Interglacial
		1						Medieval		
		2						Roman		
		3					Prehistoric	Iron Age		
		4			Mid			Bronze Age		
		6						Neolithic		
		12			Early			Mesolithic		
	2	13	Late Pleistocene	Devensian	Late	Devensian Lateglacial	Loch Lomond stadial	Upper Palaeolithic	cold	Glacial (last cold stage)
		14					Windemere interstadial		warmer	
		20					Dimlington stadial (late glacial maximum)		cold	
	3	58			Middle		Upton Warren interstadial	Middle Palaeolithic	warmer	
	4	75			Early				cold	
	5a	79					Brimpton interstadial		warmer	
	5b	96							cold	
	5c	103					Chelford interstadial		warmer	
	5d	115							cold	
	5e	125		Ipswichian				Middle Palaeolithic	warm	Interglacial
	6	190	Late Middle Pleistocene						cold	Glacial
	7	220		Aveley interglacial					warm	Interglacial

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1.3 Aims and objectives

1.3.1 As stated in **Section 1.1**, the primary aim of this report is to consider the geoarchaeological and palaeoenvironmental potential and heritage significance within the onshore part of the DCO Order Limits (**Annex A**). This in turn will help inform the need for any further mitigation measures.

1.3.2 In order to achieve this aim, a range of documents and sources has been reviewed including, but not limited to:

- a West Sussex Historic Environment Record (HER) search;
- historical mapping;
- LIDAR imagery and aerial photography;
- historical borehole data held by the British Geological Society (BGS) (BGS n.d.); and
- relevant geological, Quaternary, and archaeological literature.

1.4 Report layout

1.4.1 The site has been divided into three Landscape Zones (LZ) (**Annex A**), predominantly reflecting changes in Bedrock and Superficial Geology:

- the South Coast Plain (LZ1);
- the South Downs (LZ2); and
- the Low Weald (LZ3).

1.4.2 Landscape Zone 2 has been divided into two subzones:

- LZ2a the Chalk Upland;
- LZ2b the Scarpfoot.

1.4.3 A section within this report is dedicated to each of these zones/subzones, with consideration of the geography, topography, geology (both bedrock and superficial), geoarchaeological potential and palaeoenvironmental potential (**Sections 2 to 4**).

1.4.4 The report concludes with a section assessing the potential and heritage significance of each of the following major geological deposit types (**Section 5**):

- Alluvium,
- River Terrace Deposits,
- Raised Beach Deposits;
- Blown Sand;
- Head Deposits;
- Clay-with-flints, and

- Infill of solution pipes and fissures.

1.4.5 The assessment of potential and heritage significance is based upon professional judgement and aligns with the approach set out in **Chapter 25: Historic environment, Volume 2** (Document Reference: 6.2.25) of the ES.

1.4.6 This Appendix is supported by figures (see **Annex A**) illustrating the bedrock and superficial geology for each zone/subzone (**Figures 2 to 11**). The location of relevant boreholes referred to in the text are shown on the superficial geology maps (**Figures 8 to 11**). Three borehole transects are provided for LZ1 in **Figures 8 to 25.3.11**. The number and distribution of boreholes is too limited to produce transects for LZ2 and LZ3.

2. Landscape Zone 1: South coast plain

2.1 LZ1 Geography – Settlement and Land-use

2.1.1 Within LZ1 the site extends for about 3.8km from the coast near Atherington northward in the valley of the River Arun, crossing the river near the western outskirts of Littlehampton and generally remaining close to the eastern edge of the Arun floodplain. At a point near the village of Ford it turns eastward into the valley of a left bank tributary, the Black Ditch which it follows closely for circa (*ca*.) 1.9km before turning north then eastward again for a further *ca*. 3.3km. It crosses the valley of an un-named minor tributary of the Arun to reach a point near Hammerpot on the A27 trunk road which forms the boundary here between LZ1 and LZ2. Most of this route and the wider Landscape Zone is on low ground forming the valley floors of the River Arun and its tributaries. Historically this was an almost exclusively agricultural landscape with villages and farms at fairly regular intervals on slightly higher ground towards the edge of the valley floors above the level liable to flooding. Within the LZ to the west of the Arun, the villages of Climping and Ford are ancient settlements as witnessed by their 11th and 12th century churches. To the east of the Arun, the town of Littlehampton and the villages of Lyminster, Poling and Angmering have similar long histories. The River Arun was historically an important trade route and Littlehampton had a significant role as a port. In association with this commercial activity, engineering works affected the course of the Arun, including local realignment of the channel in the 15th and 16th centuries.

2.1.2 The only landscape evidence of pre-20th century industrial activity is in the form of brick pits recorded on early OS maps (e.g. 1st edition Six Inch map - Sussex LXIII, 1875/76) on land to the east of the A 284 road between Littlehampton and Lyminster and beside the A27 trunk road between Cross Bush and Poling Corner. These brickworks appear to have remained active at least until the Second World War. Their sites are now either built over in the northern suburbs of Littlehampton, or in the case of the site beside the A27, abandoned and flooded.

2.1.3 The lowest ground of the valley floors, the estuarine floodplains of the Arun and its tributaries are today still devoted almost entirely to agricultural land-use. Elsewhere within the valleys there is now evidence on the ground of a more diverse economy of more recent origin with several business parks and a solar farm on the outskirts of Littlehampton, and three smaller industrial estates respectively near the villages of Climping, Ford and Poling The hospitality industry is also well represented by numerous hotels, caravan parks and camp sites, mainly in the south of the Landscape Zone within easy reach of the coast. A marina and a golf course have also been developed on the outskirts of Littlehampton. There has been substantial urban growth around Littlehampton and Angmering from the 19th century onward, to the present day, and to a lesser extent around the smaller villages.

2.2 LZ1 Topography

2.2.1 The River Arun is the most striking topographic feature in LZ1. The river flows in broad meanders across an estuarine floodplain between one and two kilometres in width which occupies the middle of the valley floor. The floodplain is in a semi-natural state reflecting centuries of reclamation, management and agricultural land-use. It is drained by an irregular network of minor water courses, including natural tributaries and artificial ditches, both of which commonly serve as field boundaries. The river is tidal throughout the Landscape Zone and beyond, upstream to Pallingham Quay, north of Pulborough – a distance of *ca*. 41.0km from the coast. Minor tributaries are present on both sides of the Arun valley and the lower reaches of their floodplains are topographically continuous with the floodplain of the main river and similarly liable to flooding. Black Ditch flowing from the east between Littlehampton and Lyminster is the most substantial of these tributaries and its valley is liable to flooding for about 3.0km upstream from the edge of the Arun floodplain. In most places throughout the Arun valley and in the lower reaches of its tributaries the ground level of the floodplains is between 1.5m and 2.0m above Ordnance Datum (OD). There is a ridge of slightly higher ground (3.0-6.0m OD), partly artificial, partly coastal sand dunes, close to and parallel with the coast, and the River Arun is embanked to levels about 1.0-1.5m above the general level of the floodplain.

2.2.2 In the valley of the Arun, towards the edge of the valley floor, between the valleys of the minor tributaries the ground rises very gently to levels between 3.0m and 6.0m OD. The historic settlements and the modern urban expansion and commercial and industrial developments are located on this slightly elevated terrain. Where the cable route turns eastward into the valley of the Black Ditch, it rises gradually eastward and northward across other weakly defined minor tributary valleys from levels below 5.0m OD to levels mainly around 15.0m OD, near the A27 trunk road, the northern boundary of LZ1. Near Cross Bush the land rises more steeply to nearly 30.0m OD, close to the level of the Brighton-Norton raised beach of which a small remnant is mapped by BGS just north of Cross Bush.

2.3 LZ1 Geology

LZ1 Bedrock Geology (Figure 2)

2.3.1 Most of LZ1 is underlain by Chalk of the White Chalk Subgroup (Mortimore 1986, 1997). The Chalk is affected by minor folding, with fold axes aligned approximately east – west (Hopson 2009). In the north of the Landscape Zone close to the boundary with LZ2, Lower Tertiary sediments are present overlying the Chalk. They consist of Lambeth Group sediments and the London Clay Formation. These form part of an outcrop that occupies a synclinal structure (the Chichester-Worthing Syncline) and they extend northward into LZ2. The Lambeth Group sediments are described by BGS as '*Vertically and laterally variable sequences mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignites and occasional sandstone and conglomerate.*'. The Lambeth Group sediments are overlain by the London Clay Formation, which is mainly silty clay or clayey silt, slightly calcareous with beds of calcareous concretions, and less commonly thin beds of shells and thin beds of well-rounded flint pebbles.

2.3.2 Almost everywhere within LZ1 the bedrock is lost to view beneath superficial geological deposits. As a result, the British Geological Survey maps most of the Chalk simply as 'White Chalk Subgroup (undifferentiated)'. Only along the coast are the individual formations mapped separately – the Newhaven Chalk and the Seaford Chalk, except where an outcrop of the underlying New Pit Chalk is recorded beneath superficial deposits on the northern outskirts of Littlehampton, marking the presence there of an anticlinal fold (the Littlehampton Anticline). Because of the widespread and often deep cover of superficial geological deposits, the bedrock has relatively little direct effect on the form and character of the landscape.

LZ1 Superficial Geology (Figure 4a)

2.3.3 The superficial geology of LZ1 can be divided into two main elements:

1. Deposits of the River Arun and its tributaries, underlying their estuarine floodplains and infilling buried valleys; and
2. Deposits mantling the coastal plain cut through by the valleys of the Arun and its tributaries (see **Figure 5** to **Figure 8**).

2.3.4 A small area of Blown Sand is mapped by the BGS within the Study Area at the coast in LZ1. It is now largely occupied by the golf course on the west side of the Arun and by an amusement park on the east side of the river.'

The River Arun and tributaries

2.3.5 The floodplain sediments were originally mapped by the BGS as 'Alluvium' and in archive boreholes are often logged as 'estuarine alluvium'. They are now termed by the BGS, 'Raised Marine Deposits'. In the valley of the Arun the total thickness of these deposits recorded in BGS archive boreholes between Littlehampton and Climping reaches 36.0m. The bulk of the sediment underlying the floodplains is fine-grained, usually logged as silty clay or clayey silt, sometimes described as shelly, sometimes organic, laminated in places and with partings and beds of sand common and becoming more common towards the base of the alluvium. Gravel is recorded in some boreholes near the bottom of the alluvial sequence or resting directly on bedrock. Thin beds of peat are also patchily present within the alluvium. At least three peat horizons can be identified in the valley of the Arun, one towards the base of the alluvium at levels between -20.0m and -25.0m OD, another at levels between -9.0m and -11.0m OD, and a third locally present at the ground surface.

The Coastal Plain (Hodgson 1964; Bates *et al.,* 1997 & 2008)

2.3.6 The deposits that underlie the coastal plain in LZ1 are known only from scattered borehole records. In these records the upper part is often logged as 'brickearth', and most of the surface outcrop was originally mapped as such by the BGS. As noted above, brickpits were opened to quarry this material in the 19th century between Littlehampton and Lyminster. Now, the slightly higher ground on either side of the floodplain is mapped by the BGS as Raised Beach but the greater part of the coastal plain is mapped rather surprisingly as River Terrace Deposits. These are widely present forming much of the slightly higher ground in the valleys of the Arun and its tributaries, though upstream in the valley of the Black Ditch between Poling and Angmering, the BGS maps Head on the valley sides. Apart from the BGS, most authorities regard the deposits underlying the coastal plain as part of a complex of raised beaches that is widely recognised between Chichester and Brighton.

2.3.7 In most of LZ1, the bedrock beneath the coastal plain is recorded in BGS archive boreholes at levels between *ca*. -2.0m OD and *ca*. +4.0m OD, with some indication that more than one erosional bench is represented. Only in the north where the ground rises to levels between 15.0m and 30.0m OD is the bedrock recorded at higher levels beneath the cover of superficial deposits. In many of the boreholes in areas mapped as Raised Beach or River Terrace Deposits, sandy gravel/gravelly sand or sand is recorded resting directly on bedrock (**Figure 9**). These deposits are most likely to be marine beach or inter-tidal sediments. They are overlain by silty and clayey 'brickearth' deposits which in some places rest directly on bedrock. The silty nature of the 'brickearth' suggests the incorporation of windblown material (loess) but the common presence of sandy and pebbly horizons indicates reworking and incorporation of material from other sources. No detailed investigations of any of these superficial geological deposits have been made within LZ1, and although such investigations have been undertaken elsewhere, e.g. Norton Farm, near Chichester (Bates *et al* 2000), interpretations of the deposits remain tentative. In the light of these interpretations, most of the sand and gravel resting on bedrock beneath the coastal plain within LZ1 can reasonably be regarded as remnants of the Pagham Formation (Pagham Raised Beach), the lowest of the Sussex raised beaches and probably of MIS 5e age (the Ipswichian Interglacial; 130-115ka). Any sand and gravel at higher levels in the north of the Landscape Zone is more likely to be a remnant of the Norton Formation (Brighton/Norton Raised Beach) and probably of MIS 7 age (the 'Aveley' Interglacial; 243-191ka). The silty and clayey deposits ('brickearth') extensively present overlying the raised beach sediments are likely to be of Devensian age (115-11.5ka).

2.4 LZ1 Geoarchaeological potential

Palaeolithic potential

2.4.1 The potential for Palaeolithic remains in LZ1 is low. There are no find spots (a place where an archaeological object such as an artefact has been recovered), either Lower and Middle or Upper Palaeolithic registered in the West Sussex HER that are definitely in this LZ. A single handaze is recorded between Ford and Climping just outside the boundary of the study area Elsewhere on the coastal plain isolated finds of single artefacts are recorded but without detailed provenance and in rolled condition. From the Pagham Raised Beach only one artefact is recorded, from Selsey, and from the Brighton / Norton Raised Beach only two artefacts, one from Goring and one from the Black Rock site in Brighton. Three hand-axes are recorded from 'brickearth' overlying either the Brighton/Norton or the Pagham Raised Beach. No evidence of Upper Palaeolithic occupation has ever been identified on the Sussex Coastal Plain, although the valleys of the main rivers would seem to represent attractive environments for hunter-gatherer groups and Upper Palaeolithic occupation is known from the site at Beedings on the Lower Greensand to the north of the Chalk escarpment (Pope *et al* 2015).

Post-Palaeolithic potential

2.4.2 There is low potential for the preservation of post-Palaeolithic geoarchaeological remains within the alluvial deposits of the River Arun and its tributaries. Holocene alluvial deposits are known to preserve archaeology such as the remains of boats (Clark 2004; Green 2004), trackways (Thomas & Rackham 1996; Coles et al 2014), occupation sites (Pryor & Bamforth 2010) and occasionally human remains (Turner & Scaife 1995). In the absence of any records of such remains within LZ1, the potential for the area as a whole must be regarded as low. However, it should be recognised that the low potential largely reflects the lack of historical investigation, and post-Palaeolithic potential could be seen as uncertain.

2.5 LZ1 Palaeoenvironmental potential

2.5.1 There is plentiful evidence of palaeoenvironmental remains in boreholes penetrating the thick body of estuarine alluvium (Raised Marine Deposits) beneath the floodplain of the Arun. The clayey silts and silty clays that are the most common elements of this thick sequence are often described in borehole logs as organic or shelly or both, at many levels within the sequence from the ground surface downward. There are also peat horizons, noted above, and beds described as peaty or containing peat debris. This long sediment sequence undoubtedly contains an important record of landscape development, probably starting in the Late Devensian and certainly extending through the whole of the Holocene to include evidence of changing climatic conditions, changing patterns of vegetation, sea level behaviour, and the impact of anthropogenic occupation and land-use.

2.5.2 In contrast, there are no records of palaeoenvironmental remains from any of the deposits in LZ1 interpreted above as remnants of raised beaches (Norton and Pagham Formations) or from the overlying clayey and silty 'brickearth'. However, palaeoenvironmental remains have been recovered from equivalent deposits elsewhere on the Sussex coastal plain. At sites near Chichester (Bates et al 2000, Blinkhorn 2017, Dowsett & Blinkhorn 2018) ecofacts with evidential value of past environmental conditions (snails, foraminifera, ostracods pollen and plant remains) are recorded from deposits of the Brighton-Norton Raised Beach. At some of these sites undisturbed land surfaces are present in overlying terrestrial silts with associated pollen, plant macrofossils, insects, snails and mammal bone. Microfossil assemblages have also been recorded from marine deposits of the Pagham Formation around Pagham Harbour (Bates & Briant 2009).

