A REPORT ON THE GEOARCHAEOLOGICAL BOREHOLE INVESTIGATIONS AND DEPOSIT MODELLING ON LAND AT ALCATEL-LUCENT TELEGRAPH WORKS, BLACKWALL LANE, LONDON BOROUGH OF GREENWICH SE10 (SITE CODE: BLW15)

D.S. Young & C.R. Batchelor
Quaternary Scientific (QUEST), *School of Human and Environmental Sciences, University of Reading, Whiteknights, PO Box 227, Reading, RG6 6AB, UK*

INTRODUCTION

This report summarises the findings arising out of the geoarchaeological fieldwork and deposit modelling undertaken by Quaternary Scientific (University of Reading) in connection with the proposed development at the Alcatel-Lucent Telegraph Works, Blackwall Lane, London Borough of Greenwich SE10 (National Grid Reference centred on: TQ 3841 7866; Figures 1 and 2). The site is located towards the south-western corner of Greenwich Peninsula, bounded to the west by the River Thames and to the east by Blackwall Lane (Figure 1). Greenwich Peninsula is formed and bounded by a meander of the Thames to the west, east and north of the site, and lies opposite the confluence of the River Lea. The ground across the area originally formed part of the natural floodplain of the Thames, and is underlain by river alluvium (British Geological Survey 1:50,000 sheets 256 North London 1993, 257 Romford 1996, 270 South London 1998, 271 Dartford 1998). This alluvium consists of fine-grained mineral-rich deposits and peat, and is mapped to the south to approximately the position of the A206 where it meets higher drier ground. Beneath the alluvium, sand and gravel is present and is assigned by Gibbard (1994) to the Late Devensian Shepperton Gravel. The bedrock beneath this is mapped as the Palaeogene Lambeth Group – Clay, Silt and Sand. Ground level at the site is recorded at between 1 and 2m OD (CgMs Consulting, 2014).

Previous geoarchaeological and geotechnical investigations carried out on the site and in its immediate surroundings reveal a sequence of Shepperton Gravel overlain by Alluvium, containing Peat, capped by Made Ground. On the site itself, only one geotechnical record reaches the Shepperton Gravel surface, recording it at -4.9m OD (6.5m bgl); however, other records to the south and east of the site indicate that the gravel surface ranges between -4.5 and -6.8m OD, whilst on the Enderby Wharf site the gravel surface is recorded between approximately -2.75 and -5.0m OD (Batchelor *et al*., 2015). A number of shallow geotechnical boreholes on the site itself (largely towards the western side; e.g. MWS1 to MWS7) indicate that the alluvium overlying the Shepperton Gravel contains Peat, although the descriptions are not sufficiently detailed to indicate their thickness or depth. However, sequences from

Enderby Wharf and to the south/east of the present site indicate Peat thicknesses ranging from 0.5 to 3.0m. Radiocarbon dating of the Peat in borehole BH5 on the Enderby Wharf site indicate that it accumulated between 5450-5070 and 3390-3230 cal BP, equating to the Neolithic and Bronze Age cultural periods. This same record provides a record of the wetland and dryland vegetation history during this period (see Batchelor *et al*., 2015). Other geoarchaeological investigations on Greenwich Peninsula (see Figure 1), including at the Millennium Festival Site (BWP97; Bowsher & Corcoran, unknown date), the Cable Car South Station (CAB11; Batchelor *et al*., 2012), Greenwich Millennium Village (Miller & Halsey, 2011), the Victoria Deep Water Terminal and across Greenwich Peninsula as a whole (TUA02; Corcoran, 2002) have revealed a sequence of Shepperton Gravel, overlain by Alluvium and Made Ground. At these sites, a horizon of Peat within the alluvium has been radiocarbon dated as accumulating between approximately 6000 and 3000 cal BP, equating to the Neolithic and Bronze Age cultural periods. On the basis of the radiocarbon dates from Enderby Wharf and elsewhere on the Peninsula, it is therefore possible that Peat may have been accumulating on the present site at the same time as trackway construction occurred on the nearby 72-88 Bellot Street (Mclean, 1993; Philp, 1993) and Bellot Street (Branch *et al*., 2005) sites (Bronze Age) approximately 100m to the south.

Geoarchaeological investigation of the Alcatel-Lucent Telegraph Works site thus has the potential to increase our knowledge and understanding of the sedimentary and landscape history of Greenwich Peninsula. Furthermore, sufficiently different sequences to that recorded at the neighbouring Enderby Wharf site may provide new records of the vegetation history of the site and evidence for prehistoric activity. The latter is particularly relevant due to the aforementioned archaeological structures recorded nearby.

The aim of this report is to produce a model of the sub-surface stratigraphy of the site using a combination of the recent geoarchaeological boreholes put down by Quaternary Scientific, and existing geotechnical and BGS borehole records on or nearby to the site. This model will be used to provide a reconstruction of the site's former landscape and its evolution through time, as well as its potential utilisation by prehistoric people. Finally, this report will provide recommendations on the suitability of the site for further environmental archaeological investigations.


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West India Dock
Blackwall
River Thames
Custom House
Royal Victoria Dock
Exhibition Centre
Silvertown
West India and Millwall Docks
Millwall Outer Dock
Millwall
Isle of Dogs
Cubitt Town
Bugsby's Reach
New Charlton
Greenwich Reach
River Thames

Figure 1: Location of (1) Alcatel-Lucent Telegraph Works, Blackwell Lane, London Borough of Greenwich and selected other geoarchaeological and archaeological sites nearby: (2) Enderby Wharf, Christchurch Way, London Borough of Greenwich (Batchelor *et al*., 2015); (3) Plot MO117 (JHW13; Young & Batchelor, 2013a); (4) Plot MO115 (Young & Batchelor, 2013b); (5) Greenwich Millennium Village (Miller & Halsey, 2011); (6) Atlas Wharf (AWF98; Lakin, 1998); (7) Mast House Terrace (MHT95; Bowsher & Wilkinson, 1995); (8) Victoria Deep Water Terminal (TUA02; Corcoran, 2002); (9) Greenwich Peninsula (Corcoran, 2002); (10) Canning Town (Stafford, 2012); (11) Lower Lea Valley Mapping Project (Corcoran *et al*., 2011); (12) Bellot Street (GLB05; Branch *et al*., 2005); (13) 72-88 Bellot Street (BSG93; McLean, 1993; Philp, 1993); (14) Canning Town Regeneration Area 7 & 1C (CTR12; Green & Young, 2012); (15) the Cable Car route (CAB11; Batchelor *et al*., 2015) (A) North Station; (B) North Intermediate Tower; (C) North Tower; (D) South Tower; (E) South Station); (16) Silvertown (BWC96; Wilkinson *et al*., 2000); (17) Fort Street (HW-FO94; Wessex Archaeology, 2000; Crockett et al., 2002); (18) Greenwich Industrial Estate (GIE02; Morley, 2003); (19) Royal Docks Community School (PRG97; Holder, 1998); (20) Preston Road (PPP06; Branch *et al*., 2007); (21) East India Docks (Pepys, 1665); (22) Plot MO401 (Batchelor, 2014). (23) 105-107 Tarling Road (Batchelor & Young, 2014); (24) St Luke's Square (LUC07; Wicks, 2008); (25) Caxton Works (Young, 2014); (26) 118 Victoria Dock Road (Barnett *et al*., 2010); (27) Tidal Basin Road (Young & Batchelor, 2013c); (28) Silvertown Tunnel (Young & Green, 2015); (29) Barnwood Court (HW-BC97; Farid, 1997); (30) Thames Barrier Park East (TBP06; Green *et al*., 2006); (31) Royal Wharf, Silvertown (Batchelor *et al*., 2014); (32) Tunnel Avenue (GPF12; Batchelor, 2013) and (33) Greenwich Peninsula Central East (Young & Batchelor, 2015). *Contains Ordnance Survey data © Crown copyright and database right [2015]*

Figure 2: Location of the new geoarchaeological boreholes at the Alcatel Lucent Telegraph Works site (red outline) and existing geoarchaeological, geotechnical and BGS archive boreholes in the area of the deposit model, including those at Enderby Wharf (Batchelor *et al*., 2015; black outline). *Contains Ordnance Survey data © Crown copyright and database right [2012].*

METHODS

Field investigations

Three geoarchaeological boreholes (boreholes QBH1, QBH2 and QBH4) were put down at the site in August 2015. One of the boreholes proposed in the WSI for the site (QBH3; Batchelor, 2015) could not be put down since this area of the site was still in use. The borehole core samples were recovered using an Eijkelkamp window sampler and gouge set using an Atlas Copco TT 2-stroke percussion engine. This coring technique is a suitable method for the recovery of continuous, undisturbed core samples and provides sub-samples suitable for not only sedimentary and microfossil assessment and analysis, but also macrofossil analysis. The recovered core samples were wrapped in clear plastic to prevent moisture loss, labelled with the depth (metres from ground surface) and orientation (top and base) and returned to Quaternary Scientific for storage in a purpose built facility at 2^{o}C. This temperature prevents fungal growth on the core surface, which may lead to anomalous radiocarbon dates, and moisture loss. The spatial attributes of each borehole were recorded (Table 1 and Figure 2).

