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Geoarchaeological Deposit
Modelling Report

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TKRE CABLE TUNNEL REPLACEMENT PROJECT TILBURY, ESSEX & GRAVESEND, KENT

Desk-based Geoarchaeological
Deposit Modelling Report

NGR: TQ 66295 75834 & 67429 74097

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1. NON-TECHNICAL SUMMARY

A desk-based geoarchaeological deposit modelling was undertaken to clarify the nature, depth and extent of the below ground deposits. Existing stratigraphic data was used to produce a deposit model of the major depositional units. The results of the investigation reveal a consistent sequence of Bedrock Chalk, overlain by late Devensian Shepperton Gravel. The subsequent alluvial deposits comprise generally fine-grained inorganic sediment of the Lower and Upper Alluvium, predominantly representative of estuarine conditions. These alluvial deposits are interrupted by at least three periods of peat formation which represent semi-terrestrial marshy conditions supporting sedge-fen, reed-swamp, saltmarsh and carr woodland type communities. The alluvial and peat deposits have high potential to provide a detailed reconstruction of past environments on both the wetland and dryland. In particular, they provide the potential to increase knowledge and understanding of the interactions between hydrology (relative sea level), human activity, vegetation succession and climate.

2. INTRODUCTION

2.1. Background

This report summarises the findings arising from a desk-based geoarchaeological deposit modelling exercise undertaken on the TKRE Cable Tunnel Replacement Project (Figure 1). The Proposed Development relates to the replacement of the below ground cabled section of the TKRE 400kV circuits with the construction of new bored tunnel under the River Thames to carry new XLPE cables, together with infrastructure either side of the Thames comprising:

- Two tunnel shafts one each side of the Thames measuring approximately 15m in diameter and 50m deep;
- Two new tunnel headhouses to cover the tunnel shaft and house monitoring and ventilation equipment;
- Two new Sealing End Compounds (SECs) which will house the connection between the overhead lines and underground cable; and
- Overhead line re-stringing to connect the overhead lines to the new SECs.

Tilbury Headhouse and SEC Compound is located to the north of the Thames (NGR centred on TQ 66295 75834; Figures 2-3) and falls within the jurisdiction of Thurrock Council. The Gravesend Headhouse and SEC compound is located to the south of the River Thames (NGR centred on TQ 67429 74097; Figures 2 & 4) and falls within the jurisdiction of Gravesham Borough Council.

Quest have been commissioned by AECOM on behalf of National Grid to prepare a desk-based geoarchaeological deposit model for the TKRE site, with particular focus on the two headhouse and SEC compound areas. This report should be read in conjunction with the Historic Environment DBA prepared by AECOM (2023).

2.2. Geological and geoarchaeological context

The British Geological Survey (BGS) show the site underlain by Cretaceous Seaford and Newhaven Chalk Formation bedrock, and describes the Alluvium overlying it as 'Clay, Silty, Peaty, Sandy' (Figure 1). In fact, the alluvial deposits of the Lower Thames and its tributaries are almost everywhere underlain by Late Devensian Late Glacial Gravels (in the Thames valley, the Shepperton Gravel of Gibbard, 1985, 1994), and this gravel is widely recorded across the site and wider area.

The Tilbury Headhouse and SEC compound site lies ca. 1.75km to the south of the geological and topographical boundary of older Pleistocene gravel deposits (the Taplow Gravel / Lynch Hill Gravel)

and Head are recorded as outcropping by the BGS. The Gravesend Headhouse and SEC compound are located approximately 900m north from the edge of the same boundary.

Early work carried out by Spurrell (1889) during the construction of Tilbury Docks revealed a thick sequence of alluvial and peat deposits. Subsequently, Devoy (1979, 1982) carried out a detailed stratigraphic analysis of the southern Tilbury area by sinking over 30 boreholes; these sequences confirmed the presence of a thick sequence of intercalated alluvial and peat deposits overlying sands and gravels of the Shepperton Gravel between ca. -11m OD and -17m OD. Devoy (1979, 1982) proposed a model that identified the peat as representing semi-terrestrial conditions caused by periods of reversed, or lower Relative Sea Level Rise (RSL) rise (regression; known as Tilbury I to V), whilst periods of alluvial deposition (known as Thames I to V) represent inundation caused by increased RSL rise (transgression). At The World's End, Tilbury (Figure 1), Devoy dated these five peat horizons as follows:

<i>Tilbury I</i>	9440-8770 to 8990-8420 cal BP	ca. -13.40 to -13.20m OD
<i>Tilbury II</i>	8050-7660 to 7620-7290 cal BP	ca. -10.40 to -10.10m OD
<i>Tilbury III</i>	7320-6860 to 4520-3990 cal BP	ca. -6.50m to -5.30m OD
<i>Tilbury IV</i>	3680-3260 to 3370-3000 cal BP	ca. -2.00m to -1.90m OD
<i>Tilbury V</i>	Undated	ca. -0.70m OD

More recent geoarchaeological investigations at sites across the Tilbury and Gravesend areas have also revealed a sequence of Late Devensian Shepperton Gravel overlain by a sequence of Holocene alluvial sediments, including peat, buried beneath modern Made Ground. Three or more distinct peat horizons have been recorded at several sites on the north side of the river (e.g. Tilbury 2 – Batchelor et al., 2019; Thurrock FGP – Batchelor & Timms, 2022; Batchelor et al., in prep; the Lower Thames Crossing – National Highways, 2022a, b), towards the base, middle and top of the sequence, approximately equivalent to Devoy's Tilbury II, III and sometime between the IV and V peats. On the south side of the river in the Gravesend area, peat is also recorded, but less frequently (e.g. MET Police STC – MOLA, 2023). Nevertheless, each sequence has the potential to provide information on past environmental change, sea level change and human activity, through the preservation of biological remains (see section 2.3). Also of note is the presence of a substantial channel traversing the western side of the Thurrock FGP site to the north of the Tilbury headhouse and SEC compound (Batchelor & Timms, 2022; Batchelor et al., in prep). The channel is orientated north-south across the Thurrock FGP site, but it is unknown whether it traverses TKRE site.

2.3. Geoarchaeological & palaeoenvironmental significance

Nearby sites indicate considerable variation in the height of the Shepperton Gravel surface, and the type, thickness, and age of the subsequent Holocene deposits. Such variations are significant as they represent different environmental conditions that would have existed in a given location. For example: (1) the varying surface of the Gravel may represent the location of former channels and bars; (2) the presence of soil and peat represents former terrestrial or semi-terrestrial land-surfaces, and (3) the various alluvial units represent periods of changing hydrological conditions. Thus by studying the sub-surface stratigraphy across the site in greater detail, it will be possible to build an understanding of the former landscapes and environmental changes that took place across space and time.

In addition, given its location, the site has the potential to contribute to highly important investigations on relative sea level rise that are applicable to the Tilbury and Gravesend region and to the rest of the Lower Thames Valley (e.g. Devoy, 1979, 1982; Long, 1995; Haggart, 1995; Sidell and Long, 2000; Long *et al.*, 2000; Sidell *et al.*, 2000; Sidell, 2003). The existing models for the rates of RSL rise, such as that proposed by Devoy (1979; 1982) and Sidell (2003) for the Lower Thames Valley itself, and by Long *et al.* (2000) from three major southern England estuaries, are critical areas of research for studies of Holocene vegetation history and human activity in the Lower Thames Valley. Devoy's original model of peat formation and RSL was produced for the Lower Thames Valley as a whole in 1979, based upon a small number of records, and heavily influenced by the record from the World's End, Tilbury, and subsequent work in the Tilbury area has revealed inconsistencies in the timing and extent of peat formation (e.g. Batchelor, 2009, Batchelor *et al.*, 2014, Batchelor *et al.*, 2019). Sidell's (2003) model demonstrates that it is not possible to apply Devoy's model to the whole of the Lower Thames Valley. In addition, it has been argued (e.g. Haggart, 1995; Sidell and Long, 2000; Long *et al.*, 2000) that site-specific factors may mean that the World's End borehole (Devoy, 1979) represents an anomalous record. New RSL index points from the TKRE site would therefore contribute significantly to the debate in this area of research, and our understanding of rates of RSL rise in this area of the Lower Thames Valley.

The alluvial and organic-rich sediments (in particular peat) have high potential to provide a detailed reconstruction of past environments on both the wetland and dryland during the Holocene. In particular, they provide the potential to increase knowledge and understanding of the interactions between hydrology, human activity, vegetation succession and climate. Such investigations are carried out through the assessment/analysis of palaeoecological remains (e.g. pollen, plant macrofossils & insects) and radiocarbon dating, and have been undertaken at the nearby sites such as: Tilbury 2 (Batchelor *et al.*, 2019), Thurrock FGP (Batchelor & Timms, 2022; Batchelor *et al.* in prep), London Distribution Park (Batchelor *et al.*, 2014), Tilbury Fort (Batchelor, 2009), Tilbury Docks (Spurrell,

1889; Batchelor *et al.*, 2023) and The World's End (Devoy, 1979) (see Figure 1). No such analytical work has been undertaken in the vicinity of the Gravesend headhouse and SEC compound on the south side of the river, but at this stage the potential is also considered high. The potential of the palaeoenvironmental remains is also highlighted as being moderate to high within the archaeological desk-based assessment (sections 5.1.8 and 5.2.10; AECOM, 2023).

Finally, areas of high gravel topography, soils and peat represent potential areas that might have been utilised or even occupied by prehistoric people, evidence of which may be preserved in the archaeological (e.g. features and structures) and palaeoenvironmental record (e.g. changes in vegetation composition). No prehistoric archaeological features have been recorded within 1km of the Tilbury headhouse and SEC compound (AECOM, 2023), however, human interaction with the local environment is demonstrated by the recording of Palaeolithic and Neolithic flint artefacts more distally during excavation of the Tilbury Docks and at West Tilbury Marshes. Importantly, during construction of new dock facilities for the East and West India Dock company in 1883, a partial skeleton was found ca. 10.5m below ground level (bgl) in the uppermost 0.5m of a (possibly redeposited) Devensian sand layer, at the base of the alluvial sequence (Spurrell, 1889). More recent analysis (Schulting, 2013) has revealed the skeleton to be of Late Mesolithic date (8015–7860 cal BP); the Late Mesolithic is a period for which human skeletal finds are very rare in Britain (Schulting, 2013), and such a find highlights the presence of humans, and the potential utilisation of the floodplain within the vicinity of the site, during this period. Palaeoenvironmental investigations at the nearby London Distribution Park also indicate episodes of burning and changes in vegetation during the prehistoric period which may be associated with human activity (Batchelor *et al.*, 2014). Prehistoric features are similarly limited within 1km of the Gravesend Headhouse and SEC compound (AECOM, 2023).

2.4. Aims and objectives

The aim of the geoarchaeological deposit modelling exercise is to further clarify the nature, depth and extent of the below ground deposits, in particular, the surface of the Shepperton Gravel, and the presence and thickness of the alluvium, former land surfaces and peat deposits. The resultant deposit model will be used to help guide any requirement for further archaeological, geoarchaeological and palaeoenvironmental works. In order to address these aims, stratigraphic and chronological data from existing records will be used to produce a deposit model of the major depositional units across the site and nearby area.

3. METHODS

3.1. Deposit Modelling

The deposit model for the site was based on a review of stratigraphic records from the Quaternary Scientific Lower Thames Valley Geoarchaeological Database, combining records from various geoarchaeological and geotechnical investigations in the wider area (see Figures 1,3-4) and the British Geological Survey (BGS) borehole archive (<https://www.bgs.ac.uk/geoindex/>). Efforts were also made to obtain and integrate geoarchaeological stratigraphic data from ongoing investigations on the Lower Thames Crossing (LTC). It was not possible to extract raw sedimentary data from the LTC geoarchaeological desk-based assessment (Bates, 2020), however geotechnical records associated with the LTC are held on the BGS borehole archive; these have been interrogated and added into the model.

Sedimentary units were classified into five main groups: (1) Bedrock, (2) Gravel, (3) Lower Alluvium, (4) Lower Peat, (5) Middle Peat, (6) Upper Alluvium (7) Upper Peat and (8) Made Ground/Top Soil. The classified data for groups 1-8 were then input into a database with the RockWorks 21 geological utilities software. Borehole transects have been produced across the Tilbury and Gravesend headhouses and SEC compounds (Figures 5-6), with a longer transect along the entire TKRE route (Figure 7). A borehole transect produced by Devoy (1979), projecting eastwards from Tilbury Docks onto the TKRE site on the Tilbury side of the river is provided in Figures 8-9. A selection of radiocarbon dated sequences from across the Tilbury area is also provided in Figure 10, with sequences from the Tilbury headhouse and SEC compound as reference. Models of surface height were generated for the Bedrock (Figures 11-12), Gravel (Figures 13-14), Lower, Middle and Upper Peats (Figures 18-19, 23-24, 27-28) and Alluvium (Figures 29-30). Thickness of the Holocene alluvial sequence (Figure 15-16), Lower Peat (Figures 20-21), Middle Peat (Figure 25-26), Upper Peat (Figure 29-30), and Made Ground/Top Soil (Figures 31-32) were also modelled.

Because of the 'smoothing' effect of the modelling procedure, it should be noted that the modelled levels of stratigraphic contacts may differ slightly from the levels recorded in borehole logs and section drawings (Carey et al. 2018). As a consequence of this, the modelling procedure has been manually adjusted so that only those areas for which sufficient stratigraphic data is present will be modelled. In order to achieve this, a maximum distance cut-off filter equivalent to a 100m radius around each record is applied to all deposit models excluding the Lower, Middle and Upper Peat thickness/surface models, where a 50m radius was applied. Finally, it is important to recognise that multiple sets of boreholes are represented, put down at different times and recorded using different descriptive terms and subject to differing technical constraints in terms of recorded detail including the exact levels of the stratigraphic boundaries.

4. RESULTS, INTERPRETATION & DISCUSSION OF THE DESK BASED GEOARCHAEOLOGICAL DEPOSIT MODELLING

The results of the deposit modelling are shown in Figures 5 to 32. Figures 5-10 are two-dimensional transects across various parts of the site and wider area. Figures 11-32 are surface elevation and thickness models for each of the main stratigraphic units.

When combined, the number and spread of boreholes provides complete coverage across each headhouse and SEC compound, and partial-moderate coverage of the rest of the TKRE site and wider area. The full sequence of sediments recorded in the stratigraphic records comprises:

Made Ground / Top Soil – widely present

Alluvium (Lower and Upper) – widely present incorporating in places an:

Upper Peat

Middle Peat

Lower Peat

Gravel – widely present

Bedrock – widely present

Within the footprint of each headhouse and SEC compound, the geotechnical interventions on which the more detailed transects and models are based, comprise a combination of test-pits, cable percussion boreholes and cone penetration testing (CPT). It should be highlighted that the most reliable records are the cable percussion boreholes which reach to the bedrock and enable the investigator to directly see and record the deposits. CPT involves the pushing of an instrumented cone into the ground surface at a controlled rate. The sediments are interpreted from readings provided by this testing, rather than direct observation of the sediments. From a geoarchaeological perspective, this type of test provides reasonably accurate interpretation of the transition from alluvium into sand and gravel, but tends not to identify peat units within the alluvium. Thus, the lack of peat in these records should not be assumed to represent the absence of peat beneath the site (see e.g. Figures 5-7).

4.1. Bedrock Chalk

The bedrock Chalk was present in all boreholes that penetrated to the base of the Pleistocene deposits.

4.1.1. Tilbury & Gravesend headhouses and SEC compounds

Beneath the Tilbury headhouse and SEC compound, the chalk surface is recorded between ca. -17.0 and -17.5m OD in boreholes TKRE-BH01, BH02A and BH07A (Figures 5 & 11).

Beneath Gravesend headhouses and SEC compounds, the chalk surface is recorded between -16.5 and -17.5m OD in boreholes TKRE-BH04, BH05 and BH06 (Figures 6 & 11).

4.1.2. TKRE site and nearby vicinity

Across the rest of the TKRE site boundary and more widely (Figures 7 & 12), the chalk surface varies more widely between -16 and -20m OD. Exceptions to this are: (1) within the footprint of the LTC towards the north of the modelled area, where the bedrock surface reaches -22m OD; (2) within the channel of the River Thames, where the gravel surface rises up to -13m OD in boreholes from both the TKRE and LTC sites, and (3) beyond the margins of the floodplain to the south-west of the wider modelled area, where the surface of the bedrock rises up to 16m OD.

4.2. River Terrace Gravels

The Shepperton Gravel was present in all the boreholes that penetrated to the bottom of the Holocene sequence. It was deposited during the Late Glacial (15,000 to 10,000 years before present) and comprises the sands and gravels of a high-energy braided river system which, while it was active would have been characterised by longitudinal gravel bars and intervening low-water channels in which finer-grained sediments might have been deposited. Such a relief pattern would have been present on the valley floor at the beginning of the Holocene when a lower-energy fluvial regime was being established.

4.2.1. Tilbury & Gravesend headhouses and SEC compounds

Beneath the Tilbury headhouse and SEC compound, the gravel surface rests between -13.0 and -14.5m OD (see boreholes TKRE-BH01, BH02A, CPT7, CPT8, CPT9, CPT11; Figures 5 & 13). The exception being borehole TKRE-BH07A in which a gravel surface was not encountered, and the Lower Alluvium (see section 4.3) is recorded as resting directly on chalk bedrock. This is not in keeping with other records from the wider Tilbury area and is considered more likely to be an error rather than anomaly.

Only TKRE-BH01 and BH02A record the full thickness of the gravel in this area, both recording at ca. 3-3.5m thick.

Beneath the Gravesend headhouse and SEC compound, the gravel surface is recorded at between -11 and -14.5m OD (Figures 6 & 13). However, if the units of sand recorded in boreholes TKRE-BH04, BH06, CPT12A, CPT14 and CPT16 are interpreted as representing the uppermost deposits of the Shepperton Gravel, the gravel surface is more consistently recorded at -11m OD across this area (Figure 6). Three sequences record the full thickness of the gravel in this area, all indicating it is around 6m thick.

4.2.2. TKRE site and nearby vicinity

The topography of the Shepperton Gravel undulates across the wider modelled area (Figures 7 & 14), but generally falls in the direction of the present-day River Thames as would be expected. On the northern side of the Thames, across the Tilbury 2 site, the surface of the Gravel is generally higher towards the north and west, generally lying between approximately -9.5 and -12.5m OD. It falls in a south-easterly direction to between -12.5 and -15m OD, incorporating much of the northern part of the TKRE site. Boreholes associated with the proposed Lower Thames Crossing indicate gravel surface heights falling in a south-easterly direction from -16 and -17m OD to -19m OD towards the north bank of the Thames channel. Gravel thicknesses are generally around 6m thick, but within the confines of the River Thames tend to be much thinner (e.g. <1m thick in TKRE-MRC1 to MRC3; Figure 7).

Devoy (1979) also produced a transect of boreholes orientated west-east from Tilbury Docks onto the TKRE site (Figure 8), and from north to south on the western side of Tilbury Docks (Figure 9), both of which record the gravel between -12 and -15m OD and up to ca. 6m thick.

In the Gravesend area, the gravel surface is recorded as rising in the area of Canal Basin and the Embankment site from -5m to >0m OD, whilst at Dalefield Way it rises from -8m to >0m OD. In both instances this rising surface represents the very edge of the floodplain.

Of note towards the southern end of the modelled area on the LTC route, are a cluster of five boreholes that indicate the gravel deposits are separated by thick deposits of silty or clayey material that the geotechnical engineers described as being possible interglacial deposits (highlighted in Figure 14). These deposits are at levels between approximately -4.0 and -18.0m OD and underlie normal Holocene alluvial sequences (see subsequent sections). However, it is difficult to visualise which interglacial might be represented by these deposits; there is no known literature relevant to downcutting by the Thames to these levels in this area before the Late Devensian, when the present

floodplain was formed. The base of the Gravel in these sequences is also consistent with other sequences across the Gravesend area. Rather than being of interglacial/interstadial deposits, it would seem more likely that the deposits represent bedrock in the form of Thanet Formation and Lambeth Group sediments carried downslope possibly in a landslide onto the floodplain as the gravel was aggrading. These Tertiary deposits include shelly horizons, gravel beds and multicoloured sands and clays - all features mentioned in the borehole logs. However, there is no indication that these deposits extend into the Gravesend headhouse and SEC compound; boreholes TKRE-BH04, BH05 and BH06 record only sand and gravel within the River Terrace Gravel deposits.

4.3. Lower Alluvium & Upper Alluvium

Alluvial deposits of sands, silts and clays rest above the Shepperton Gravel across the floodplain on both sides of the river (see Figures 5 to 10). The Alluvium tends to contain a greater sand component in the lower half of the sequence, and where this can be identified, it is referred to as the Lower Alluvium. With height it tends to become more silty and clayey, and is referred to as the Upper Alluvium. This distinction can be difficult to make, particularly in geotechnical records, as well as in sequences that do not contain the Middle Peat which tends to separate the two units (see section 4.5). Both the Lower and Upper Alluvium contain varying quantities of organic material and detrital plant remains (specifically sedges and reeds).