2.5.3 In summary, there is high potential for the preservation of palaeoenvironmental remains in LZ1 in alluvial deposits that underlie the coastal plain as well as those that infill the buried valleys of the Arun and its tributaries. There is uncertain but probably low potential for palaeoenvironmental remains within raised beach deposits.

3. Landscape Zone 2: South Downs

3.1.1 A major part of the Rampion route in LZ2 passes across the Chalk of the South Downs. The route extends over a total distance of 12.5km from a point on the A27 trunk road north of Angmering to the low ground at the foot of the Chalk escarpment. The route is divided here into two Subzones which are separately described in the following account.

- 2a – The Chalk Upland (8.1km); and
- 2b – The Scarpfoot (4.4km).

3.2 Subzone 2a: the Chalk Upland

LZ2a Geography – Settlement and Land-use

3.2.1 This part of the site extends over a distance of *ca*. 8.1km from a boundary formed by the A27 trunk road on rising ground to the north of Angmering to the foot of the Chalk escarpment between Sullington Hill and Barnsfarm Hill to the south of the village of Sullington near the watershed separating the headwaters of the river Arun to the west from the headwaters of the River Adur to the east. The Chalk Upland Subzone is a landscape devoted almost entirely to agricultural land-use or woodland. There are large areas of woodland on heavier soils at the southern end of the Subzone, but much of it is a landscape of wide vistas across typical Chalk Downland. Here enclosure is mainly in large rectilinear fields most commonly bounded by hedgerows and linked by unpaved tracks. There are small, scattered areas of woodland, mainly on steeper valley sides and more extensive woodland on the Chalk escarpment.

3.2.2 Permanent water courses are present in the form of a few minor streams near the southern boundary of the Subzone where less permeable geological deposits overlie the Chalk. Elsewhere within the Subzone surface water is almost completely absent. There are few paved roads within the Subzone and no centres of population. Isolated farms are the only form of occupied habitation. Apart from the modern field system, topographic features of anthropogenic origin are historic and prehistoric earthworks, including barrows, enclosures, linear ditches and embankments, small pits and quarries, dew ponds and prehistoric field systems. Prehistoric flint mines are also present within the Subzone on Harrow Hill where some 245 shafts and pits have been recorded in an area of uneven ground occupying about 8.0ha on the summit of the hill (Barber *et al* 1999).

LZ2a Topography

3.2.3 The broad features controlling the regional topography of the Chalk Upland Subzone are the dip and scarp slopes of the Chalk. The dip slope rises northward over a distance of 6 to 7km from levels around 15m OD in the south to levels over 200m OD on the crest of the escarpment. The foot of the scarp slope which forms the boundary between the Chalk Upland Subzone and the Scarpfoot Subzone is generally close to 110m OD and the scarp slope falls steeply to this level over a distance which in most places is less than 0.5km. In detail the relief of the Study Area is determined by the form and pattern of the dry valleys that dissect both the dip slope and the scarp slope of the Chalk. On the dip slope, in the south of the Subzone the dry valleys form headward extensions of the Black Ditch. In the north a more extensive dry valley system heads close to the escarpment and falls southward to join a tributary of the Black Ditch that rises just south of Patching. The spurs of higher ground that separate the dry valleys have gently concave lower slopes and broad convex summits, giving rise to typical Chalk Downland.

3.2.4 The site crosses the Chalk upland from south to north. From the boundary with LZ1, the route rises gradually on higher ground between the principal dry valleys to reach a level of c.120m OD on the eastern flank of Barpham Hill. From this high point it falls steeply down over a distance of a few hundred metres to levels close to 60m OD, turning eastward and crossing the floors of two dry valleys. It then turns north again up the dip slope crossing another dry valley but generally avoiding the lowest ground of the valley floors. It reaches a level of nearly 200m OD on the crest of the Chalk escarpment before falling steeply towards the boundary with the Scarpfoot Subzone. Unlike the dry valleys on the dip slope, those that dissect the Chalk escarpment are short and steep, and in many cases little more than shallow indentations in the scarp face. However, close to the point where the site crosses the escarpment there are three deeper and broader dry valleys, up to a kilometre in length. The route itself descends the escarpment in one of these more extended dry valleys.

LZ2a Geology

3.2.5 There are no modern borehole records within the Chalk Upland Subzone and such records as do exist in the BGS archive provide very little or no detail about the rocks through which they pass.

Bedrock Geology (Figure 3)

3.2.6 Most of the Chalk Upland Subzone is underlain by the Chalk which consists here of the following Members (Mortimore 1986, 1997):

- White Chalk Subgroup:
  - Spetisbury Chalk;
  - Tarrant Chalk;
  - Newhaven Chalk;
  - Seaford Chalk; and
  - Lewes Nodular Chalk.
- Grey Chalk Subgroup:
  - New Pit Chalk; and
  - Holywell Nodular Chalk.

3.2.7 However, in the south of the Chalk Upland Subzone, Lower Tertiary sediments are present that overlie the Chalk and form a narrow outcrop close to the boundary with LZ1. They consist of Lambeth Group sediments overlain by the London Clay Formation. As noted above (**Section 2.3**) these form part of an outcrop that occupies a synclinal structure (the Chichester-Worthing Syncline) and they extend southward into LZ1. They are less permeable than the Chalk and support the headwater reaches of permanent streams draining southward onto the South Coast Plain. They also support heavier soils than those typically developed on the Chalk itself.

3.2.8 The broad regional pattern of the Chalk outcrop reflects the tilting of the strata down to the south in the geological past and their subsequent truncation by erosion. Thus the dipslope is strictly speaking a plane of erosion and accordingly the outcrop on the dipslope reveals the oldest beds at the top of the slope and progressively younger beds further downslope. The scarp face is formed by the Grey Chalk Subgroup comprising the New Pit Chalk and Holywell Nodular Chalk. The highest ground forming the escarpment crest is underlain by the Lewes Nodular Chalk, the oldest member of the White Chalk Subgroup. The hard chalk of the Chalk Rock near the base of this member plays a significant role in determining the position of the escarpment. Lower down on the dipslope younger members are exposed, up to and including the Spetisbury Chalk, with large parts of the Study Area underlain by the Seaford Chalk. On the lower dipslope the outcrop pattern reflects the topography, with dry valleys cutting through the younger Chalk members to reveal the older members beneath.

3.2.9 The Chalk of the White Chalk Subgroup is lithologically remarkably uniform comprising a very pure white limestone with many bands of flint which are particularly numerous in the Seaford Chalk. Like all limestones the White Chalk is susceptible to solution, and solution features such as pipes and dolines may therefore be present, though none have ever attracted geological or archaeological attention within the Study Area. However, coastal exposures in Sussex reveal the surface of the Seaford Chalk extensively penetrated by such features. Although joints in the rock and beds of flint and harder chalk may be responsible for minor topographic features, the lithological uniformity of the White Chalk is responsible for a similar uniformity in the landforms developed on the outcrop – the unmistakable landscape of Chalk Downland. The Grey Chalk which outcrops in the face of the Chalk escarpment contains more marl bands and no flint. The Melbourne Rock at the base of the Holywell Chalk coincides with the topographic foot of the escarpment. The Grey Chalk is more erodible than the White Chalk and the complete removal of the New Pit Chalk and the Holywell Nodular Chalk beyond the escarpment is obvious evidence of this.

Superficial Geology (Figure 9)

3.2.10 Across much of the Subzone the only superficial deposits recorded by the BGS are narrow outcrops of Head (clay, silt, sand and gravel) on the floors of the dry valleys. As noted above, the site crosses several dry valleys but there are no published descriptions of the associated dry valley deposits (Head). Records from elsewhere on the Chalk in Sussex and more widely in southern England (Bell 1983; Allen 1988) show that such deposits are rarely earlier than Late Devensian in age and date mainly from the Holocene. They consist largely of colluvial material introduced by slope processes from the neighbouring valley sides. Water-laid material may also sometimes be present. A borehole to the south of the Subzone (TQ00NE31), down-valley near Patching recorded 13' 6" (4.1m) of sandy clay beneath the valley floor. Where the route encounters the upper reaches of the dry valley system the Head deposits are likely to be substantially thinner. The Head is usually a clayey or silty deposit with variable amounts of chalk and flint. The silt component is thought to be derived from loessic (wind-blown) deposits which appear to have been widely present at the beginning of the Holocene as a thin mantle on the Chalk and other rocks in southern England (Catt, 1977). In most places on the Chalk, from the Neolithic onward slope processes have been intensified by agricultural activity and associated soil erosion. As a result, on slopes and summit areas the bedrock Chalk is often very close to the surface (<0.5m).

3.2.11 The only other superficial deposit recorded by BGS within the Chalk Upland Subzone is Clay-with-flints. A substantial outcrop is present on the rising ground of the Spetisbury Chalk on the southern flank of Barpham Hill at the southern end of the Chalk Upland Subzone. A borehole (TQ00NE38) at a level of 385' (117.3m) towards the summit of Barpham Hill provides a basic description of the Clay-with-flints: 2'6" (0.76m) of 'soil and gravel' over 8' (2.4m) of 'red clay and flints'. The Clay-with-flints is generally regarded as including the insoluble residue of the Chalk but consisting mainly of reworked material derived from the Lower Tertiary sediments that overlie the Chalk. As noted above, Lower Tertiary sediments form an outcrop that straddles the boundary between LZ1 and LZ2, extending northward within the Chalk Upland Sub-zone close to the southern edge of the clay-with-flints on Barpham Hill. As well as deriving a large part of its clay content from these Lower Tertiary sediments, the Clay-with-flints often contains bodies of sand and quantities of well-rounded flint pebbles from the same source. Sarsen is also associated with the sediments that overlie the Chalk and there are numerous examples on the South Downs near Brighton and near Chichester (Ullyot *et al* 2004), but none have been recorded in the Chalk Upland Subzone.

LZ2a Georchaeological potential

Palaeolithic potential

3.2.12 The potential for Palaeolithic remains in the Chalk Upland Subzone is low. No Lower or Middle Palaeolithic findspots are recorded by Roe (1968), Woodcock (1981), Wymer (1999) or Bates *et al* (2008) and there is no evidence for Upper Palaeolithic occupation. However, important evidence of Lower Palaeolithic occupation is present in raised beach deposits on the Sussex coastal plain at Boxgrove, about 16.0km to the west (Roberts & Parfitt 1999) and there is evidence of Early Upper Palaeolithic occupation in the Weald, e.g., at Beedings on the Lower Greensand about 10.0km to the north of the Subzone (Pope *et al* 2015). It is likely therefore that Palaeolithic groups or individuals were occasionally present on the Chalk Upland. Preservation *in situ* of artefacts discarded by Palaeolithic visitors is unlikely however (low potential), particularly where the bedrock Chalk was close to the ground surface. Such material would be subject to redistribution by colluvial processes, particularly during the cold stages of the Pleistocene and if preserved might be found in the Head deposits underlying the floors of the dry valleys. A different context for the potential preservation of Palaeolithic material is provided by the Clay-with-flints. Near-surface Palaeolithic remains have been recovered from Clay-with-flints on the South Downs near Eastbourne (Todd 1934; Scott-Jackson 2000). Another potential context for the preservation of Palaeolithic remains on the Chalk Upland is the sedimentary infill of solution features such as pipes and dolines. There are no records of such features in the Chalk Upland Subzone but elsewhere on the White Chalk in southern England they are common, particularly where there are deposits nearby overlying the Chalk, such as Lower Tertiary sediments or Clay-with-flints.

Post-Palaeolithic potential

3.2.13 There is medium potential for post-Palaeolithic geoarchaeological remains in the Chalk Upland Subzone is the Head. The potential context for the preservation of post-Palaeolithic geoarchaeological remains in the Chalk Upland Subzone is the Head deposits on the floors of the dry valleys. The upper reaches of two dry valley systems lie within the Subzone but there are no detailed accounts of any of these deposits. However, elsewhere on the Chalk uplands of southern Britain the stratigraphy and sedimentology of similar deposits has been the subject of investigation (Bell 1981,1983; Allen 1988; Wilkinson 2003). In some cases, archaeological remains, principally pottery sherds and / or flint artefacts, have been systematically recorded in dry valley deposits (Bell 1981, Day 1999). In a study of the upper reaches of dry valleys on the Berkshire Downs (Day 1999) colluvial deposits were found to be thin (<0.5m) but OSL dating indicated a sequence of prehistoric, Roman, and post-Roman accumulation. Archaeological remains here consisted of scattered and randomly distributed pottery sherds of prehistoric to post-Roman age. Elsewhere, flintwork of early Mesolithic age has also been recorded in dry valley deposits, e.g., at Peacehaven in East Sussex (Hart, 2015).

LZ2a Palaeoenvironmental potential

3.2.14 The superficial deposits overlying the Chalk in the Chalk Upland Subzone offer low potential for the preservation of palaeoenvironmental remains. They are effectively absent from the Clay-with-flints throughout its extent in southern England and cannot be expected here in Sussex.

3.2.15 On the other hand, in the Head deposits underlying the floors of the dry valleys within the Chalk Upland Subzone there may be medium potential, e.g. from remains of snails and charcoal, to reconstruct part at least of its Holocene history, recording both palaeoenvironmental conditions and prehistoric and historic land-use.

3.3 Subzone 2b: the Scarpfoot

LZ2b Geography – Settlement and Land-use

3.3.1 Within this Subzone, the onshore cable corridor extends for approximately 4.4km from the topographic foot of the Chalk escarpment (taken here to be the base of the Holywell Nodular Chalk) to the boundary between LZ2 and LZ3. This boundary is aligned approximately west-east and follows the A283 road which coincides approximately with the geological boundary between the Gault Formation and the Folkestone Formation (see Geology; **paragraph 3.3.3**). From the foot of the escarpment, the onshore cable corridor turns eastward trending gradually away from the escarpment towards the boundary between LZ2 and LZ3. As the onshore cable corridor is roughly parallel with, and in places very close to the boundary between LZ2 and LZ3, the Study Area extends southward across the Chalk escarpment to include Chalk Downland forming a continuation of the Chalk Upland of Subzone 2a (**Section 3.2**). North of the onshore cable corridor, the Study Area forms part of LZ3 (**Section 4**). The area of particular interest in Subzone 2b is therefore the low ground sloping away from the foot of the Chalk escarpment. This is a rural landscape of mainly agricultural land-use with some small areas of woodland. Fields are small relative to those on the Chalk Upland and are bounded by hedges with many hedgerow trees. The A24 trunk road crosses the Subzone 2b from south to north passing through the village of Washington. Settlement otherwise includes the small village of Sullington but is mainly in the form of scattered farms, linked by minor roads to the A283.

LZ2b Topography

3.3.2 This is a landscape of low relief sloping generally northward from the foot of the Chalk escarpment with weakly developed and discontinuous secondary escarpments marking the outcrops of the Zig Zag Chalk and the Upper Greensand. This terrain is dissected by small streams flowing northward from the scarp foot. These are headwater tributaries of the River Arun in the west and the River Adur in the east. They occupy broad shallow valleys with gently sloping valley sides. The heads of most of these valleys form little more than shallow indentations in the scarp face, but there are three deeper re-entrants with broad gently sloping floors.

LZ2b Geology

Bedrock Geology (**Figure 3**)

3.3.3 The Scarpfoot Subzone is underlain by relatively weak rocks, readily susceptible to erosion and hence giving rise to low ground. At the immediate scarpfoot they comprise Chalk of the Grey Chalk Subgroup - the Zig Zag Chalk overlying the West Melbury Marly Chalk. These chalk formations rest on the Upper Greensand which rests in turn on the clay of the Gault Formation. These rocks are tilted down to the south so that slightly stronger beds, notably the Upper Greensand and the Tenuis Limestone at the base of the Zig Zag Chalk form low and discontinuous north-facing escarpments parallel with the main Chalk escarpment. The West Melbury Marly Chalk and the clay of the Gault Formation form the low ground, with the West Melbury Chalk forming the broad floors of the deeper dry valley re-entrants in the main Chalk escarpment.

