Geoarchaeology

ARCA

March 2015

Report Number: 1415-2

DARENT VALLEY, EYNSFORD TO SOUTH DARENTH, KENT: GEOARCHAEOLOGICAL ASSESSMENT AND DEPOSIT MODEL

Prepared for Thames Water

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Version	Date	Status*	Prepared by	Author's signature	Approved by	Approver's Signature
01	30/03/15	E	Phil Stastney			
*I – Internal draft; E – External draft; F – Final						

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SUMMARY

This report presents a geoarchaeological deposit model for the Darent Valley, between Eynsford and South Darenth, Kent. A total of 66 borehole records held on the British Geological Survey (BGS) database were combined with data from three purposive geoarchaeological boreholes drilled in the floodplain of the River Darent to produce the model.

Five main stratigraphic units were identified: Upper Chalk, Terrace Gravels, Head, Alluvium, and Made Ground. Recording of the alluvium in the BGS records was variable, resulting in poor overall modelling of the extent and thickness of alluvium in the Study Area. However, the three geoarchaeological boreholes (ARCA BH1, ARCA BH2, and ARCA BH3) revealed up to 0.86m of fine-grained mineral sediments.

No waterlogged or organic sediments were noted in any of the boreholes in the Study Area, and therefore the Alluvium was assessed as being of low to moderate archaeological and palaeoenvironmental potential. Sediments of higher potential might occur in some places within the Study Area, but more detailed borehole studies would be required to improve the deposit models and to identify and assess any such strata should they exist.

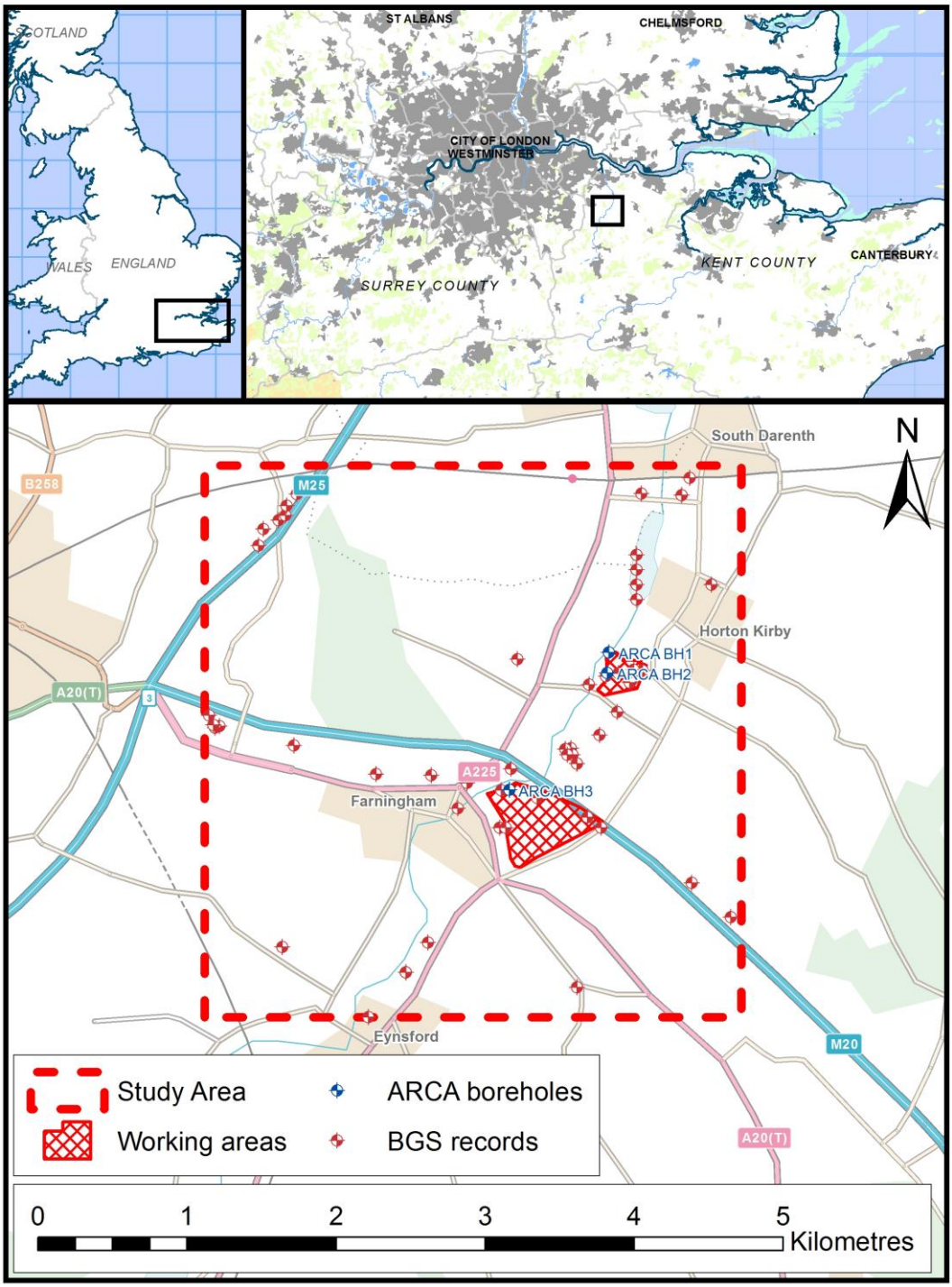
1. INTRODUCTION

1.1 A geoarchaeological borehole study was carried out by ARCA of the Darent valley between the villages of Eynsford and South Darenth (henceforth 'the Study Area') at the request of Thames Water. ARCA examined 66 existing logs from previous geotechnical boreholes and test pits and drilled three geoarchaeological boreholes in February 2015.

1.2 This report presents the results of the geoarchaeological works, namely the production of deposit models based on the logs of geotechnical and geoarchaeological boreholes, and an assessment of the stratigraphy recovered in the geoarchaeological boreholes. This report is arranged as follows: first a brief account is provided of the geographic, geological and methodological background to the geoarchaeological project; secondly the borehole stratigraphy is described in detail; and thirdly the potential of the sample resource in the boreholes to address the questions outlined in Section 1.6 is addressed. A bibliography and an appendix containing lithological descriptions of the geoarchaeological borehole stratigraphy completes the document.

1.3 The Study Area encompasses the stretch of the River Darent between the village of Eynsford in the south, and southern fringes of the village of South Darenth in the north (see Figure 1). The Study Area is rectangular, stretching 3.6 km from west to east and 3.7 km from north to south, covering an area of 1,332 ha. The south-western corner of the Study Area is at NGR TQ 53000 65700, the north-eastern corner is at NGR TQ 56600 69400. The Study Area is centred on two 'working areas' defined by Thames Water: a northern area covering approximately 6 ha in the village of Horton Kirby (centred on NGR TQ 55800 68000), and a second area further south covering approximately 22 ha immediately north of Farningham (centred on NGR TQ 55200 67000). A section of the middle reaches of the River Darent flows through the Study Area from north to south. The River Darent is a tributary of the River Thames, rising from springs near Westerham, Kent, and flowing into the Thames to the north of Dartford. The section of the River Darent within the Study Area is a meandering stream, with a number of on-line lakes in the north of the Study Area, between Horton Kirby and South Darenth, resulting from gravel extraction. The base of the Darent valley ranges in elevation from c. +40m OD in the south to c. +20m OD in the north, with areas of higher ground on

either side of the valley reaching elevations of up to c. +125m OD.