Lithostratigraphic descriptions

The lithostratigraphy of boreholes QBH1, QBH2 and QBH4 was described in the laboratory using standard procedures for recording unconsolidated sediment and organic sediments, noting the physical properties (colour), composition (gravel, sand, clay, silt and organic matter) and inclusions (e.g. artefacts) (Tröels-Smith, 1955). The procedure involved: (1) cleaning the samples with a spatula or scalpel blade and distilled water to remove surface contaminants; (2) recording the physical properties, most notably colour using a Munsell Soil Colour Chart; (3) recording the composition; gravel (Grana glareosa; Gg), fine sand (Grana arenosa; Ga), silt (Argilla granosa; Ag) and clay (Argilla steatoides); (4) recording the degree of peat humification and (5) recording the unit boundaries e.g. sharp or diffuse. The results are displayed in Tables 2 to 4.

Deposit modelling

The deposit model was based on a review of 47 borehole records, including the three new geoarchaeological boreholes and seven existing geotechnical boreholes (Merebrook Consulting, 2012) for the site, three geoarchaeological and seven geotechnical boreholes from the Enderby Wharf site (Batchelor *et al*., 2015) and 27 BGS archive boreholes (www.bgs.ac.uk/opengeoscience) (Figure 2; Table 1). Modelling was undertaken using RockWorks 16 geological utilities software. The term 'deposit modelling' describes any method used to depict the sub-surface arrangement of geological deposits, but particularly

the use of computer software to create contoured maps or three dimensional representations of contacts between stratigraphic units. The first requirement is to classify the recorded borehole sequences into uniformly identifiable stratigraphic units. At the Alcatel-Lucent site, the sedimentary units were classified into six groupings: (1) Gravel, (2) Sand, (3) Lower Alluvium, (4) Peat, (5) Upper Alluvium and (6) Made Ground. Models of surface height (using a nearest neighbour routine) were generated for the Gravel, the Lower Alluvium, the Peat and the Upper Alluvium (Figures 3, 4, 5 and 7). Thickness of the Peat (Figure 6), combined Alluvial units (Sand, Lower Alluvium, Peat and Upper Alluvium) (Figure 8) and Made Ground (Figure 9) was also modelled (also using a nearest neighbour routine).

How effectively Rockworks portrays the relief features of stratigraphic contacts or the thickness of sediment bodies depends on the number of data points (boreholes/test pits) per unit area, and the extent to which these points are evenly distributed across the area of interest. The portrayal is also affected by the significance assigned to these data points, in terms of the extent of the area around the point to which the data are deemed to apply. This can be predetermined for each data set, and in the present case the value chosen for each data point (borehole) is equivalent to an area of 100m radius for all models, except for the Peat, where a radius of 50m was used. The boreholes are relatively well distributed over the area of investigation. In general, reliability improves towards the core area of boreholes where mutually supportive data are likely to be available from several adjacent data points. Reliability is also affected by the quality of the stratigraphic records, which in turn are affected by the nature of the sediments and/or their post-depositional disturbance during previous stages of land-use on the site. Quality is also affected where boreholes have been 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. Of the records used in the deposit model, the cores from the geoarchaeological boreholes put down by Quaternary Scientific represent the most detailed record of the sediment sequences. Finally, because of the 'smoothing' effect of the modelling procedure, the modelled levels of stratigraphic contacts may differ slightly from the levels recorded in borehole logs.

Table 1: Borehole attributes for the records used in the deposit model, Alcatel-Lucent Telegraph Works, Blackwall Lane, London Borough of Greenwich SE10.

Borehole	Easting	Northing	Elevation (m OD)
Geoarchaeological boreholes (present site)			
QBH1	539351	178714	1.80
QBH2	539417	178711	1.80
QBH4	539344	178651	2.02

Geoarchaeological boreholes from Enderby Wharf (Batchelor et al., 2015)			
EWQBH1	539270.4	178740	1.84
EWQBH2	539216	178659.4	2.32
EWQBH3	539428.3	178765.3	1.59
Geotechnical boreholes (present site; Merebrook Consulting, 2012)			
MWS1	539292	178761	1.40
MWS2	539327	178757	1.50
MWS3	539320	178716	1.80
MWS4	539294	178701	2.00
MWS5	539346	178635	2.10
MWS6	539346	178669	1.90
MWS7	539314	178660	2.10
Geotechnical boreholes from Enderby Wharf (Batchelor et al., 2015)			
EWBH1	539161	178803	2.25
EWBH2	539258	178827	1.90
EWBH3	539149	178692	2.77
EWBH4	539201	178717	2.16
EWBH5	539271	178740	2.05
EWBH6	539261	178689	2.05
EWBH7	539215	178657	2.44
BGS archive boreholes			
TQ37NE1998	539140	178810	5.20
TQ37NE1756	539450	178580	1.33
TQ37NE1757	539420	178570	1.27
TQ37NE1946	539509	178860	3.05
TQ37NE1947	539495	178575	1.34
TQ37NE1948	539255	178525	1.19
TQ37NE2098	539170	178940	3.66
TQ37NE2099	539210	178990	3.87
TQ37NE2101	539100	179000	3.66
TQ37NE2157	539430	178630	1.57
TQ37NE2158	539530	178660	1.69
TQ37NE3948	539669	178727	2.01
TQ37NE602	539280	178985	4.27
TQ37NE603	539302	178980	4.27
TQ37NE623	539561	178577	1.86
TQ37NE631	539625	178642	1.92
TQ37NE698	539475	178969	2.29
TQ37NE721	539470	178990	2.31
TQ37NE722	539500	178980	1.41
TQ37NE724	539530	178920	1.05
TQ37NE725	539550	178940	3.30
TQ37NE730	539650	179000	1.09
TQ37NE731	539670	178960	0.87

TQ37NE735	539560	178830	2.42
TQ37NE737	539610	178820	1.21
TQ37NE739	539660	178770	1.35
TQ37NE779	539170	178930	2.74

RESULTS AND INTERPRETATION OF THE GEOARCHAEOLOGICAL FIELDWORK AND DEPOSIT MODELLING

The results of the deposit modelling are displayed in Figures 3 to 10. Figures 3 to 9 provide surface elevation and thickness models for each of the main stratigraphic units, whilst Figure 10 provides a 2-Dimensional northwest-southeast stratigraphic profile across the site. The results of the deposit modelling indicate that a sufficient number and spread of boreholes have been put down in the area of the site to permit deposit modelling of the major stratigraphic units.

The basal unit recorded in the deposit model for the site is a horizon of sand and gravel (the Shepperton Gravel). These sediments were deposited during the Late Devensian (Marine Isotope Stage 2, *ca*. 16,000-11,500 cal BP), within a high energy braided river system. The surface of this unit is recorded in the three new geoarchaeological boreholes at -4.15 (QBH1), -3.54 (QBH2) and -3.91m OD (QBH4), similar to the levels recorded at the Enderby Wharf site immediately to the west (-3.5 to -4.0m OD; Batchelor *et al*., 2015). The Gravel surface falls towards the southeast of the site to -4.93m OD in BGS borehole TQ37NE2157, -6.81m OD in TQ37NE2158 and -5.4m OD in TQ37NE631. To the south of the Alcatel-Lucent and Enderby Wharf sites the Gravel rises to -2.73m OD in TQ37NE1757, and -1.25m OD in TQ37NE1948, whilst to the northwest and northeast of these sites the Gravel surface generally lies above -3m OD (see Figure 3). An area of lower Gravel surfaces is also recorded in the area of boreholes TQ37NE2099, TQ37NE602, TQ37NE603 and TQ37NE698, where the Gravel generally lies below -4m OD.

The Gravel topography in the modelled area is indicative of an east-west aligned depression, indicative of a broad palaeochannel across the area of the Alcatel-Lucent and Enderby Wharf sites (see Figure 10). It is unclear from the present model whether the depression to the north of the modelled area is connected to this palaeochannel, or represents a separate topographic feature. In several of the boreholes within the east-west aligned palaeochannel the Gravel surface is overlain by a horizon of sand (QBH4, EWQBH1, EWQBH2, EWBH7, TQ37NE2157, TQ37NE1756 and TQ37NE623), indicative of a gradual reduction in flow rate in this channel during the Early Holocene. Elsewhere, the Shepperton Gravel is overlain by sandy or clayey silt with frequent detrital organic inclusions of wood or herbaceous material,

considered here to represent the Lower Alluvium and indicative of the former presence of low energy fluvial or estuarine conditions during the Early to Middle Holocene. The surface of this unit across the site lies at between *ca*. -3.5 and -2.0m OD (Figure 4), generally sloping downwards from west to east across the area of the site.

In boreholes QBH1 and QBH2 the Lower Alluvium is overlain by a horizon of woody Peat with occasional herbaceous remains, indicative of a transition to semi-terrestrial conditions supporting the growth of wetland vegetation in this area of the site. In borehole QBH4 no Peat is recorded, but a horizon of organic-rich Alluvium is present at the same elevation as the Peat identified elsewhere. In QBH1 Peat is recorded at between -0.85 and -2.52m OD, separated by a horizon of organic Alluvium between -1.35 and -1.94m OD; in QBH2 the Peat is recorded at between -2.20 and -2.81m OD. Towards the southeast of the site, Peat was also recorded in BGS borehole TQ37NE2157, between -0.38 and -3.68m OD. No Peat was recorded in the majority of the existing geotechnical boreholes from the site; however, none of these boreholes penetrated beyond 4m depth, and only in MWS5 was the surface of the Peat recorded (-0.7m OD). Notably, the horizon of organic Alluvium that separates the Peat in QBH1 was also identified within the Peat sequence at the Enderby Wharf site, here of variable thicknesses between *ca*. 0.5 and 1.0m and generally recorded between *ca*. -1.0 and -2.0m OD. Given the spatial extent of this horizon, it may represent a contemporaneous period of flood events and mineral-rich sedimentation that occurred across much of the Alcatel-Lucent site and the wider area.