Superficial Geology (**Figure 6**)

3.3.4 The only superficial geological deposit recorded by the BGS in the Scarpfoot Subzone is Head (Clay, Silt, Sand and Gravel). This is mapped resting on West

Melbury Marly Chalk on the floors of the three dry valleys that form deep re-entrants in the main Chalk escarpment. From one of these, the dry valley between Sullington Hill and Barnsfarm Hill (intersected by the site) the Head outcrop spreads widely northward from the Chalk across the Upper Greensand onto the Gault and beyond onto the Folkestone Formation in LZ3. Head is also present in valleys on the Upper Greensand and Gault to the east of Washington. There is only one adequately logged archive borehole (TQ11SW58) recording the Head deposits in the Scarpfoot Subzone. This is beside the A24 trunk road to the south of Washington and it records 9' (2.74m) of 'light brown chalk-flecked silty clay' resting on 'hard light brown silty clay and claystone'. This brief description suggests deposits similar to dry valley infill on the Chalk elsewhere in southern England. While very little is known about the superficial deposits in the Scarpfoot Subzone, elsewhere in southern England in similar situations on the low ground at the foot of the Chalk escarpment, quite complex sediment sequences are recorded, e.g. at Holywell Coombe (Preece & Bridgland 1999) and Brook in Kent (Kerney *et al* 1964) where Late Devensian and Holocene deposits have been recorded, and at Marsworth at the foot of the Chiltern escarpment (Green *et al* 1984; Murton *et al* 2001) where deposits dating back at least to MIS 7 (the 'Aveley' Interglacial; 243-191ka) are present.

LZ2b Geoarchaeological potential

Palaeolithic potential

3.3.5 The potential for the preservation of Lower or Middle Palaeolithic remains within the Scarpfoot Subzone is low. There are no River Terrace Deposits, which in southern Britain are generally the main source of Palaeolithic material. There are no find spots recorded in the West Sussex HER within the Scarpfoot Subzone, but Lower Palaeolithic artefacts have been recorded nearby in Storrington and on the Chalk escarpment on Kithurst Hill indicating that Palaeolithic individuals or groups were present in the area. There is therefore the possibility of surface finds or incorporation of artefacts into Head deposits. There are no records of Upper Palaeolithic remains within the Scarpfoot Subzone and they are rare elsewhere in the wider West Sussex region. The Early Upper Palaeolithic site at Beedings lies about 10km to the north-west (Pope *et al* 2015), so Upper Palaeolithic groups or individuals might have penetrated into the Subzone and the possibility exists that casually discarded Upper Palaeolithic remains might be preserved in Head deposits. There is also the possibility that evidence of a more substantial Upper Palaeolithic presence might be preserved in the Head.

Post-Palaeolithic potential

3.3.6 The potential for the preservation of post-Palaeolithic geoarchaeological remains in LZ2b is low. The context for the preservation of post-Palaeolithic remains in the Scarpfoot Subzone is the Head deposits on the floors of the dry valleys dissecting the scarp and extending across the scarp foot-slope. There are no records of buried Holocene geoarchaeological remains within the Scarpfoot Subzone but the potential circumstance for their preservation is essentially the same as those described above (**Paragraph 3.2.13**) for dry valleys in general on the Chalk of southern England. Kerney et al (1964) describe similar deposits near Brook in

Kent extending from the Chalk escarpment across the underlying Gault foot-slope. Here pottery ranging in date from Iron Age to Romano-British was recovered from the deposits.

LZ2b Palaeoenvironmental potential

3.3.7 No palaeoenvironmental remains have been observed or recorded within the Scarpfoot Subzone, which is probably mainly due to an absence of investigation. The Head deposits underlying the floors of the dry valleys that form substantial embayments in the Chalk escarpment are likely to incorporate some palaeoenvironmental material, e.g., snails and charcoal.

3.3.8 Elsewhere in southern England, deposits on the low ground at the foot of the Chalk escarpment include a rich variety of organic remains in well preserved stratigraphic sequences, as noted above at Holywell Coombe and Brook in Kent and at Marsworth at the foot of the Chiltern escarpment in Buckinghamshire. The possibility must therefore be recognised that such remains might be present where Head is preserved on the Chalk or extends beyond the Chalk outcrop onto earlier bedrock outcrops. In summary, there is medium potential for palaeoenvironmental remains within LZ2b.

4. Landscape Zone 3: Low Weald (with Wealdon Greensand and High Weald)

4.1 LZ3 Geography – Settlement and Land-use

4.1.1 The onshore cable corridor in LZ3 extends over a distance of *ca*. 14.6km from the A283 road near the scattered village of Wiston in a generally north-easterly direction across the Sussex Low Weald and the upper catchment of the River Adur to the A272 road east of the village of Cowfold. The whole of LZ3 has a thoroughly rural character. This is a landscape of farmland and scattered woodland with fields generally of small or medium size bounded by hedgerows with many hedgerow trees. Agriculture is mainly pastoral on the lower ground including the valley floors of the Upper Adur and its tributaries, with mixed grassland and arable on the higher ground. Settlement is predominantly scattered, in farmsteads and linear roadside hamlets, generally avoiding the lowest ground of the river valleys. Medieval churches of the 12th and 13th centuries indicate the presence of four ancient villages – Cowfold and Ashurst and the scattered villages of Wiston and Shermansbury. The growth of Partridge Green is a more recent development as witnessed by its late Victorian parish church. The only substantial impact of industrial activity is in the form of quarries at the southern end of the Landscape Zone beside the A283 road where the Lower Greensand (Folkestone Formation) has been quarried in several large sand pits between Wiston and Storrington. In the past, small pits worked clay, sand and gravel to serve local demand but none remain commercially active today and most have been reclaimed or have become overgrown. Across most of LZ3, the impact of present-day industrial and commercial activity is limited. There are small industrial estates on the outskirts of Partridge Green and on the A272 near Cowfold, and the hospitality industry is represented by several camp sites and caravan parks.

4.2 LZ3 Topography

4.2.1 This is a well-watered landscape of low relief and gentle slopes. The higher ground rarely rises above the 30m contour, and the floors of the broad shallow valleys of both branches of the Upper Adur and their main tributaries are everywhere below the 10m contour. The broad pattern of relief is dictated to a significant extent by the underlying geology which has a well-marked E-W structural grain. This creates a rolling landscape with low, rounded ridges trending E-W and marking the presence of more resistant rock types with intervening low ground on weaker rocks. The valleys of the Adur and its tributaries are the other pervasive element in the relief of this Landscape Zone. The two branches of the Upper Adur meet near the site to the NW of Ashurst. The river is tidal to Bines Bridge on the western branch of the river and to a point near Shermanbury church on the eastern branch. Up to these tidal limits the level of the alluvial floodplain is generally below 3.0m OD and the river is embanked. The Adur has many headwater tributaries which occupy a network of shallow valleys extending across the whole of LZ3.

4.3 LZ3 Geology

LZ3 Bedrock Geology (Figure 4)

4.3.1 Most of LZ3 is underlain by the Weald Clay, but at the southern end of the Study Area the Weald Clay is overlain by rocks of the Lower Greensand Group, undifferentiated below but including as its uppermost element the sandstone of the Folkestone Formation which forms a well-marked but discontinuous escarpment from west-northwest to east-south-east between Storrington and Wappingthorn. Rocks of the Lower Greensand Group reappear as a narrow outcrop extending E-W across the Landscape Zone and forming the higher ground on which the village of Ashurst is situated. At the northern end of the Landscape Zone, sandstones are again a major element of the bedrock, represented by outcrops of the Horsham Stone Member near the base of the Weald Clay Formation and of the underlying Upper Tunbridge Wells Sand Formation. These are some of the rocks that underlie the High Weald which is formally recognised to the east of LZ3 in the High Weald Area of Outstanding Natural Beauty (AONB). Here however they form landscape similar to that elsewhere in LZ3. The Weald Clay Formation consists mainly of mudstones but also includes thin beds of sandstone and limestone (Paludina Limestone). These beds form the higher ground in the subdued pattern of ridge and vale that characterises the relief of Weald Clay outcrop.

LZ3 Superficial Geology (Figure 7)

4.3.2 Alluvium underlies the floodplains of the Adur and its principal tributaries. The only BGS archive borehole record of these deposits within LZ3 is a group of four boreholes (TQ11NE22-25) at Bines Bridge near the tidal limit of the western Adur. Between 12.8m and 14.8m of alluvium were recorded here resting on Weald Clay. The alluvium consisted of silty clay with one or two thin beds of flint gravel. In the valleys of the Adur and its principal tributaries, a sequence of three River Terrace Deposits is mapped by BGS. River Terrace Deposits 1 are immediately adjacent to and only slightly above the level of the alluvium on the valley floor. River Terrace Deposits 2 are at a level about 4.0m above the floodplain and generally separated from it by a low bluff of Weald Clay. Only one outcrop of River Terrace Deposits 3 is mapped within LZ3, to the east of the Adur opposite the village of Ashurst at a level *ca*. 12.0m above the floodplain. There appear to have been no detailed investigations of the River Terrace Deposits in the Adur Valley either within or beyond LZ3. By comparison with terrace sequences elsewhere in southern Britain it seems likely that River Terrace Deposits 1 and 2 of the Adur are composed largely of material laid down during the Devensian cold stage (115-11.5ka) but they may include sediments dating back to MIS5e (the Ipswichian Interglacial: 130-115ka).

4.3.3 Head deposits (clay, silt, sand and gravel) are widely distributed as scattered outcrops in the southern part of LZ3, to the south of Partridge Green. On the Weald Clay they are found mainly on valley side slopes, sometimes extending onto and across the valley floor as far as the alluvial floodplain. They are also present on the Lower Greensand outcrop, notably at the foot of the Folkestone Formation escarpment. There are no detailed accounts of any of these deposits and no useful BGS archive borehole records. There is no obvious explanation for the complete lack of Head deposits in the northern half of LZ3 in terrain closely resembling that of the southern half.

LZ3 Geoarchaeological potential

LZ3 Palaeolithic potential

4.3.4 On the basis of the existing records of geoarchaeological remains in LZ3, Palaeolithic potential for the area must be regarded as low. However, it should be recognised that this scarcity may in part at least reflect the lack of historical investigation and potential is therefore deemed low or uncertain. At the same time, there are various geological and topographic settings within LZ3 that in other parts of southern Britain are contexts from which geoarchaeological remains have been recovered. In particular, there are extensive River Terrace Deposits in the valley of the Adur which have never been subject to the substantial commercial exploitation that elsewhere has provided opportunities for collecting and investigation. Only four Lower or Middle Palaeolithic artefacts are recorded in the West Sussex HER in or close to LZ3: a surface find on Weald Clay near Wiston, a Levallois implement dredged from the Adur near Ashurst and a handaxe and flake found on the outcrop of Third Terrace Deposits above the left bank of the Adur in the same area. Palaeolithic artefacts are also recorded from Third Terrace deposits just outside LZ3 on the northern outskirts of Henfield and from Head or River Terrace Deposits at a few sites further downstream in the Adur valley.

LZ3 Post-Palaeolithic potential

4.3.5 No geoarchaeological remains have been recorded in the Holocene deposits of LZ3. There is however potential for preservation in the alluvial deposits of the river Adur as described above in connection with the alluvial deposits of the river Arun (**Paragraph 2.4.2**). There is also potential for the preservation of Holocene geoarchaeological remains within the Head deposits widely present in the southern part of LZ3. Incorporation of Holocene geoarchaeological remains is less likely in hillslope outcrops of Head where emplacement of the deposits can generally be related to pre-Holocene cold climate slope processes. However, on foot-slopes and where Head extends onto a valley floor it may include deposits that are the product of Holocene hillslope erosion and may therefore incorporate Holocene geoarchaeological remains as described above in connection with Head deposits in LZ2 (**Paragraphs 3.2.10**, **3.3.4**).

LZ3 Palaeoenvironmental potential

4.3.6 No Pleistocene or Holocene palaeoenvironmental remains are recorded in the West Sussex HER. However, potential contexts for their recovery include the Holocene alluvium underlying the floodplains of the principal rivers and the Pleistocene River Terrace Deposits widely present in the same river valleys. There is also the possibility that palaeoenvironmental remains might be preserved within or beneath the Head deposits, especially where they overlie the broad and gently sloping valley floors. Remains might also be preserved in fissures on some of the sandstone and limestone outcrops, though ideal conditions for the development of such fissures – steep valley side slopes - are rarely present.

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5. Archaeological and Palaeoenvironment Potential and Heritage Significance of Geological Deposits

5.1.1 This section summarises the various geological contexts in which geoarchaeological or palaeoenvironmental remains may be preserved within the Study Area (see also **Figure 11**). It is important to understand that very little detailed investigation of such remains or their geological contexts has ever been undertaken in the West Sussex region occupied by the Study Area. The following account is therefore based almost entirely on records of similar contexts elsewhere in Britain. In such contexts Palaeolithic remains consist almost exclusively of stone artefacts (tools and waste material/debitage) while post-Palaeolithic (Holocene) archaeological remains involve a much wider range of materials including pottery, wooden structures such as trackways, buildings and boats, and human remains. Palaeoenvironmental remains consist principally of pollen and plant macrofossils, snails, insects, diatoms, foraminifera, ostracods and animal bone and teeth. For each context assessments are provided for:

1. The potential (Very High, High, Medium, Low) for Palaeolithic, post-Palaeolithic and palaeoenvironmental remains to be encountered, based on the recorded incidence of such remains in each geological context within the Study Area; and
2. The likely heritage significance of geoarchaeological or palaeoenvironmental remains which may be present within the Study Area is assessed (High, Medium, Low, Very Low) in terms of the extent to which such remains hold or potentially hold evidence of past human activity worthy of expert investigation. Such remains may be found in primary context (i.e. as originally deposited), or in secondary context (i.e. derived from pre-existing deposits or ex-situ). These conditions affect the heritage significance of the remains and where appropriate are therefore assessed separately.

5.1.2 Definitions of potential and heritage significance have been selected to align with the methodology set out in **Chapter 25: Historic environment, Volume 2** (Document Reference: 6.2.25) of the ES.

5.1.3 The potential and significance of the deposits is summarised in **Table 5-1** and conclusions described in **Sections 5.2** to **5.7**.

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Table 5-1 Significance and potential of the main deposit types along the proposed route

Deposit type	Asset	Archaeological potential		Palaeo-environmental potential	Heritage significance			Notes
					Archaeological			For details of relevant evidence see Sub-Sections on Geoarchaeological and Palaeoenvironmental Potential in Sections 3-5
		Palaeolithic	Post Palaeolithic		Primary	Secondary	Palaeo-environmental	
Alluvium	Palaeo-environmental remains Archaeological remains	Low	Low/ uncertain	Very high	Medium	Low	High	Assessment based on archive borehole records and Holocene alluvial sites outside the study area.
River Terrace Deposits	Flint artefacts Palaeo-environmental remains	Low /uncertain to Medium	n/a	Low	Medium	Low	Medium	Evidence of Palaeolithic presence in West Sussex Recovery of isolated flint artefact from River Terrace Deposits of River Arun
Raised Beaches	Palaeo-environmental remains Flint artefacts	Low	n/a	Medium	High	Low	Medium	Flint artefacts and palaeoenvironmental remains recovered from raised beach contexts in West Sussex

Deposit type	Asset	Archaeological potential		Palaeo-environmental potential	Heritage significance			Notes
					Archaeological			For details of relevant evidence see Sub-Sections on Geoarchaeological and Palaeoenvironmental Potential in Sections 3-5
		Palaeolithic	Post Palaeolithic		Primary	Secondary	Palaeo-environmental	
Clay-with-Flints	Flint artefacts	Low	n/a	Very low	Medium	Low	n/a	Near-surface recovery of artefacts from Clay-with-Flints near Eastbourne
Head	Palaeo-environmental remains Flint artefacts	Low	Medium	Medium	Medium	Low	Medium	Assessment based on evidence from Head deposits elsewhere in southern England, e.g., in dry valleys and on scarpfoot slopes over Chalk bedrock.
Infill of solution pipes and fissures	Palaeo-environmental remains Flint artefacts	Low	n/a	Low	Medium	Low	Low	Assessment based on evidence from sites elsewhere in southern England

Table 5-2 Approximate extent of the geological contexts underlying the main onshore cable corridor (with underlying bedrock indicated for Head deposits)

Geological Context		Length (km) of main onshore cable corridor underlain by each geological context	Percentage of onshore cable corridor (%)	Number of separate superficial geological outcrops crossed by the onshore cable corridor
Bedrock	Weald Clay	10.3	28.9	
	Chalk	5.7	16.0	
	Lower Cretaceous	2.6	7.3	
Superficial	Alluvium (Arun)	2.6	7.3	2
	Alluvium (Adur)	1.5	4.2	7
	RTD (Adur)	1.1	3.1	7
	Raised Beach	5.2	14.6	3
	Clay with flints	0.7	2.0	1
	Head/Chalk	0.9	2.5	3
	Head/ L.Cretaceous	1.6	4.5	6
	Head/Weald Clay	1.7	4.8	8
	Head/Raised Beach	0.3	0.8	1
	Head/Tertiary	1.4	3.9	2
	Head (total)	6.2	17.4	20

5.2 Alluvium

5.2.1 Within LZ1, the estuarine alluvium of the River Arun and its tributaries is mapped by the BGS as Raised Marine Deposits. Elsewhere, in LZ2 and LZ3, Holocene freshwater clays in the upper catchments of the Arun and Adur are mapped by the BGS as Alluvium. Raised Marine Deposits and Alluvium are considered together as both are Holocene deposits, either deposited by tidal incursion within channels and creeks or on river floodplains.