The Lower Alluvium is interpreted as being indicative of deposition during the early to mid-Holocene, when the main course of the Thames probably became confined to a single meandering channel. During this period, the surface of the Shepperton Gravel was progressively buried beneath the sandy and silty flood deposits of the river. The organic nature of the Lower Alluvium suggests that this was a period during which the valley floor was occupied by a network of actively shifting channels, with a drainage pattern on the floodplain that was still largely determined by the relief on the surface of the underlying Shepperton Gravel. A horizon or horizons of peat/organic-rich sediment, described here as the Lower Peat, was recorded within the Lower Alluvium (see section 4.4).

The sediments of the Alluvium are indicative of deposition within low energy fluvial and/or semi-aquatic conditions during the Holocene. The high mineral content of the sediments may reflect increased sediment loads resulting from intensification of agricultural land use from the later prehistoric period onward, combined with the effects of rising sea level. A horizon of peat, described here as the Upper Peat (see section 4.6), was recorded within the Upper Alluvium at selected locations (see below).

The thickness of the alluvium is normally inversely proportional to the gravel surface; i.e. the alluvium is thicker when the gravel surface is lower and vice versa. This is the case across both the Tilbury &

Gravesend headhouses and compounds (Figure 16), the rest of the TKRE site and wider area (Figure 17). The resultant effect is an alluvial surface that generally rests between 0 and 1m OD across the floodplain on both sides of the river (Figures 29 & 30). The exceptions to this are: (1) within the channel of the River Thames, where the alluvium is either thin or absent altogether, and in areas of previous development, where the alluvium has been truncated.

4.4. Lower Peat

4.4.1. Tilbury & Gravesend headhouses and SEC compounds

Recorded either directly overlying the Shepperton Gravel or within the Lower Alluvium in several boreholes across the Tilbury area are unit(s) of organic-rich sediment and/or peat. These horizons are referred to here as the lower peat. Within the footprint of the Tilbury headhouse and SE compound (Figures 5, 17-18), a 0.5m thick lower peat was only recorded in one borehole; TKRE-BH07A, most likely towards the base of the Lower Alluvium between -10.10 and -10.60m OD (given that Shepperton Gravel most likely lies at ca. 13.5m OD in this record; see section 4.2.3). However, given the number of records just outside the headhouse and SEC compound to contain a lower peat unit, it would seem likely that such units do exist within the footprint of the site; they have just been missed due to the nature of the geotechnical drilling.

A lower peat unit is not recorded within the footprint of the Gravesend headhouse and compound, according to the records from TKRE-BH05 and BH06 (Figure 6). However, lower peat units are recorded in records close by in TKRE-BH04 (between -9.6 and -10.5m OD) and in MET-BH1 and BH2 from the MET Police STC site (at ca. -9.5m OD) (Figures 6 & 17-18). Similarly to within the Tilbury headhouse and SEC compound, there is therefore a reasonable chance that lower peat units will be recorded beneath the Gravesend headhouse and SEC compound.

4.4.2. TKRE site and nearby vicinity

Across the rest of the TKRE site on the northern side of the river and elsewhere within the Tilbury area, lower peat horizons are generally between 0.5 and 1m in thickness lying at elevations of between ca. -16 and -9m OD, its surface lying at variable elevations between ca. -7.8 and 15.4m OD (Figures 19-20). However, thicknesses of up to 2.5m are recorded, especially to the south of the Tilbury headhouse and SEC compound within the TKRE footprint. Here, the greater thicknesses recorded ordinarily represent multiple peat units separated by substantial thicknesses of Lower Alluvial sediment. And to the northeast on the Thurrock FGP site (just beyond the modelled area), three thin peat horizons were recorded; with a 'basal peat' immediately above the Shepperton Gravel between -10.93 and -10.80m OD, then at -10.63 to -10.57m OD and finally -9.63 to -9.48m OD. As outlined in 4.4.1, it therefore seems likely that lower peat(s) are present beneath the Tilbury headhouse and SEC

compound. In the Gravesend area, lower peat units are restricted to the two boreholes already highlighted in section 4.4.1.

4.4.3. Nature and chronology of the Lower Peat

The lower peat has only been recorded and dated in detail in the Tilbury area. Where recorded, the lower Peat is largely comprised of herbaceous remains with occasional wood. This is indicative of a transition towards semi-terrestrial (marshy) conditions, supporting the growth of either saltmarsh, sedge fen/reed swamp with less common woodland.

Radiocarbon dating has been undertaken on several lower peat units across the Tilbury area. Selected records are provided in Figure 10 for comparative purposes. Sites such as London Distribution Park (Batchelor et al., 2014), Tilbury 2 (Batchelor et al., 2019), Aggregate Industries (Batchelor et al., 2023) and Thurrock FGP (Batchelor, in prep) all provide determinations of between 7200 and 8000 cal BP, correlating most closely in age and elevation to Devoy's Tilbury II peat as recorded at the World's End. These dates equate to accumulation during the late Mesolithic, with some units being of very similar date to the age of the skeleton recovered and dated from Tilbury Docks (8015–7860 cal BP; see section 2.3).

Finally, although these peat units are referred to here as the Lower Peat for deposit modelling purposes, several geoarchaeological records confirm that two or more distinct horizons can often be identified, representing different mechanisms and ages of peat formation: particularly those that directly overlie the Gravel, and those that lie at higher elevations within the Lower Alluvium.

None of the peats recorded correlate with his basal, Tilbury I peat which accumulated between 9440-8770 to 8990-8420 cal BP (Figure 10).

4.5. Middle Peat

4.5.1. Tilbury & Gravesend headhouses and SEC compounds

Often separating the deposits of the Lower and Upper Alluvium on the Lower Thames Valley floodplain is a horizon of peat, referred to here as the middle peat. The middle peat is recorded in all three cable percussion boreholes put down within the footprint of the Tilbury headhouse and compound. It is recorded between -3.44 and -5.54m OD (TKRE-BH01), -4.63 and -6.13m OD (TKRE-BH02A) and -4.40 and -5.60m OD (TKRE-BH07A). The total thickness beneath this area therefore appears to range between 1.2 and 2.1m, with an upper surface ranging between -3.44 and -4.63m OD (Figures 5, 21-22).

No middle peat horizons are recorded within the footprint of the Gravesend headhouse and SEC compound. Thin horizons (<0.5m) are recorded across the MET Police STC site at ca -3m OD. Given the thin nature of these deposits, it is possible that such units exist beneath the headhouse and SEC compound; they have just been missed due to the nature of the geotechnical drilling.

4.5.2. TKRE site and nearby vicinity

Across the rest of the TKRE site and wider area on the northern side of the river, and elsewhere within the Tilbury area, the middle peat tends to range between 1.0 and 2.5m in thickness, with greater thicknesses tending to occur on the southern part of the floodplain (Figures 7 & 23). Thicknesses can be hugely variable however, and sometimes the middle peat is absent altogether (see also section 4.7). Within the historic geotechnical records, this should be taken with caution as the drilling and descriptive techniques may be insufficiently precise / accurate to detect them. The surface of the peat can also be highly variable but is generally recorded between -4.0 and -6.0m OD (Figures 7 & 24). On the southern side of the Thames in the Gravesend area, middle peat units are sporadic, varying between <1 and >3m in thickness (Figures 7 & 23), but with a surface elevation around -3m OD (Figure 24).

4.5.3. Nature and chronology of the Middle Peat

The middle peat has only been recorded and dated in detail in the Tilbury area. Where recorded, it is almost solely composed of herbaceous remains with wood less common. This is indicative of a transition towards semi-terrestrial (marshy) conditions, supporting the growth of saltmarsh and/or sedge fen/reed swamp.

Radiocarbon dating has been undertaken on several lower peat units across the Tilbury area. Selected records are provided in Figure 10 for comparative purposes. Sites such as London Distribution Park (Batchelor et al., 2014), Tilbury 2 (Batchelor et al., 2019), Aggregate Industries (Batchelor et al., 2023) and Thurrock FGP (Batchelor, in prep) all provide determinations of between 6500 and 3500 cal BP, correlating most closely in age and elevation to Devoy's Tilbury III peat. These dates equate to accumulation from the Mesolithic-Neolithic transition through to the Bronze Age.

4.6. Upper Peat

4.6.1. Tilbury & Gravesend headhouses and SEC compounds

A thin horizon of peat is frequently recorded towards the top of the alluvium in records from across the Tilbury region (henceforth referred to as the upper peat).

Within the footprint of the Tilbury headhouse and SEC compound, a thin horizon of upper peat was encountered at the base of test-pit TKRE-TP02 measuring at least 0.05m thick, with a surface at -

0.47m OD (Figures 5 & 25-26). No other upper peat units were recorded in the geotechnical interventions put down within this footprint or the immediately surrounding area. No upper peat units were recorded within the footprint of the Gravesend headhouse and SEC compound or nearby area.

4.6.2. TKRE site and nearby vicinity

The upper peat is recorded in only a few records from the TKRE site on the northern side of the River Thames. It is however recorded in several records from Tilbury 2 (Batchelor et al., 2019) and Thurrock FGP (Batchelor & Timms, 2022) sites, and other regions of Tilbury. Indeed, on the Thurrock FGP site, an upper peat was recorded in fourteen of twenty-two interventions. Here it was generally <0.3m thick (and sometimes was <0.02m thick), resting between -1 and 1m OD (Figures 3 & 27-28). On the Tilbury 2 site and other sites in the Tilbury area it was more localised, present in thickness of up to 1m between ca. 0 and -2m OD. Due to the location of the units close to the surface (normally around 1m bgl), it is possible that in some of the locations across Tilbury, the peat has been removed by ploughing. It is also very thin in most instances so could easily be overlooked during geotechnical works. As such, it is possible that the upper peat may be present across the Tilbury headhouse and SEC compound.

The upper peat has not been encountered in any interventions from the southern side of the river in the Gravesend area.

4.6.3. Nature and chronology of the Upper Peat

The upper peat has only been recorded and dated in detail in the Tilbury area. Where recorded, it is almost solely composed of herbaceous remains, but tends to be highly humified, thus making the herbaceous remains unidentifiable. Nevertheless, the occurrence of these units is indicative of a brief transition towards semi-terrestrial (marshy) conditions, supporting the growth of sedge fen/reed swamp communities.

Radiocarbon dating has been undertaken on several lower peat units across the Tilbury area. Selected records are provided in Figure 10 for comparative purposes. Sites such as London Distribution Park (Batchelor et al., 2014), Tilbury 2 (Batchelor et al., 2019), Aggregate Industries (Batchelor et al., 2023) and Thurrock FGP (Batchelor, in prep) all provide determinations of between 2150 and 3000 cal BP. This equates to accumulation during the Iron Age. In terms of elevation, the unit generally correlates with Devoy's Tilbury IV peat, but accumulated over a 1000 years later (3680-3270 to 3370-3000 cal BP in Devoy's sequence).

4.7. Channel deposits

On the western side of the Thurrock FGP site (to the north of the Tilbury headhouse and SEC compound), the lower and middle peat horizons were absent entirely, and the alluvial deposits overlying the Shepperton Gravel frequently contained either laminations or beds of sand alternating with silty clay (Batchelor & Timms, 2022). In two sequences, a more diverse mixture of material was recorded above the Shepperton Gravel surface consisting of finer gravels, coarse sands and within them, a thin peat deposit.

The composition and nature of the alluvial deposits in these boreholes, combined with the apparent absence of a Lower and Middle Peat horizon, suggests that a large channel (250-400m wide) previously traversed the western part of the Thurrock FGP site, of (at least at times) high energy flow. On the basis of existing evidence it would appear that the channel is orientated on an approximately north-south trajectory. This would also be a logical orientation on the basis of a depression in the natural topography beyond the edge of the floodplain to the north (and thus possible origin of the channel), and position of the Thames towards the south.

Given that the lower and middle peats are present in boreholes from the Tilbury headhouse and SEC compound, it would appear that the channel did not pass through this part of the site. It is likely however, that the channel passed nearby to the west or east of the site.

At this stage the channel is undated, but it must have been infilled prior to the accumulation of the upper peat, which on the Thurrock site was radiocarbon dated to 2700-2350 cal BP (Iron Age).

4.8. Top Soil

Beneath the Tilbury headhouse and SEC compound, the borehole records indicate the presence of Made Ground up to 2.2m thick and comprising sands, gravels, brick, concrete and plastic (e.g. boreholes BH01, BH02A and BH07). By comparison, the Made Ground deposits on the Gravesend headhouse and SEC compound are up to 2m thick but tend to be much 'cleaner' consisting of a gravelly clay with only rare fragments of flint and brick, overlain by Top Soil (Figure 31).

Across the wider area (Figure 32), 1-2m of Top Soil is generally recorded, with greater thicknesses of Made Ground up to 3m thick in areas of previous development.

5. CONCLUSIONS

A desk-based geoarchaeological deposit modelling exercise was undertaken on the proposed TKRE site with particular emphasis on the Tilbury and Gravesend headhouses and compounds located on either side of the River Thames. The aims of the exercise were to further clarify the nature, depth and extent of the below ground deposits, in particular, the surface of the Shepperton Gravel, and the presence and thickness of the alluvium, former land surfaces and peat deposits. The resultant deposit model will be used to help guide any requirement for further archaeological, geoarchaeological and palaeoenvironmental works. In order to address these aims, stratigraphic and chronological data from existing records were used to produce a deposit model of the major depositional units across the site and nearby area.

The results of the investigation reveal a broadly consistent chalk surface on both sides of the River Thames at ca. -17.5m OD, overlain by late Devensian Shepperton Gravel to between -11 and -14.5m OD. The subsequent alluvial deposits comprise generally fine-grained inorganic sediment of the Lower and Upper Alluvium, predominantly representative of estuarine conditions. These alluvial deposits are interrupted by at least three periods of peat formation which represent semi-terrestrial marshy conditions supporting sedge-fen, reed-swamp, saltmarsh and carr woodland type communities. Nearby sites suggest these are likely to have formed sometime during the following timeframes: ca. 8000-7000 cal BP (the late Mesolithic period; the lower peat), ca. 6500-3500 cal BP (the Mesolithic-Neolithic transition, Neolithic and Bronze Age periods; the middle peat) and ca. 3000-2150 cal BP (the Iron Age; the upper peat). Peat formation is clearly diachronous however, so would need to be clarified by further radiocarbon dating.

As outlined in section 2.3, the alluvial and peat deposits have high potential to provide a detailed reconstruction of past environments on both the wetland and dryland. In particular, they provide the potential to increase knowledge and understanding of the interactions between hydrology, human activity, vegetation succession and climate. Based upon the presence of a lower peat beneath at least the Tilbury headhouse and SEC compound, there would seem to be good potential to encounter deposits equivalent in age to the Late Mesolithic skeleton that was discovered during construction of new dock facilities for the East and West India Dock company in 1883 (Spurrell, 1889; Schulting, 2013). As such, it should be possible to produce a palaeoenvironmental reconstruction during a period in which humans were known to utilise the nearby landscape at Tilbury Docks. In addition, given its location, the site has the potential to contribute to highly important investigations on relative sea level rise that are applicable to the Tilbury region and the rest of the Lower Thames Valley (e.g. Devoy, 1979, 1982; Long, 1995; Haggart, 1995; Sidell and Long, 2000; Long *et al.*, 2000; Sidell *et al.*, 2000; Sidell, 2003).

Across the Gravesend headhouse and SEC compound site, the palaeoenvironmental potential would appear to be lower due to the apparent lack of peat horizons within the geotechnical borehole records. However, the very nature of the geotechnical drilling / descriptive techniques may mean that any thin units were not identified. It should be noted that such thin horizons were recorded during the course of geoarchaeological interventions on the neighbouring MET Police STC site. Furthermore, it could be argued that recovering, dating and assessing/analysing any peat units from the Gravesend headhouse and SEC compound is as important as on the Tilbury site, due to the limited knowledge and understanding of the deposits on the south side of the river in this area.

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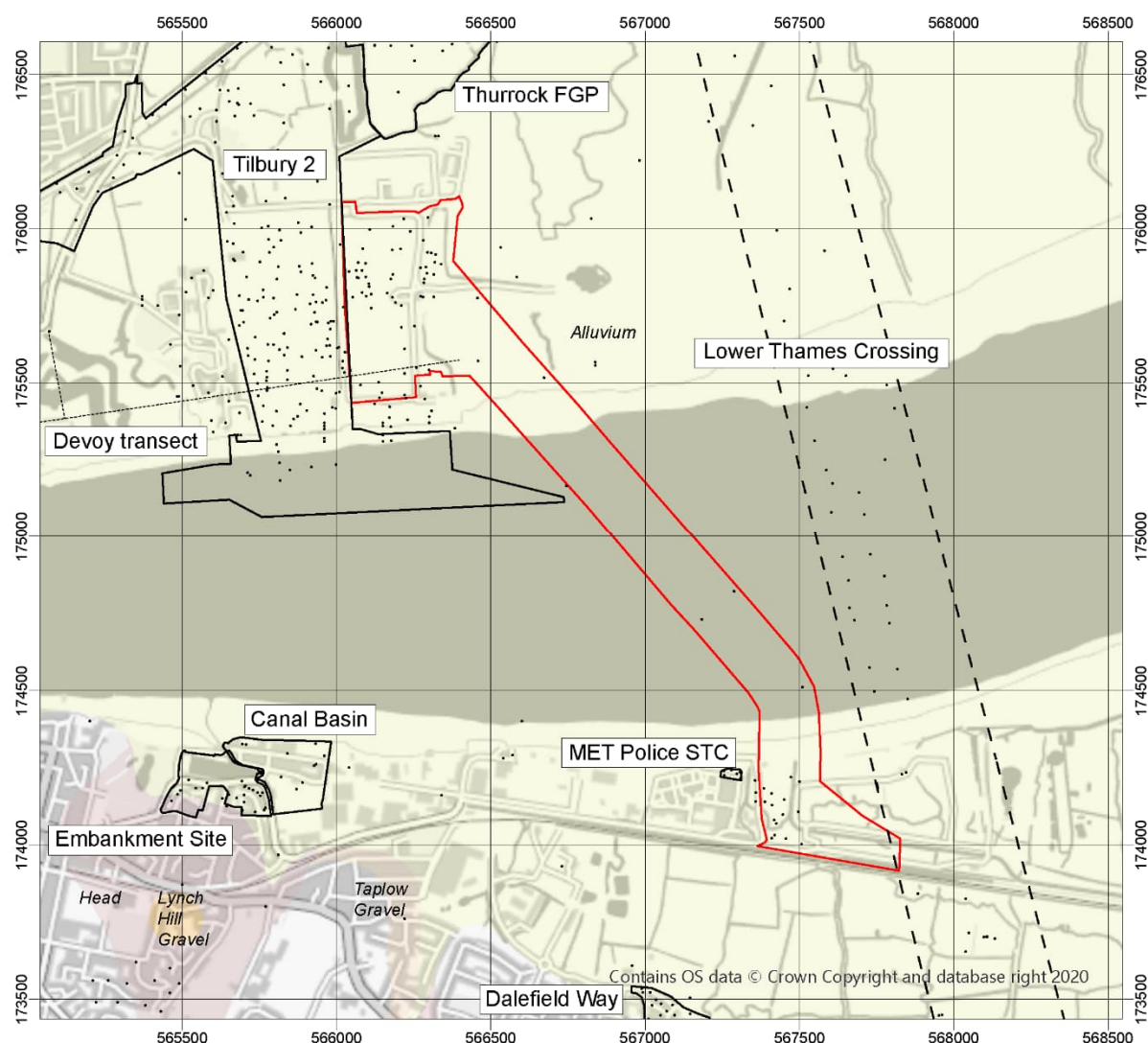
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Lower Thames Crossing outline estimated from coverage of boreholes held on the British Geological Survey (BGS) borehole archive (<https://www.bgs.ac.uk/geoindex/>)

Figure 1: Location of the TKRE project area (red), and other nearby sites of geoarchaeological and palaeoenvironmental interest. Superimposed on British Geological Survey mapping of the superficial deposits.