The thickness of the Peat is variable across the site, recorded as 1.67m in QBH1 (inclusive of the intervening organic Alluvium), 0.61m in QBH2 and 3.3m in TQ37NE2157 (Figure 5). The wider deposit model suggests that Peat thickness is generally greatest within the east-west aligned palaeochannel identified above, with the greatest thicknesses to the southeast and east of the Alcatel-Lucent site. At the Enderby Wharf site to the west Peat was identified at elevations between 0.0 and -2.5m OD, and was generally between 0.5 and 2m thick (see Figure 5). The upper surface of the Peat is highly variable, lying at between -0.38 and -2.2m OD within the area of the site and at similar elevations elsewhere in the wider deposit model (Figure 6).

The Peat is overlain across the site by a horizon of silty clay, referred to here as the Upper Alluvium and representative of inundation of the Peat surface and sediment accumulation on the floodplain at a distance from any active channels. The surface of the Upper Alluvium is relatively even across the site, generally lying at between 1.0 and 0.5m OD (Figure 7). The total thickness of the Holocene alluvial units at the site, incorporating the Sand, Lower

Alluvium, Peat and Upper Alluvium is shown in Figure 8; total thickness of between 4.34 and 4.9m are recorded in the area of the site. The sequence at the site is capped by between 1.0 and 1.5m of Made Ground (Figure 9), so that the modern surface of the site lies at between *ca*. 1.5 and 2.0m OD.

Table 2: Lithostratigraphic description of borehole QBH1, Alcatel-Lucent Telegraph Works, Blackwall Lane, London Borough of Greenwich SE10.

Depth (m OD)	Depth (m bgs)	Composition
1.80 to 0.80	0.00 to 1.00	Made Ground
0.80 to 0.30	1.00 to 1.50	As3 Ag1; brown silty clay with frequent iron staining particularly in worm and root hollows. Diffuse contact in to:
0.30 to -0.20	1.50 to 2.00	As3 Ag1; blue grey silty clay with some iron staining.
-0.20 to -0.44	2.00 to 2.24	Gley 1 4/10Y; Ag2 As2; dark greenish grey clay and silt with iron staining. Diffuse contact in to:
-0.44 to -0.61	2.24 to 2.41	Gley 1 5/N; Ag3 As1; grey clayey silt with less frequent iron staining. Diffuse contact in to:
-0.61 to -0.85	2.41 to 2.65	7.5YR 4/1; Ag2 As1 Sh1 Dl+ Dh+; dark grey organic clayey silt with traces of detrital wood and detrital herbaceous material. Diffuse contact in to:
-0.85 to -1.35	2.65 to 3.15	7.5YR 3/1; Sh3 Ag1 Th+ Tl+; humo. 2/3; very dark grey moderately to well humified silty peat with traces of wood and herbaceous material. Diffuse contact in to:
-1.35 to -1.94	3.15 to 3.74	10YR 4/1; Ag2 Ga1 Sh1 Dl+ Dh+; dark grey organic sandy silt with traces of detrital wood and detrital herbaceous material. Some more organic or sandy horizons within this unit. Diffuse contact in to:
-1.94 to -2.52	3.74 to 4.32	10YR 2/1; Sh3 $Tl^2$1 Ag+; humo. 2; black woody moderately humified peat with a trace of silt.
-2.52 to -3.20	4.32 to 5.00	Gley 1 5/10Y; Ag3 As1 Dl+; greenish grey clayey silt with a trace of detrital wood.
-3.20 to -3.82	5.00 to 5.62	Gley 1 6/10Y; Ag3 As1 Ga+ Dl+; greenish grey clayey silt with a trace of sand and detrital wood. Diffuse contact in to:
-3.82 to -4.07	5.62 to 5.87	Gley 1 5/10Y; Ga2 Ag2; greenish grey sand and silt. Sharp contact in to:
-4.07 to -4.09	5.87 to 5.89	Gg3 Ga1; sandy gravel. Clasts are flint, up to 20mm in diameter, sub-angular to sub-rounded. Sharp contact in to:
-4.09 to -4.15	5.89 to 5.95	Gley 1 5/10Y; Ga2 Ag2; greenish grey sand and silt. Sharp contact in to:
-4.15 to -4.20	5.95 to 6.00	Gg3 Ga1; sandy gravel. Clasts are flint, up to 30mm in diameter, sub-angular to sub-rounded.

Table 3: Lithostratigraphic description of borehole QBH2, Alcatel-Lucent Telegraph Works, Blackwall Lane, London Borough of Greenwich SE10.

Depth (m OD)	Depth (m bgs)	Composition
1.80 to 0.80	0.00 to 1.00	Made Ground
0.80 to 0.30	1.00 to 1.50	As3 Ag1; brown silty clay with frequent iron staining particularly in worm and root hollows. Diffuse contact

Depth (m OD)	Depth (m bgs)	Composition
		in to:
0.30 to -0.20	1.50 to 2.00	As3 Ag1; blue grey silty clay with some iron staining.
-0.20 to -0.92	2.00 to 2.72	10YR 5/2; As3 Ag1; greyish brown silty clay with some iron staining. Diffuse contact in to:
-0.92 to -1.20	2.72 to 3.00	10YR 4/2; Ag3 As1 Sh+ Dl+; dark greyish brown clayey silt with traces of organic matter and detrital wood.
-1.20 to -1.40	3.00 to 3.20	2.5Y 4/1; Ag3 As1 Dh+; dark grey clayey silt with a trace of detrital wood. Diffuse contact in to:
-1.40 to -1.59	3.20 to 3.39	2.5Y 3/1; Ag2 Sh1 Dl1 Ga+; very dark grey organic silt with detrital wood and a trace of sand. Diffuse contact in to:
-1.59 to -2.20	3.39 to 4.00	Gley 1 4/10Y; Ag3 As1 Sh+ Dl+; dark grey clayey silt with traces of organic matter and detrital wood.
-2.20 to -2.81	4.00 to 4.61	10YR 2/1; Sh2 $Tl^2$2 Th+ Ag+; humo. 2; black moderately humified wood peat with traces of herbaceous material and silt. Sharp contact in to:
-2.81 to -3.20	4.61 to 5.00	Gley 1 4/10Y; Ag2 As2 Dh+ Ga+; dark greenish grey clay and silt with traces of detrital herbaceous material and sand.
-3.20 to -3.54	5.00 to 5.34	Gley 1 5/10Y; Ag2 As1 Ga1 Dh+; greenish grey sandy clayey silt with a trace of detrital herbaceous material. Some vertical sedge rooting. Sharp contact in to:
-3.54 to -4.20	5.34 to 6.00	Gg3 Ga1; sandy gravel. Clasts are flint, up to 40mm in diameter, sub-angular to well-rounded.

Table 4: Lithostratigraphic description of borehole QBH4, Alcatel-Lucent Telegraph Works, Blackwall Lane, London Borough of Greenwich SE10.

Depth (m OD)	Depth (m bgs)	Composition
2.02 to 1.02	0.00 to 1.00	Made Ground
1.02 to 0.97	1.00 to 1.05	Disturbed Alluvium (Made Ground)
0.97 to 0.02	1.05 to 2.00	As3 Ag1; blue grey silty clay with some iron staining.
0.02 to -0.61	2.00 to 2.63	Gley 1 5/10Y; Ag2 As2; greenish grey clay and silt. Diffuse contact in to:
-0.61 to -0.98	2.63 to 3.00	10YR 3/1; Ag2 As1 Dl1 Dh+ Sh+; very dark grey clayey silt with detrital wood and traces of detrital herbaceous material and organic matter.
-0.98 to -1.98	3.00 to 4.00	10YR 4/1; Ag2 Sh1 Dl1 Dh+; dark grey organic silt with detrital wood and a trace of detrital herbaceous material.
-1.98 to -2.24	4.00 to 4.26	10YR 3/1; Ag2 As1 Dl1 Sh+ Ga+; very dark grey clayey silt with detrital wood and traces of organic matter and sand. Diffuse contact in to:
-2.24 to -2.84	4.26 to 4.86	10YR 2/1; Ag2 Sh1 Dl1 Ga+; black organic silt with detrital wood and a trace of sand. Some more sandy horizontal beds. Diffuse contact in to:
-2.84 to -2.98	4.86 to 5.00	Gley 1 5/10Y; Ag2 Ga1 Dl1; greenish grey sandy silt with detrital wood. Frequent Mollusca.
-2.98 to -3.80	5.00 to 5.82	Gley 1 5/10Y; Ag2 As1 Ga1 Gg+; greenish grey sandy clayey silt with occasional gravel clasts. Very sharp contact in to:
-3.80 to -3.91	5.82 to 5.93	Gley 1 4/10Y; Ga4 Ag+; dark greenish grey sand with a trace of silt. Sharp contact in to:

-3.91 to -3.98	5.93 to 6.00	Gg3 Ga1; sandy gravel. Clasts are flint, up to 40mm in diameter, sub-angular to well-rounded.