5.2.2 Alluvium comprises deposits of sands, silts and clays laid down in low-energy environments in river valleys, tidal creeks, on floodplains, backwaters, abandoned channels and ponds. Organic sediment and peat may also be present, and towards the edge of the valley floor, alluvium may interdigitate with slope deposits (colluvium or Head) derived from the valley side. The thickness of alluvium in the River Arun increases downstream, exceeding 30m in the lowest catchment. Alluvial sequences often grade upwards from the 'Lateglacial' (Devensian) gravel of the valley floor to early Holocene (Mesolithic) sands and silt/clay flood deposits intercalated with organic beds that represent former marsh or wetland (Neolithic/Bronze Age). The upper horizons often represent silt/clay overbank flooding from the late prehistoric (Iron Age) onwards when the climate deteriorated (became wetter), coupled with the effects of deforestation in the riparian environment. Alluvial stratigraphy can be complex, reflecting a variety of river settings and can represent rapid and/or long-term Holocene sedimentation. Thick sequences such as those in the lower Arun valley can contain a detailed record of Holocene environmental and climate change, sea-level history and human land-use.

5.3 River Terrace Deposits

5.3.1 In the Study Area, the BGS applies the term River Terrace Deposit to two different groups of deposits which occupy different geological and topographic settings:

1. Deposits underlying the river terraces of the Adur and its tributaries, and
2. Deposits underlying the West Sussex Coastal Plain. The following paragraph deals only with the first group of deposits. The second group is described together with Raised Beach Deposits (**Section 5.4**).

5.3.2 River Terrace Deposits consist mainly of water-lain sediment deposited in various fluvial environments. These include the deposits of active channels, generally gravel or sand. Soil horizons (palaeosols) and prehistoric land surfaces may also be present in fluvial sediment sequences. Palaeolithic and palaeoenvironmental remains may be associated with any of these deposits. The stratigraphy of River Terrace Deposits can be complex, reflecting the variety of depositional settings in the fluvial environment and the potential for both rapid and long-term change in their spatial arrangement. River Terrace Deposits underlie topographic terraces on the valley sides and where multiple terrace sequences are present, higher terraces are generally older. The major rivers of unglaciated southern Britain have terrace sequences representing an episodic record of the whole or most of the Pleistocene.

5.4 Raised Beach Deposits

5.4.1 The long-term uplift of southern Britain means that the oldest raised beaches are at the highest elevation and furthest from the present coast, while beaches from later interglacials are progressively lower and closer to the coast (Westaway et al. 2006).

5.4.2 In current BGS nomenclature, two different terms are used within the Study Area to identify deposits that include the remains of raised marine beaches: (1) Raised Beach Deposits, mapped in LZ1 on the floor of the Arun valley at levels slightly above the floodplain alluvium, and; (2) River Terrace Deposits, underlying the higher parts of the West Sussex Coastal Plain in LZ1 and formerly mapped by BGS as Brickearth (on the 1" Geology maps).

5.4.3 Raised beach material consists most distinctively of well-rounded pebbles or shingle, predominantly flint in West Sussex but with a small admixture of other lithologies. In addition, sands, silts, and clays may be present representing intertidal deposition or deposition in low-energy environments in beach shingle sequences (e.g. enclosed depressions, tidal creeks). Prehistoric land surfaces may be preserved in raised beach sediment sequences. Raised beaches in southern Britain provide an episodic record of changing Pleistocene sea levels and uplift of the British landmass. Palaeolithic and palaeoenvironmental remains may be preserved in raised beach deposits, and nationally important assemblages have been recorded from West Sussex raised beaches. However, most of the raised beach deposits in the Study Area, those in LZ1, probably relate to a period of time when Palaeolithic groups were absent from the British Isles (Ipswichian Interglacial – MIS 5e; 130-115ka).

5.4.4 In those parts of the West Sussex Coastal Plain mapped by the BGS as River Terrace Deposits, raised beach material is found resting directly on bedrock and is overlain by deposits formerly mapped as Brickearth. These 'brickearth' deposits are often rich in silt which is generally assumed to indicate the presence of a windblown dust component (loess). However, these are not undisturbed loess deposits. They include lenses and seams of sand and pebbles which indicate mixing with material from other sediment sources and point to a colluvial origin for the 'brickearth'. Such 'brickearth' deposits are quite widely distributed in southeast England often overlying River Terrace Deposits, and in some localities have been given formal stratigraphic recognition (Langley Silt, Crayford Silt). Palaeolithic and palaeoenvironmental remains may be preserved in 'brickearth' deposits.

5.5 Head Deposits

5.5.1 Head is a slope deposit that consists of eroded bedrock and superficial material moved downhill by gravity and often redistributed freeze-thaw and wind and weathered in-situ. It is largely mapped in relict or dry valleys on chalky slopes. In the Study Area, Head can be divided into two broad categories:

- Underlying the floors of dry valleys on the Chalk outcrop;
- Mantling the valley-side slopes and valley floors of the Arun and Adur and their tributaries.

5.5.2 Head deposits are variable, depending on the source material and the processes of redistribution. They are generally poorly-sorted and can be deposited by mass movement (e.g., solifluction) or slope-wash (creep), then weathered in situ. Lateral continuity of individual beds is generally limited and difficult to trace.

5.5.3 Dry valley deposits may include 'Lateglacial' soliflucted sands and gravels but consist mainly of material derived during the Holocene from the valley sides.

5.5.4 Head mantling slopes and valley floors may incorporate reworked artefacts and ecofacts (remains ex-situ or in secondary context). Much less commonly Head may be stratified, reflecting episodic accumulation under varying environmental conditions during the Pleistocene and include material in primary context.

5.6 Clay-with-Flints

5.6.1 Clay-with-Flints are unbedded heterogenous deposits formed through the dissolution, decalcification and cryoturbation of Cretaceous Chalk leaving the insoluble residue together with flint nodules, mixed with material later deposits, here mainly the Lambeth Group. The Clay-with-Flints is therefore a stony clay incorporating lenses and seams of sand and flint pebbles and has often been remobilised to form extensive Head deposits. Palaeolithic remains in primary and secondary contexts are known from deposits occupying depressions on the surface of the Clay-with-Flints. No Holocene archaeological remains have been recorded from such contexts in West Sussex.

5.7 Infill of solution pipes and fissures

5.7.1 Enclosed depressions in bedrock can become sites for localised accumulation of sediment in which Palaeolithic and palaeoenvironmental remains may be preserved. In the Study Area, the potential for the development of such depressions exists in two situations:

- On the Chalk where localised solution of the bedrock in pipes and dolines may create surface depressions. Such features are most common where deposits overlying the Chalk are nearby (Clay-with-flints, Lambeth Group sediments, etc.). Such conditions are of limited extent on the Chalk outcrop in the Study Area and no such features appear ever to have been recorded there; and
- On various lithologies (sandstones and limestones) widening of joints as a result of near surface mass movement of the rock can create fissures and localised areas of subsidence (graben). Such processes are mainly associated with areas of substantial relative relief and steep slopes. Such conditions are rarely present in the Study Area and no features of this type appear ever to have been recorded there.

6. Glossary of terms and abbreviations

Term	Definition
AAR – Amino-Acid Racemisation	A dating method that measures relative abundance of amino acids in biological materials and uses the results to estimate age over the last ca. 400,000 years.
Alluvium	Clay, silt, sand or gravel deposited by running water in a stream, estuary, or delta or on a floodplain.
Anticline	A fold of stratified sediments in which the strata slope down from the fold axis.
Brickearth	A 19th century term used to describe fine-grained, largely stoneless superficial geological deposits used for brickmaking, often found capping river terrace deposits.
Buried valley	A valley formed by erosional down-cutting and then infilled with alluvial deposits, sometimes found beneath the present course and floodplain of a river.
Claystone	A rock consisting of clay size particles cemented together
Clay-with-flints	A deposit of clay with whole and broken flints and inclusions of sand and pebbles, widely present overlying the Chalk in southern England and incorporating the insoluble residue of the Chalk and the remains of overlying sediments.
Colluvial	Relating to deposits on and at the foot of slopes, and to the processes producing them. (see also Solifluction)
Conglomerate	A rock consisting of rounded and sub-round rock fragments cemented together.
ES	Environmental Statement
Devensian	The last glacial period, spanning the period ca. 115,000–11,500 years ago. Climate was generally cold, with conditions at their harshest during the Last Glacial Maximum, ca. 26,000–19,000 years ago.
Diatom	Microscopic single celled plants found in rivers, soils and the sea.
Dip slope	A land surface sloping in the same direction as underlying geological strata.

Term	Definition
Doline	A surface depression in a limestone region formed by solution of the underlying rock.
Dry valley	A valley formed by river activity but no longer supporting a perennial stream.
ESR – electron spin resonance	A dating method that detects the presence of electrons trapped in biological and mineral material and uses the results to estimate the age of the material.
Floodplain	The part of a valley floor liable to flooding and the accumulation of water-laid deposits
Foraminifera	Single-celled marine micro-organisms usually protected by an exterior shell.
Graben	A block of land displaced downward due to movement on faults separating it from the surrounding land.
Handaxe	A stone tool fashioned in various shapes, including pointed, oval, pear or tear-drop, commonly interpreted as large cutting tools, used in butchery. They first appeared in the British record between ca. 600,000–500,000 years ago.
Head	Variable geological deposits, originating on valley sides and transported downslope by colluvial processes including solifluction (see below).
Holocene	The most recent interval of Earth history which began ca. 11,500 years ago following the last glaciation
Hominin	All the fossil 'human' taxa that are more closely related to modern humans than they are to any other living taxon (e.g. chimpanzees).
kV	kilovolt
Lambeth Group	Lower Tertiary geological deposits, mainly sandy or silty clays with some pebbly gravels.
Levallois	Name given to a Palaeolithic stone tool preparation technology defined by careful preparation of cores to produce tools of particular sizes and shapes.
Lignite	A low grade coal intermediate in character between peat and bituminous coal.

Term	Definition
Lithology	The visible character of a rock in terms of texture, colour, mineral composition and structure.
Loess	A geological deposit consisting of wind-blown dust.
Marl	An earthy, fine-grained, lime-rich geological deposit.
Mesolithic	The Middle Stone age, in Britain the cultural period from ca. 11,600-6,300 years ago.
MIS – Marine Isotope Stage	Alternating warm and cool periods in the Earth's history, indicated by changing oxygen isotope values in deep sea cores, reflecting variations in global temperatures.
Neolithic	The New Stone Age, in Britain the cultural period from ca. 6,300-4,500 years ago.
OSL – Optically Stimulated Luminescence	A method for dating mineral deposits based on determining the last time the sediment was exposed to sunlight
Palaeolithic	The Old Stone Age, in Britain the cultural period from ca. 959,000–11,500 years ago.
Palaeosol	An ancient soil buried beneath later geological deposits.
Pipe	A vertical, roughly circular void in limestone bedrock, produced by solution and varying in size from less than a meter across to several meters, usually infilled with deposits washed in from above.
Pleistocene	The interval of Earth history that lasted from about 2,580,000 to 11,500 years ago, characterised by repeated glaciations.
Proposed Development	The development that is subject to the application for development consent, as described in **Chapter 4: The Proposed Development, Volume 2** of the ES (Document Reference: 6.2.4).
Radiocarbon dating	A method for dating objects containing organic material by measuring the abundance of the radioactive form of carbon
Raised beach	Deposit associated with a raised shoreline feature which may include shingle, sand or silt.
RED	Rampion Extension Development Ltd (the Applicant)

Term	Definition
River terrace	A remnant of a former valley floor, which has been preserved on the valley side as a by-product of downcutting by the river. River terraces are often underlain by river terrace deposits in which gravel and sand are major components.
Sarsen	Dense, hard sandstone blocks patchily present on the surface of the Chalk in southern England and representing the remains of formerly overlying deposits.
Solifluction	Slow downslope flow of water-saturated soil and sediment, typically associated with freeze-thaw processes in cold climates.
Stratigraphy	the study of sedimentary and volcanic layered rocks and their relationship to the geological timescale.
Superficial Geology	Loose and weakly consolidated geological deposits of Pleistocene and Holocene age emplaced on bedrock by water, wind and glacial ice or moved by gravity
Syncline	A fold of stratified sediments in which the strata slope upwards from the fold axis.
WTG	Wind Turbine Generator

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Annex A
Figures

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Figure 1 Landscape Zones and Subzones

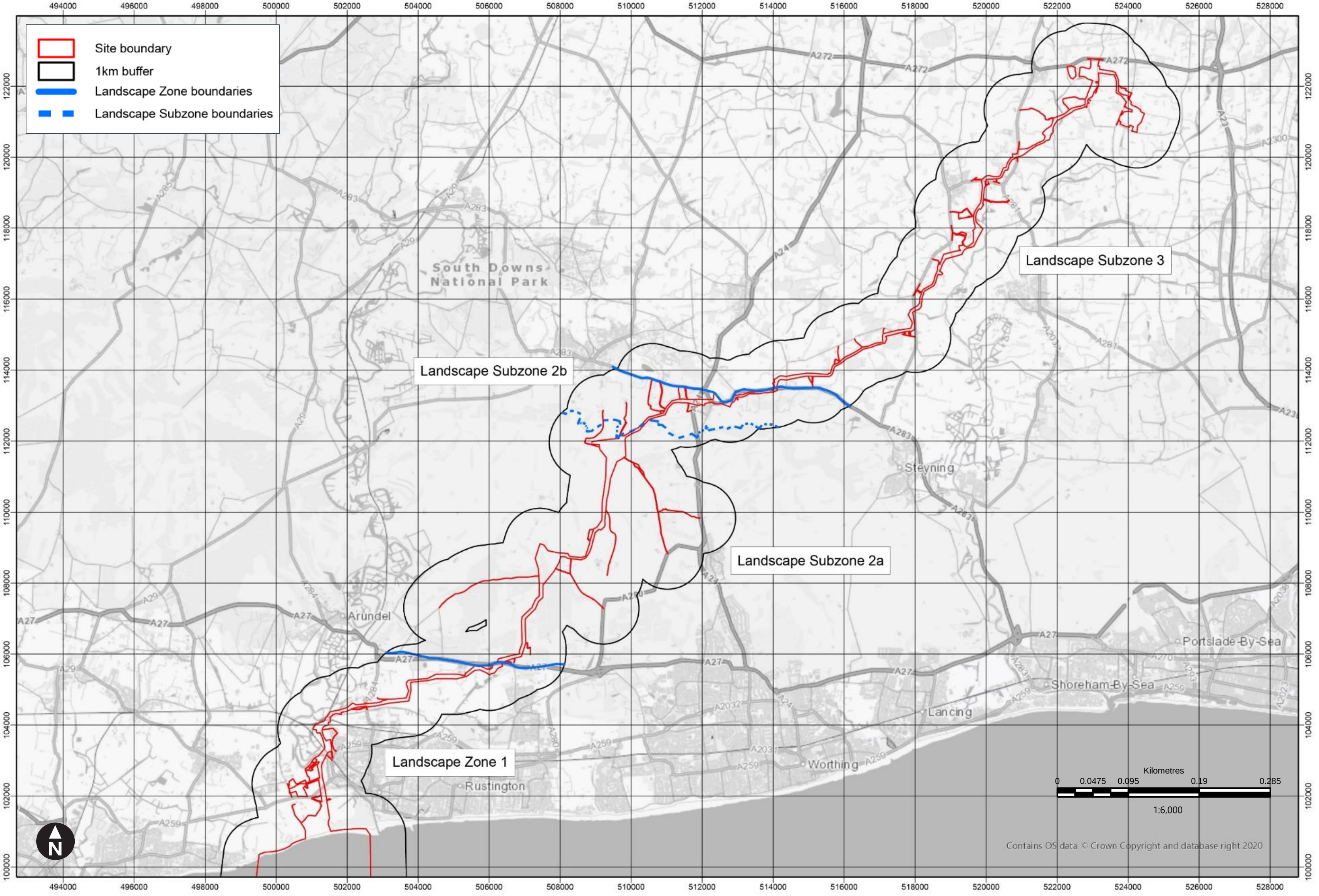


Figure 2 Bedrock Geology of Landscape Zone 1 (British Geological Survey (c) UKRI 2021)