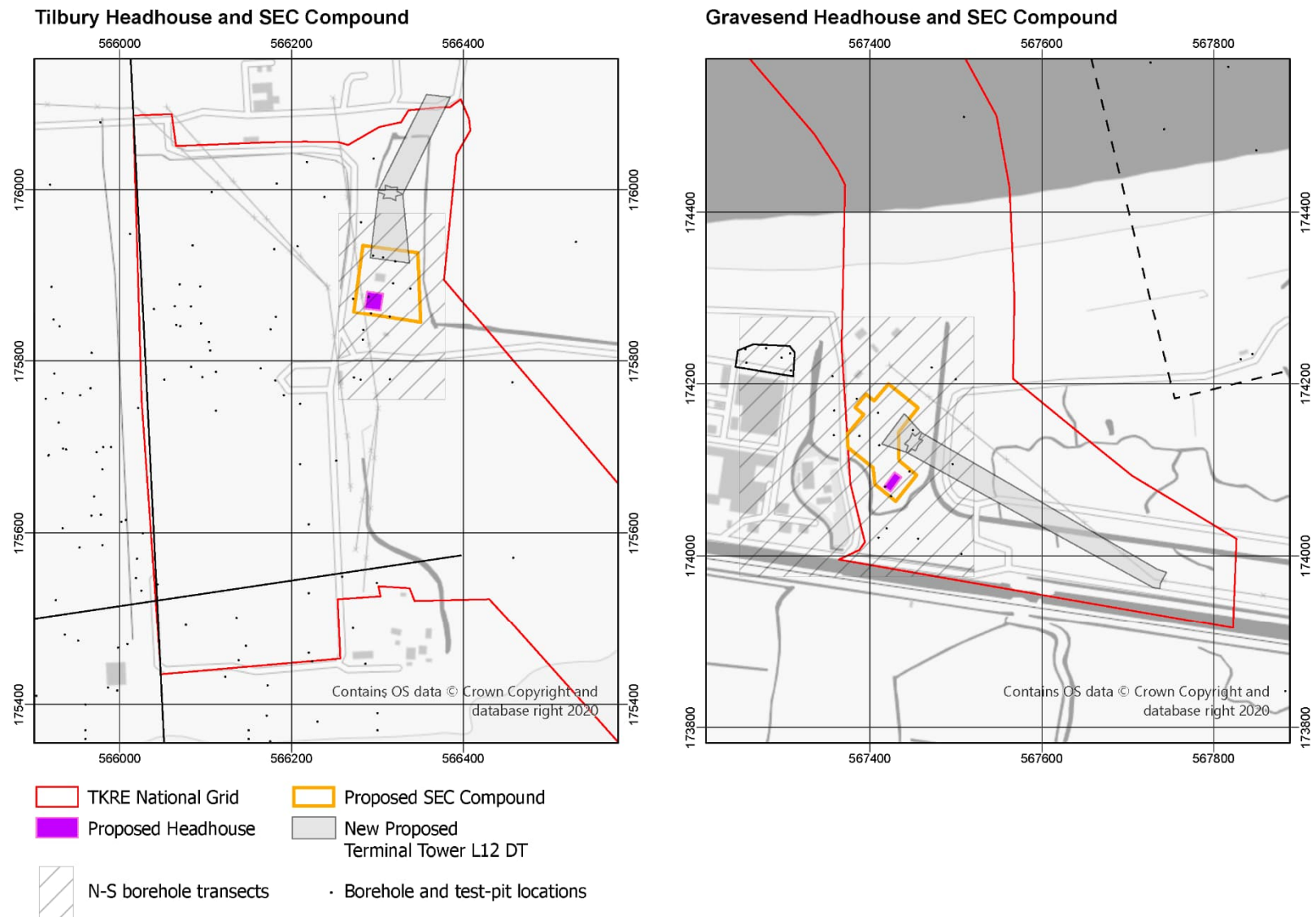


Figure 2: TKRE Tilbury & Gravesend Headhouse and SEC Compound locations

Tilbury Headhouse and SEC Compound

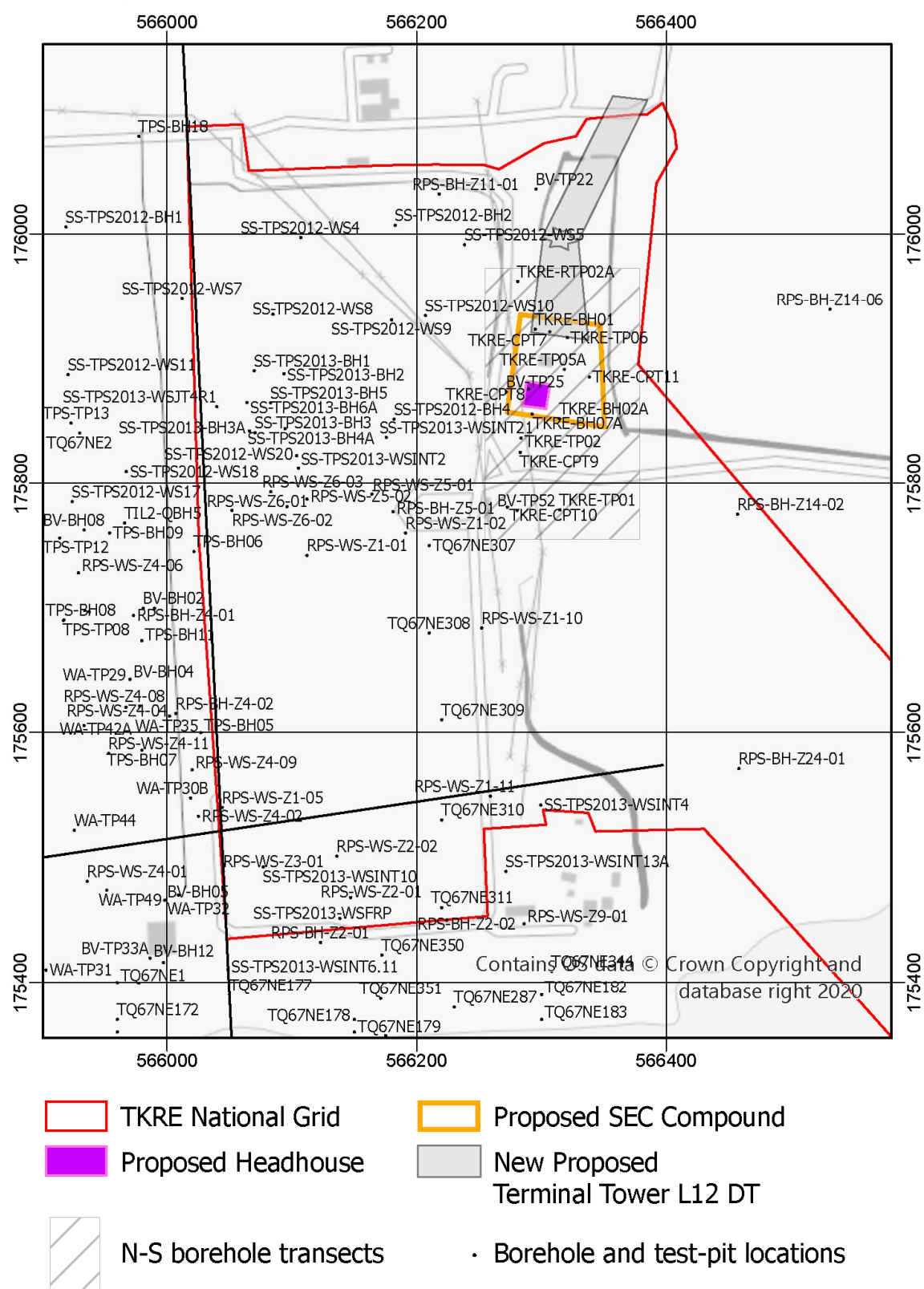


Figure 3: TKRE Tilbury Headhouse and SEC Compound locations with labelled borehole locations

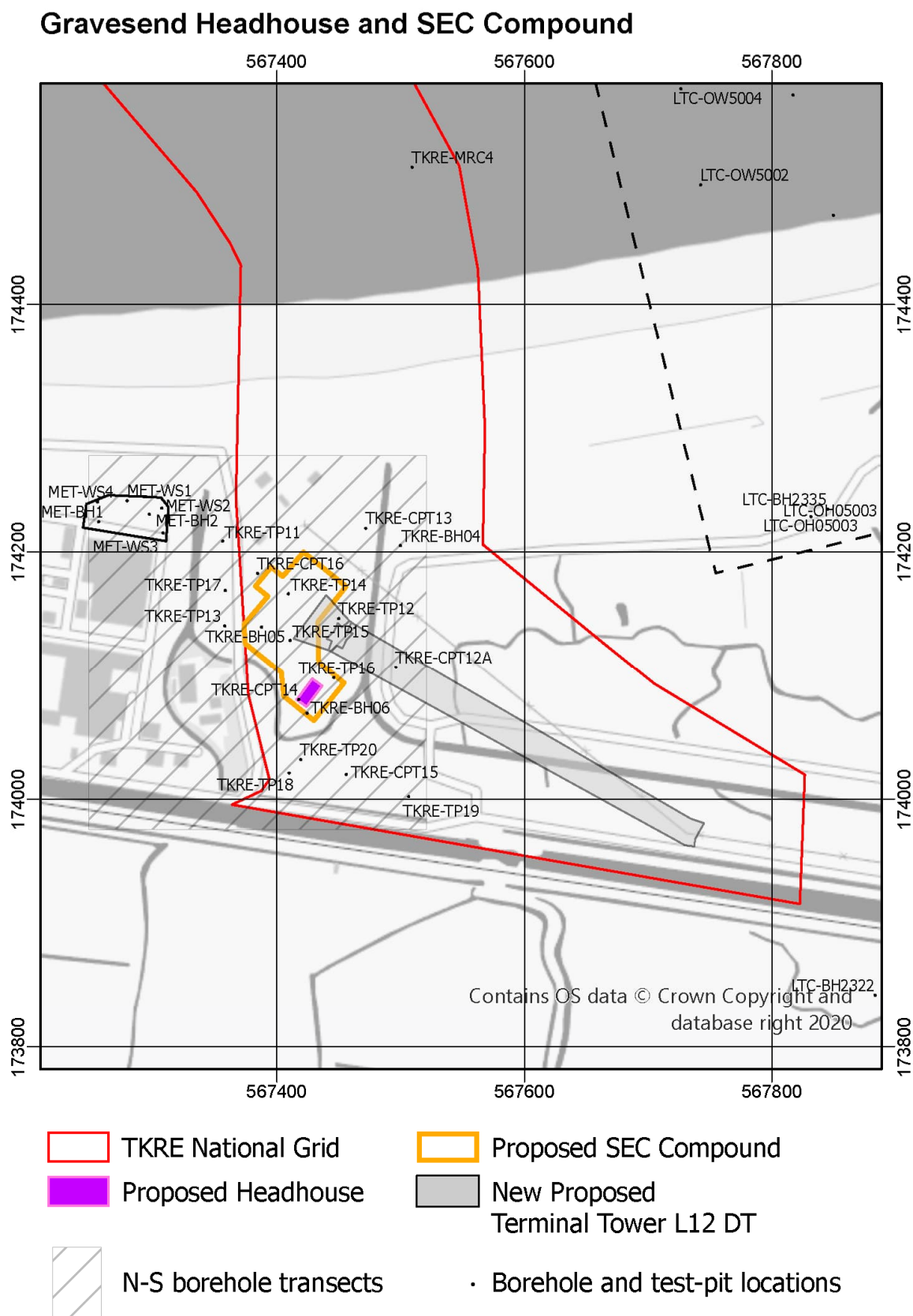


Figure 4: TKRE Gravesend Headhouse and SEC Compound locations with labelled borehole locations

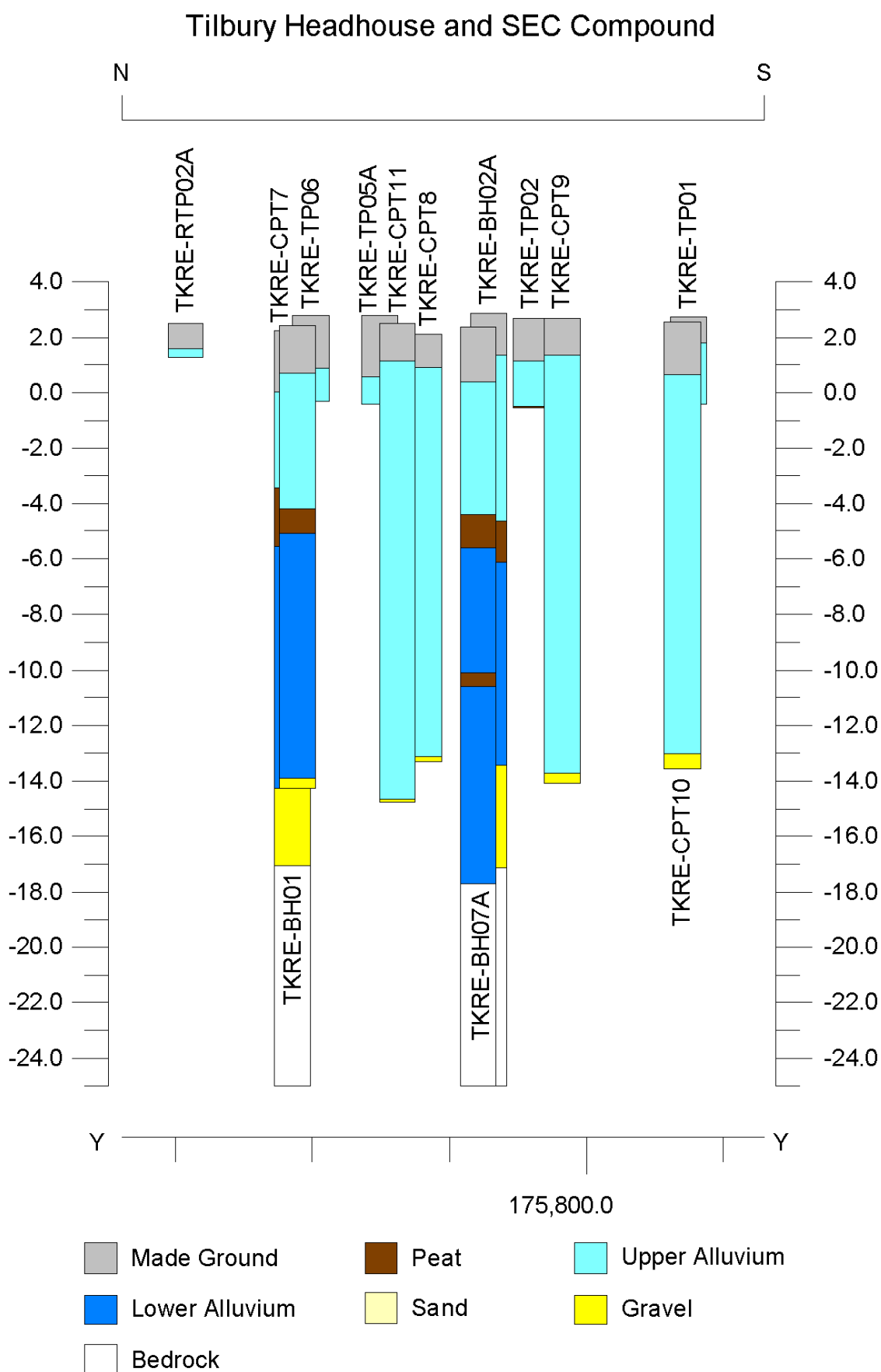


Figure 5: North-south borehole transect across Tilbury Headhouse and SEC Compound borehole transect

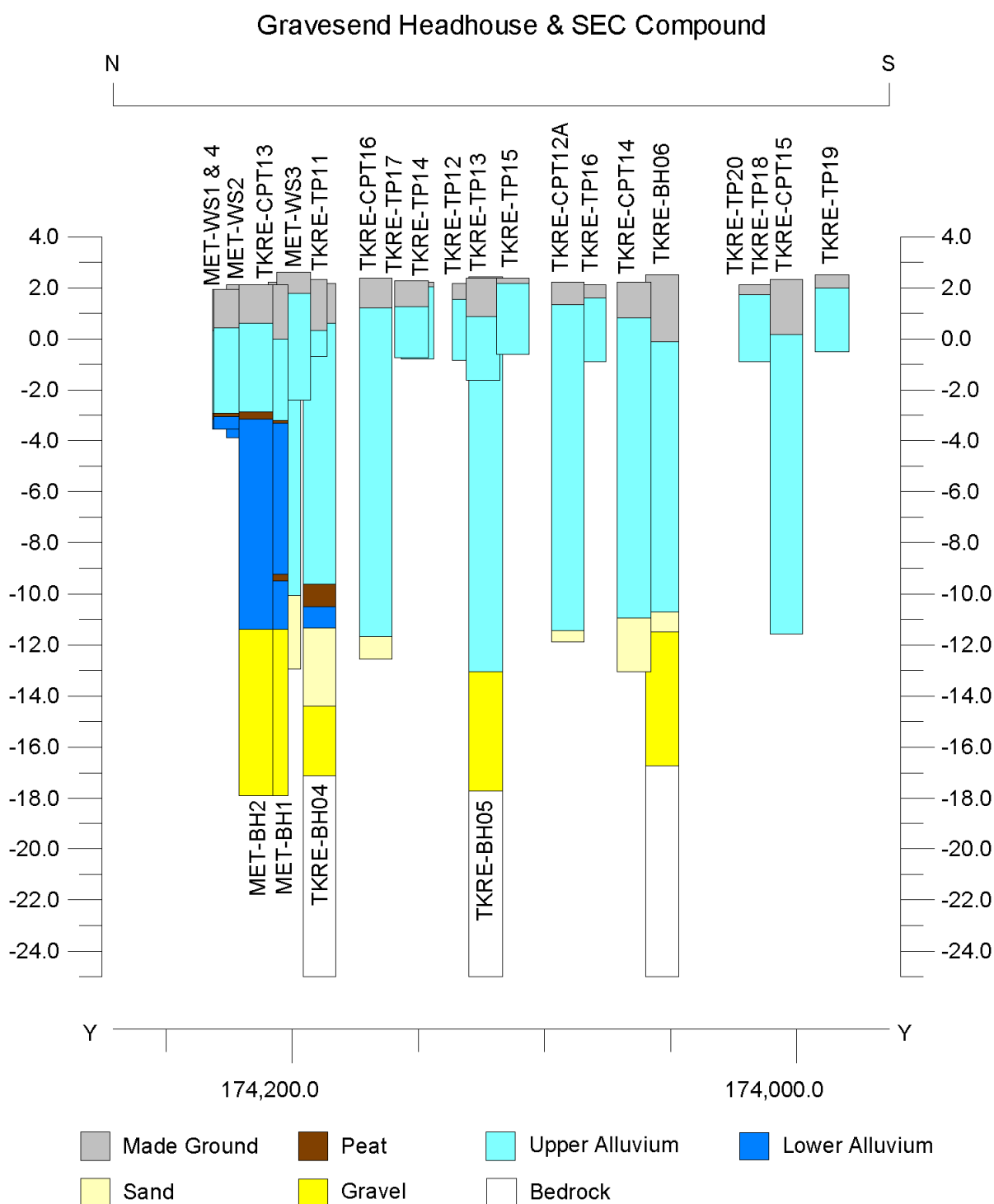


Figure 6: North-south borehole transect across Gravesend Headhouse and SEC Compound borehole transect