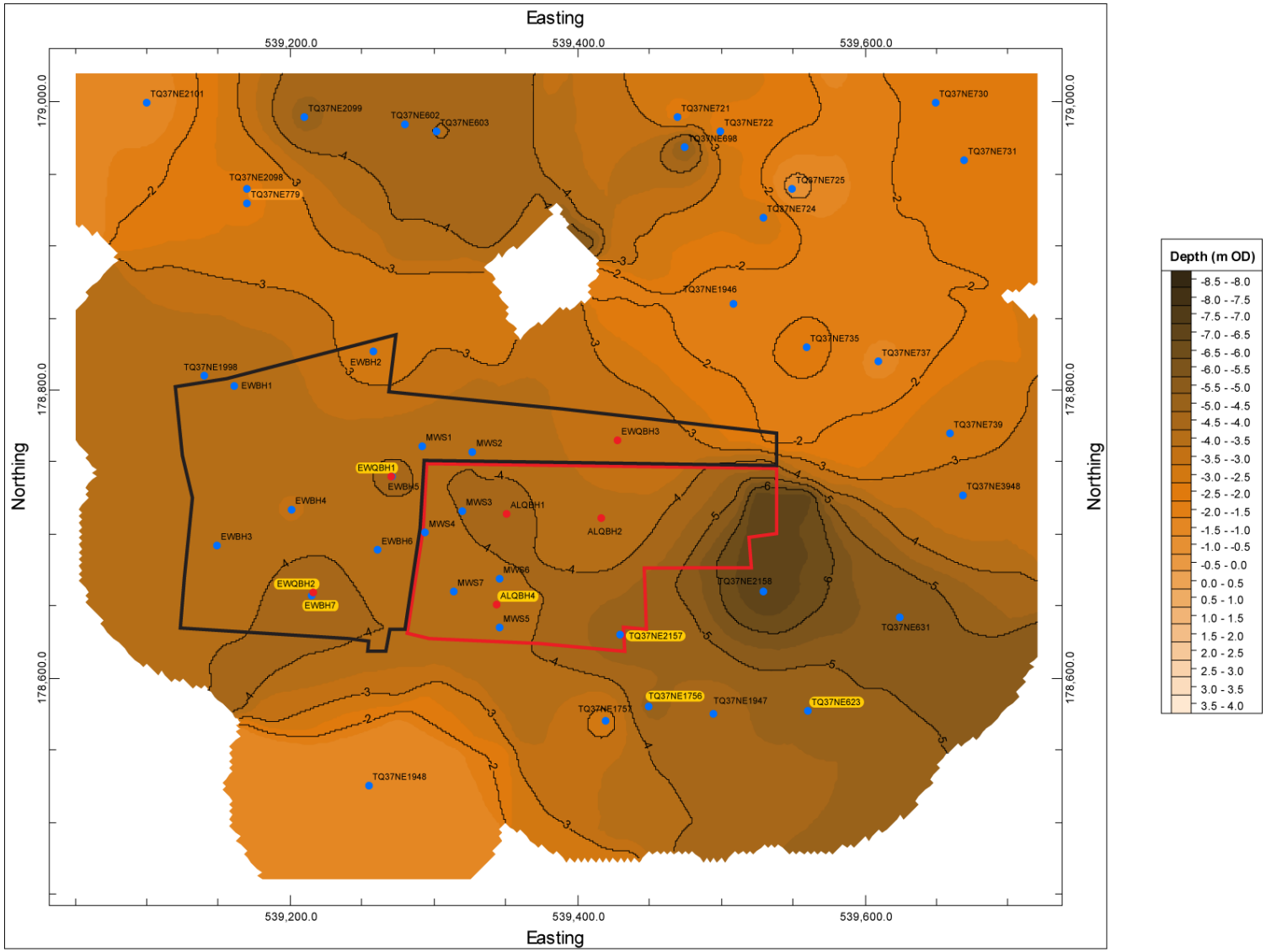

Figure 3: Modelled surface of the Shepperton Gravel (contour heights in metres OD). Boreholes with sand overlying the Shepperton Gravel are highlighted in yellow.

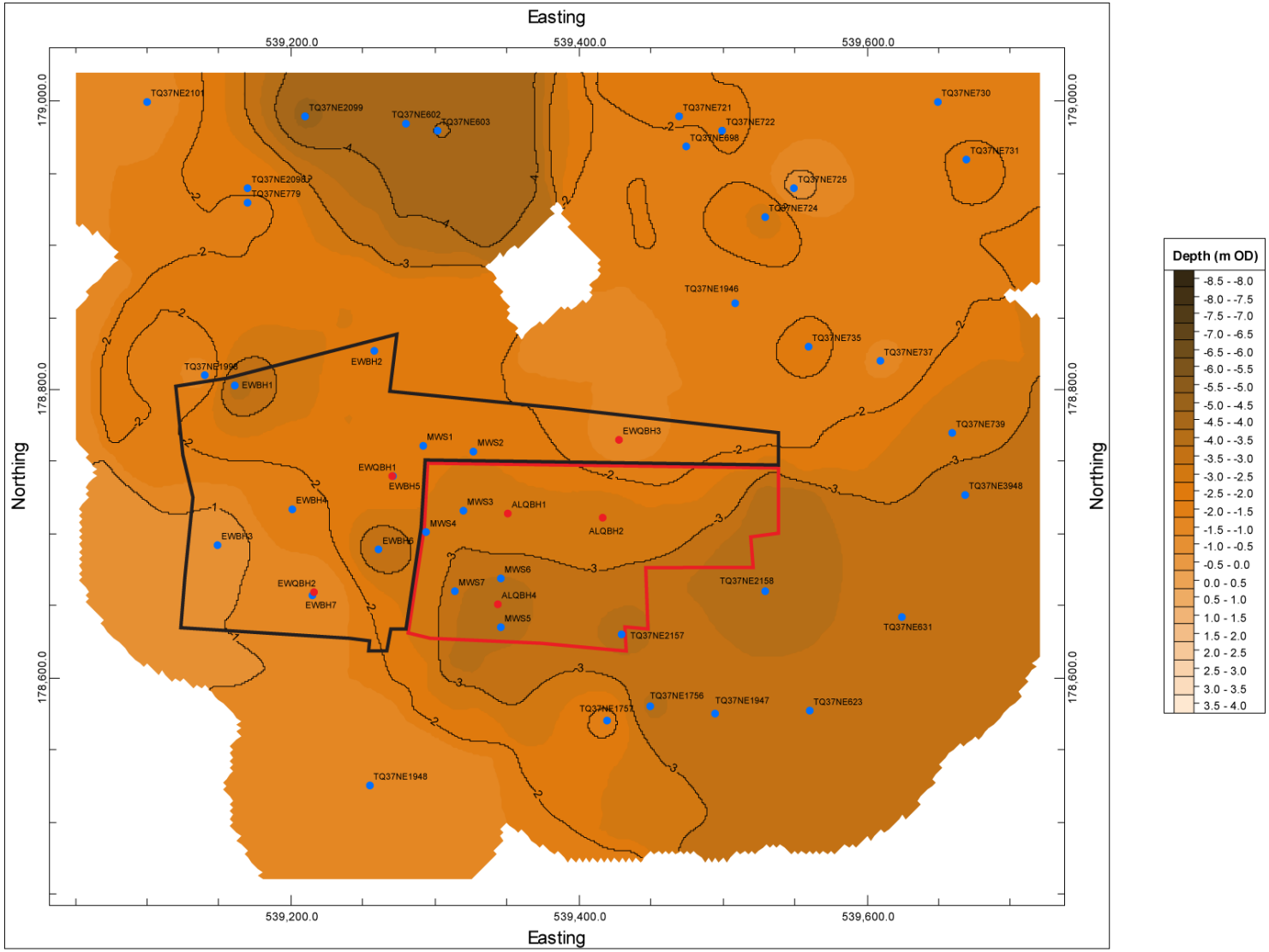

Figure 4: Modelled surface of the Lower Alluvium (contour heights in metres OD).