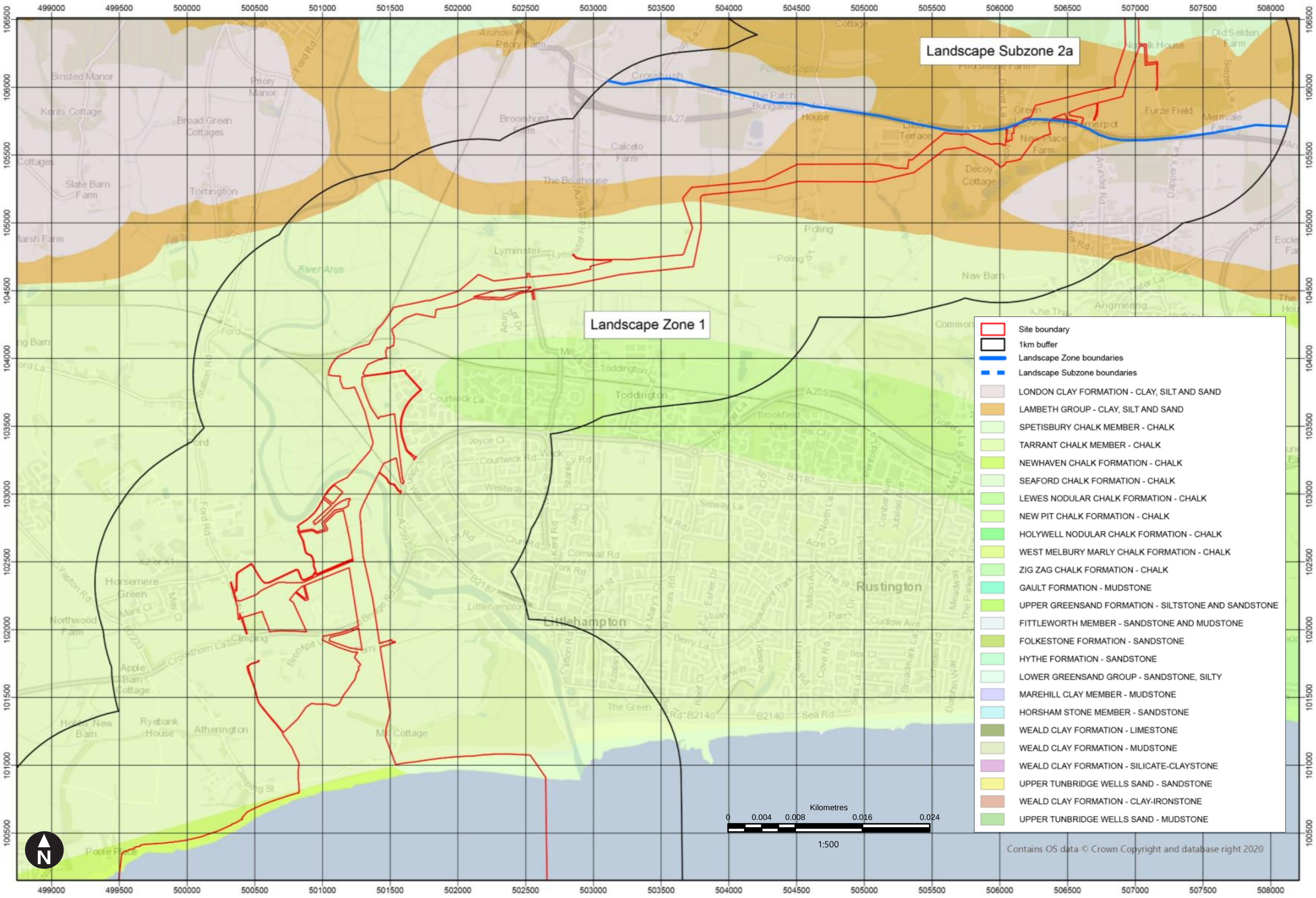


Figure 3a Bedrock Geology of Landscape Zone 2 (British Geological Survey (c) UKRI 2021)

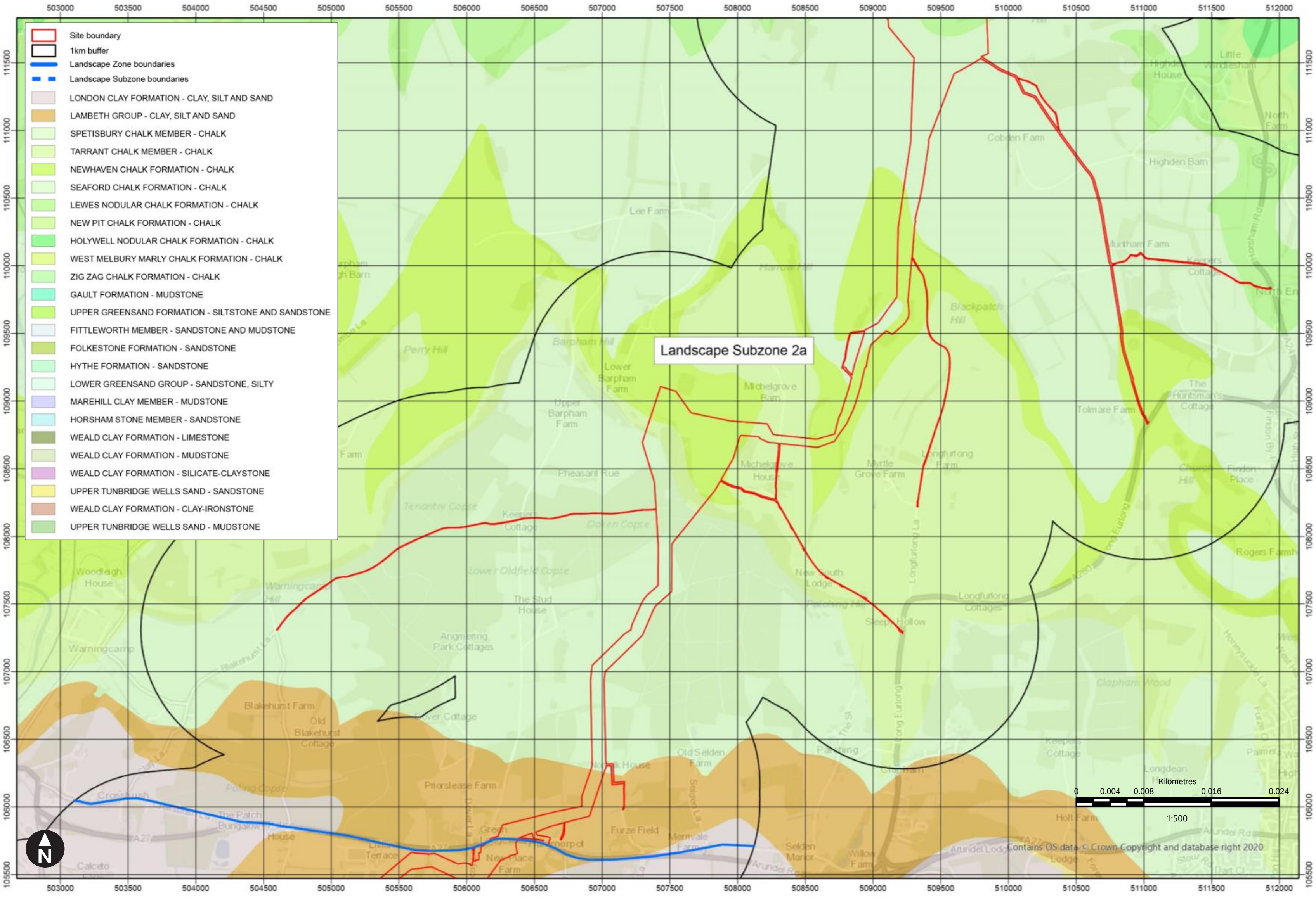


Figure 3b Bedrock Geology of Landscape Zone 2 (British Geological Survey (c) UKRI 2021)

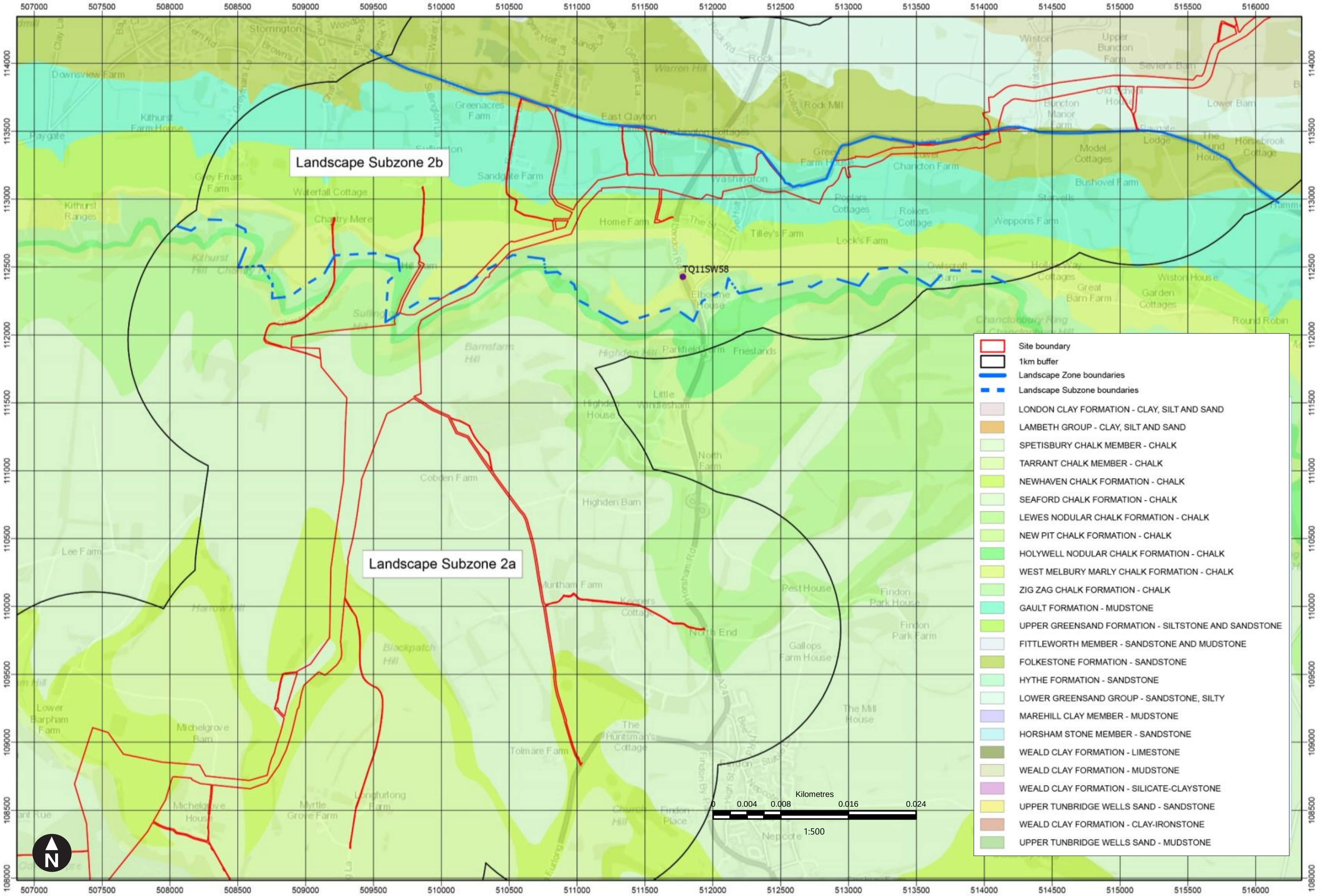


Figure 4a Bedrock Geology of Landscape Zone 3 (British Geological Survey (c) UKRI 2021)

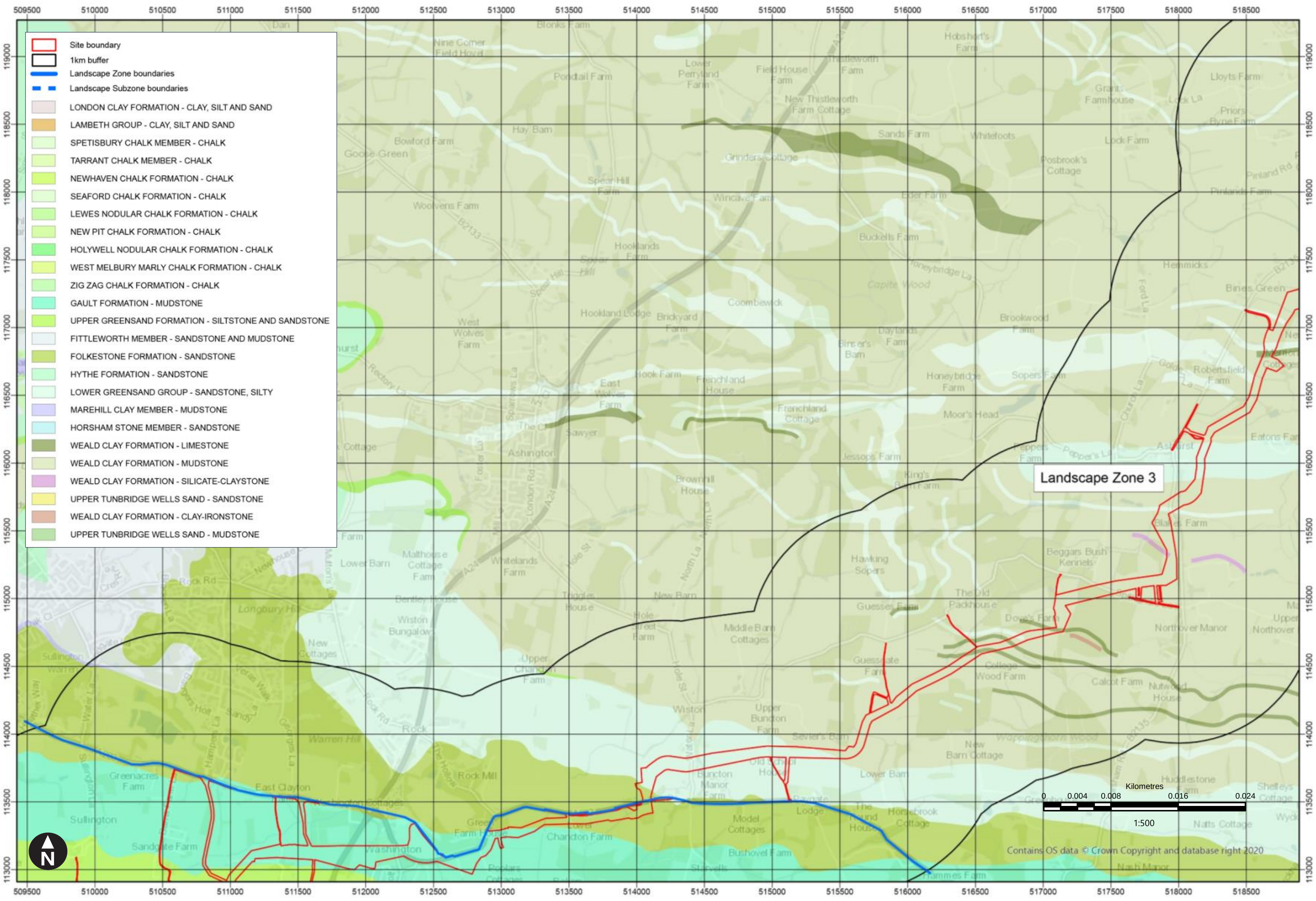


Figure 4b Bedrock Geology of Landscape Zone 3 (British Geological Survey (c) UKRI 2021)