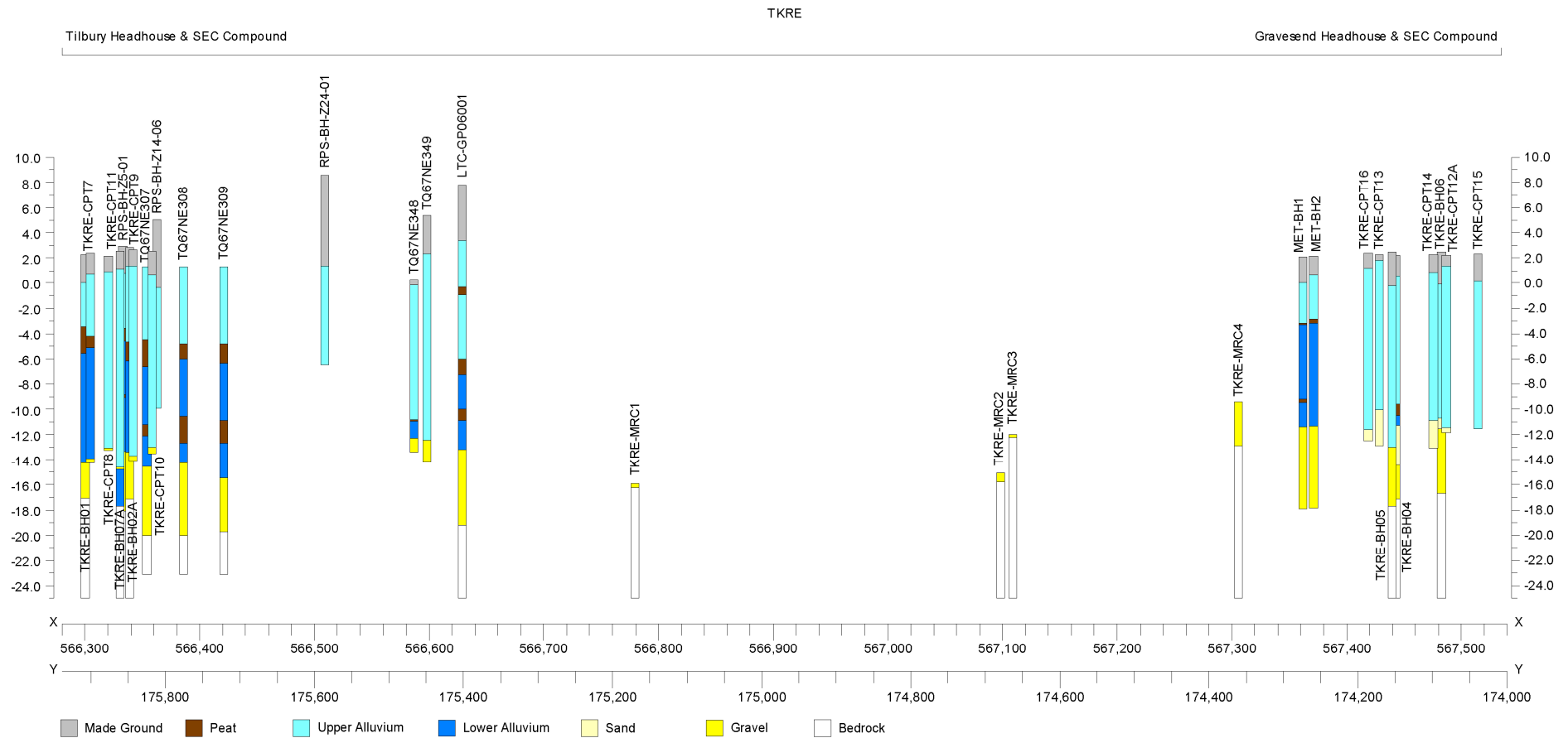


Figure 7: North-west to south-east borehole transect across the entire TKRE site

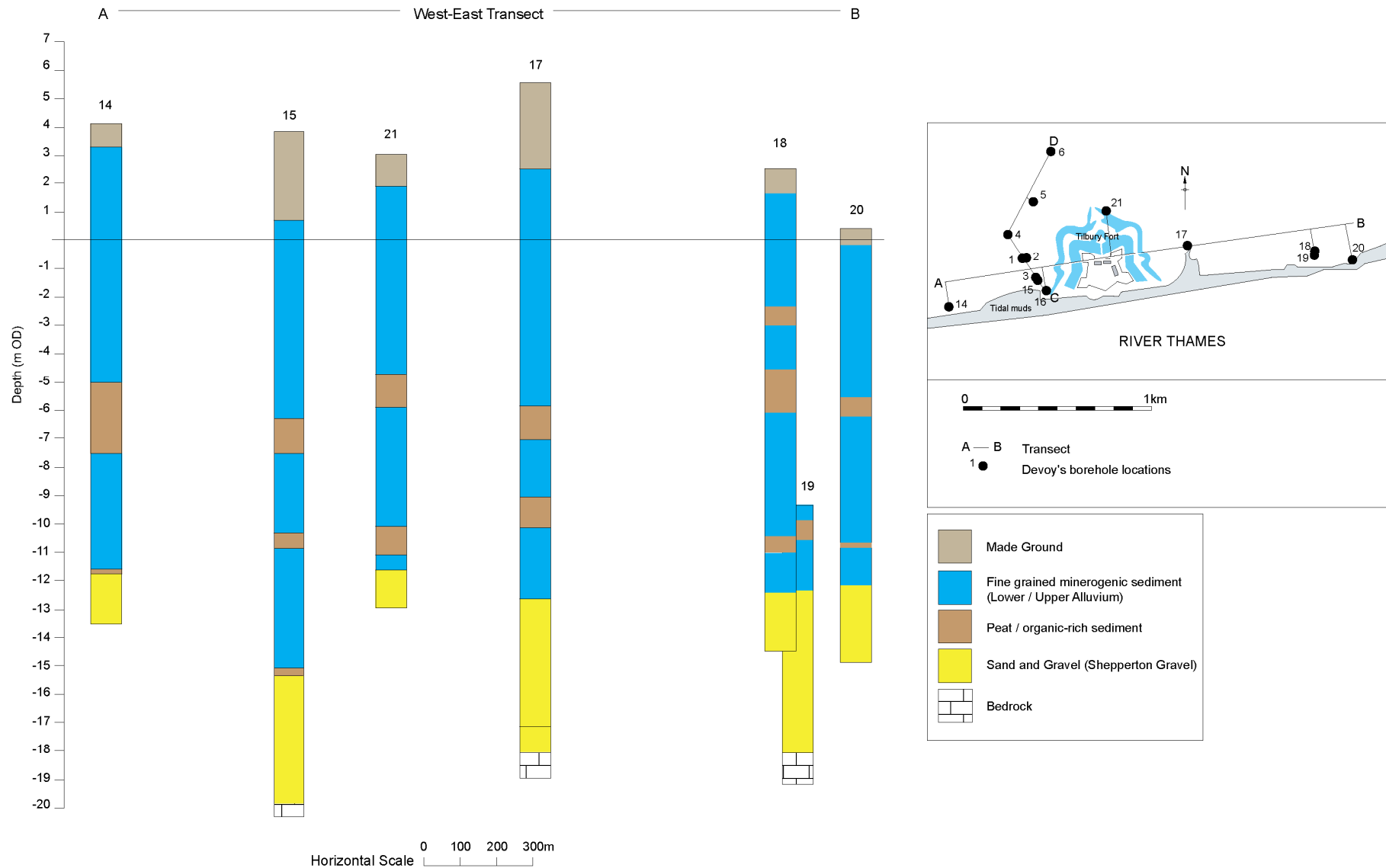


Figure 8: Devoy's west-east borehole transect orientated across Tilbury Fort, Tilbury 2 and the southern part of the Tilbury Headhouse and SEC compound site (reproduced from Devoy, 1979)

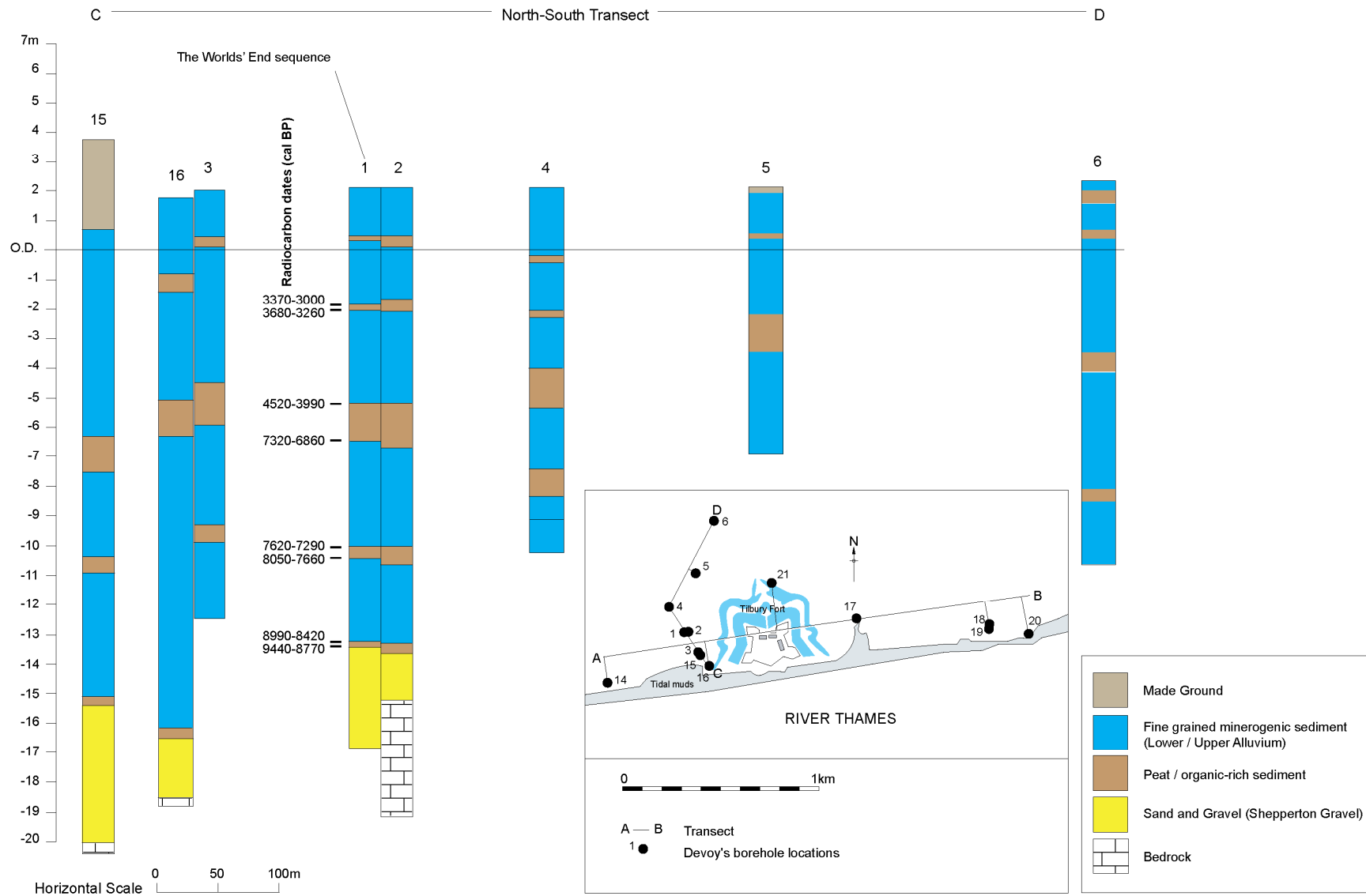


Figure 9: Devoy's north-south borehole transect orientated adjacent to Tilbury Fort, west of Tilbury Headhouse and SEC compound site (reproduced from Devoy, 1979)

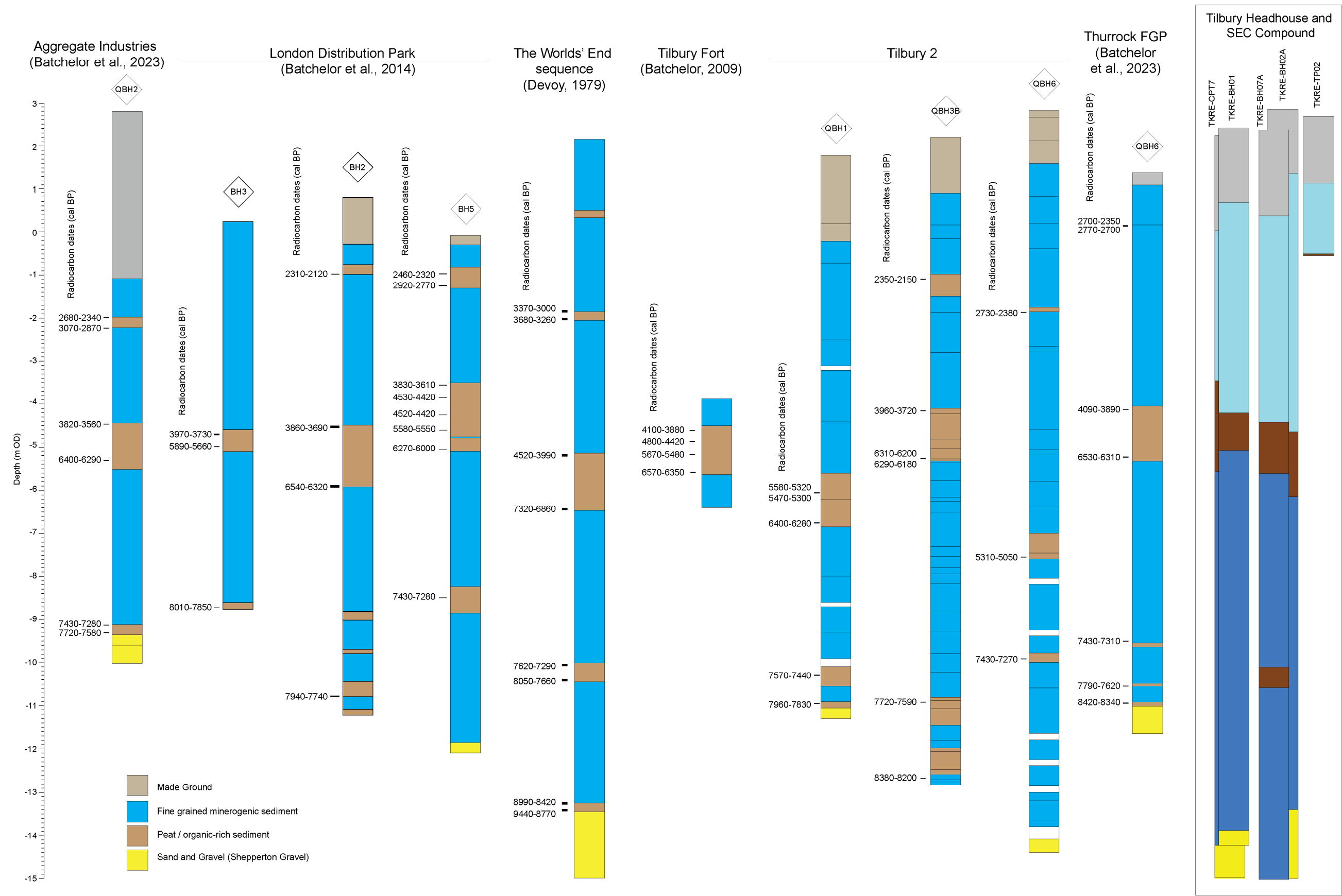


Figure 10: Radiocarbon dated sequences arranged from west to east across the Tilbury area. Also displaying selected sequences from the Tilbury Headhouse and SEC Compound for comparative purposes

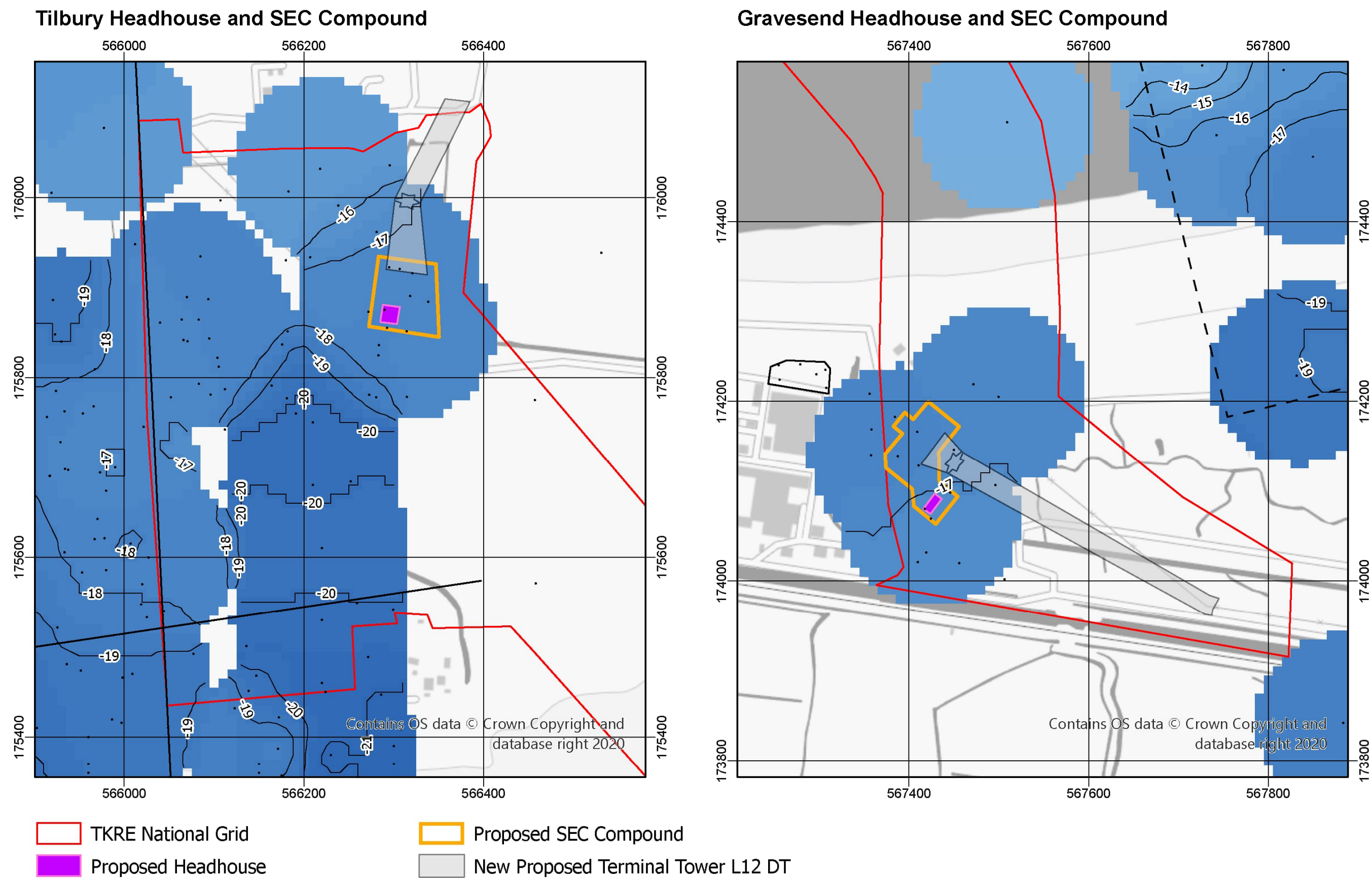


Figure 11: Bedrock surface (m OD) across the Tilbury & Gravesend Headhouse and SEC Compound sites