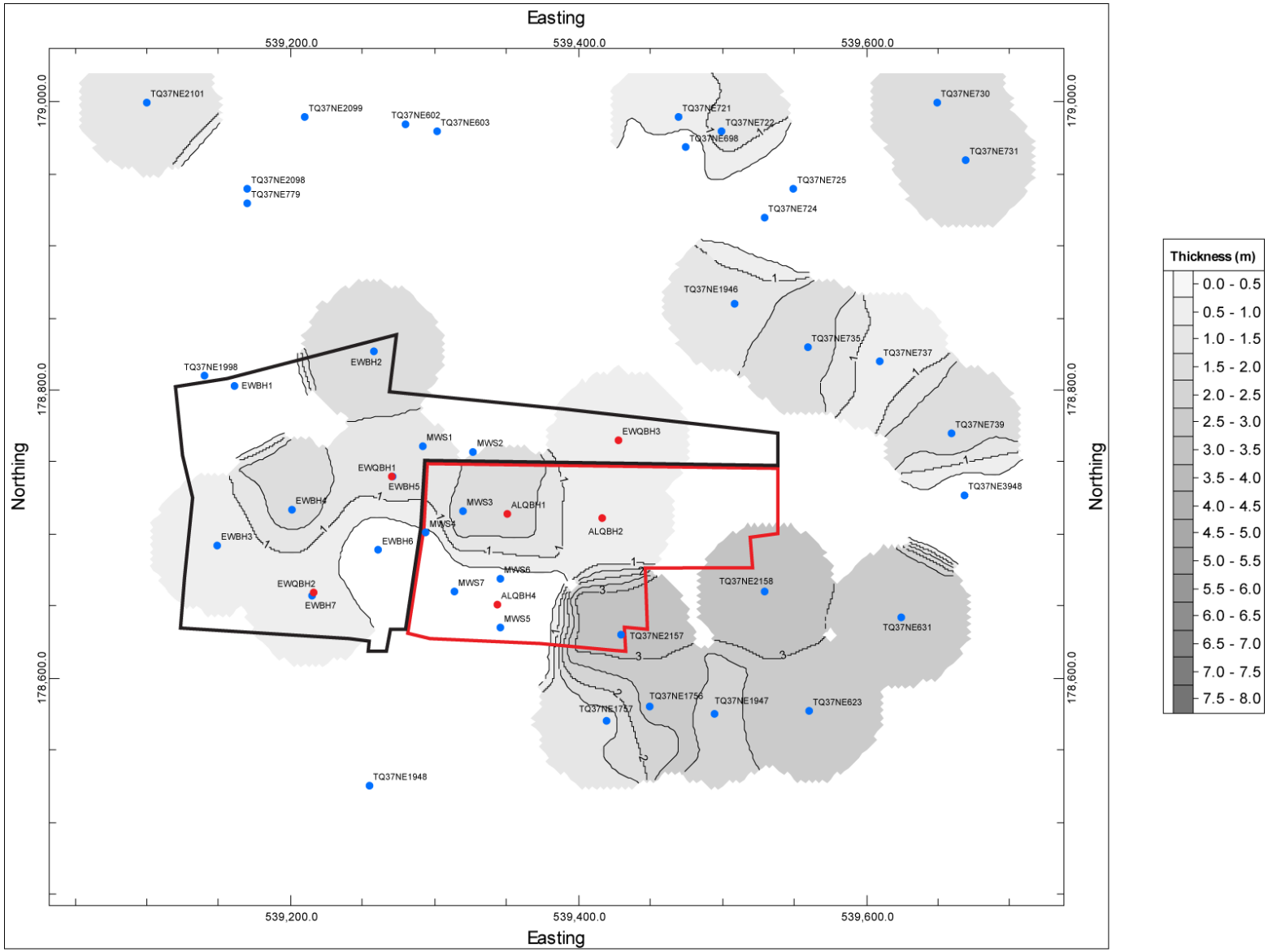

Figure 5: Modelled thickness of the Peat (metres).

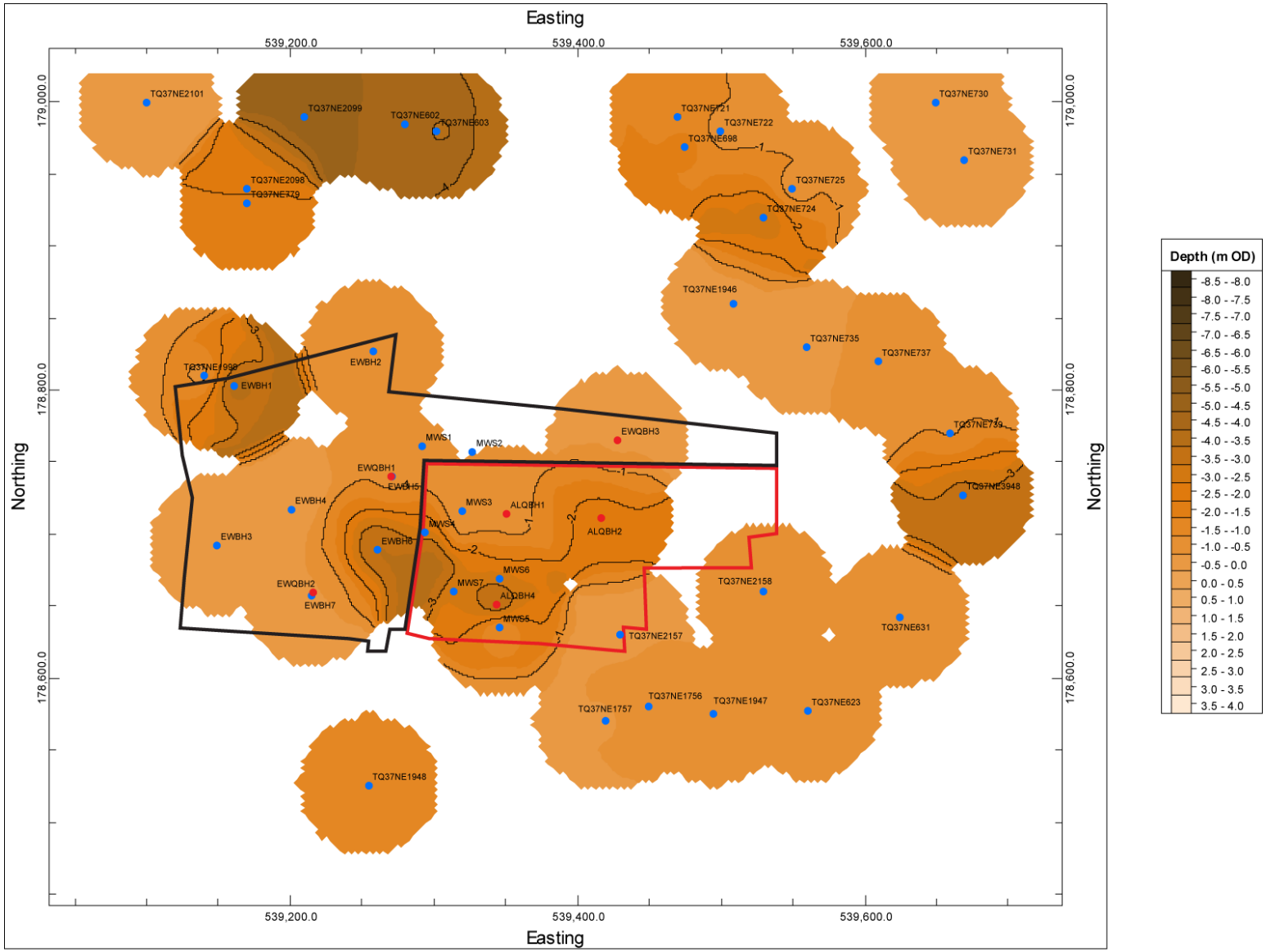

Figure 6: Modelled surface of the Peat (contour heights in metres OD).

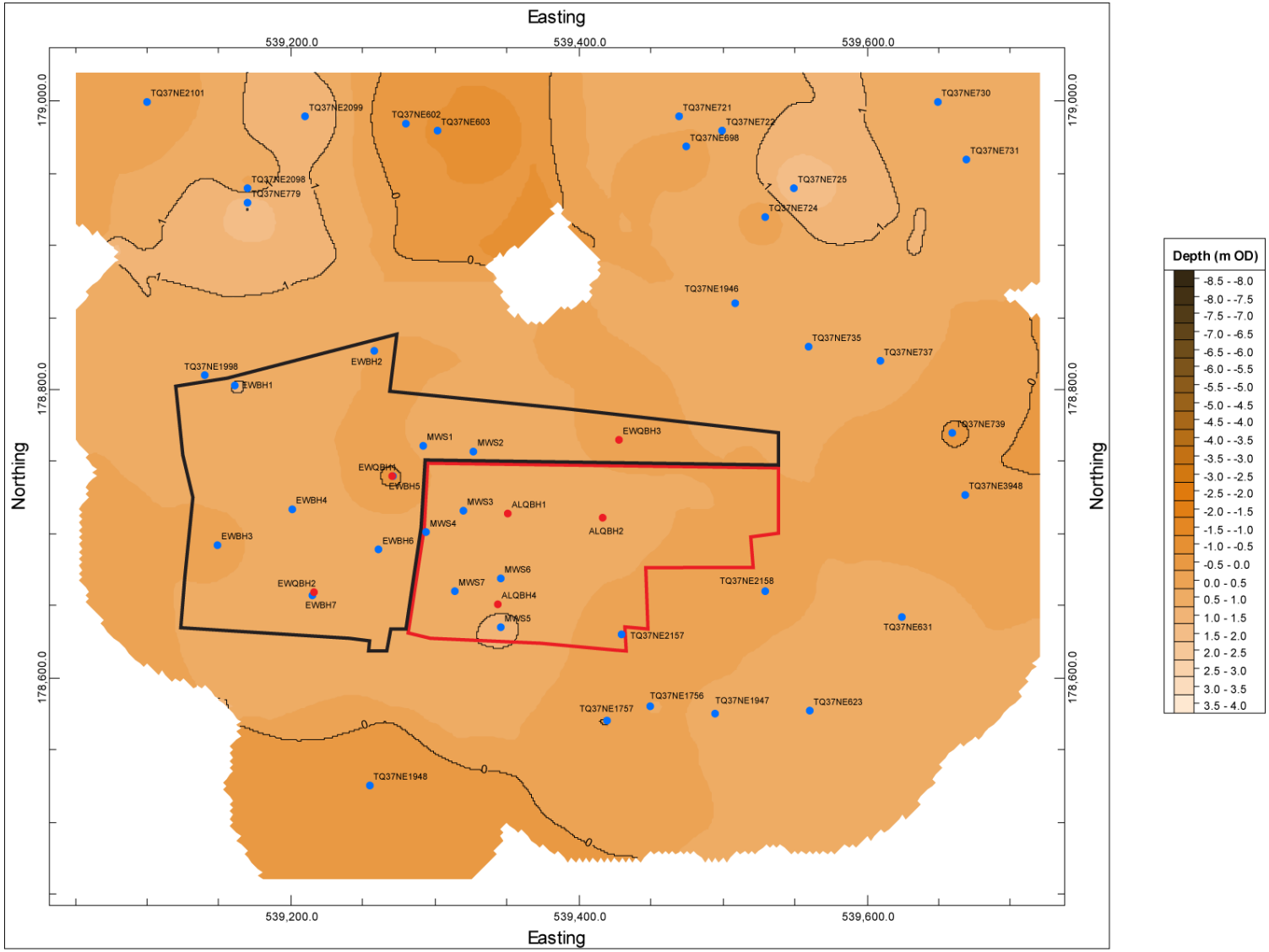

Figure 7: Modelled surface of the Upper Alluvium (contour heights in metres OD)