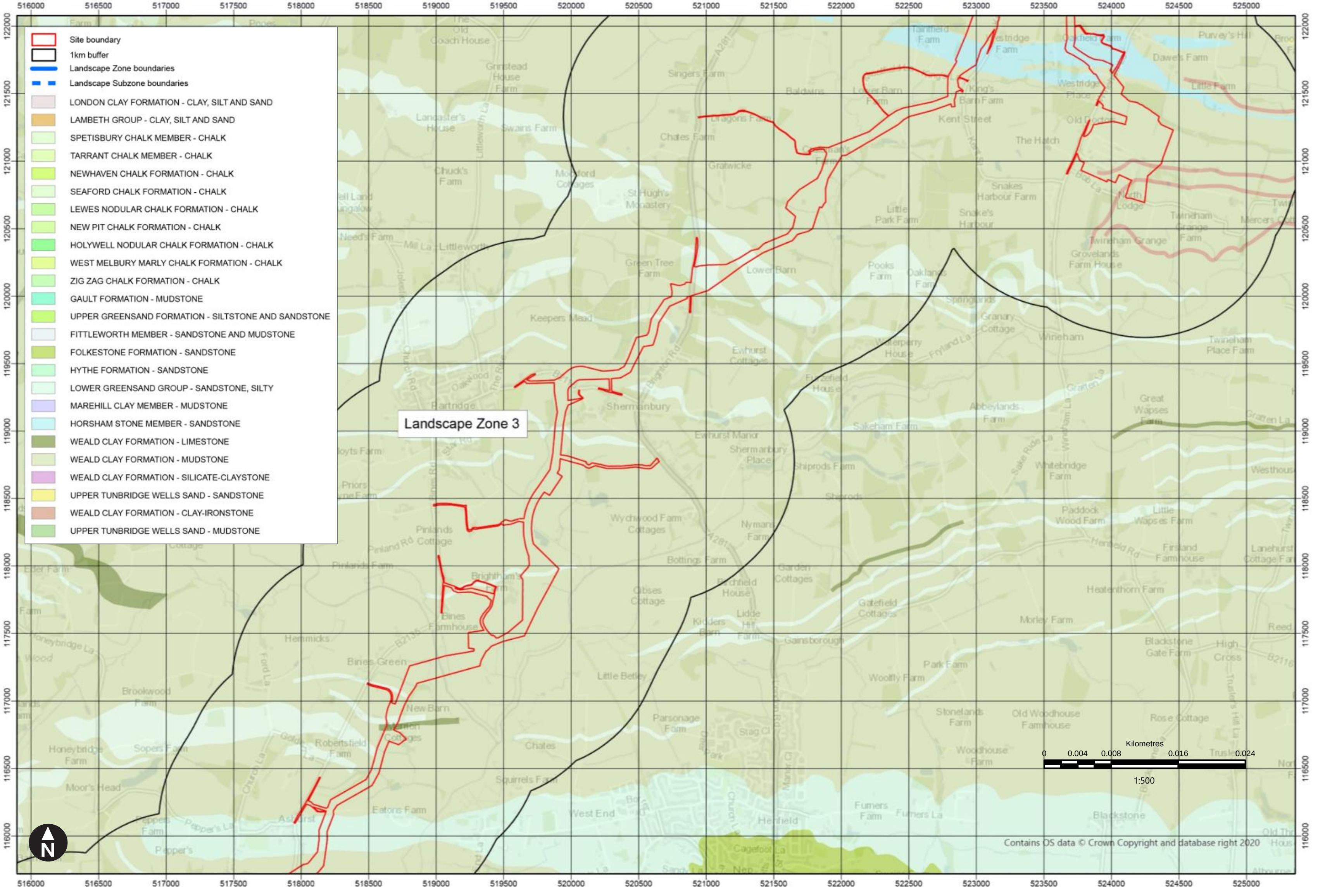


Figure 4c Bedrock Geology of Landscape Zone 3 (British Geological Survey (c) UKRI 2021)

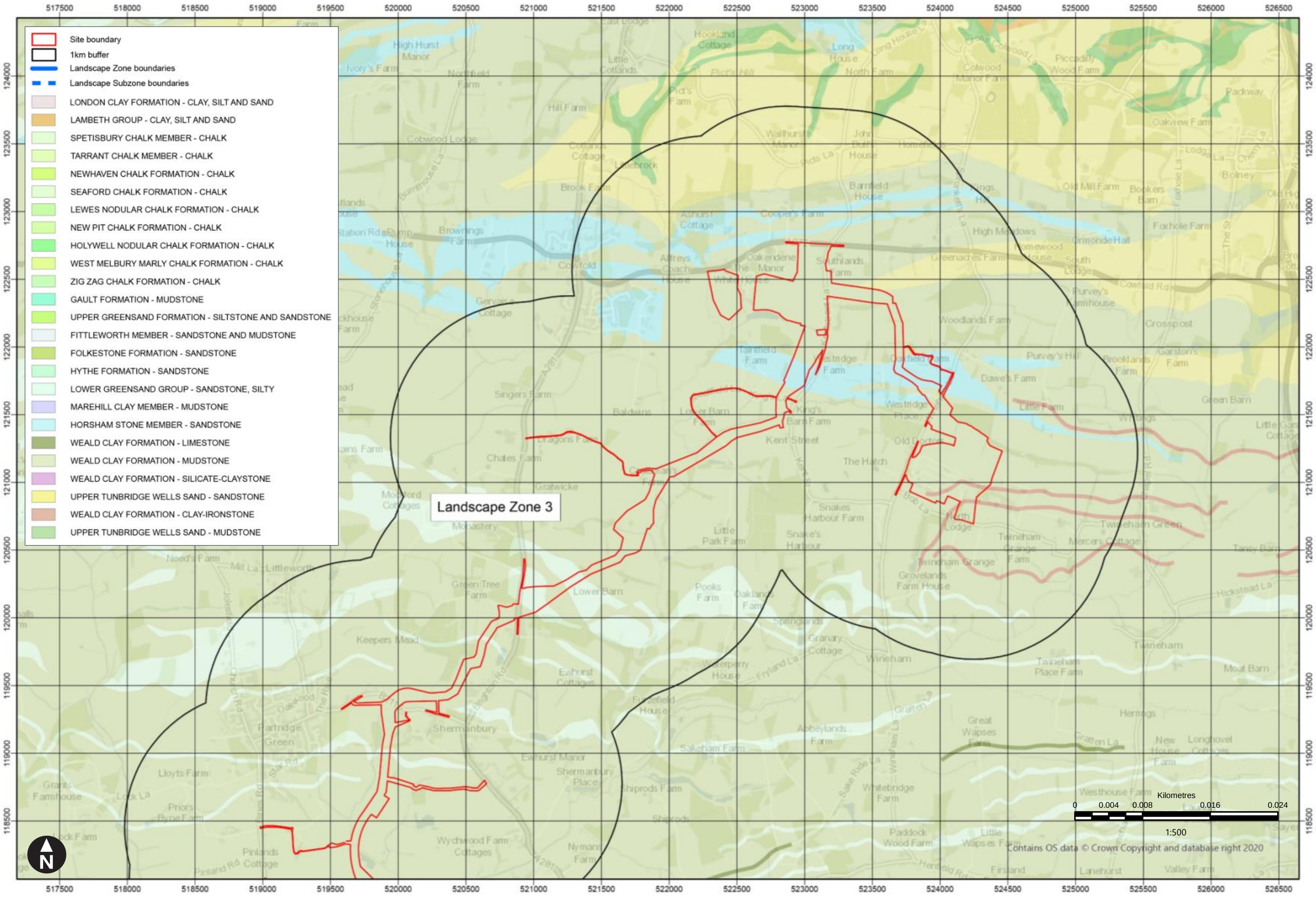


Figure 5 Superficial Geology of Landscape Zone 1 with relevant BGS boreholes locations (British Geological Survey (c) UKRI 2021)

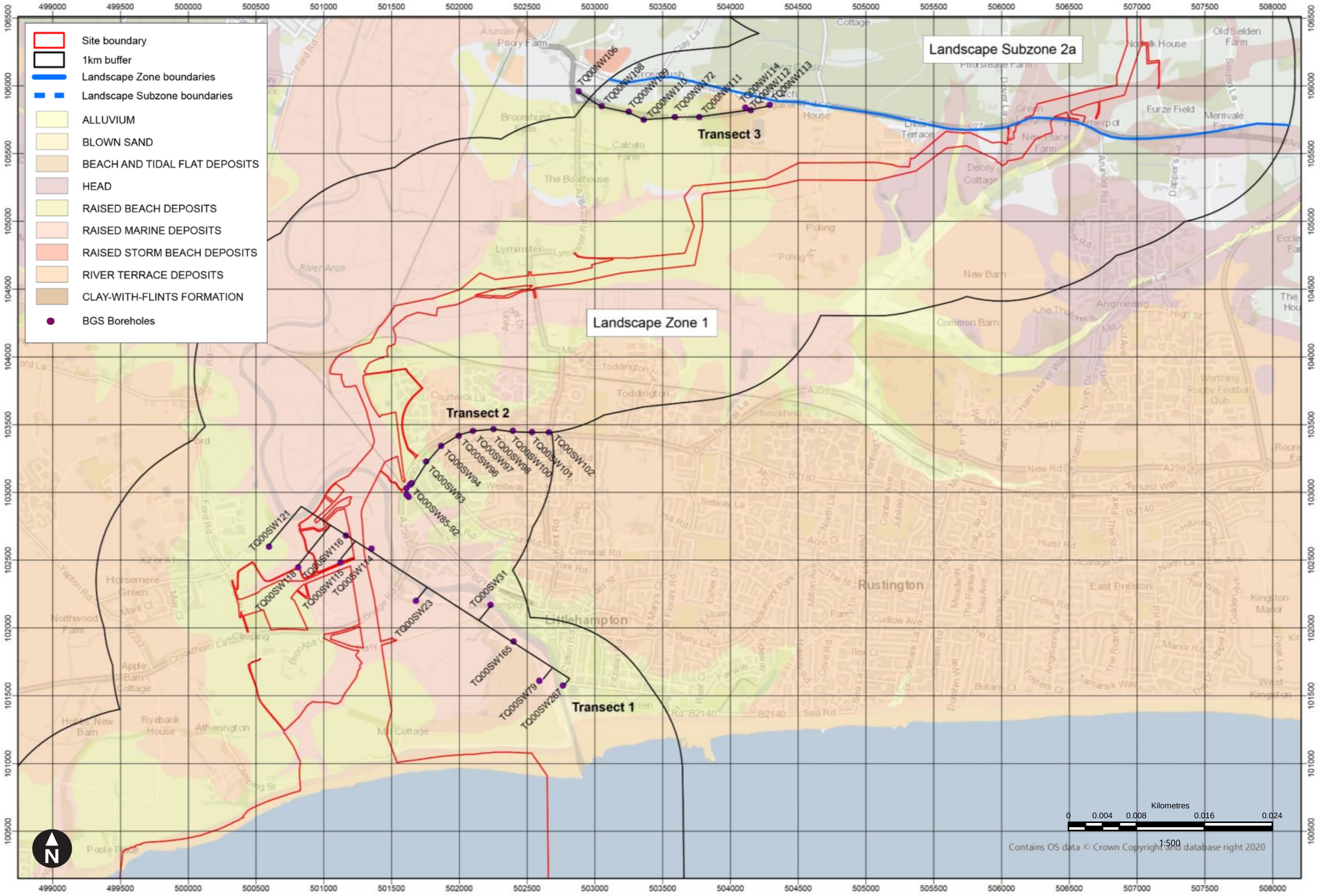


Figure 6a Superficial Geology of Landscape Zone 2 with relevant BGS boreholes locations (British Geological Survey (c) UKRI 2021)

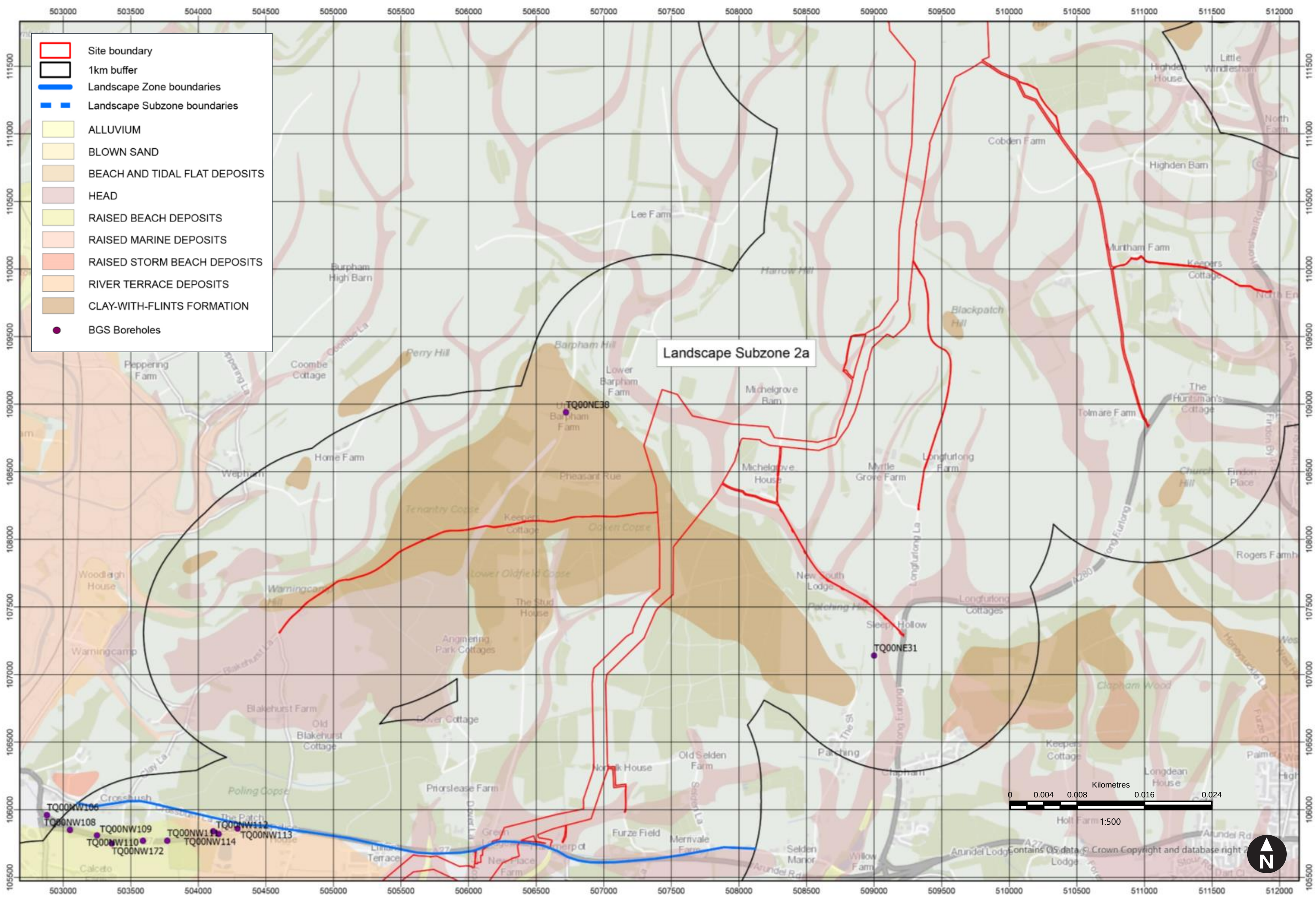


Figure 6b Superficial Geology of Landscape Zone 2 with relevant BGS boreholes locations (British Geological Survey (c) UKRI 2021)