Project: Darent Valley, Kent: Geoarchaeological deposit model

Location map

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Figure 1: Location map.

1.4 The British Geological Survey (BGS) map the majority of the Study Area as lying on rock of the Seaford Chalk Formation, part of the White Chalk Group (formerly the Upper Chalk), a Cretaceous deposit dating from 89-71 my BP. A succession of younger deposits that overlie the Chalk outcrop on an area of higher ground in the north-west of the Study Area at Farningham Wood: the Thanet Formation (59-56 my BP), overlain by the Lambeth Group (66-56 my BP), and finally the Harwich Formation (66-34 my BP) (BGS 2014). The BGS map outcrops of Head occupying several dry valleys either side of the River Darent; within the Darent valley itself a somewhat discontinuous outcrop of alluvium is mapped overlying sands and gravels of the Taplow Gravel Formation. The term 'Taplow Gravel', however, relates to gravel units of the Middle Thames outcropping between the Goring gap and London (Bridgland 1994, 83). Bridgland (1994, 175-176) ascribes the deposits classified as Taplow Gravel by the BGS in the Dartford area to the Mucking Gravel, a unit thought to have accumulated between Marine Isotope Stages (MIS) 8 and 6 (301-127 ky BP).

1.5 Whilst a series of geoarchaeological investigations have recently been completed at Long Reach, Dartford, c. 500m south-east of the mouth of the River Darent (Wilkinson 2012, Wilkinson *et al.* 2012, Wilkinson 2013, Stastney *et al.* 2014); few previous geoarchaeological investigations have taken place around the middle and upper reaches of the Darent, and none have taken place within the Study Area. A number of archaeological investigations have, however, taken place in the vicinity of the study area revealing evidence for human activity around the River Darent from Early Prehistory onwards (e.g. Simmonds *et al.* 2011). An archaeological and archaeoenvironmental evaluation at the site of Horton Kirby Paper Mill, immediately to the north of the Study Area, revealed a sequence of deposits consisting of gravels overlain by a peat layer (between +18.38m OD and +18.90m OD) which was in turn overlain by mineral alluvial strata cut by a small palaeochannel, and sealed by modern Made Ground (Seddon 2006). Subsequent ^{14}C dating of the sequence suggests that the peat accumulated during the Late Mesolithic[1] and that the mineral alluvial strata were deposited during the Early Medieval period[2] (Batchelor *et al.* 2014, 270). Sites of known archaeological significance within

[1] Beta-224491 - 6630±60 BP (5650-5480 cal BC); Beta-316484 - 6480±40 BP (5530-5360 cal BC); Beta-238526 - 5950±40 BP (4940-4720 cal BC); Beta-238527 - 6270±40 BP (5330-5070 cal BC); Beta-316485 - 6250±40 BP (5320-5070 cal BC); Beta-321893 - 6310±30 BP (5360-5210 cal BC) (Bachelor *et al.* 2014, 270).

[2] Beta-224490 - 1300±40 BP (cal AD 640-800) (Batchelor *et al.* 2014, 270).

the Study Area include a number of Roman villas, the 11th/12th century Eynsford Castle, and the 16th century Franks Hall and adjacent 13th century moated house in Horton Kirby (ADS 2014)

1.6 The objectives of the geoarchaeological works were to:

1.6.1 Determine the Holocene sedimentary sequence in the Study Area.

1.6.2 Assess the archaeological, palaeoenvironmental and geoarchaeological potential of the Holocene sedimentary units encountered.

2. METHODOLOGY

2.0.1 The project presented here comprised two stages of geoarchaeological works: firstly, examination of existing geotechnical borehole records; and second, the drilling of dedicated geoarchaeological boreholes within the two working areas within the Study Area (see Section 1.3).

2.1 Geotechnical borehole records

2.1.1 Logs of all 66 geotechnical boreholes and test pits within the Study Area were collated (see Figure 2); these included both publically-available records (available online at http://www.bgs.ac.uk/data/bmd.html), and records held privately by Thames Water, which were collated by Claire Hallybone (Thames Water's archaeologists) and passed to ARCA at the outset of the project. The geotechnical borehole records spanned the period from the 1940s onwards and were of highly variable spatial and stratigraphic resolution, and descriptive quality.

2.1.2 Positional and descriptive information was manually entered into a RockWorks v.15 (RockWare 2013) database. Standard lithological criteria were then imposed upon each unit recorded in the logs using the loggers' geotechnical descriptions as a basis for assignation. Finally the units were assigned to one of the formal geological units mapped in the Study Area (see Section 1.4). It should be noted that the process of transforming geotechnical borehole logs into standard lithological classes and subsequent assignation of those classes to a defined and published geological unit ('Stratigraphic units' in RockWorks terminology) is open to interpretation. Correct transformation is entirely dependent on the quality and objectivity of the original logs, which as noted in Section 2.1.1, were highly variable.

2.1.3 The RockWorks database, updated to include lithological information from the geoarchaeological boreholes (Section 2.2.3) was used to plot the composite cross sections in Figure 3 and Figure 4, and the surface/thickness models of Figure 5 to Figure 13. The latter were produced using a Kriging algorithm and are based on interpolations of strata recorded in varying numbers of boreholes depending on the particular surface/thickness to be modelled. It should be emphasised that the models need to be treated very cautiously, particularly in spatial locations where there are few datapoints (i.e. boreholes). Kriging algorithms are an effective way of interpolating data that

are not uniformly distributed, but even so model uncertainty increases rapidly away from known points.

2.2 Geoarchaeological boreholes

2.2.1 The three geoarchaeological boreholes were positioned as shown in Figure 2 within the two 'working areas' in Horton Kirby (ARCA BH1 and ARCA BH2) and east of Farningham (ARCA BH3) (see also Figure 1).

2.2.2 Eijkelkamp auger heads and extension rods powered by a Makita heaver breaker and operated by a crew of three were used to drill the boreholes. Sediment recovered in the gouge auger heads were photographed and logged in the field according to standard geological criteria and then discarded (Tucker 1982, Jones *et al.* 1999, Munsell Color 2000).

2.2.3 Lithological descriptions obtained in the field were combined with GPS-derived positional information within the same RockWorks database that housed the geotechnical records (see Section 2.1.2 and 2.1.3). Full lithological descriptions of the three geoarchaeological boreholes are given in Appendix 1.