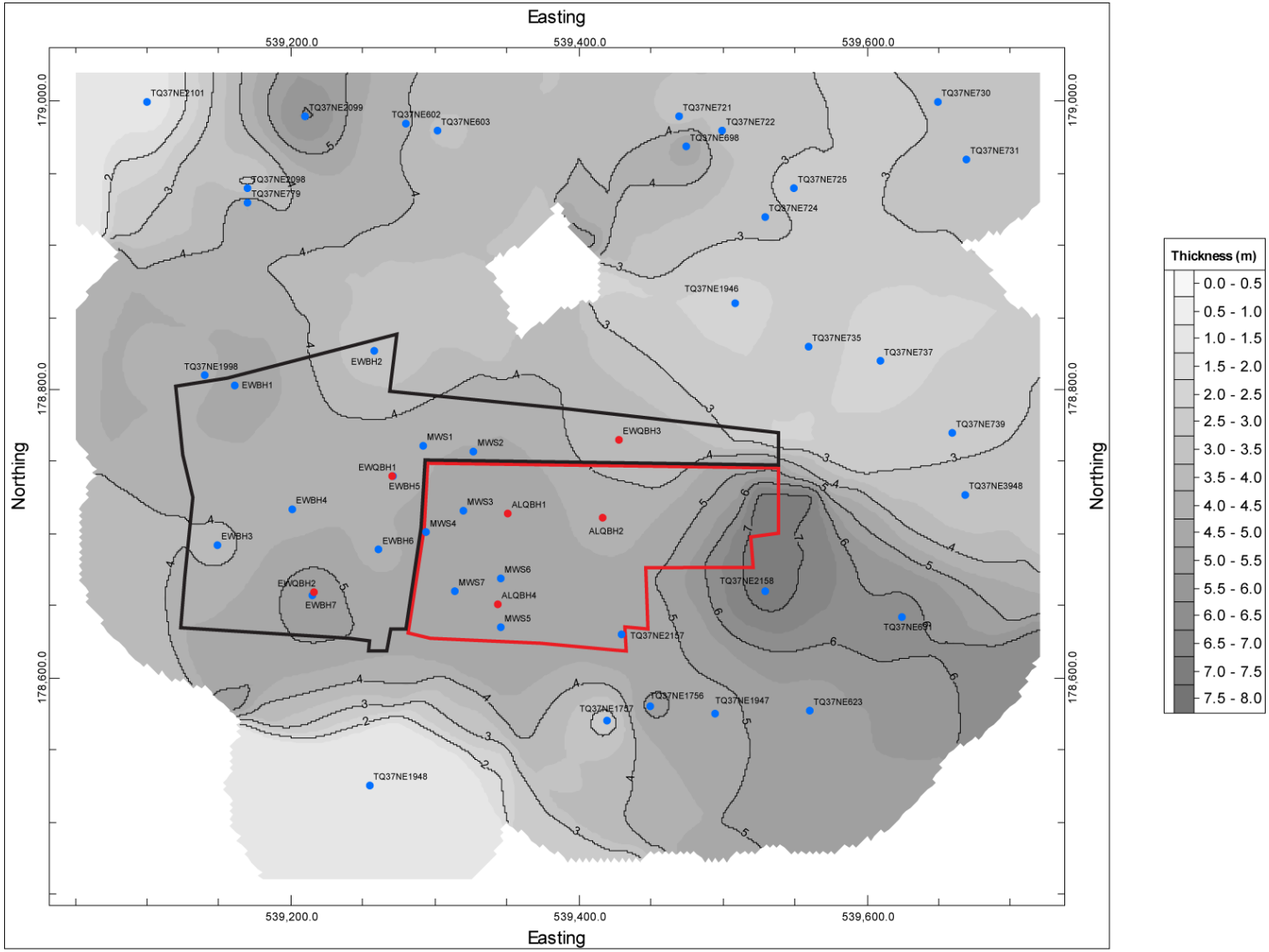

Figure 8: Modelled thickness of the combined Alluvium (incorporating the Sand, Lower Alluvium, Peat and Upper Alluvium) (metres)

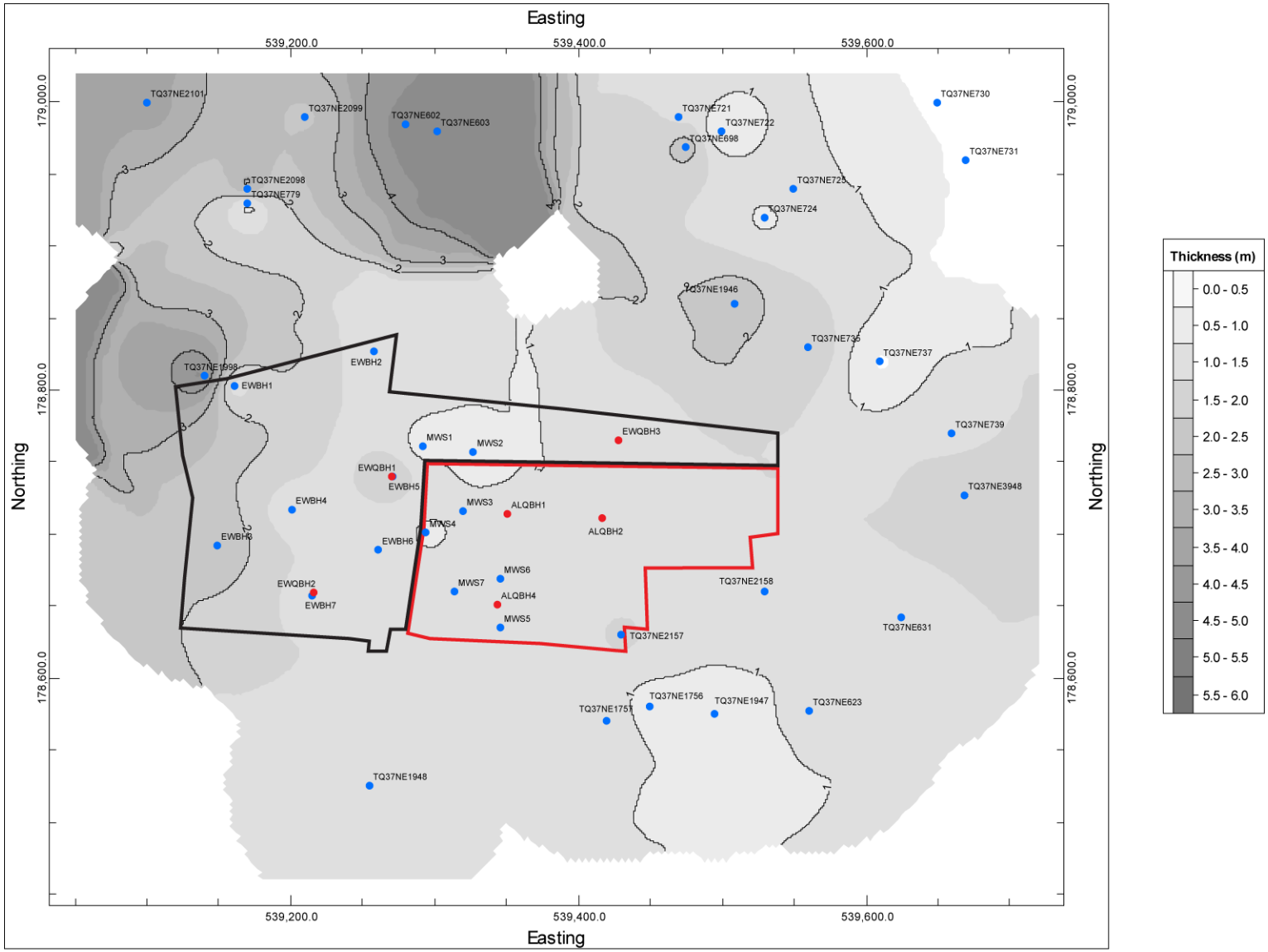

Figure 9: Modelled thickness of the Made Ground (metres)