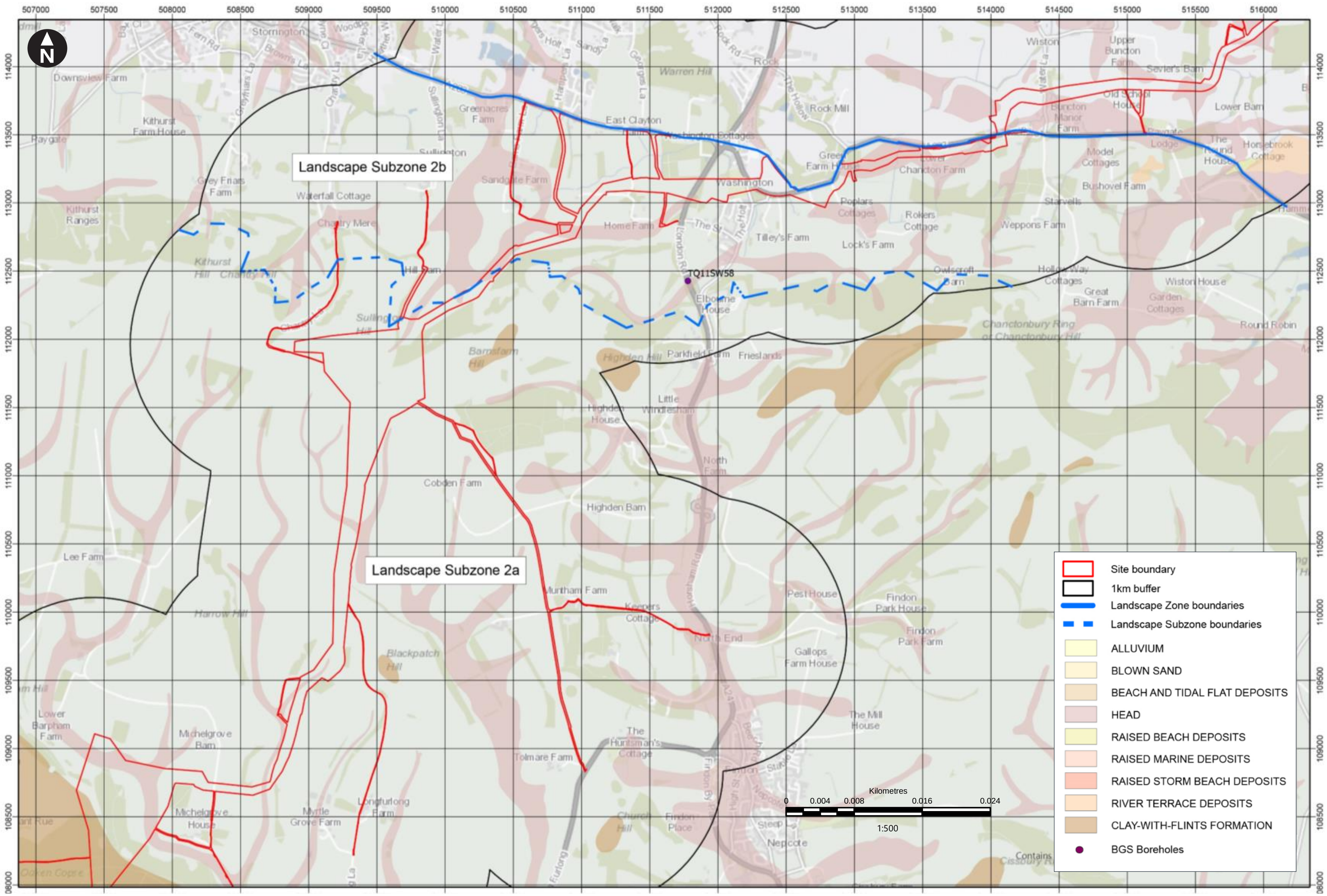


Figure 7a Superficial Geology of Landscape Zone 3. The location of relevant BGS boreholes (British Geological Survey materials (c) UKRI 2021)

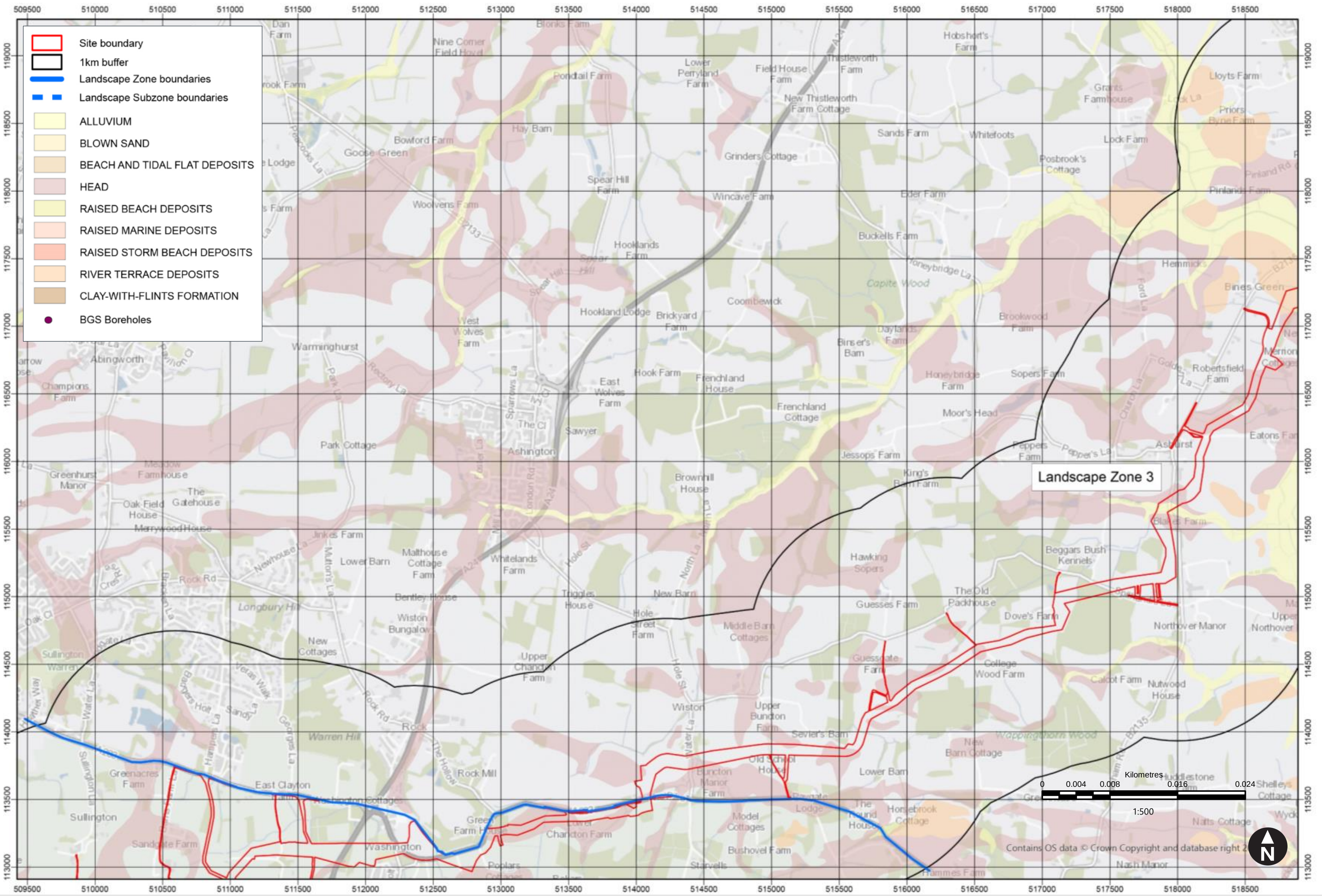


Figure 7b Superficial Geology of Landscape Zone 3. The location of relevant BGS boreholes (British Geological Survey materials (c) UKRI 2021)

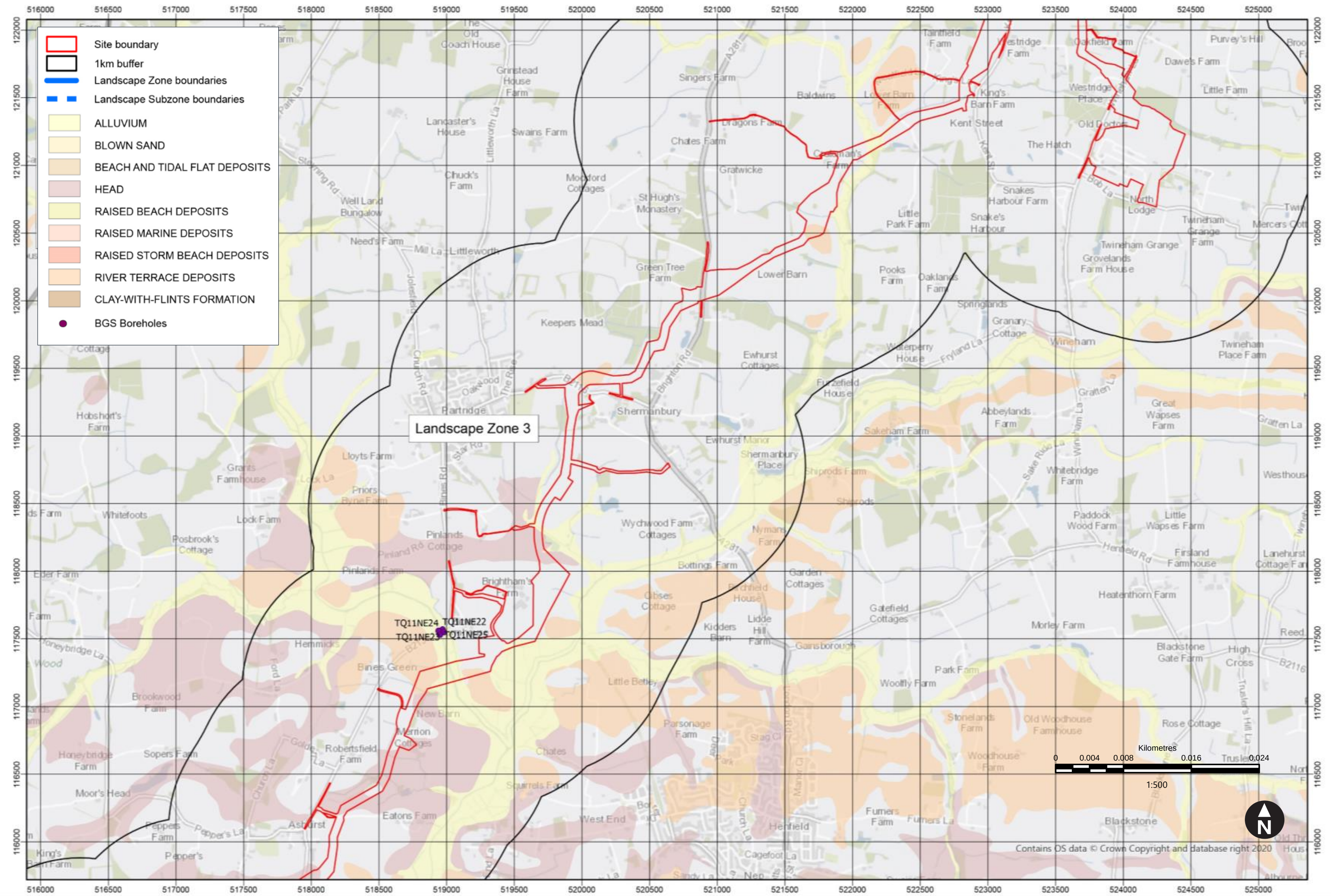


Figure 7c Superficial Geology of Landscape Zone 3. The location of relevant BGS boreholes (British Geological Survey materials (c) UKRI 2021)

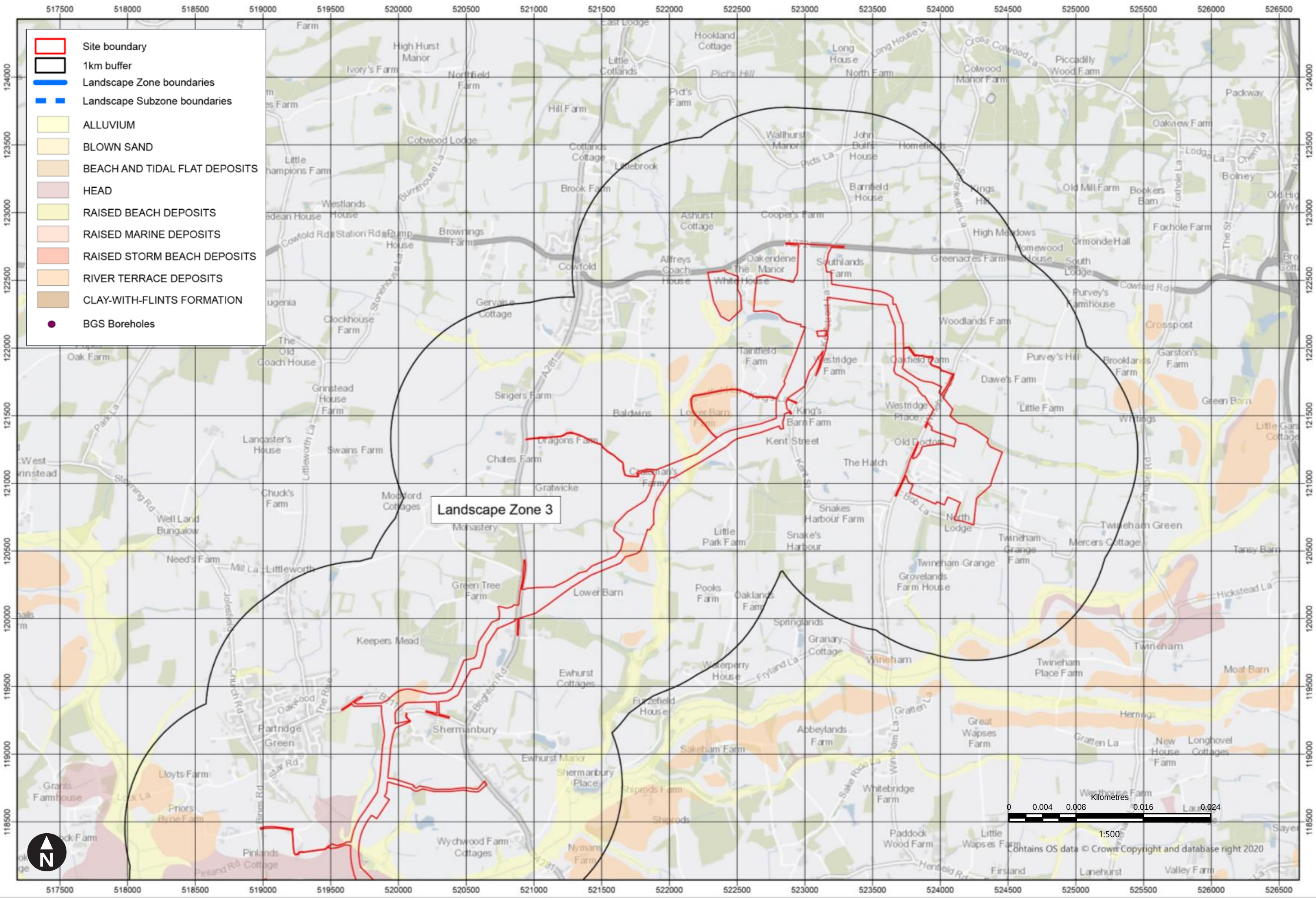


Figure 8 **Transect 1 - North-west to south-east transect of boreholes along the southern margin of Landscape Zone 1, showing the deep buried channel of the River Arun (see Figure 5) (boreholes spaced approximately to scale)**