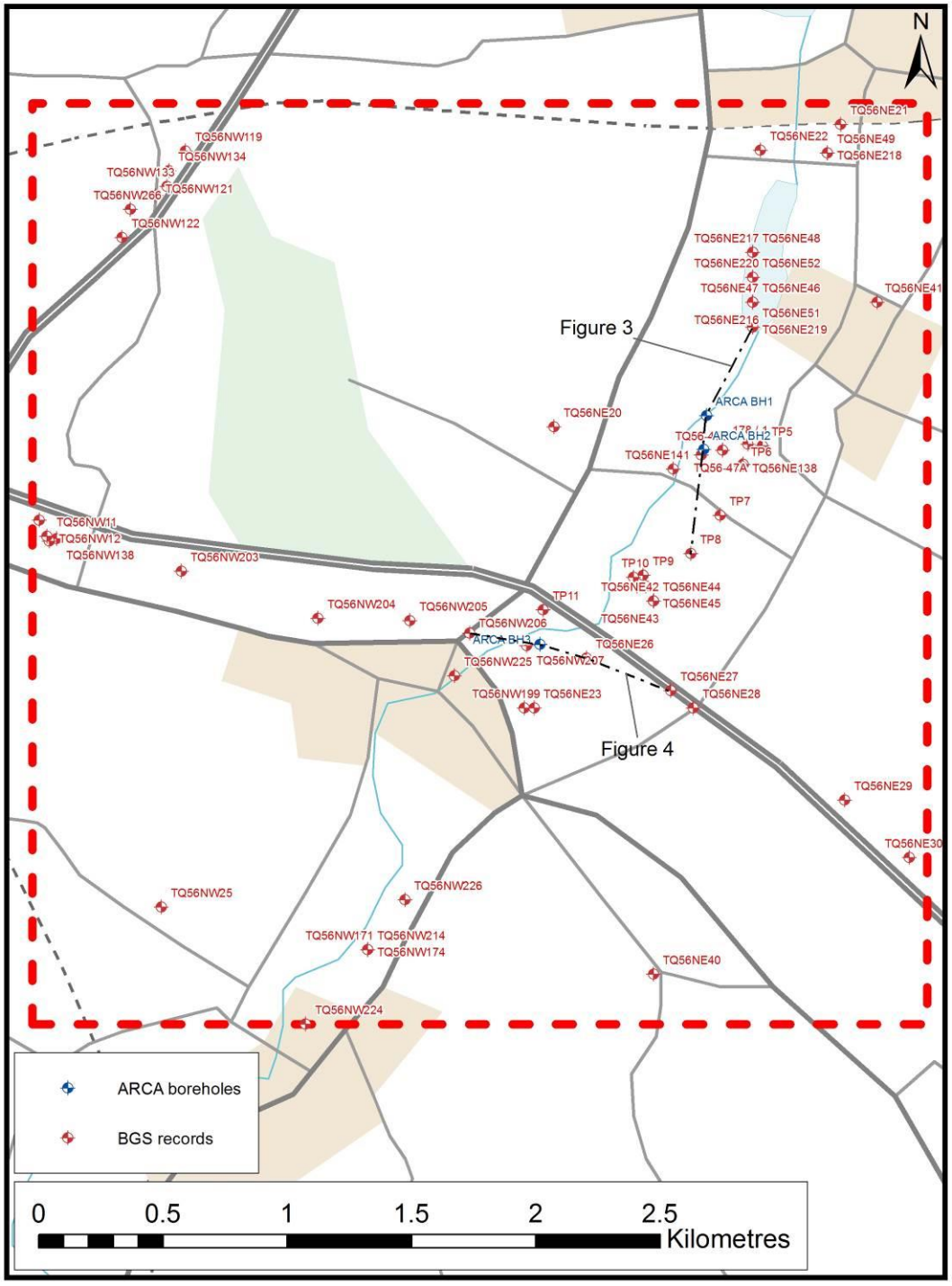

Figure 2: Location of ARCA boreholes and BGS stratigraphic records. Dashed lines indicate positions of the cross-sections shown in Figure 3 and Figure 4.

3. LITHOSTRATIGRAPHY

3.0.1 Five broad stratigraphic units (*sensu* RockWare 2013) were encountered in the geoarchaeological and prior geotechnical boreholes within the Study Area. These are reviewed below in relative chronological order. Lithostratigraphic cross-sections are shown in Figure 3 and Figure 4.

3.1 Upper Chalk (Seaford Chalk Formation)

3.1.1 Bedrock of the Seaford Chalk Formation was encountered in the majority of the BGS borehole records, but not in the purposive geoarchaeological boreholes drilled by ARCA.

3.1.2 Chalk bedrock was generally recovered as weak 'putty chalk' overlying hard chalk with flints.

3.1.3 Seaford Chalk Formation bedrock generally outcropped at, or near to, the surface in the areas of higher ground either side of the River Darent; elsewhere the Chalk was unconformably overlain by Head, Terrace Gravels, or Made Ground.

3.1.4 Bedrock of the Thanet Formation and Lambeth Group are mapped in the north-western part of the Study Area (i.e. in the area of the Farningham Wood Nature Reserve) by the BGS (2014). None of the borehole records within the Study Area encountered undisturbed bedrock of either formation, although much of the Head deposits are likely to have been derived from reworked Thanet Formation or Lambeth Group strata.

3.2 Terrace Gravels (Taplow Gravel Formation)

3.2.1 Late Pleistocene Terrace Gravels of the Taplow Gravel Formation (or 'Mucking Gravel', see Section 1.4) were encountered in the majority of borehole records across the base of the Darent Valley.

3.2.2 Terrace Gravel deposits generally consisted of poorly sorted sands and flint gravels which are likely to have formed on the braid plain of the Late Pleistocene River Darent.

3.2.3 Terrace Gravels were often encountered at, or just below, the surface throughout the valley bottom, occasionally overlain by Holocene Alluvium.