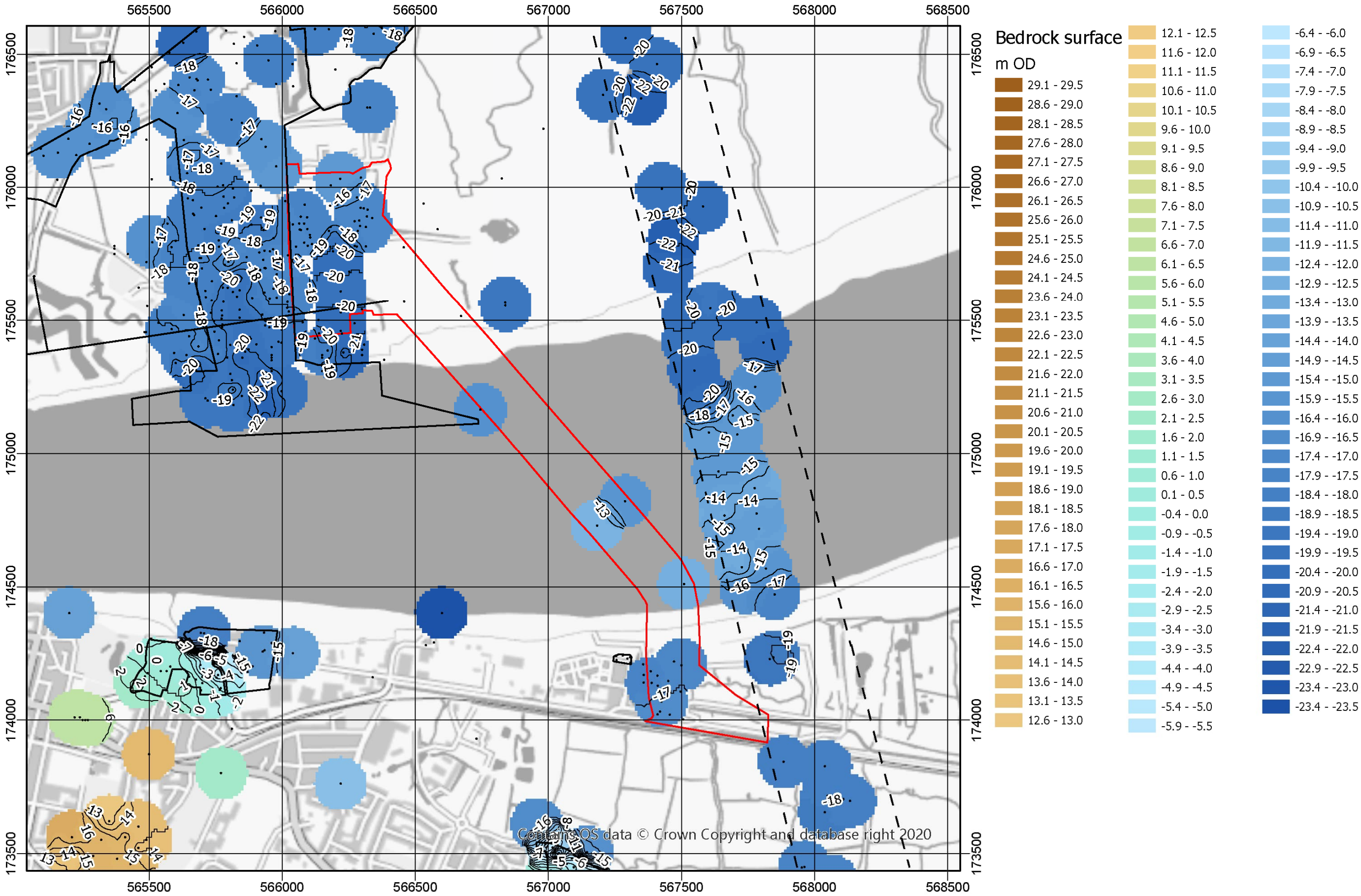
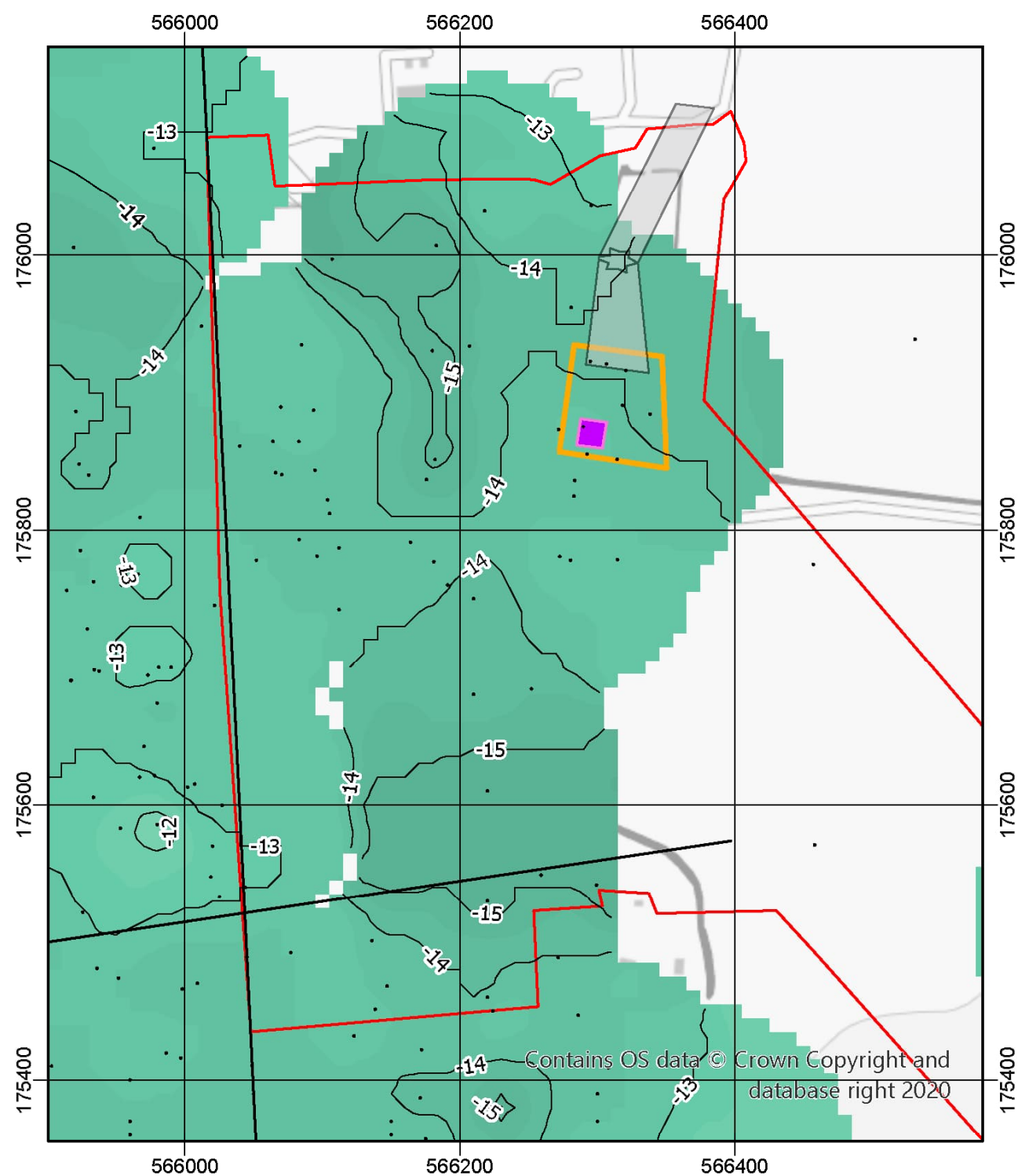
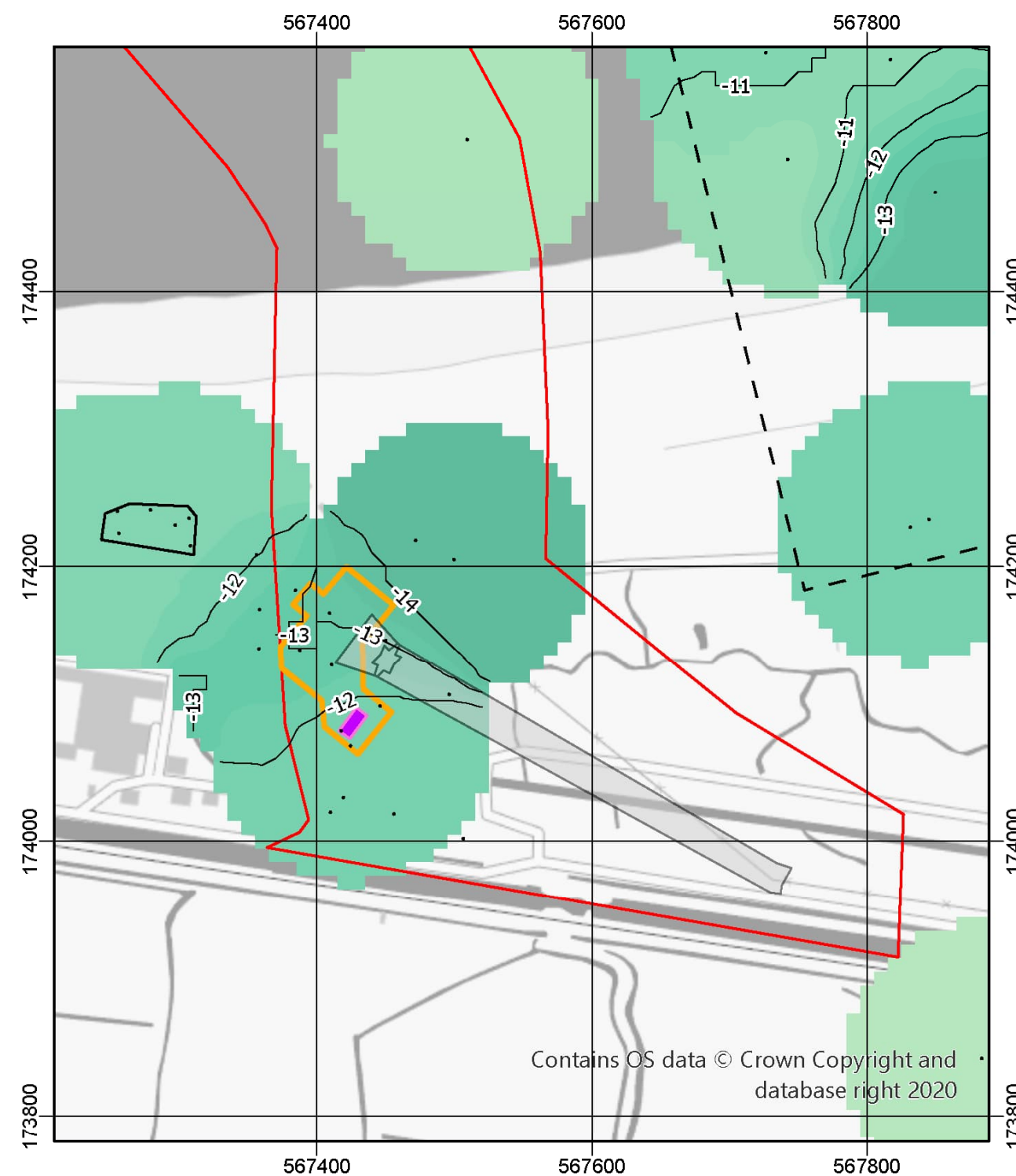


Figure 12: Bedrock surface (m OD) across the TKRE site and wider area

Tilbury Headhouse and SEC Compound



Gravesend Headhouse and SEC Compound



- TKRE National Grid
- Proposed SEC Compound
- Proposed Headhouse
- New Proposed Terminal Tower L12 DT

For colour scheme see Gravel surface for the wider area

Figure 13: Gravel surface (m OD) across the Tilbury & Gravesend Headhouse and SEC Compound sites

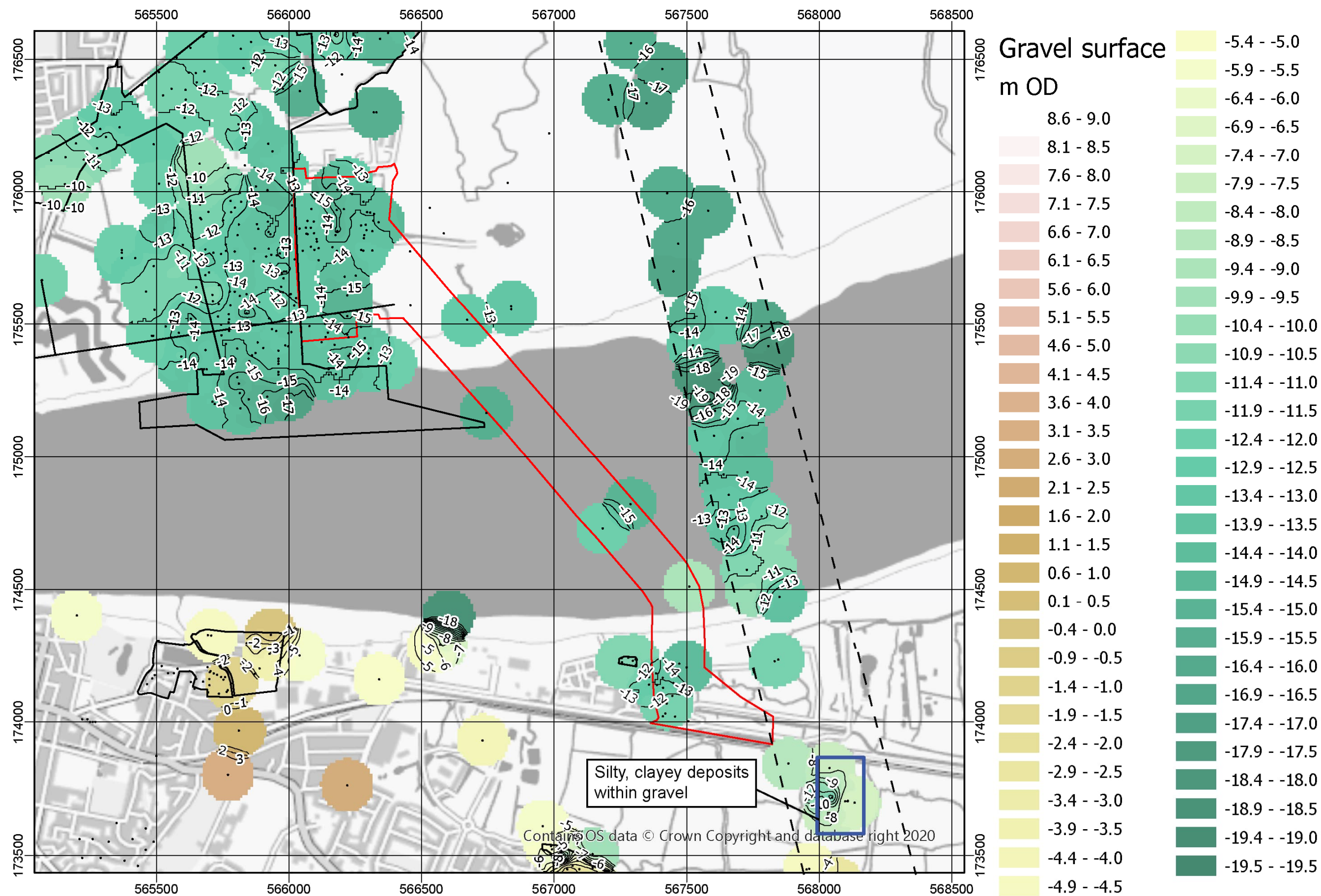
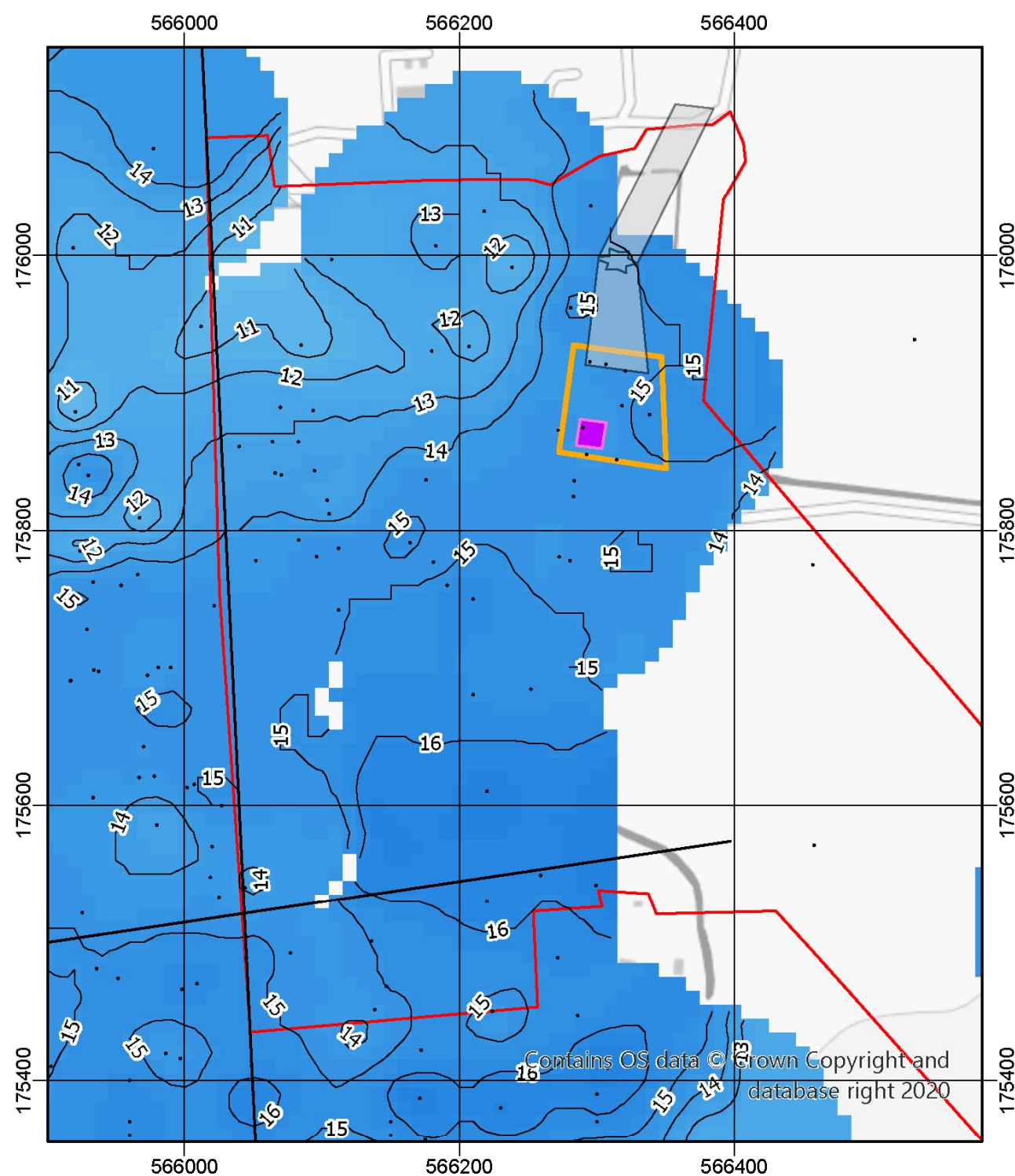
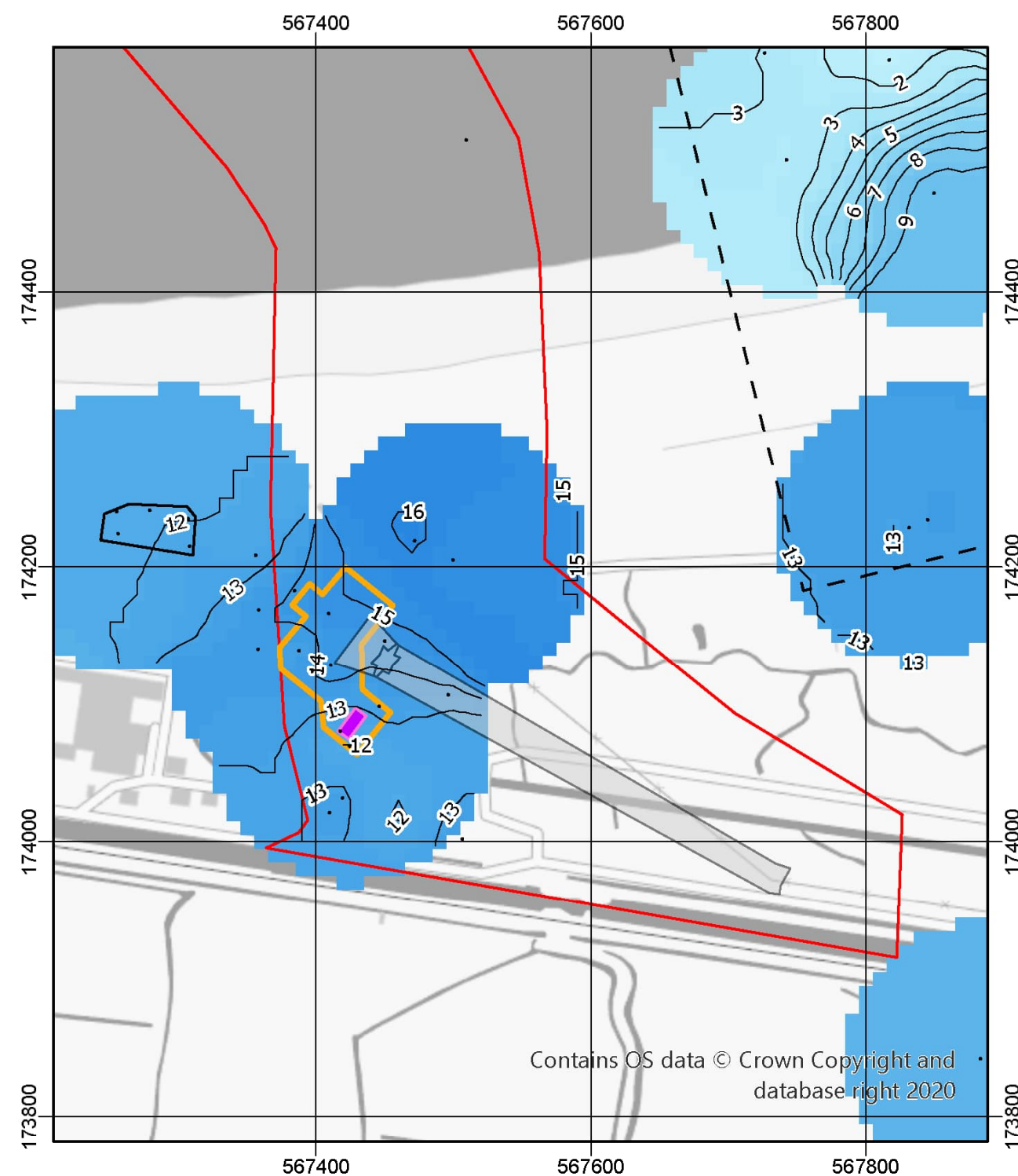


Figure 14: Gravel surface (m OD) across the TKRE site and wider area

Tilbury Headhouse and SEC Compound



Gravesend Headhouse and SEC Compound



- TKRE National Grid
- Proposed SEC Compound
- Proposed Headhouse
- New Proposed Terminal Tower L12 DT

For colour scheme see Total Alluvium thickness for the wider area

Figure 15: Total Alluvium thickness (m) (inclusive of Lower & Upper Alluvium, Lower, Middle and Upper Peats) across the Tilbury & Gravesend Headhouse and SEC Compound sites