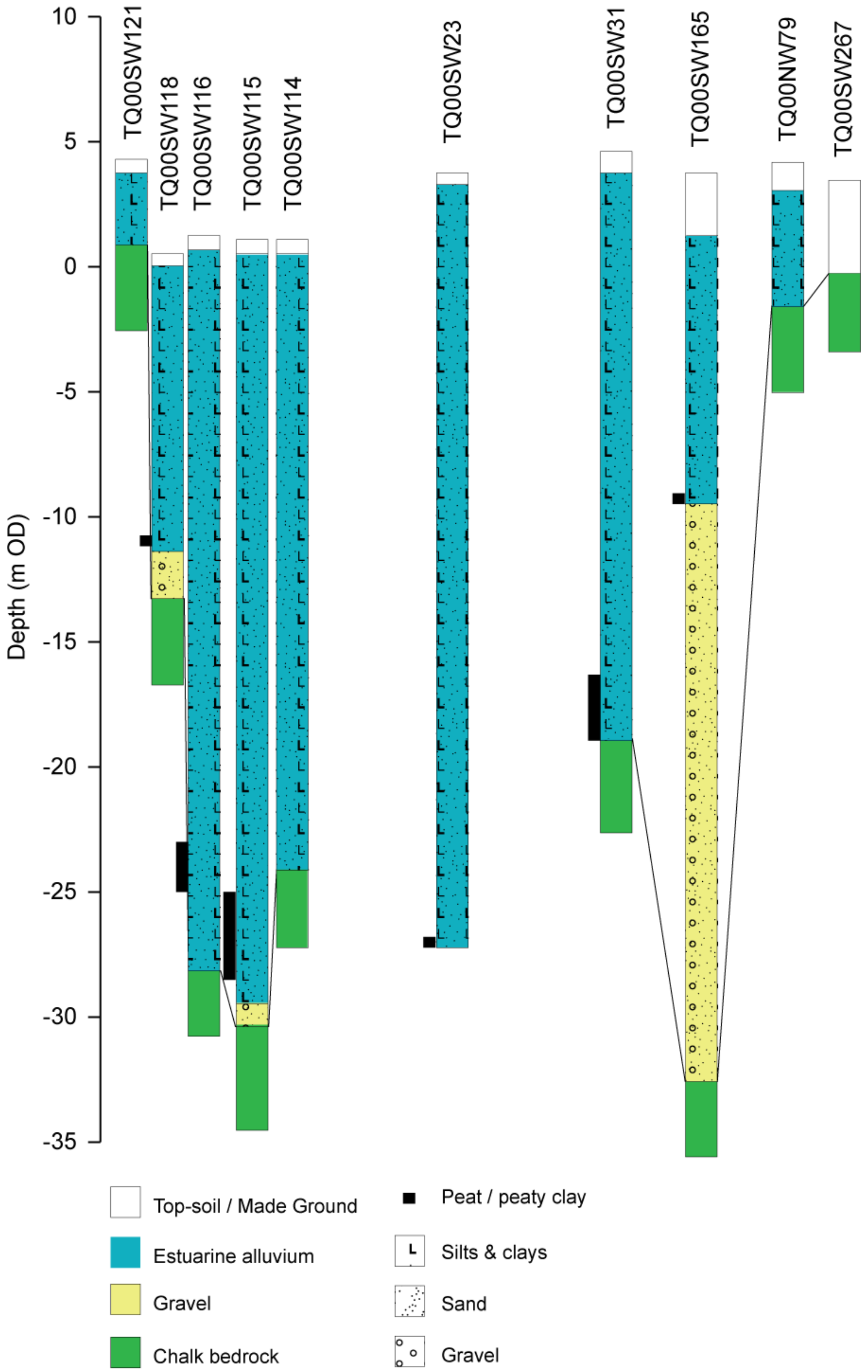


Figure 9 Transect 2 – North-east to south-west transect of boreholes beside the A259 road on north-west outskirts of Littlehampton, Landscape Zone 1 (see Figure 5) showing arrangement of raised beach and 'brickearth' deposits (boreholes are spaced approximately to scale)

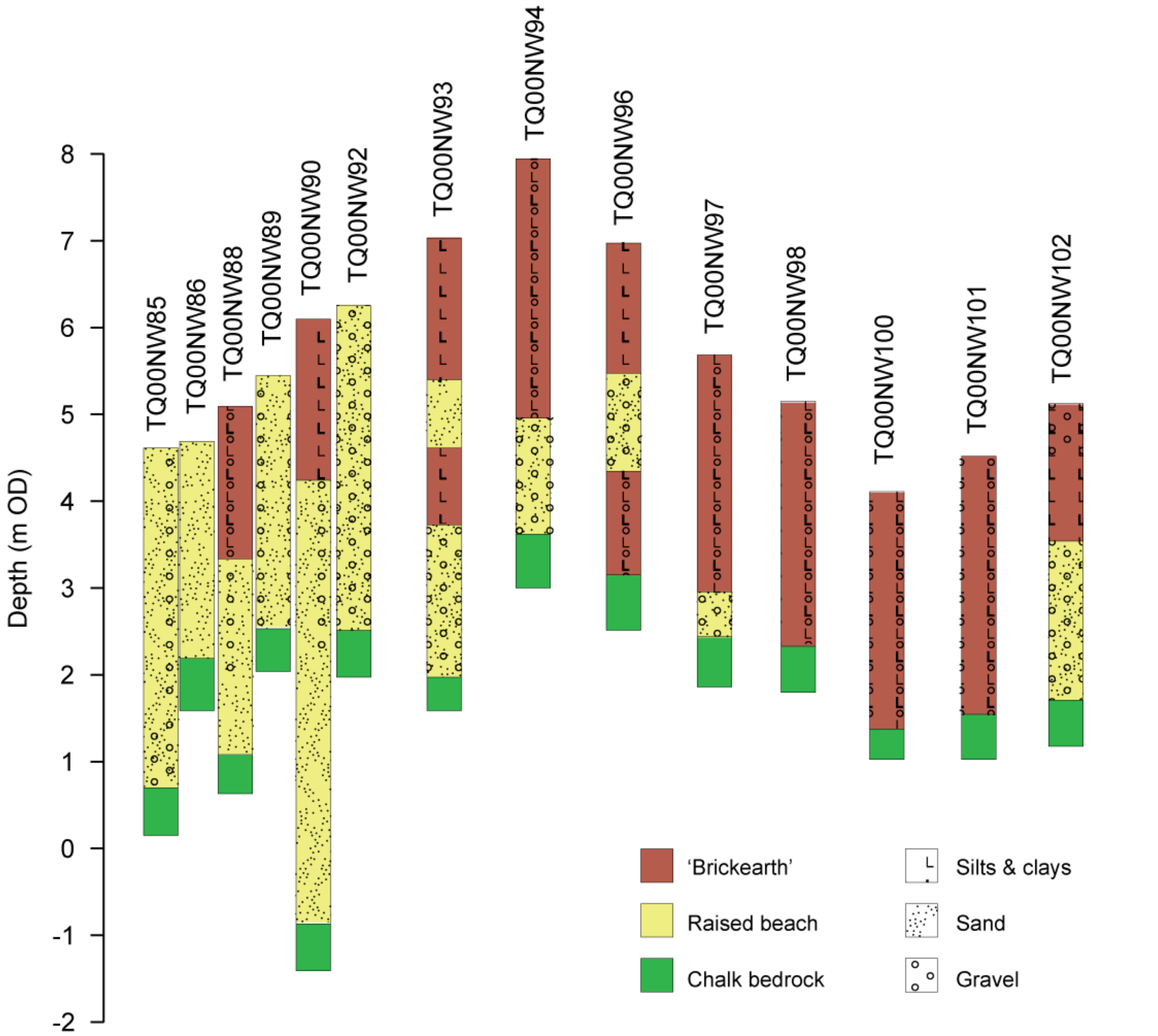


Figure 10 Transect 3 - West to east transect of boreholes along the north-western margin of Landscape Zone 1, on ground mapped by the BGS as either Raised Beach or River Terrace Deposits (see Figure 5) (boreholes spaced approximately to scale)

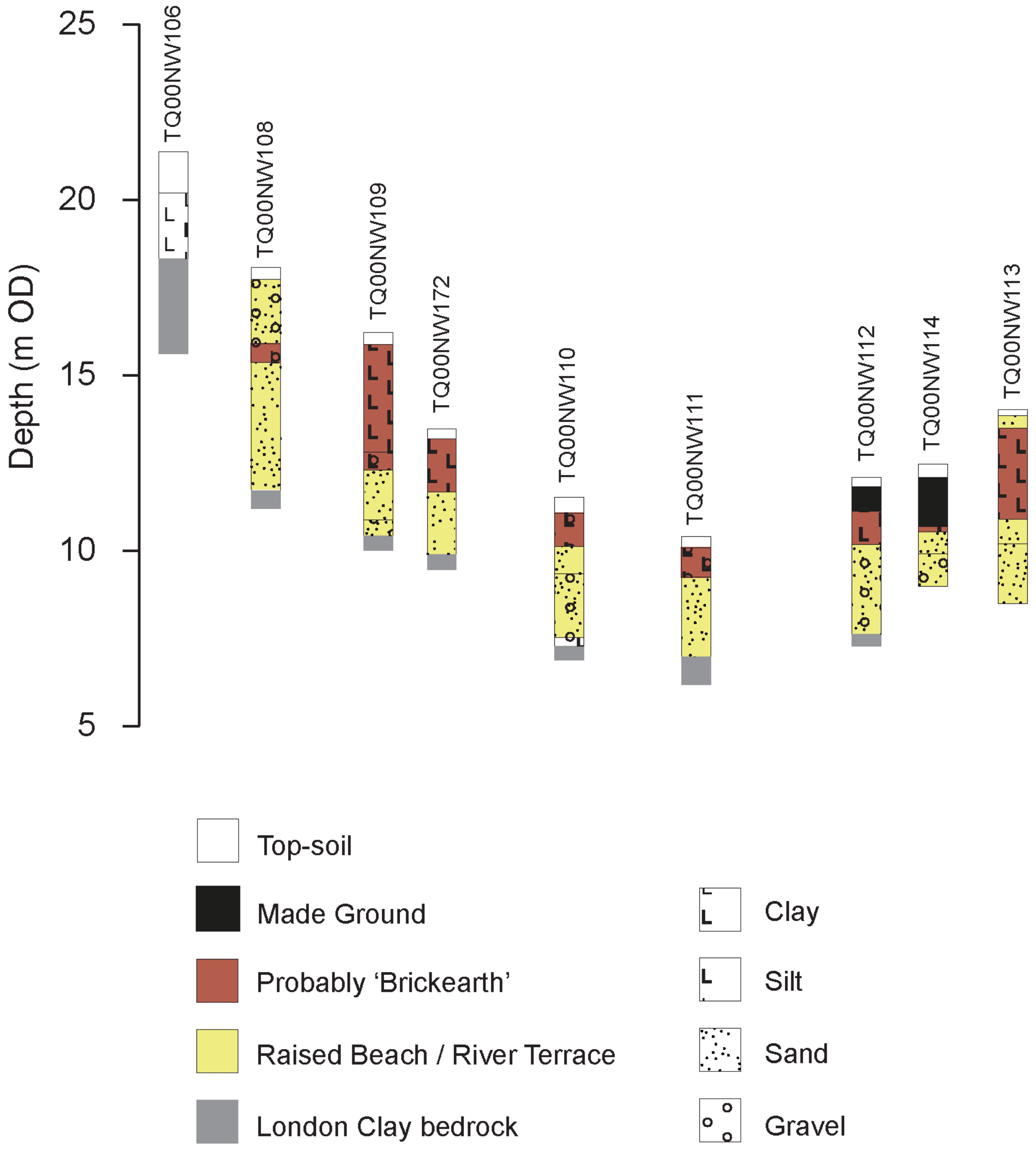
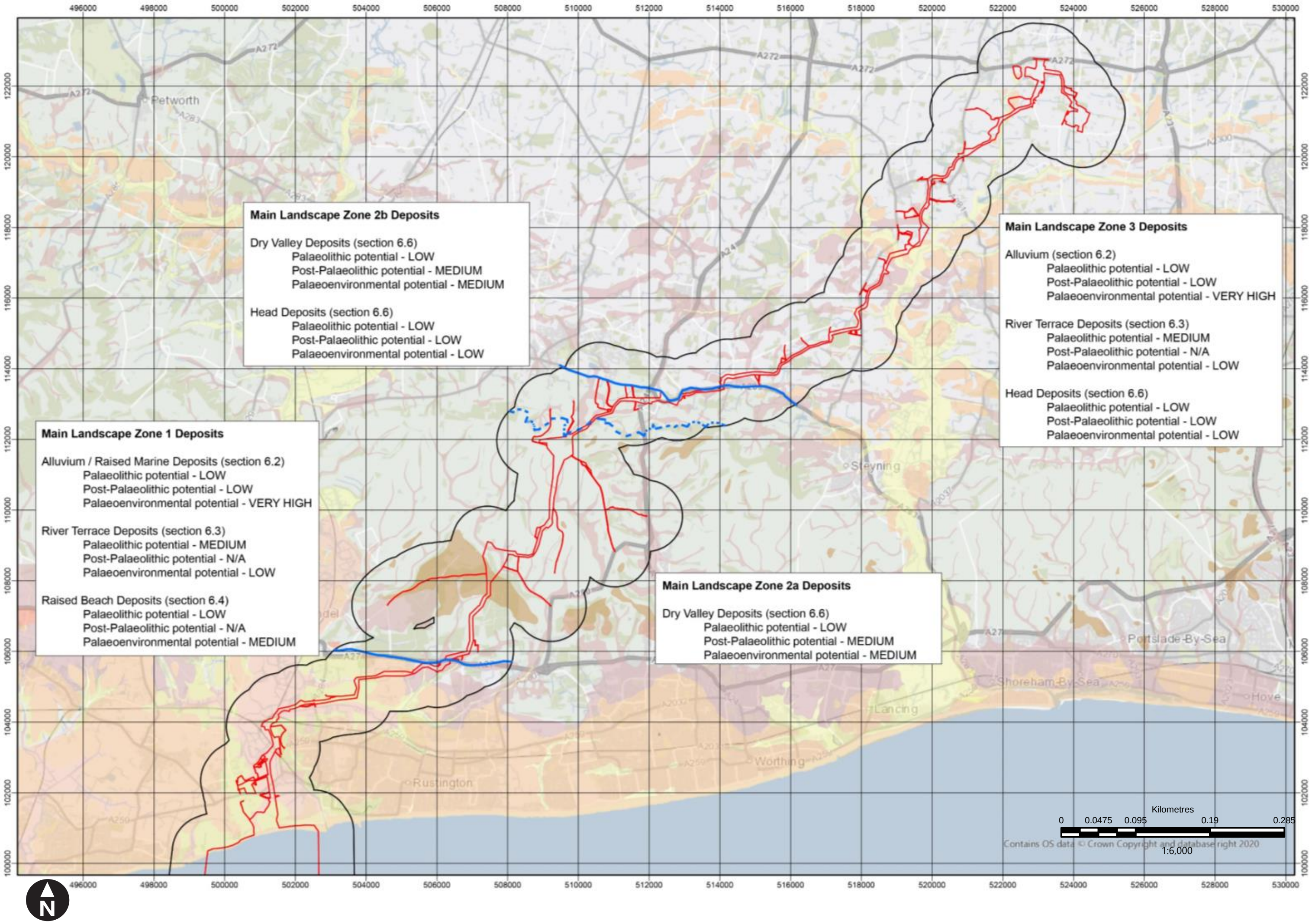


Figure 11 Palaeolithic and Palaeoenvironmental potential of principal superficial geological contexts across the site Landscape Zones (based on the criteria and assessments outlined in Section 6) (British Geological Survey materials (c) UKRI 2021)



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Rampion 2
WIND FARM