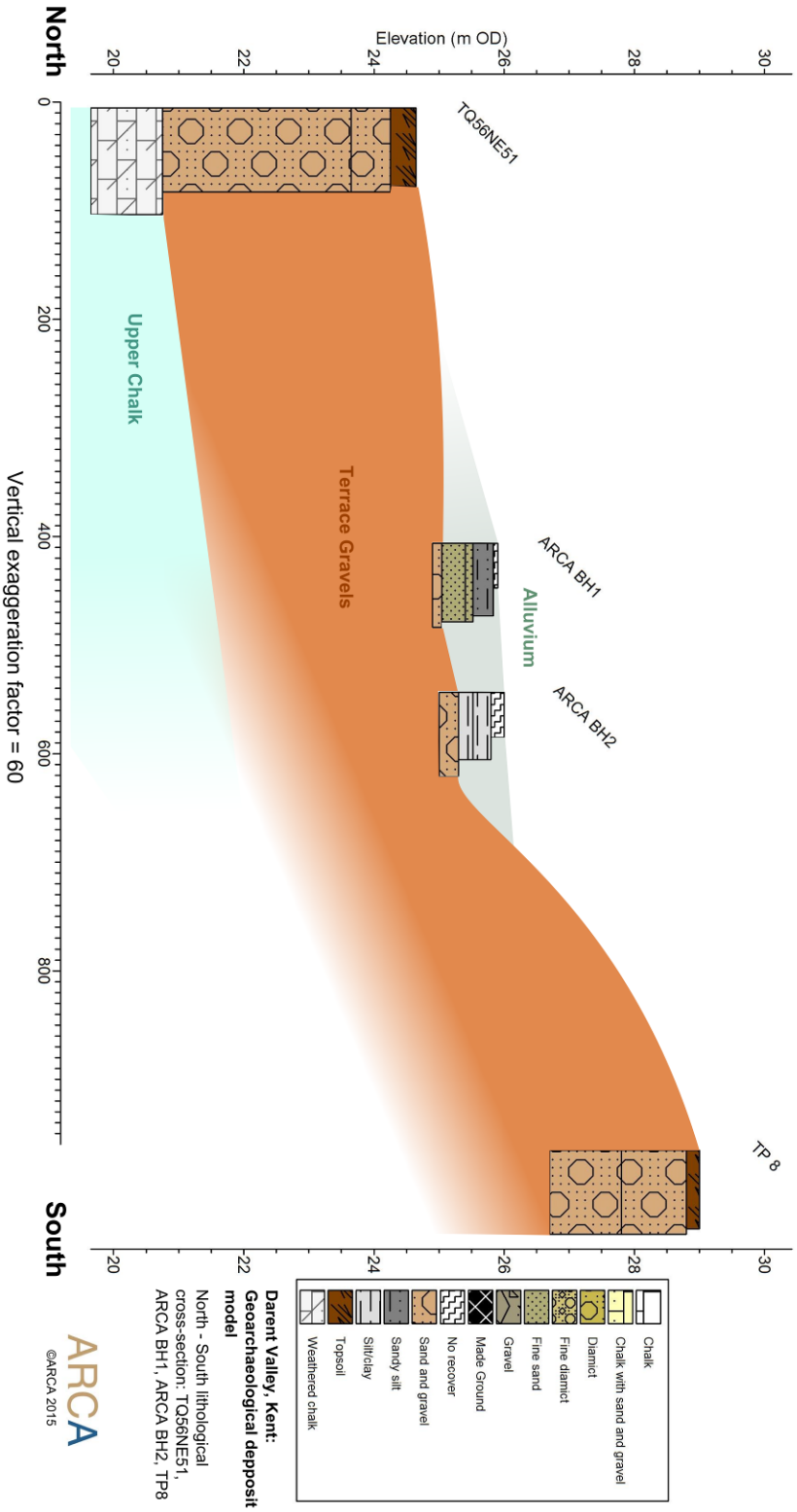

Figure 3: North - South lithostratigraphic cross section.

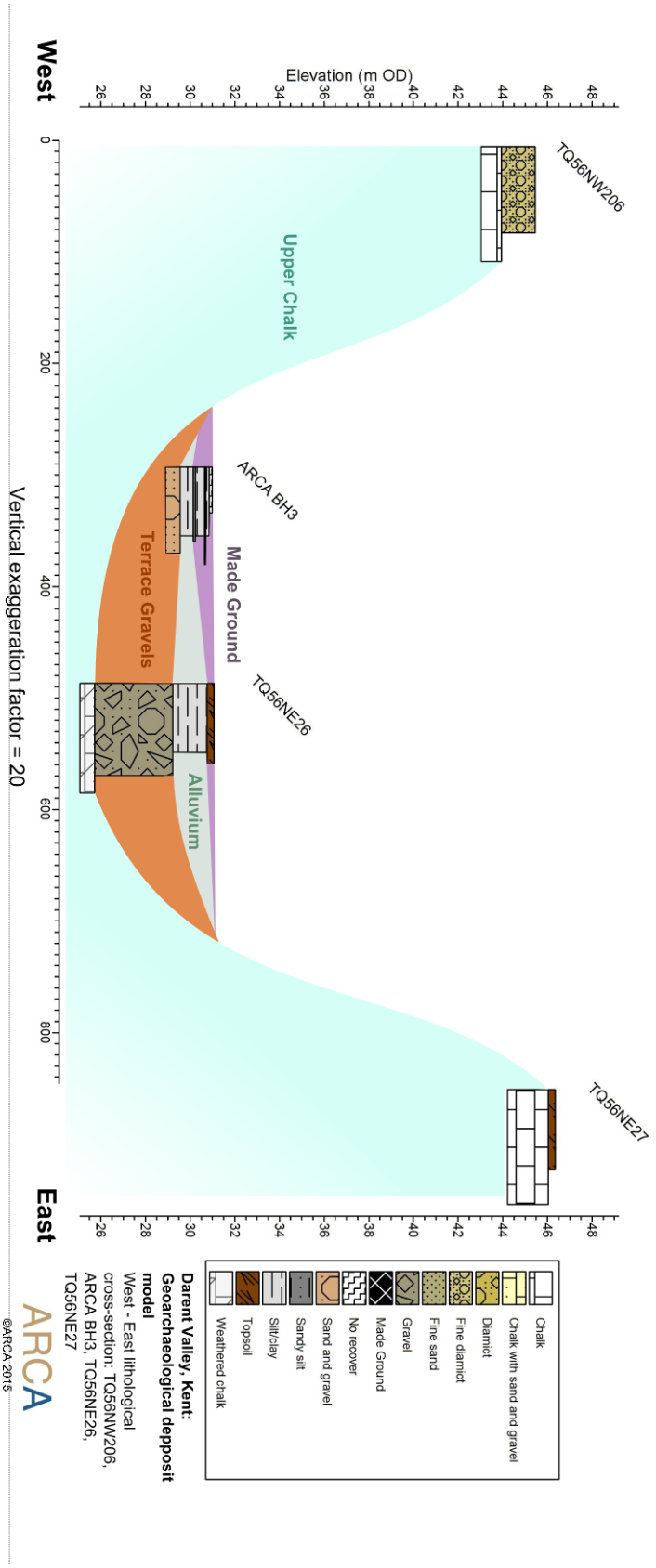

Figure 4: West - East lithostratigraphic cross section.

3.3 Head

3.3.1 'Head' is a generic term employed by the BGS to describe poorly sorted and poorly stratified deposits formed by solifluction and/or hillwash.

3.3.2 Head deposits within the Study Area were generally encountered in boreholes on the areas of higher ground either side of the Darent Valley, particularly in the north-west where bedrock of the Thanet Formation is mapped by the BGS. Head deposits within the study area generally comprised poorly sorted sands and silty-sands, much of which is likely to be derived from reworked Thanet Formation bedrock.