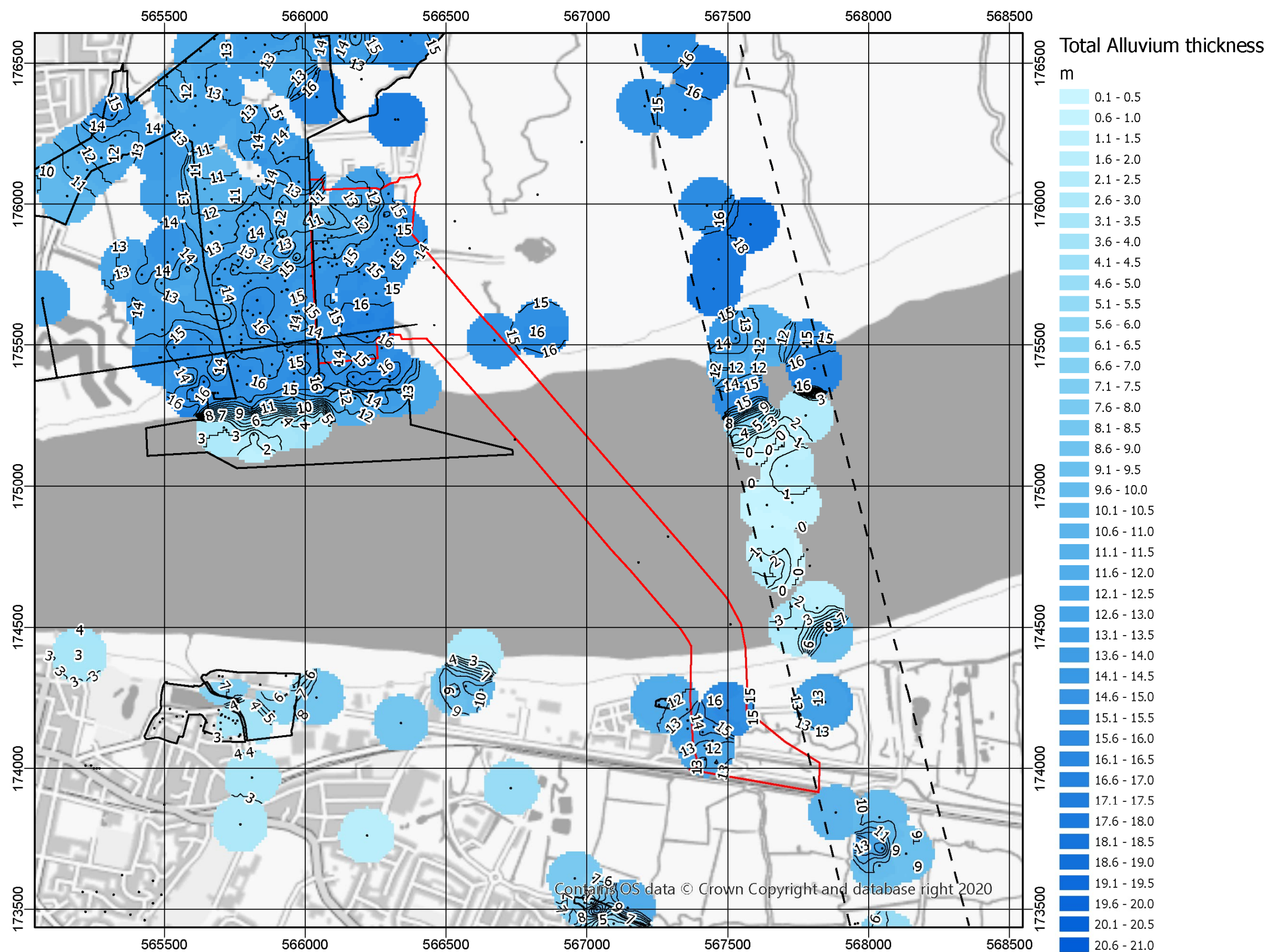


Figure 16: Total Alluvium thickness (m) (inclusive of Lower & Upper Alluvium, Lower, Middle and Upper Peats) across the TKRE site and wider area

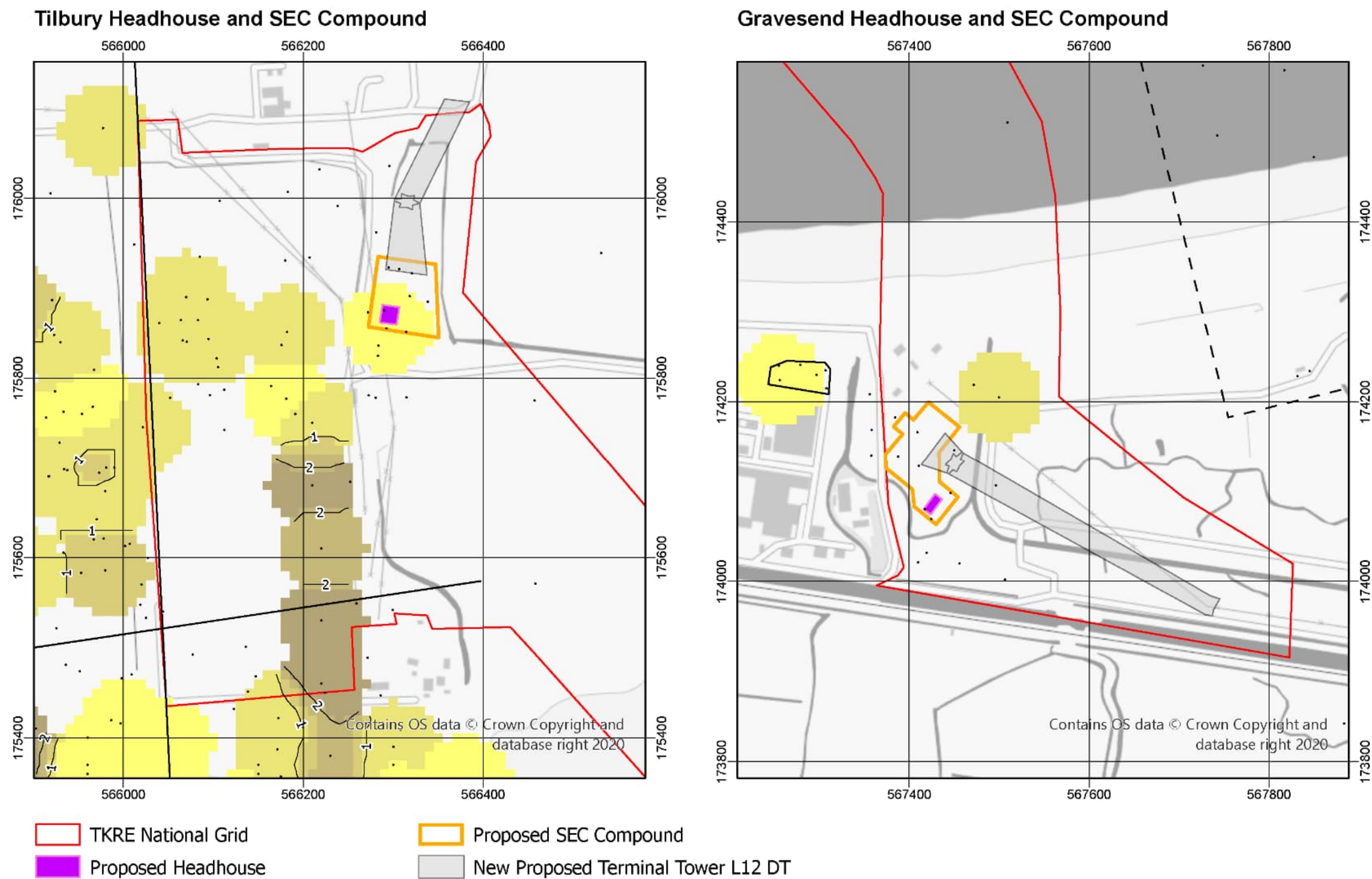


Figure 17: Lower Peat thickness (m) across the Tilbury & Gravesend Headhouse and SEC Compound sites



Figure 18: Lower Peat surface (m OD) across the Tilbury & Gravesend Headhouse and SEC Compound sites

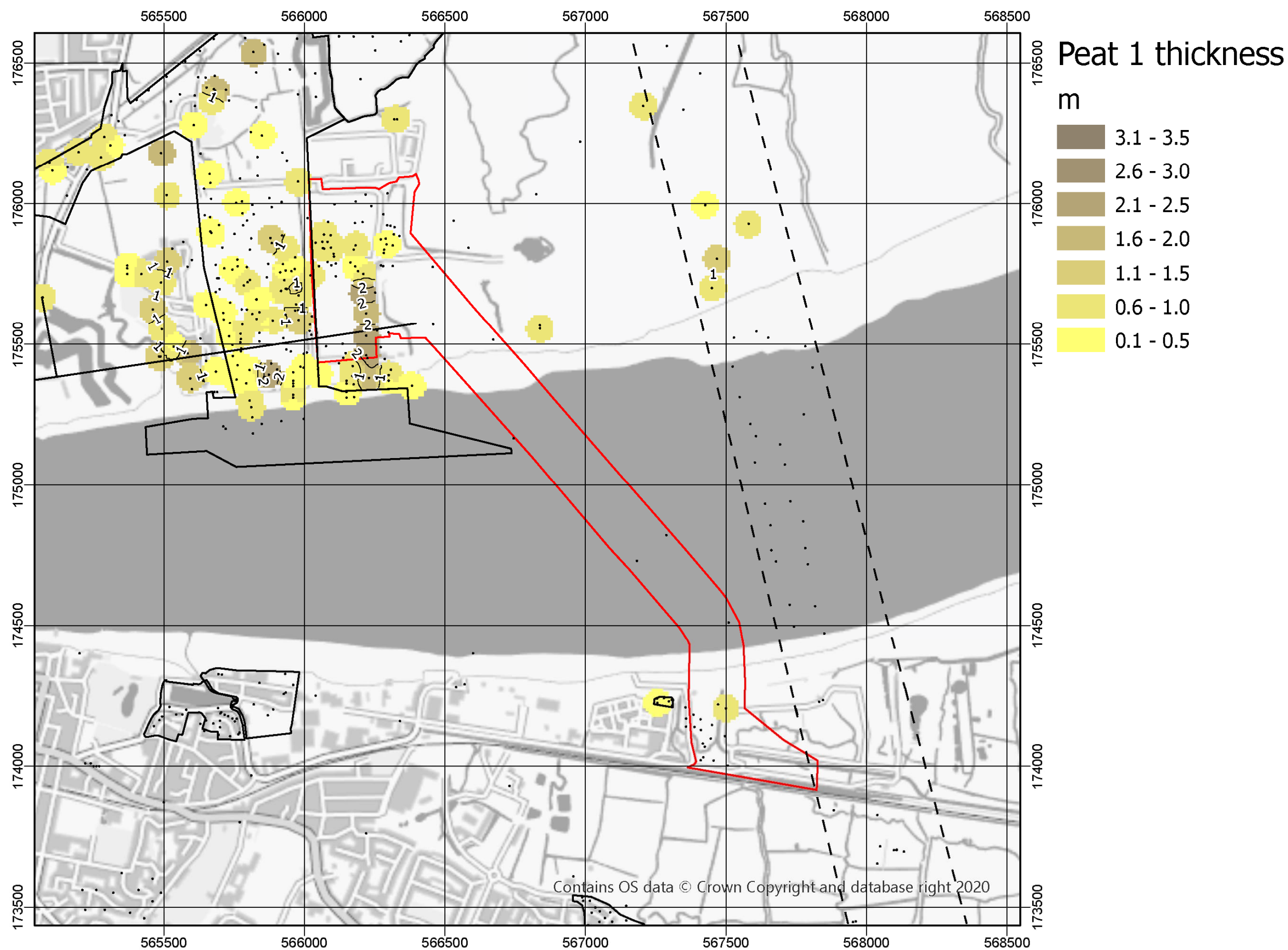


Figure 19: Lower Peat thickness (m) across the TKRE site and wider area

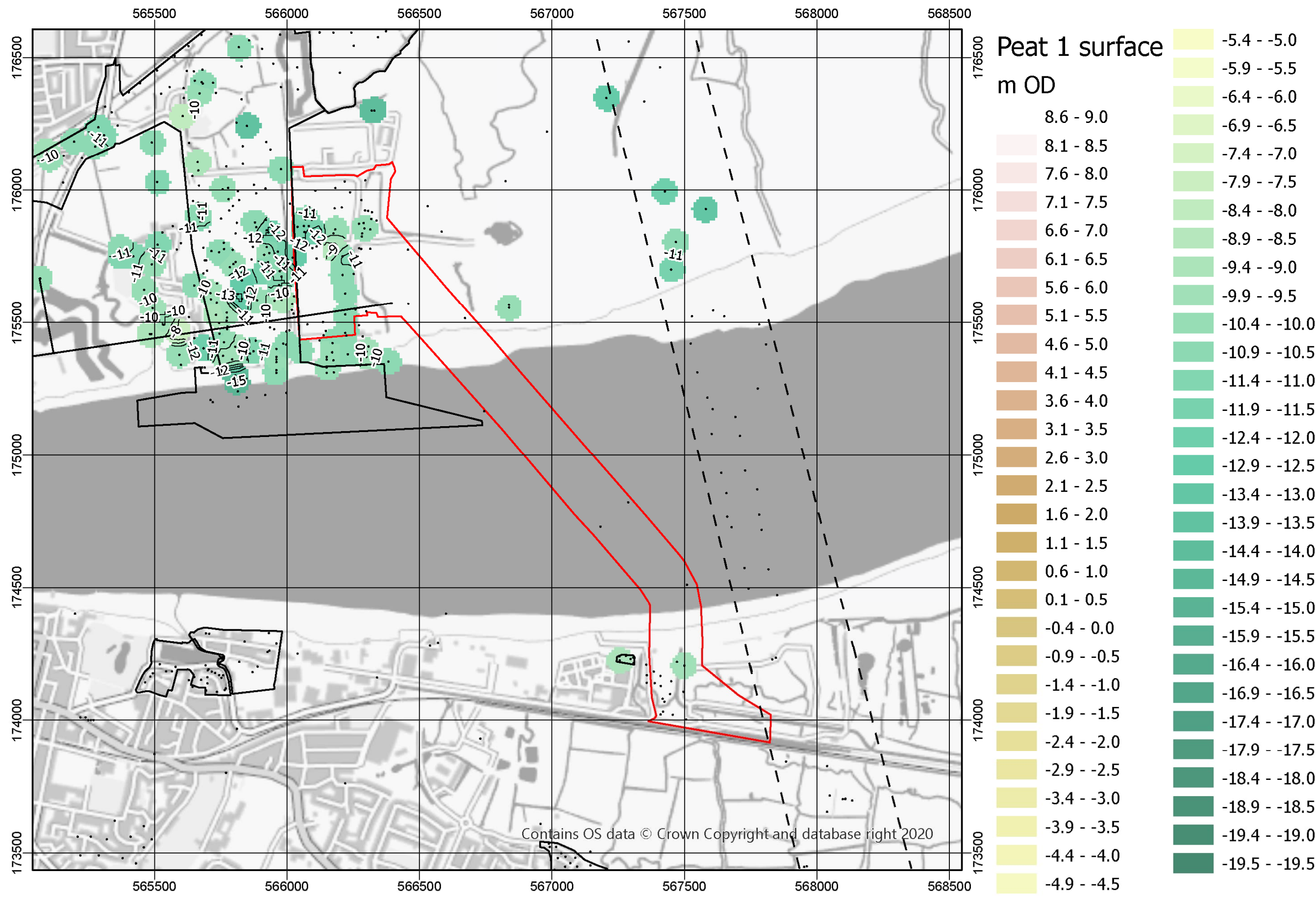
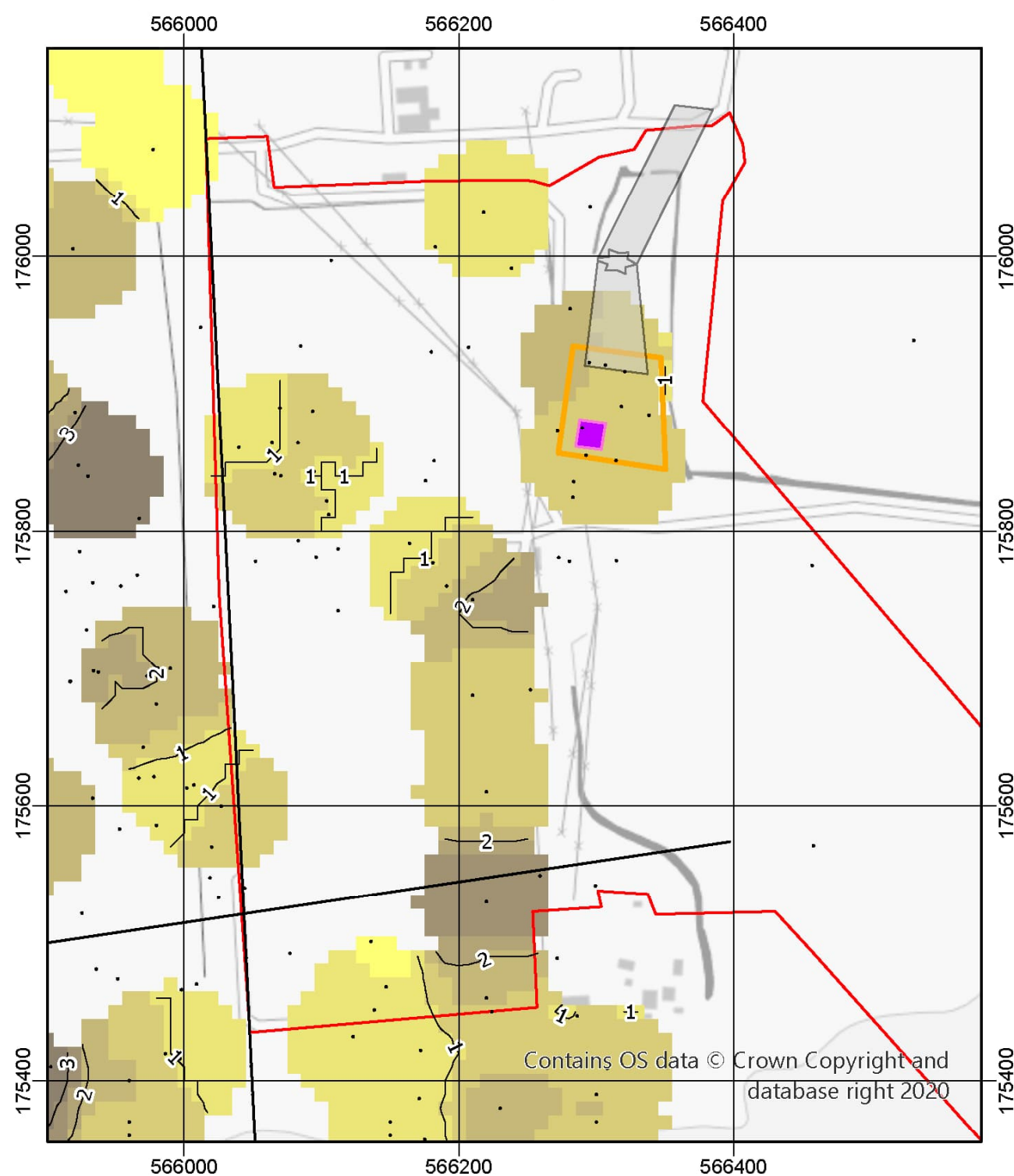