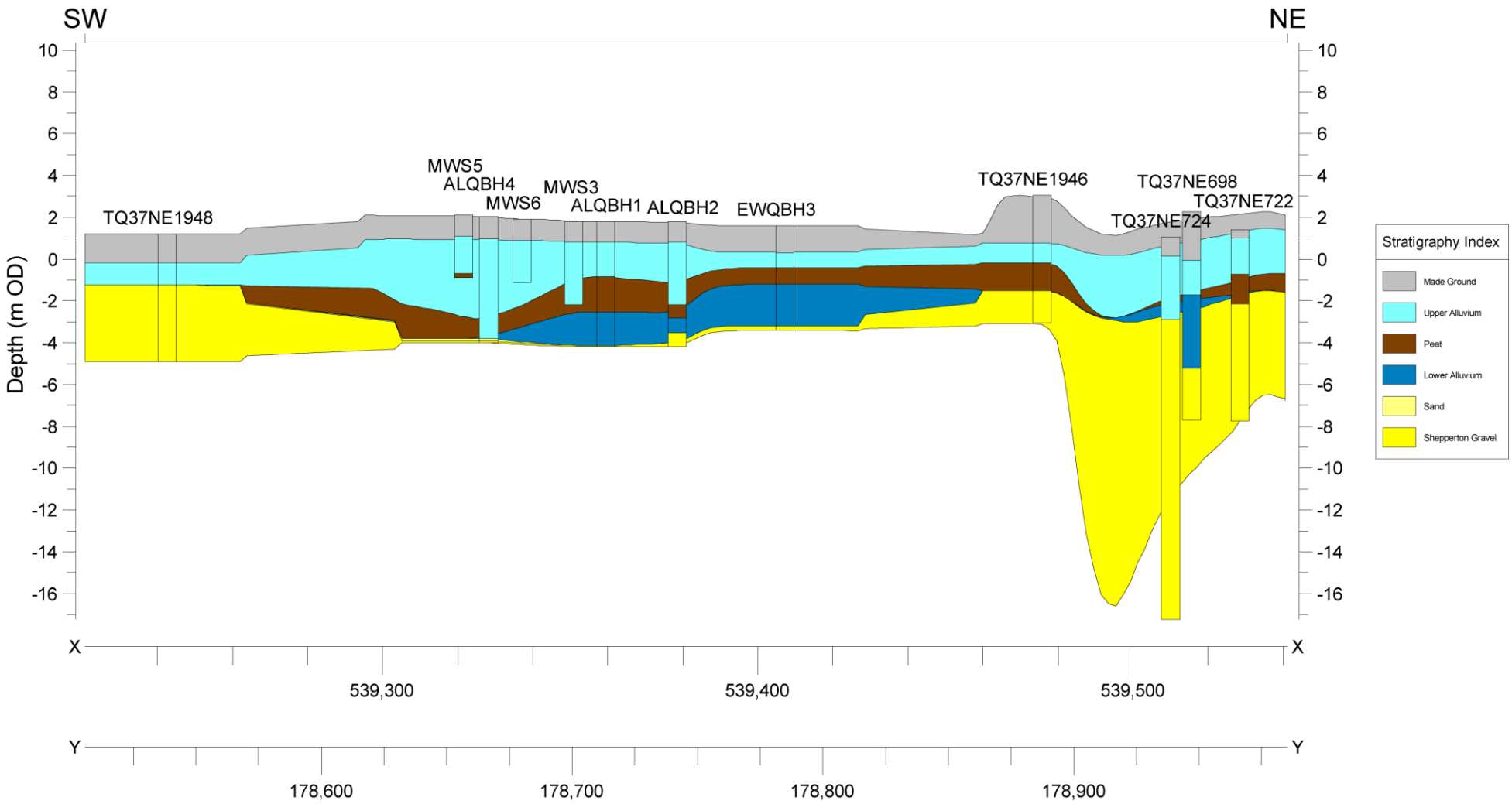

Figure 10: Northeast-Southwest stratigraphic profile of boreholes across the site and the wider area.

DISCUSSION

The results of the deposit modelling indicate that the sediments recorded at the Enderby Wharf site are analogous to those recorded elsewhere on Greenwich Peninsula and in the Lower Thames Valley, with a sequence of Shepperton Gravel overlain by Holocene Alluvium containing Peat, capped by Made Ground. The surface of the Late Devensian Shepperton Gravel at the site lies at between -3.54 and -4.93m OD, the results of the deposit modelling indicating that the site lies within a broad east-west aligned palaeochannel, in which Holocene alluvial deposits have accumulated (see Figure 10). The site lies to the southwest of the area of Greenwich Peninsula investigated by Corcoran (2002), who defined landscape zones based on the geoarchaeological characteristics of those areas. In this investigation, four landscape zones were identified as follows: Landscape Zone A, representing an area of higher Gravel surface (higher than -2m OD); Landscape Zone B, where the Gravel surface lies at between -2 and -4m OD; and Landscape Zones C and D, where it lies below -4m OD. The Alcatel-Lucent site lies *ca*. 300m southwest of Corcoran's (2002) Landscape Zone B, where the Gravel surface is described as lying at between -4 and -2m OD, and 'probably not overlain by sand'. The deposit model for the site shows that the surface of the Shepperton Gravel lies within or below this range. However, a horizon of Sand considered to represent Early Holocene fluvial deposition overlies the Gravel surface within much of the aforementioned palaeochannel, analogous to that recorded elsewhere on the Peninsula (Corcoran, 2002).

At the Bellot Street site (Branch *et al*., 2005) *ca*. 100m to the south, the Shepperton Gravel surface rises to between -0.70 and -1.49m OD. Elsewhere on Greenwich Peninsula, relatively high Shepperton Gravel surfaces (between *ca*. -1 and -1.7m OD) have been recorded at the Tunnel Avenue (Landscape Zone B; Batchelor, 2013) and Victoria Deep Water Terminal sites (Landscape Zone A; Corcoran, 2002). Towards the north-east of the Tunnel Avenue site however, the Shepperton Gravel surface drops to below -4m OD. It does the same towards the south-west and south-east of the MO115 (Landscape Zone B; Young & Batchelor, 2013a) and MO117 (Landscape Zones A and B; Young & Batchelor, 2013b) sites, in the far south-eastern corner of Greenwich Millennium Village (Miller & Halsey, 2011) and at the Greenwich Peninsula Central East site (Young & Batchelor, 2015). In addition, smaller 'patches' of lower gravel surface >-4m OD were recorded towards the centre and south-western areas of the Millennium Festival Site (Landscape Zone D; Bowsher & Corcoran, unknown). These areas of lower Gravel surface have been interpreted as either localised hollows, or part of interconnected palaeochannels.

The Alluvium that accumulated at the site contains woody Peat, recorded in the new

geoarchaeological boreholes at elevations between -0.38 and -2.81m OD and in thicknesses of between 0.61 and 1.67m, similar to the sequence recorded at the Enderby Wharf site immediately to the west (Batchelor *et al*., 2015). At the Enderby Wharf site a lower, silty peat horizon was recorded within the Lower Alluvium (EWQBH1) between -2.61 and -2.77m OD. Subsequent radiocarbon dating indicated that peat accumulation commenced here around 5450-5070 cal BP (middle Neolithic). This horizon was considered to be distinct to a thicker complex of generally woody or herbaceous Peat and organic sediment, considered to be equivalent to that recorded at the Alcatel-Lucent site. Radiocarbon dating of the base of this horizon at Enderby Wharf demonstrated that the accumulation of this horizon began at around 5290-4980 cal BP (middle Neolithic).

As at the Alcatel-Lucent site the Peat at Enderby Wharf was divided by a horizon of clayey or organic clayey silt, of variable thicknesses between *ca*. 0.5 and 1.0m. Although not recorded at exactly the same elevation in all boreholes, this horizon is considered to represent a broadly contemporaneous episode of flood events which brought an influx of mineral-rich material across the Peat surface. At Enderby Wharf the increased occurrence of *Chenopodium* type pollen at the beginning of this period was considered to be a possible indication of flooding influenced by enhanced saline conditions (Batchelor *et al*., 2015). Radiocarbon dating indicates that this event occurred prior to 4420-4240 cal BP (late Neolithic/early Bronze Age), by which time peat formation had re-commenced. The cessation of Peat formation was radiocarbon dated to 3390-3230 cal BP (middle-late Bronze Age). The results of the environmental archaeological analysis at this site (Batchelor *et al*., 2015) indicated that during the early stages of peat formation between 5450-5070 and 5290-4980 cal BP (middle Neolithic), the wetland environment was occupied by alder-carr swamp and sedge fen communities with areas of standing water, and potentially a limited tidal influence. The dryland environment at this time was occupied by mixed deciduous woodland dominated by oak with lime, birch, hazel, elm and ash. From shortly after 5290-4980 to around 3390-3230 cal BP (middle Neolithic to Bronze Age) the wetland vegetation community underwent a transition towards more mature and drier fen carr woodland dominated by alder, but may also have included hazel, ivy, elm, ash and yew. Changes in the structure and composition of the dryland woodland also occurred shortly after 5290-4980 cal BP, as both lime and elm increased relative to oak. At the very top of the sequence around 3390-3320 cal BP, a reduction in fen woodland cover and increase in herbaceous and aquatic taxa indicate the transition towards a wetter environment at the site. No definitive indicators of human activity were recorded through the sequence, and specifically around the time of trackway construction at the 72-88 Bellot Street (Philp & Garrod, 1994; 3380 to 3500 cal BP) and Bellot Street (Branch *et al*., 2005; (3890-3680 to 3720-3570 cal BP) sites.