3.3.3 Head deposits generally outcropped at the surface, or were unconformably overlain by Made Ground.

3.4 Alluvium

3.4.1 Holocene alluvium was generally poorly represented in the BGS borehole records within the Study Area. Some records did not clearly distinguish Alluvium from Terrace Gravel deposits, and several records that did record Alluvium did not provide any further lithological information.

3.4.2 The purposive geoarchaeological boreholes drilled by ARCA during the present works (ARCA BH1, ARCA BH2 and ARCA BH3) were all positioned in the present floodplain of the Darent with the aim of characterising the alluvium within the Study Area.

3.4.3 ARCA BH1 was drilled within a meander of the Darent in the north of the Horton Kirby working area. Terrace Gravels were encountered at the base, overlain by 0.86m of Alluvium which consisted of a fining-upwards sequence sands, and silty fine sands overlain by humic topsoil. Fining-upwards sequences such as these are indicative of deposition on a point bar, indicating gradually decreasing depositional energy as the channel migrated towards the north.

3.4.4 ARCA BH2 was drilled immediately east of the Darent, *c.*140m south of ARCA BH1. In this borehole, Terrace gravels were overlain by 0.70m of structureless (i.e. not bedded) silt/clay which is typical of low-energy overbank deposition on a floodplain.

3.4.5 ARCA BH3 was drilled adjacent to a public footpath running alongside the Darent in the north of the Farningham working area. Terrace Gravel strata at the base of this borehole were overlain by 0.67m of alluvium comprising stiff greyish brown sandy silt/clay. The Alluvium was in turn unconformably overlain by 0.77m of Made Ground.

3.4.6 Alluvium generally outcropped at the surface in the immediate vicinity of the channel of the River Darent within the Study Area, but was occasionally overlain by Made Ground (e.g. ARCA BH3).

3.4.7 Although organic strata were encountered within the Alluvium at Horton Kirby Paper Mill (Batchelor *et al.* 2014), just to the north of the Study Area, no similar organic strata were found in any borehole records within the Study Area. Alluvium within the Study Area was generally less than 1.00m in thickness. All alluvial strata encountered in the purposive geoarchaeological boreholes displayed evidence for redox processes (i.e. iron and manganese oxide granules, mottling, and a generally brownish colour) indicating that these strata have undergone some oxidation (most likely due to seasonal water table fluctuation). Nevertheless, given the variable distribution of boreholes within the Study Area and the variable detail contained in these records, it is possible that some waterlogged organic strata may occur elsewhere in the floodplain of the Darent.

3.5 Made Ground

3.5.1 'Made Ground' is a term used by the British Geological Survey to encompass deposits formed as a product of human action (BGS 2014). By their very nature such strata are likely to be of highly variable composition and of localised distribution.

3.5.2 Made Ground encountered in ARCA BH3 comprised a layer of concrete overlain by poorly sorted clayey gravel.

4. ASSESSMENT

4.1 Deposit models

4.1.1 Figures 5 to 13 display modelled surfaces and thickness of all major stratigraphic units (*sensu* RockWare 2013) encountered in borehole records within the Study Area.

4.1.2 As described in Section 2.1.3, above, the deposit models were generated using a Kriging algorithm, where the value of each point is estimated based on the 12 nearest datapoints (i.e. boreholes). This algorithm is widely used for modelling where datapoints are not uniformly distributed; however, uncertainty increases rapidly away from datapoints. Given that the majority of borehole records encountered Chalk bedrock, the surface model for the Upper Chalk is likely to be generally robust. Conversely, units with more restricted distribution that were encountered in fewer boreholes (e.g. Alluvium) are rather poorly modelled. The lack of boreholes along the margins of the floodplain in particular has resulted in poor modelling of the edges of the outcrops of Alluvium and Terrace Gravels. Furthermore, the variable recording of Alluvium/Terrace Gravel deposits in the BGS records has resulted in the modelled thickness of Alluvium being highly irregular. Similarly, the modelled thickness of Made Ground is likely to be far smoother than in reality. For these reasons, the models presented below should be interpreted with caution.

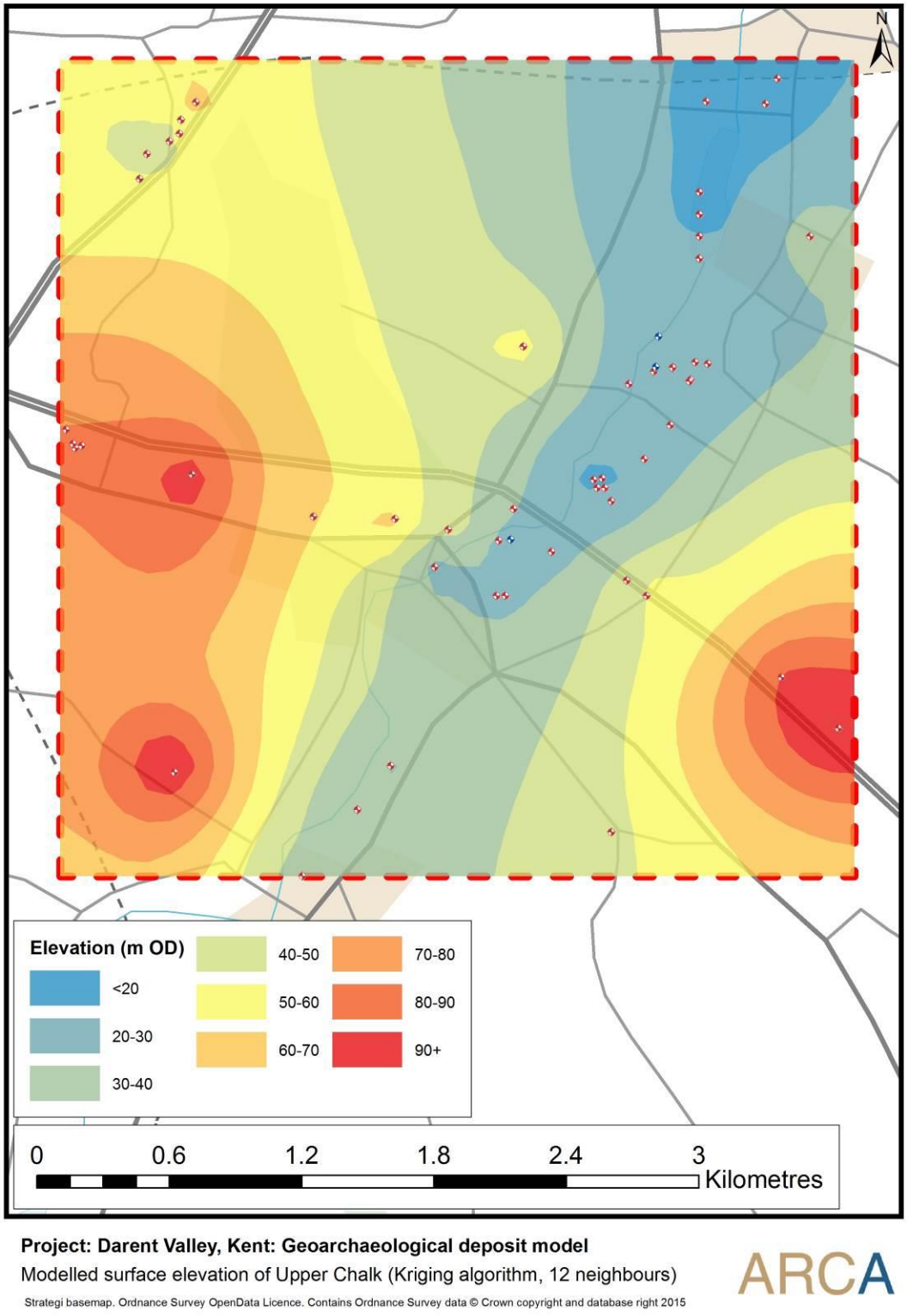

Figure 5: Modelled surface of the Chalk.