Figure 20: Lower Peat surface (m OD) across the TKRE site and wider area

Tilbury Headhouse and SEC Compound



TKRE National Grid
Proposed Headhouse

Proposed SEC Compound
New Proposed Terminal Tower L12 DT

For colour scheme see Peat thickness for the wider area

Gravesend Headhouse and SEC Compound

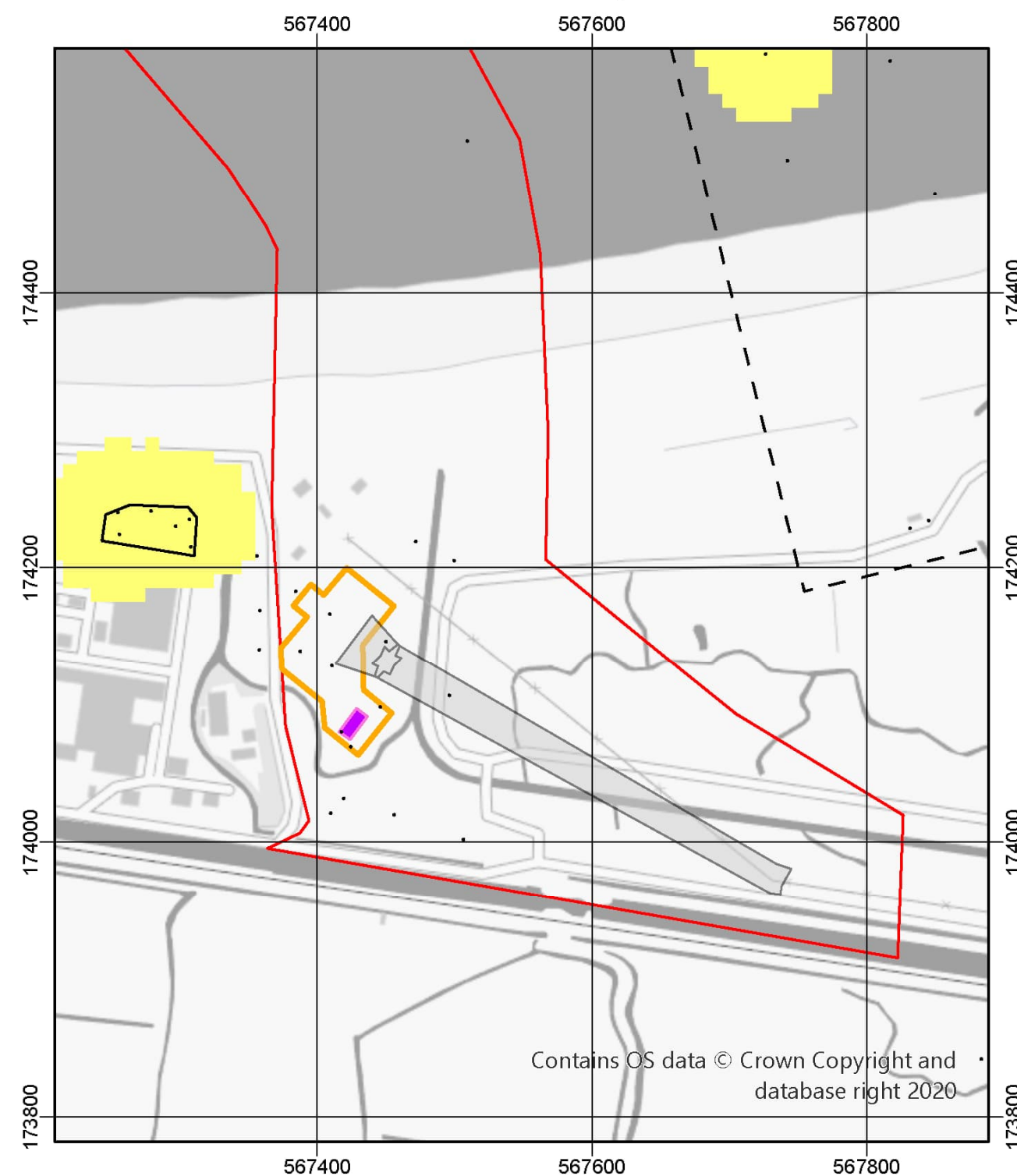


Figure 21: Middle Peat thickness (m) across the Tilbury & Gravesend Headhouse and SEC Compound sites

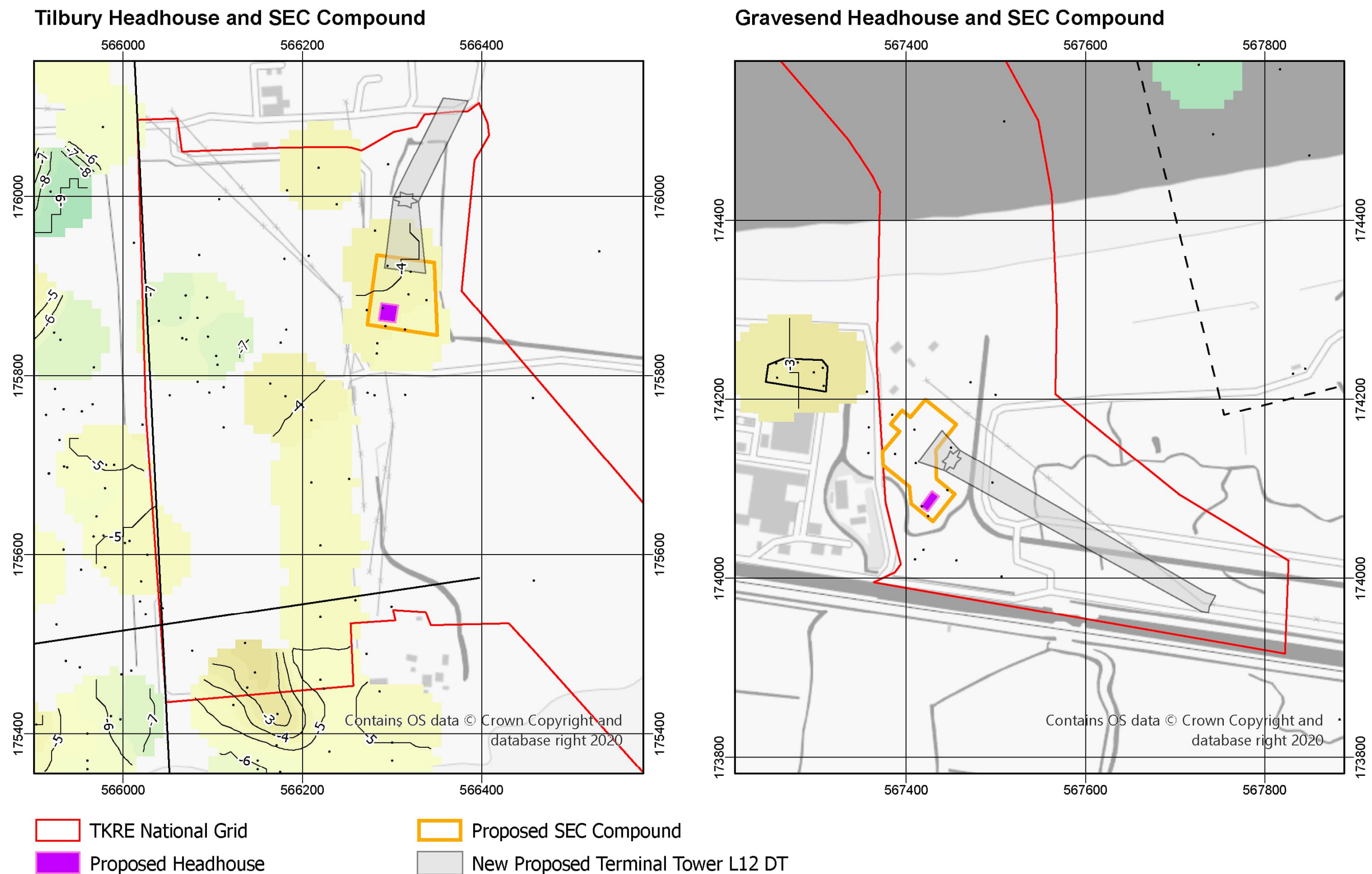


Figure 22: Middle Peat surface (m OD) across the Tilbury & Gravesend Headhouse and SEC Compound sites

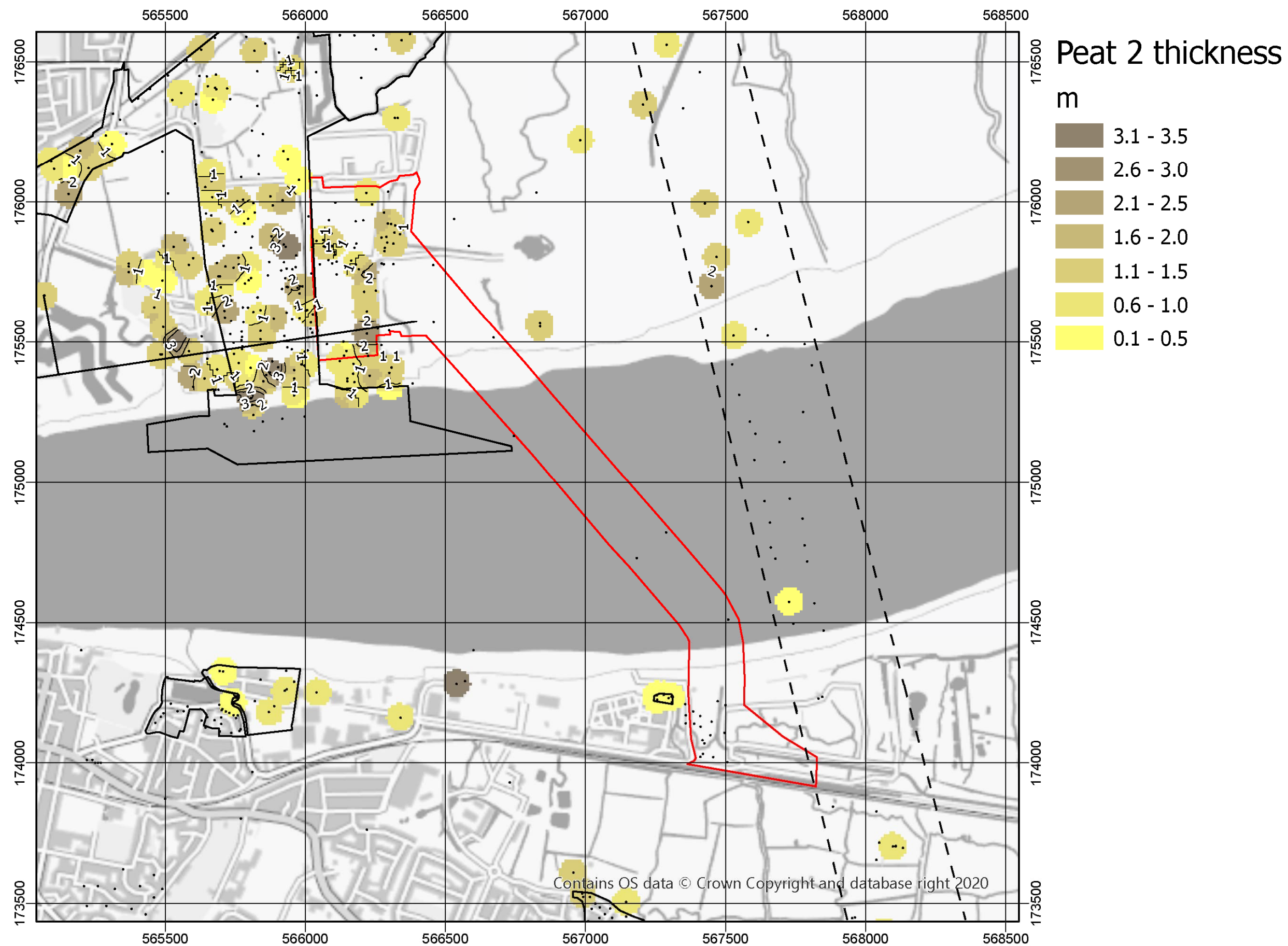


Figure 23: Middle Peat thickness (m) across the TKRE site and wider area

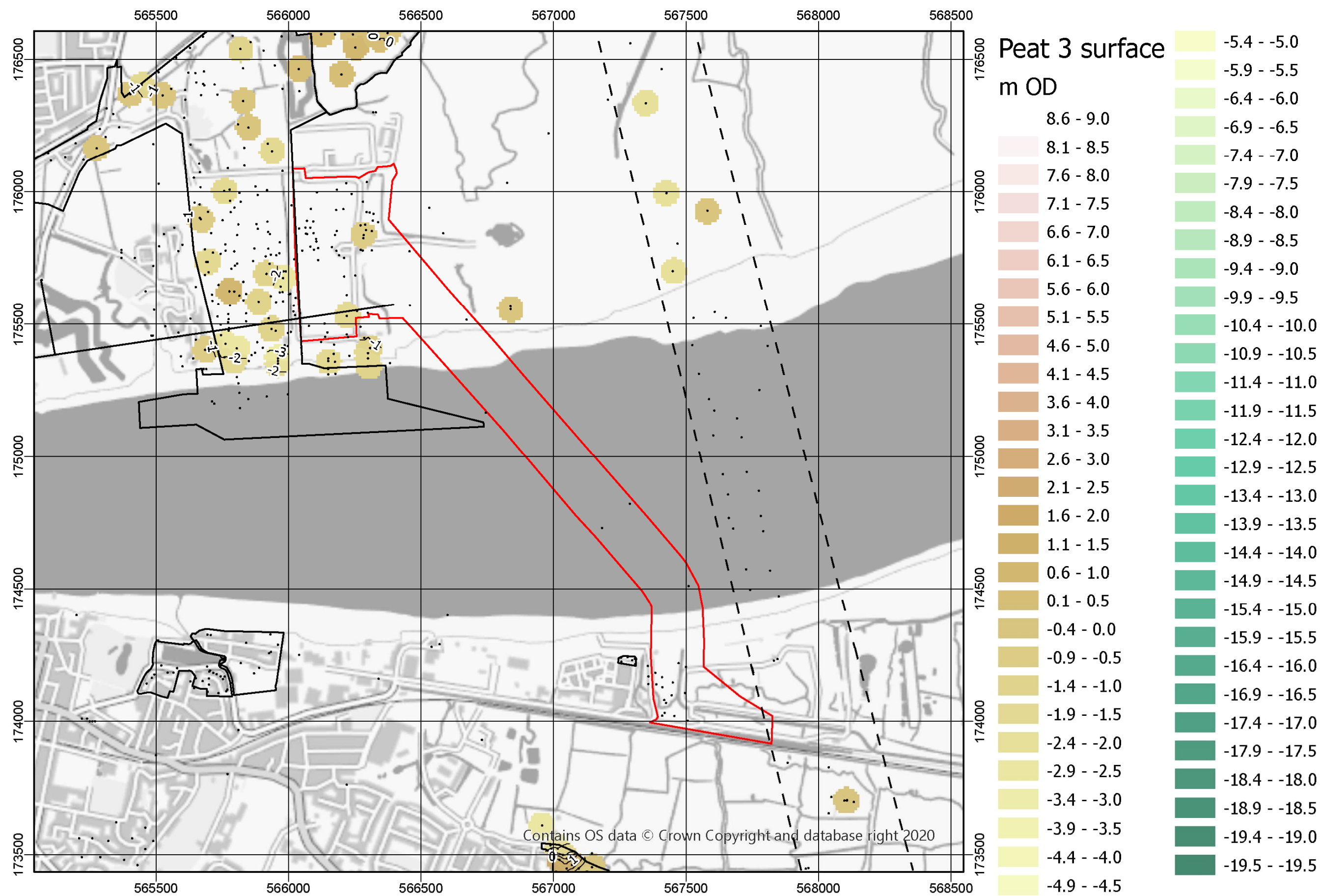


Figure 24: Middle Peat surface (m OD) across the TKRE site and wider area

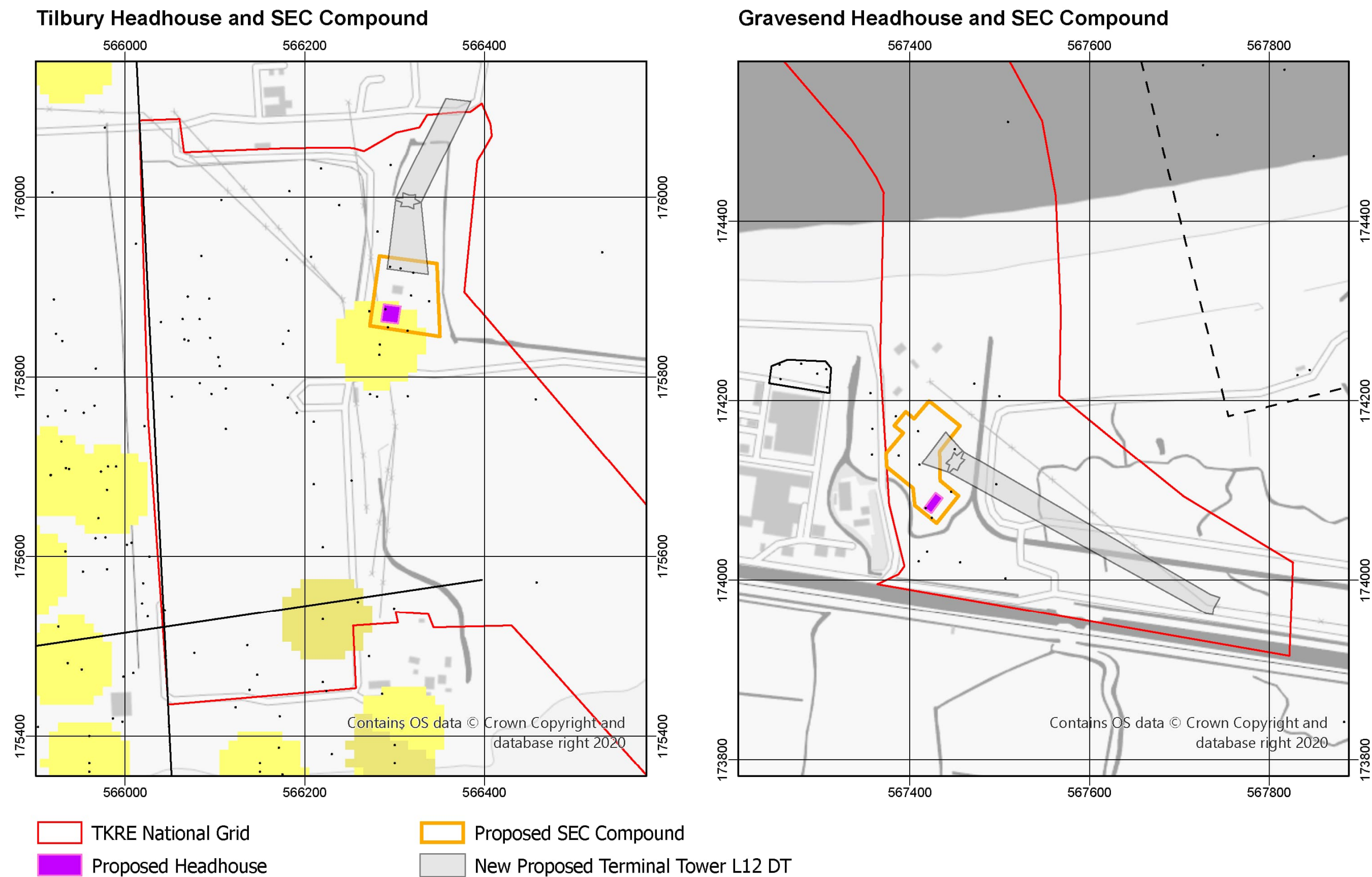


Figure 25: Upper Peat thickness (m) across the Tilbury & Gravesend Headhouse and SEC Compound sites



For colour scheme see Peat surface for the wider area
 Figure 26: Upper Peat surface (m OD) across the Tilbury & Gravesend Headhouse and SEC Compound sites