At the Victoria Deep Water Terminal site (see Figure 1; Corcoran, 2002), Peat accumulation was radiocarbon dated to 5280-4660 cal BP (Neolithic), whilst at the Cable Car South Station in SSBH1C (Batchelor *et al*., 2015), the base of the Peat was recorded at around 5580-5310/5890-5610 cal BP and continued until 3380-3210 cal BP (Neolithic through to Bronze Age). At the Bellot Street (Branch *et al*., 2005) site *ca*. 100m to the south, variable thicknesses of Peat were recorded between -1.52 and -0.12m OD. Significantly, a Bronze Age trackway aligned north-south was found within Peat at -0.50m OD at the 72-88 Bellot Street site (Mclean, 1993; Philp, 1993), and a wooden structure was recorded within the Peat at Bellot Street (MLO98089, Branch *et al*., 2005) between -0.31m OD and -0.22m OD. Radiocarbon dating of the Peat above and below the structure at Bellot Street (Branch *et al.*, 2005) showed that both the Peat horizon and wooden structure were of Middle Bronze Age date (3890-3680 to 3720-3570 cal BP). Environmental archaeological assessment of this Peat horizon showed that the vegetation cover during its formation consisted of alder carr woodland on the wetland surface, with lime, oak, elm and birch woodland dominating the nearby dryland; during the period of Peat formation associated with the wooden structure, a general reduction in woodland cover on the dryland was recorded, with evidence for increasingly wet conditions on the wetland which may have led to the abandonment of the structure (Branch *et al*., 2005).

CONCLUSIONS AND RECOMMENDATIONS

The aim of this report was to produce a model of the sub-surface stratigraphy of the site to (1) provide a reconstruction of the site's former landscape and its evolution through time, as well as its potential exploitation by prehistoric people; and (2) to provide recommendations on the suitability for further geoarchaeological investigations at the site. The results of the deposit modelling have revealed a sequence of Shepperton Gravel overlain by Holocene Alluvium, containing Peat, and Made Ground. The Peat horizon is present in thicknesses of between 0.61 and 1.67m thick across the site, and represents a period of semi-terrestrial conditions that on the basis of nearby investigations, may date to the Neolithic through to Bronze Age periods, and may be contemporaneous with Bronze Age archaeology recorded within *ca*. 100m at the 72-88 Bellot Street (Mclean, 1993; Philp, 1993) and Bellot Street (Branch *et al*., 2005) sites.

The palaeoenvironmental potential of the sequences at the Alcatel-Lucent site is therefore considered to be high. On the basis of the investigations already carried out at the neighbouring Enderby Wharf site, it is recommended that an environmental archaeological assessment of one borehole sequence is carried out. This assessment should consist of: (1)

radiocarbon dating of the base and top of the Peat in order to ascertain the age of Peat accumulation and cessation; (2) organic matter determinations to aid identification of the sedimentary units; (3) assessment of the palaeobotanical remains (pollen, waterlogged wood and seeds) to provide a provisional reconstruction of the vegetation history; (4) assessment of the diatoms to provide an indication of the palaeohydrology (e.g. marine, brackish or freshwater), and (5) assessment of the zooarchaeological remains (insects and Mollusca) to provide information on the general environmental conditions, climatic change and hydrology of the site. The assessment will also highlight any indications of nearby human activity, and provide recommendations for further analysis (if necessary).

REFERENCES

Barnett, C., Allen, M.J., Evans, G., Grimm, J.M., Scaife, R., Stevens, C.J. & Wyles, S.F. (2011) A Submerged Forest with Evidence of Early Neolithic Burning Activity and the Tilbury Alluvial Sequence at Canning Town, East London. *Transactions of the London and Middlesex Archaeological Society*, **61**, 1-15.

Batchelor, C.R. (2013) A report on the geoarchaeological borehole investigations and deposit modelling on land at Greenwich Peninsula, Tunnel Avenue, London Borough of Greenwich (Site Code: GPF12). *Quaternary Scientific (QUEST) Unpublished Report February 2013; Project Number 079/12.*

Batchelor, C.R., Young, D.S., Green, C.P., Austin, P., Cameron, N. & Elias, S. (2012). A Report on the Environmental Archaeological Analysis of Boreholes collected from the London Cable Car Route, London Boroughs of Newham and Greenwich (site code: CAB11). *Quaternary Scientific (QUEST) Unpublished Report January 2012; Project Number 140/10.*

Batchelor, C.R. (2015) Written Scheme of Investigation for the geoarchaeological investigation of land at Alcatel-Lucent Telegraph Works, Blackwall Lane, London Borough of Greenwich SE10. *Quaternary Scientific (QUEST) Unpublished WSI, June 2015; Project Number 094/15.*

Batchelor, C.R., Young, D.S. and Green, C.P. (2015) Land at Enderby Wharf, Christchurch Way, London Borough of Greenwich SE10 0AG (NGR: TQ 3925 7873): Environmental Archaeological Analysis Report. *Quaternary Scientific (QUEST) Unpublished Report May 2015; Project Number 140/13.*

Branch, N.P., Green, C.P., Vaughan-Williams, A., Elias, S., Swindle, G., & Batchelor, C.R.

(2005) Bellot Street, Maze Hill, London Borough of Greenwich (site code: GBL05): environmental archaeological assessment. *ArchaeoScape Unpublished Report.*

Branch, N.P., Batchelor, C.R., Elias, S., Green., C.P. & Swindle, G.E. (2007) Preston Road, Poplar High Street, Poplar, London Borough of Hamlets (site code: PPP06): environmental archaeological analysis. *ArchaeoScape Unpublished Report.*

CgMs Consulting (2014) Archaeological Desk Based Assessment: Alcatel-Lucent Telegraph Works, Blackwall Lane, Greenwich, London SE10. *CgMs Consulting Unpublished DBA, January 2014.*

Corcoran, J. (2002) Greenwich Peninsula SE10: a geoarchaeological report. *MoLAS unpublished report.*

Corcoran, J., Halsey, C., Spurr, G., Burton, E. and Jamieson, D. (2011) Mapping past landscapes in the lower Lea valley: A geoarchaeological study of the Quaternary sequence. *Museum of London Archaeology, MOLA Monograph 55.*

Gibbard, P.L. (1994) *Pleistocene History of the Lower Thames Valley*. Cambridge University Press, Cambridge.

Green, C.P. & Young, D.S. (2012) A Report on the Geoarchaeological Borehole Investigations and Deposit Modelling on Land at Canning Town Regeneration Area 7/1C, London Borough of Newham (NGR 539610 181443). *Quaternary Scientific (QUEST) Unpublished Report June 2012; Project Number 048/12*

Holder, N. (1998) An Archaeological Excavation Assessment and Updated Project Design for Royal Docks Community School Site, Prince Regent Lane, Newham*. MoLAS Unpublished Report.*

Lakin, D. (1998) Atlas Wharf, Westferry Road, Isle of Dogs. *MoLAS unpublished report.*

McLean. G. (1993) An outline report on an archaeological evaluation at the land at the rear of 72-88 Bellot Street Greenwich London SE10. *SELAU Unpublished Report.*

Miller, P. and Halsey, C. (2011) Greenwich Millennium Village Phase 3-5, Greenwich SE10: A geoarchaeological and historic environment assessment. *Museum of London Archaeology*

Unpublished Report 2011.

Morley, M. (2003) Greenwich Industrial Estate, Bugsby's Way, Charlton, London SE7, a Geoarchaeological Investigation. *MoLAS Unpublished Report*.

Pepys, S. (1665). *Samuel Pepys Diary September 1665*. Available at http://www.pepysinfo/1665/ 1665sep.html accessed on 20th April 2007.

Philp, B. (1993) An Outline Report on an Archaeological Evaluation Excavation at the Land at the Rear of 72-88 Bellot Street, Greenwich, London SE10. *SELAU Unpublished Report.*

Sidell, E.J. (2003) *Relative sea-level change and archaeology in the inner Thames estuary during the Holocene.* University College, London, Unpublished PhD Thesis.

Stafford, E. (2012) *Landscape and Prehistory of the East London Wetlands*. Oxford Archaeology Monograph no. 17.

Wessex Archaeology (2000) Fort Street (West) Silvertown, London, E16, Archaeological excavation assessment report. *Wessex Archaeology: Unpublished Report.*

Wilkinson, K.N., Scaife, R.J. & Sidell, E.J. (2000) Environmental and sea-level changes in London from 10,500 BP to the present: a case study from Silvertown. *Proceedings of the Geologists' Association,* **111**, 41-54.

Young, D.S. and Batchelor, C.R. (2013a) A report on the geoarchaeological borehole investigations and deposit modelling on land at Plot MO115, Greenwich Peninsula, London Borough of Greenwich (site code: CHB13). *Quaternary Scientific (QUEST) Unpublished Report February 2013; Project Number 224/12.*

Young, D.S. and Batchelor, C.R. (2013b) A report on the geoarchaeological borehole investigations and deposit modelling on land at Plot MO117, Greenwich Peninsula, London Borough of Greenwich (site code: JHW13). *Quaternary Scientific (QUEST) Unpublished Report February 2013; Project Number 210/12.*

Young, D.S. and Green, C.P. (2015) A report on the geoarchaeological deposit modelling on land associated with the Silvertown Tunnel, London Boroughs of Greenwich and Newham.

Quaternary Scientific (QUEST) Unpublished Report May 2015; Project Number 046/15.

Young, D.S. and Batchelor, C.R. (2015) Greenwich Peninsula Central East Plots NO205, NO206 and NO207 (Site Code: CTT15): Environmental Archaeological Assessment Report. *Quaternary Scientific (QUEST) Unpublished Report August 2015; Project Number 067/15.*