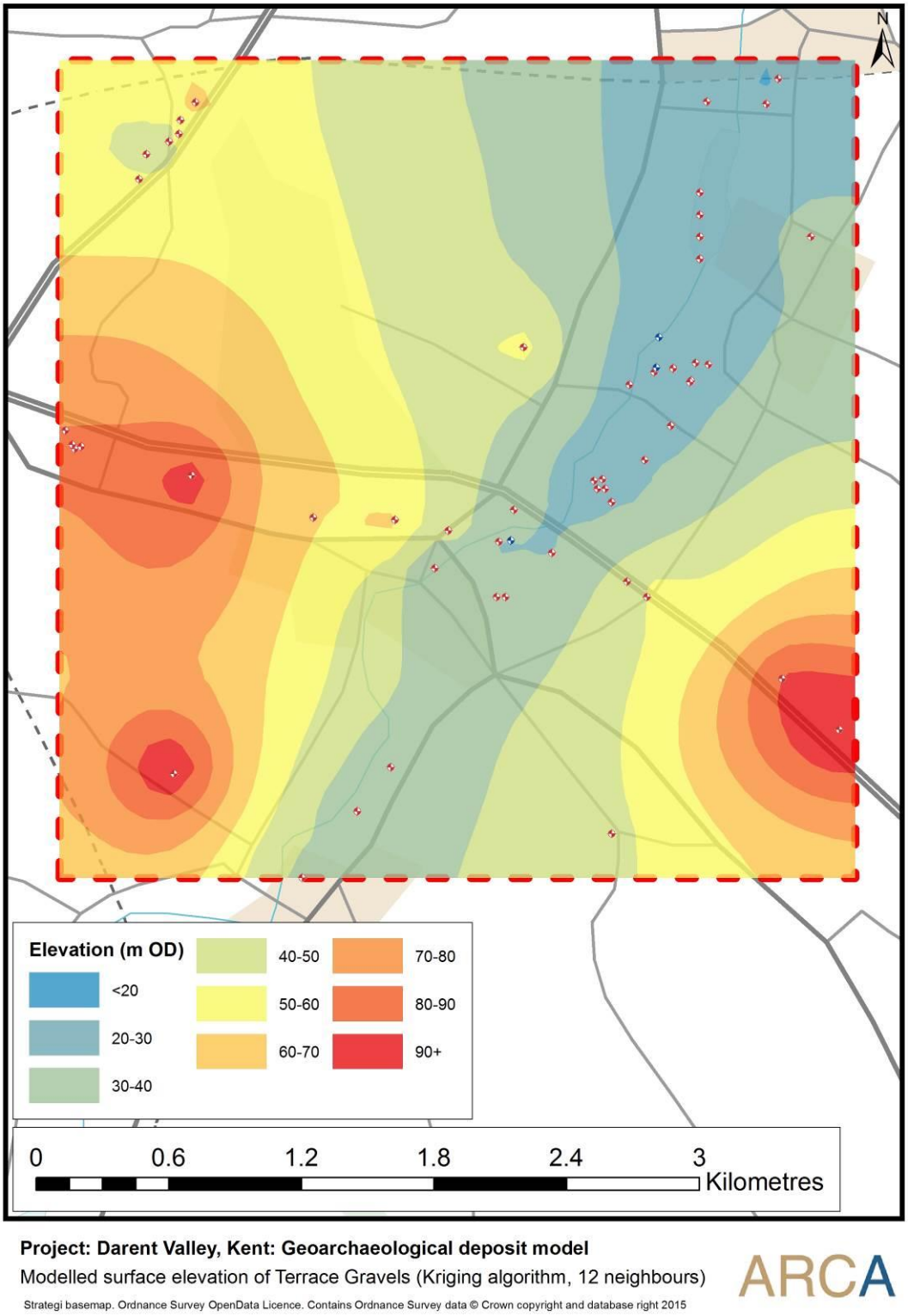

Figure 6: Modelled surface of the Terrace Gravels.