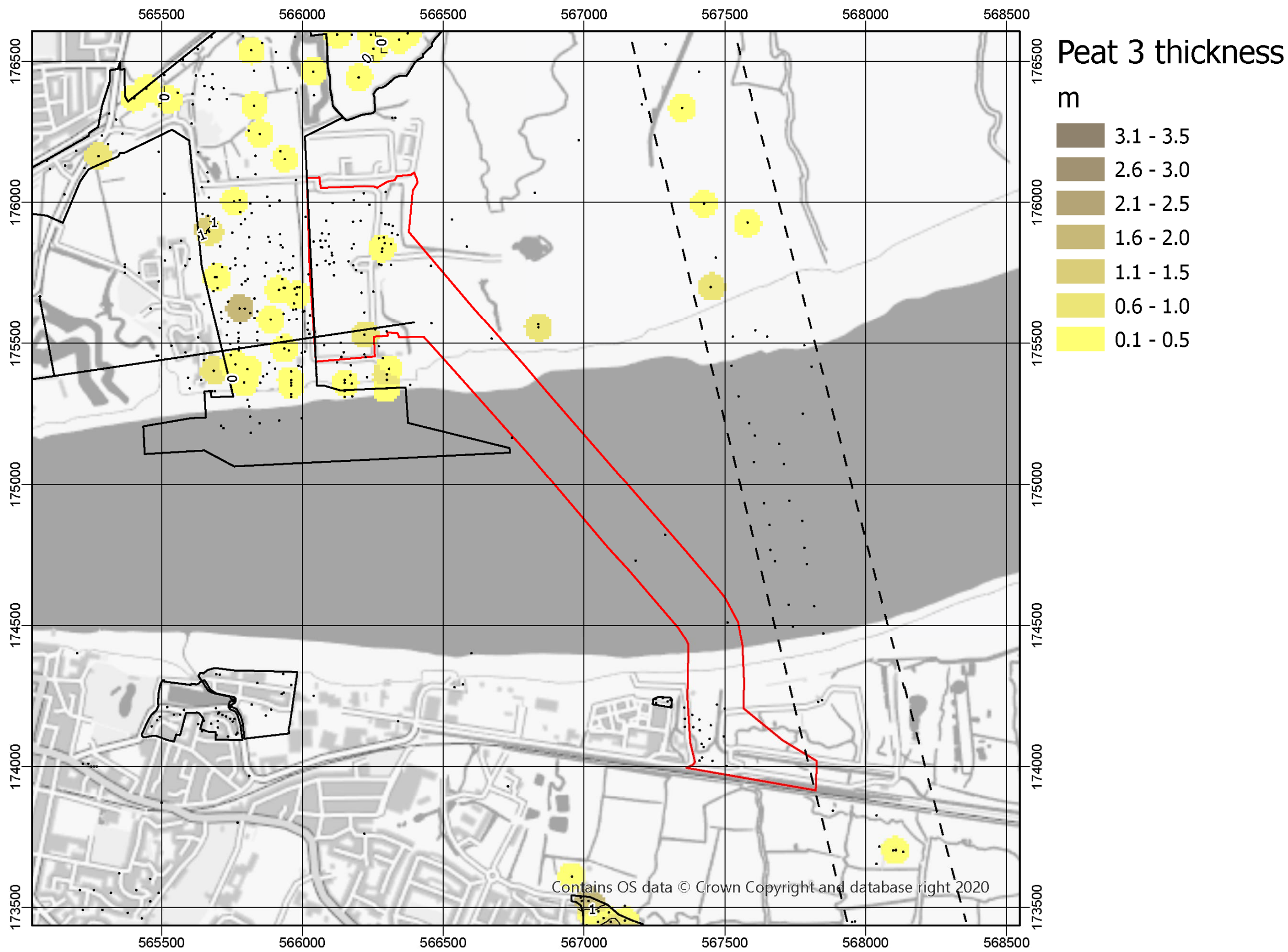


Figure 27: Upper Peat thickness (m) across the TKRE site and wider area

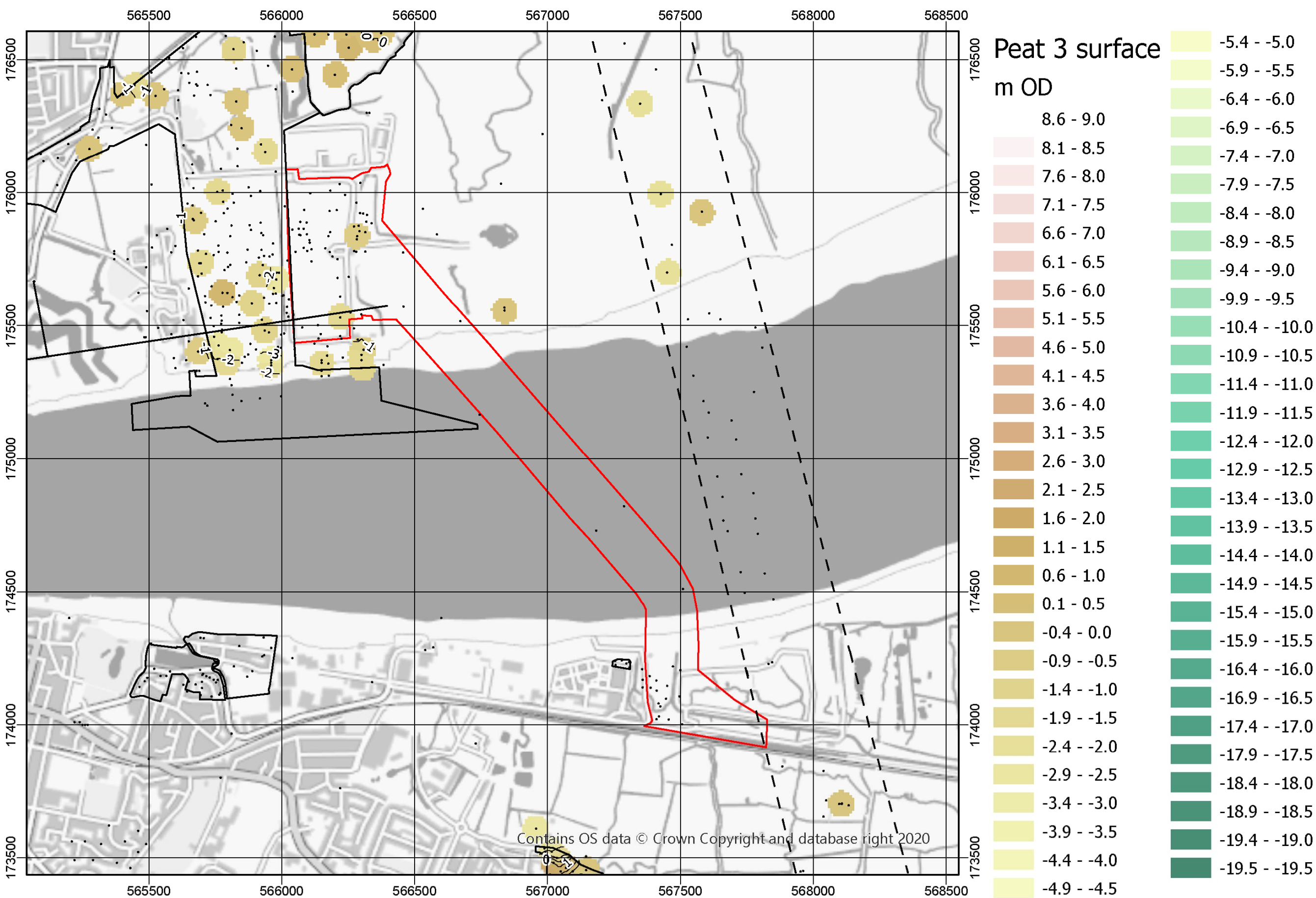
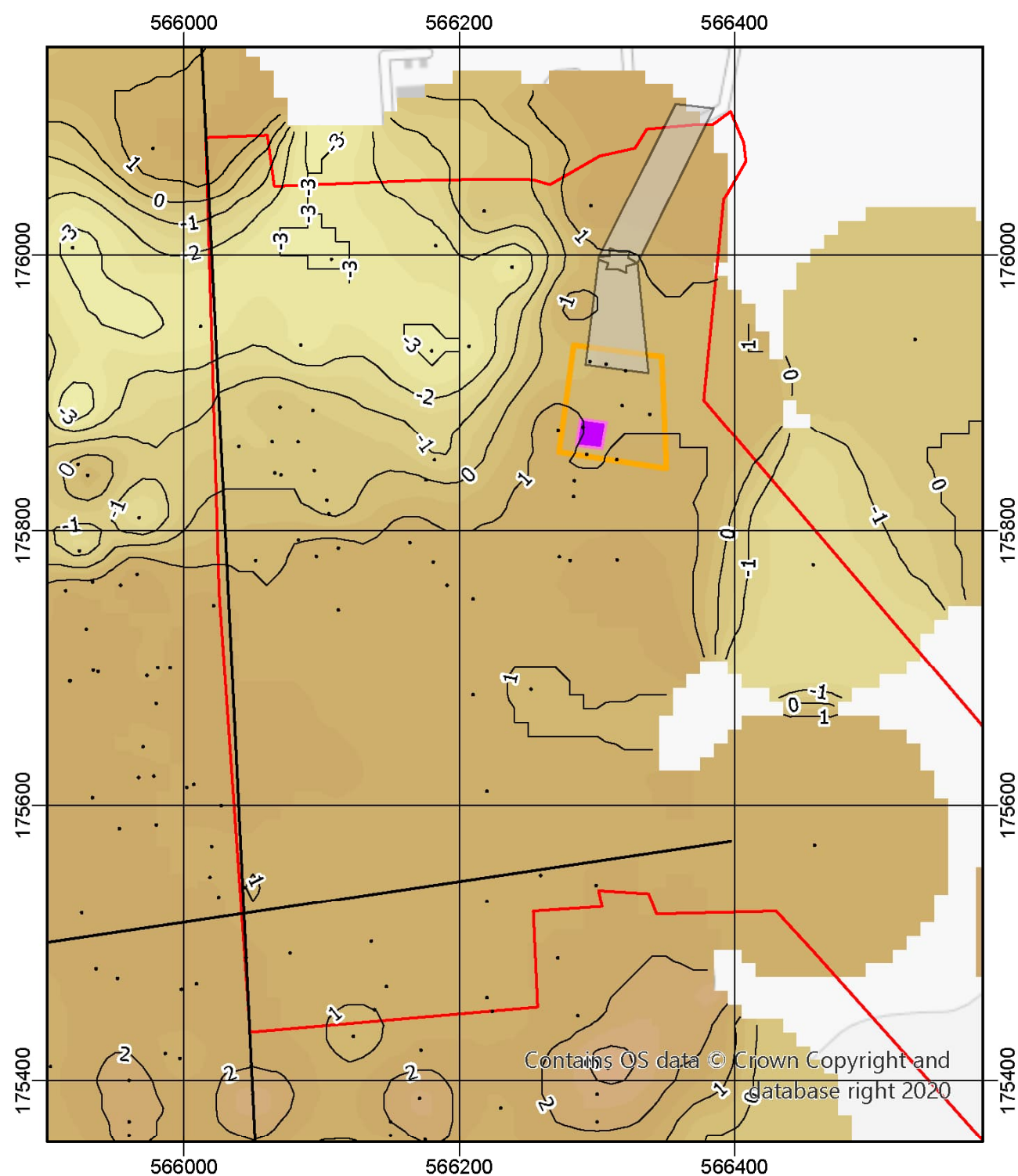
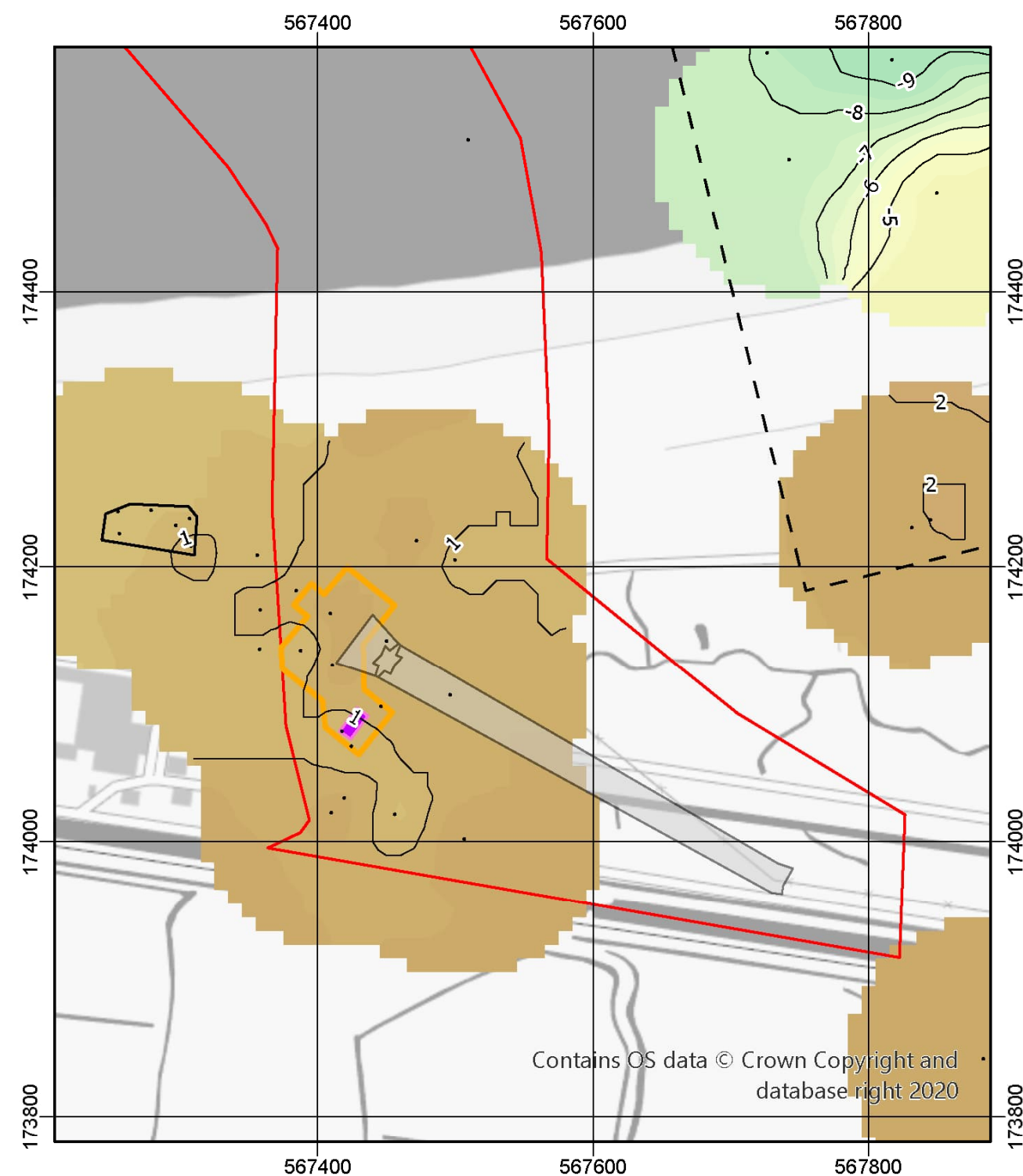


Figure 28: Upper Peat surface (m OD) across the TKRE site and wider area

Tilbury Headhouse and SEC Compound



Gravesend Headhouse and SEC Compound



- TKRE National Grid
- Proposed SEC Compound
- Proposed Headhouse
- New Proposed Terminal Tower L12 DT

For colour scheme see Upper Alluvium surface for the wider area

Figure 29: Alluvium surface (m OD) across the Tilbury & Gravesend Headhouse and SEC Compound sites

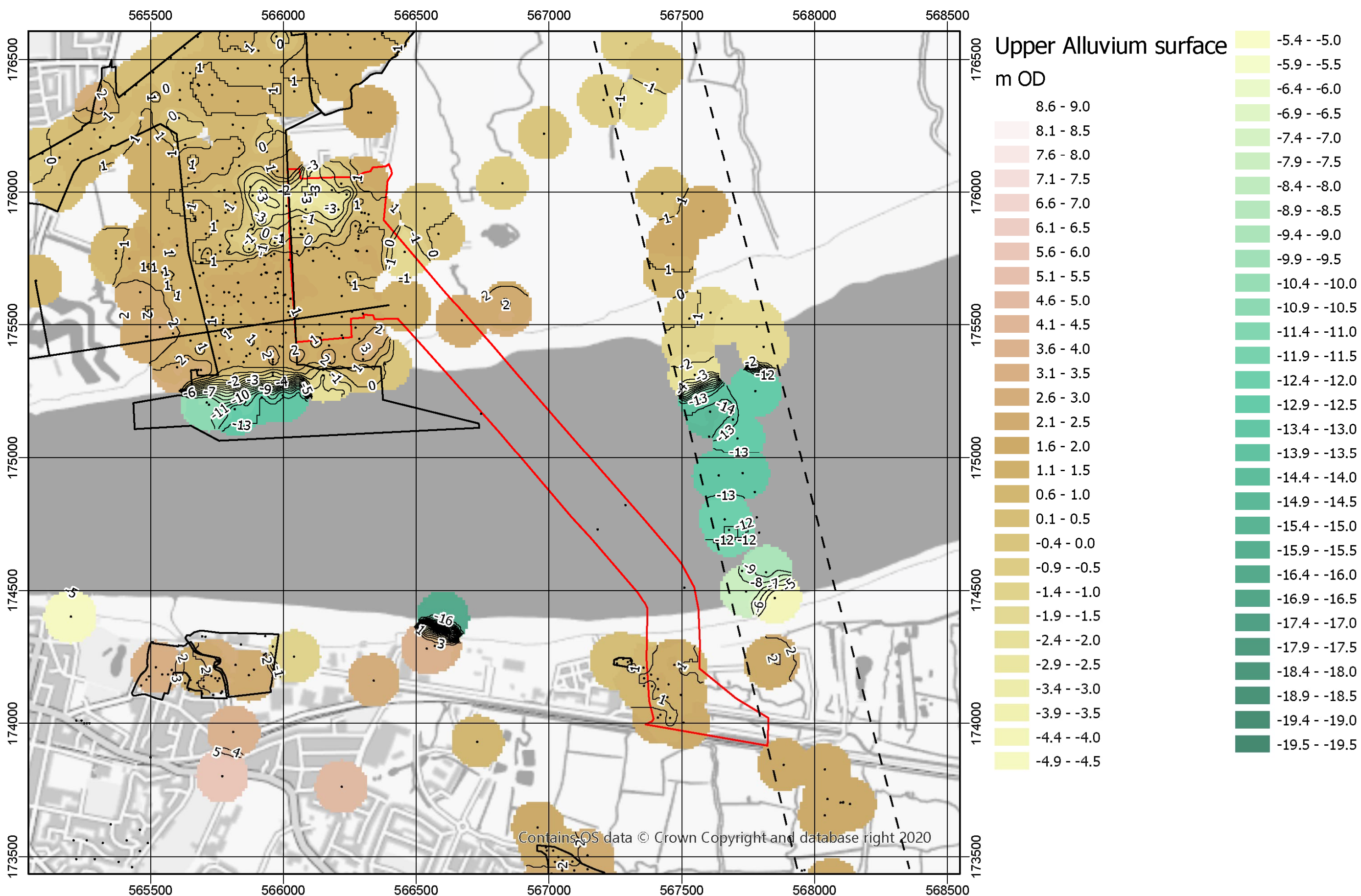


Figure 30: Alluvium surface (m OD) across the TKRE site and wider area

Tilbury Headhouse and SEC Compound



- TKRE National Grid
- Proposed SEC Compound
- Proposed Headhouse
- New Proposed Terminal Tower L12 DT

For colour scheme see Made Ground thickness for the wider area

Gravesend Headhouse and SEC Compound

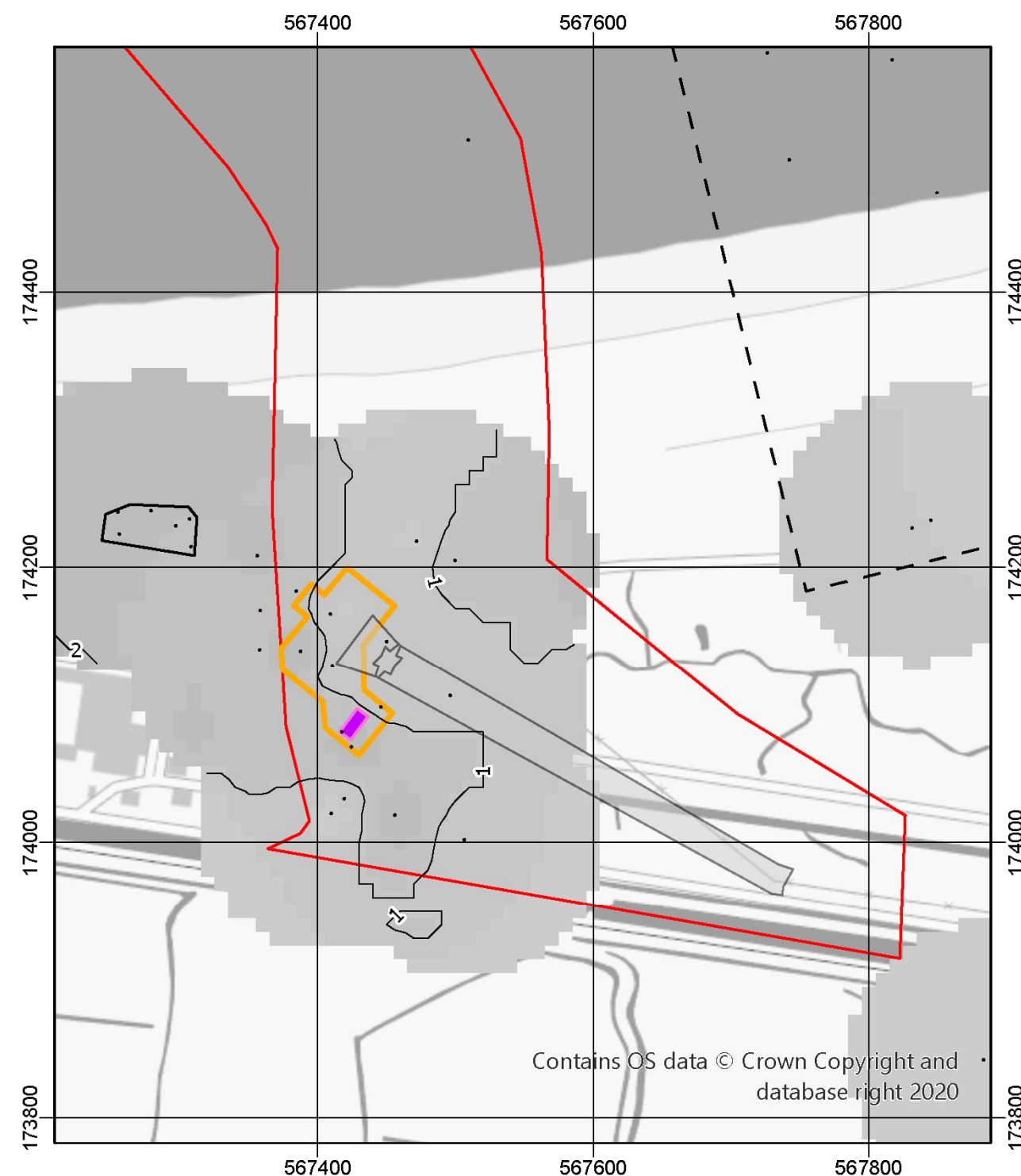


Figure 31: Top-soil / Made Ground thickness (m) across the Tilbury & Gravesend Headhouse and SEC Compound sites



Figure 32: Top-soil / Made Ground thickness (m) across the TKRE site and wider area