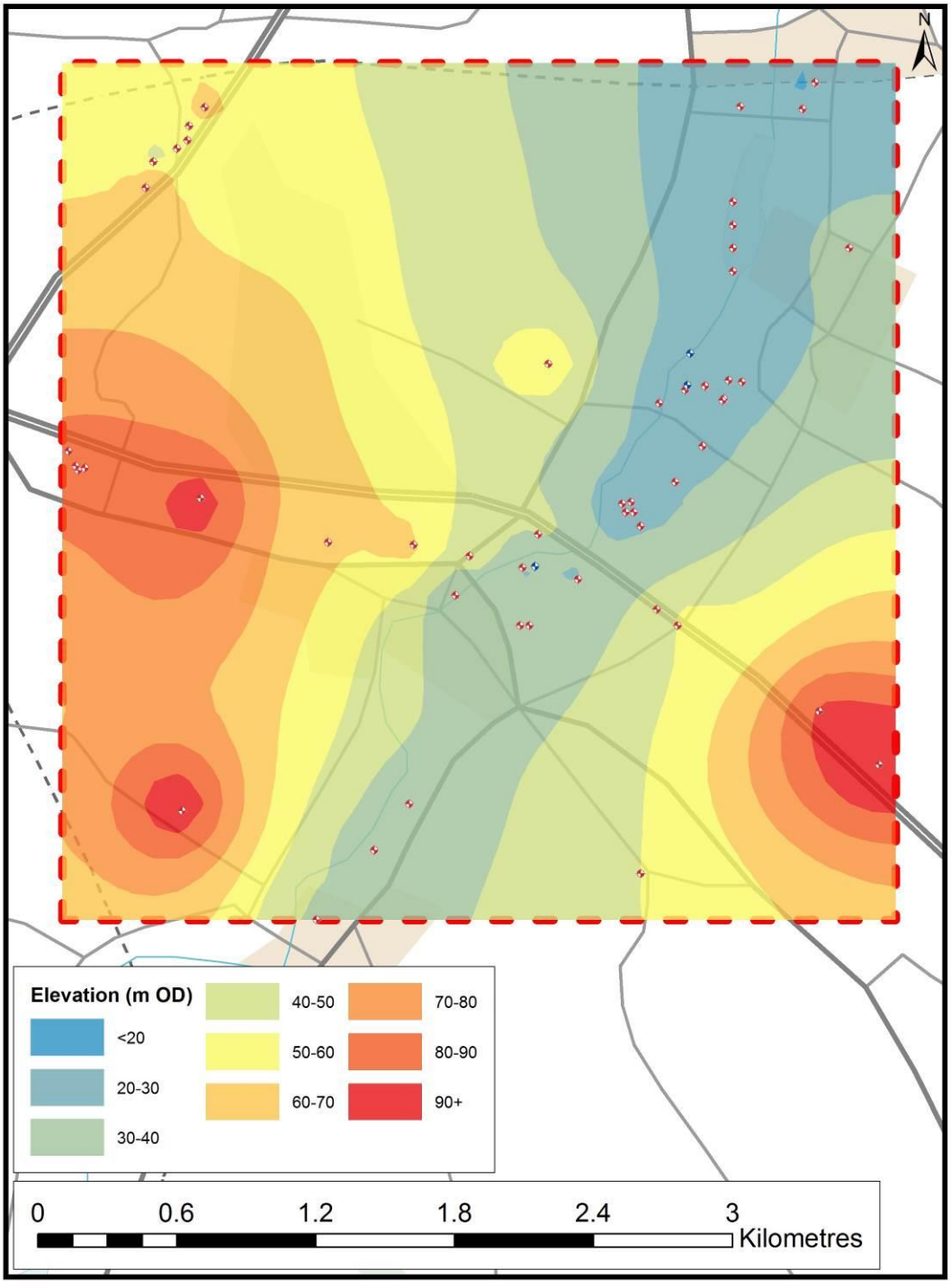

Figure 7: Modelled surface of Head deposits.

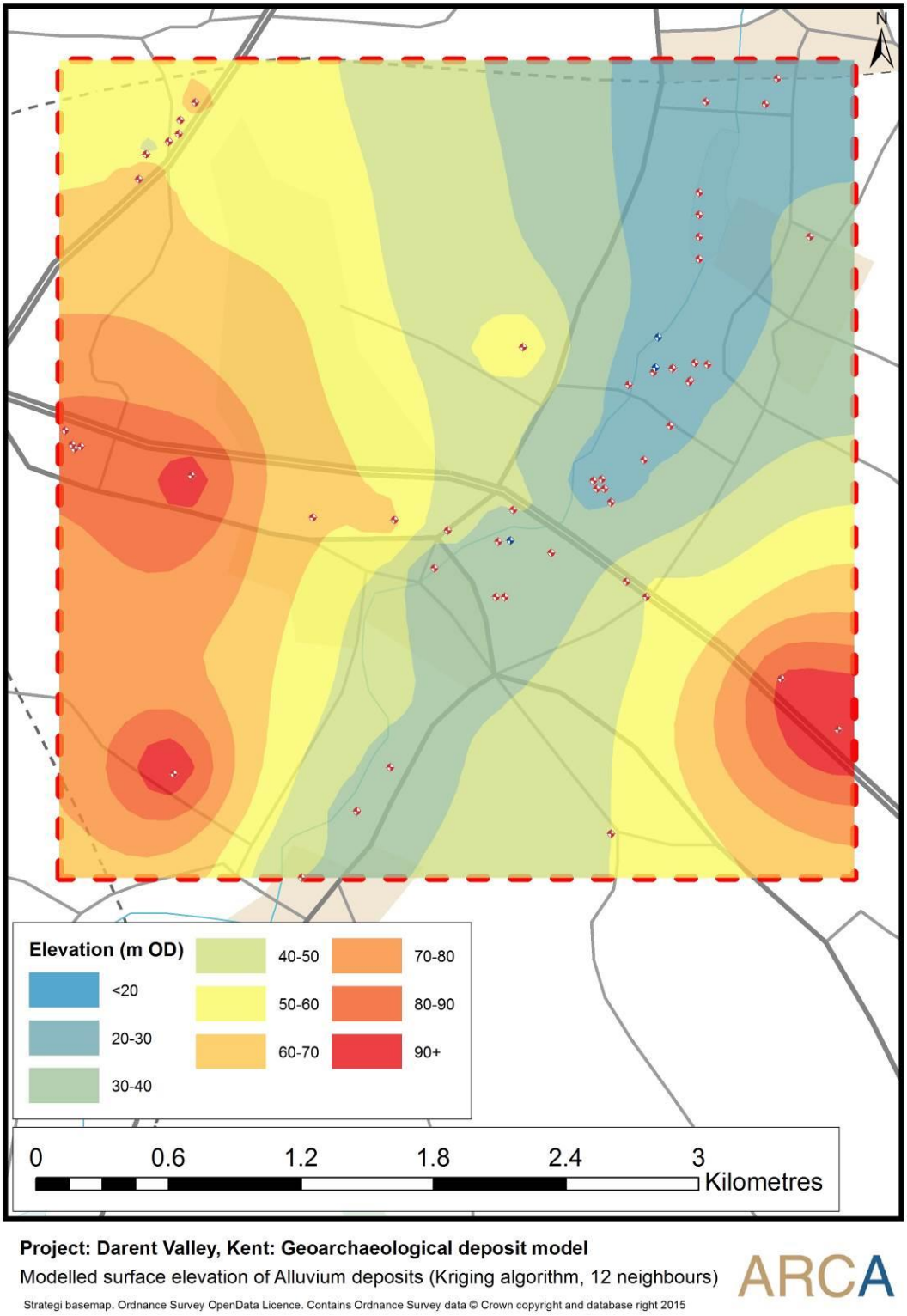

Figure 8: Modelled surface of Alluvium.

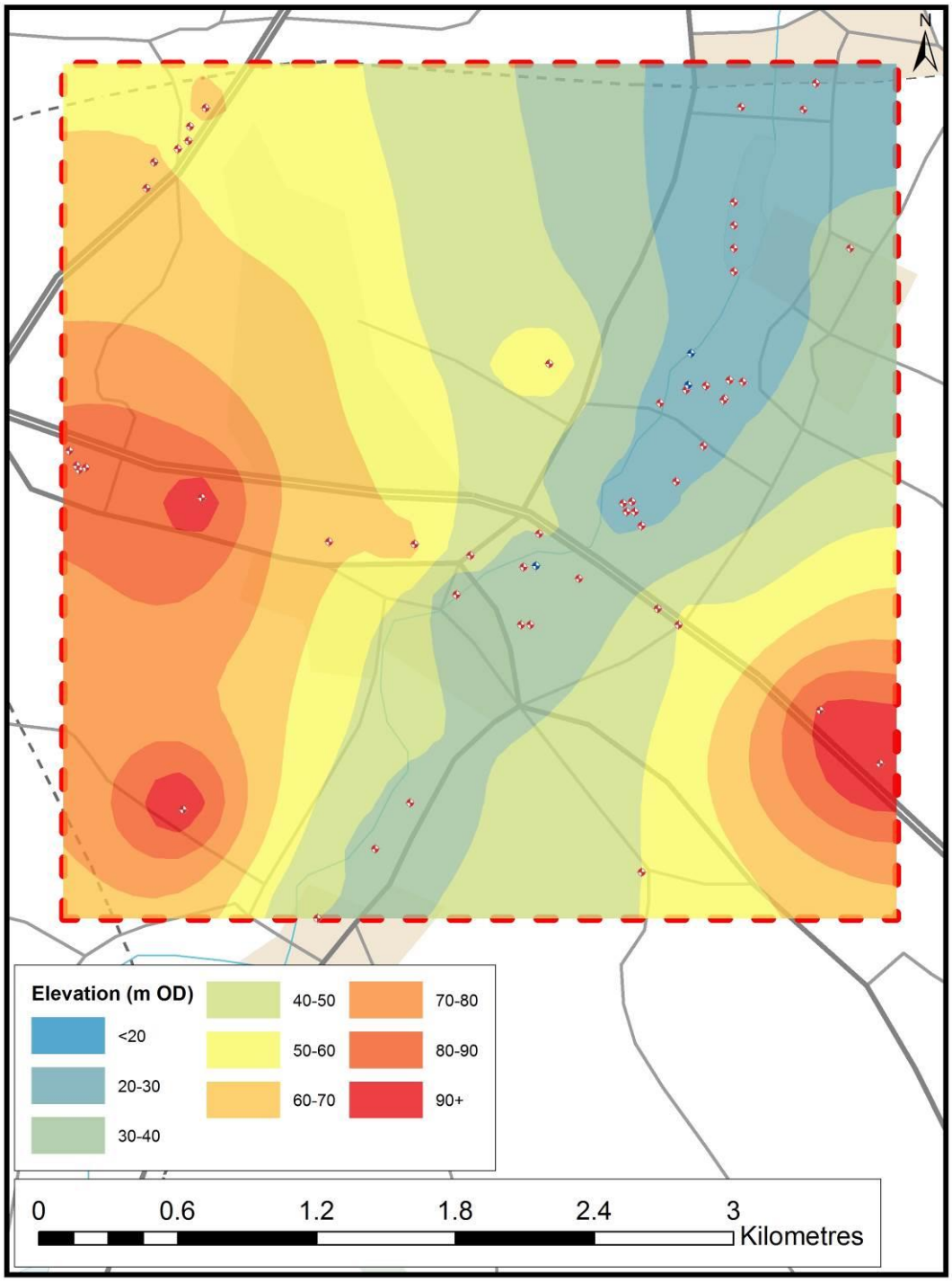

Figure 9: Modelled surface of Made Ground.

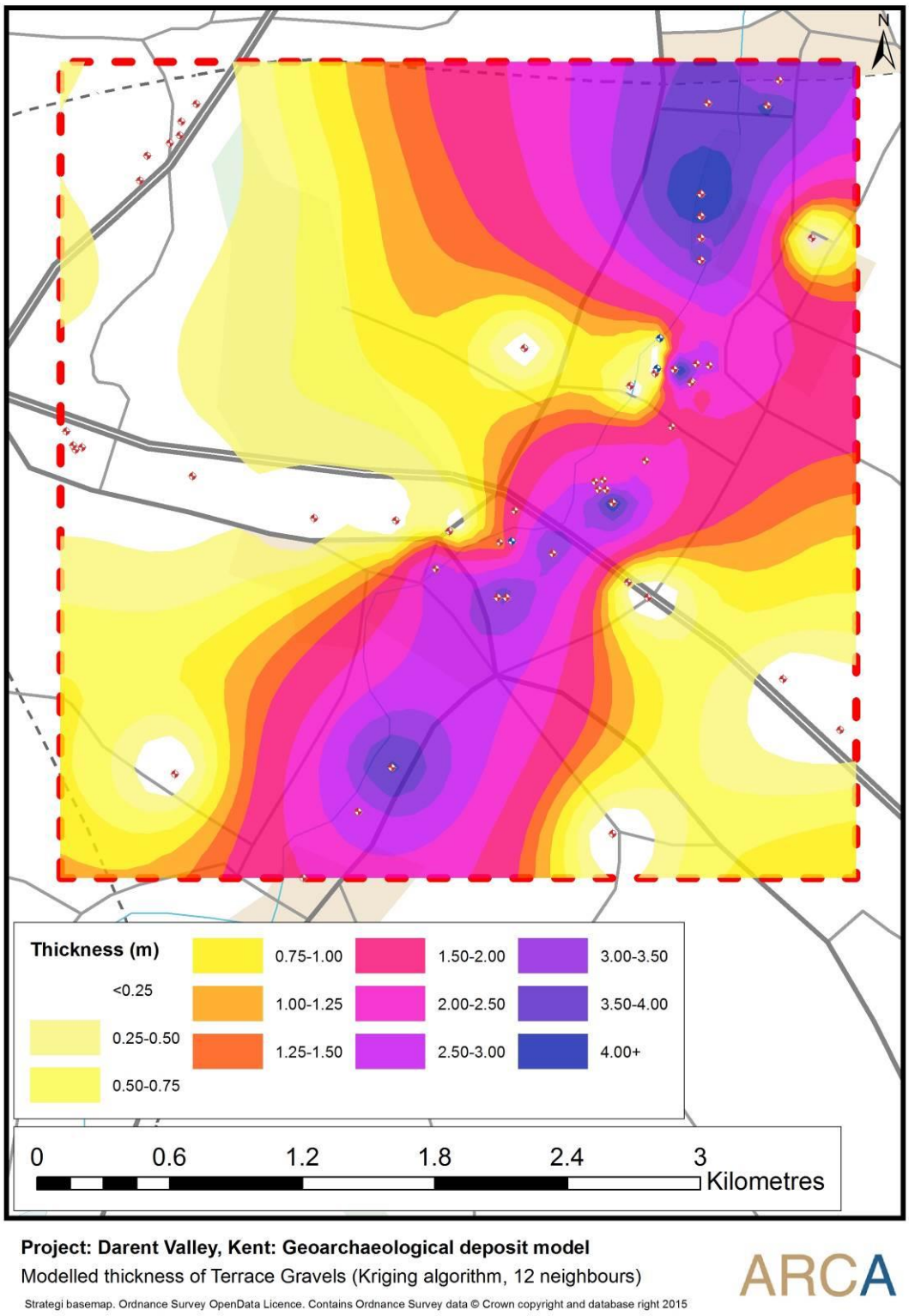

Figure 10: Modelled thickness of Terrace Gravels.

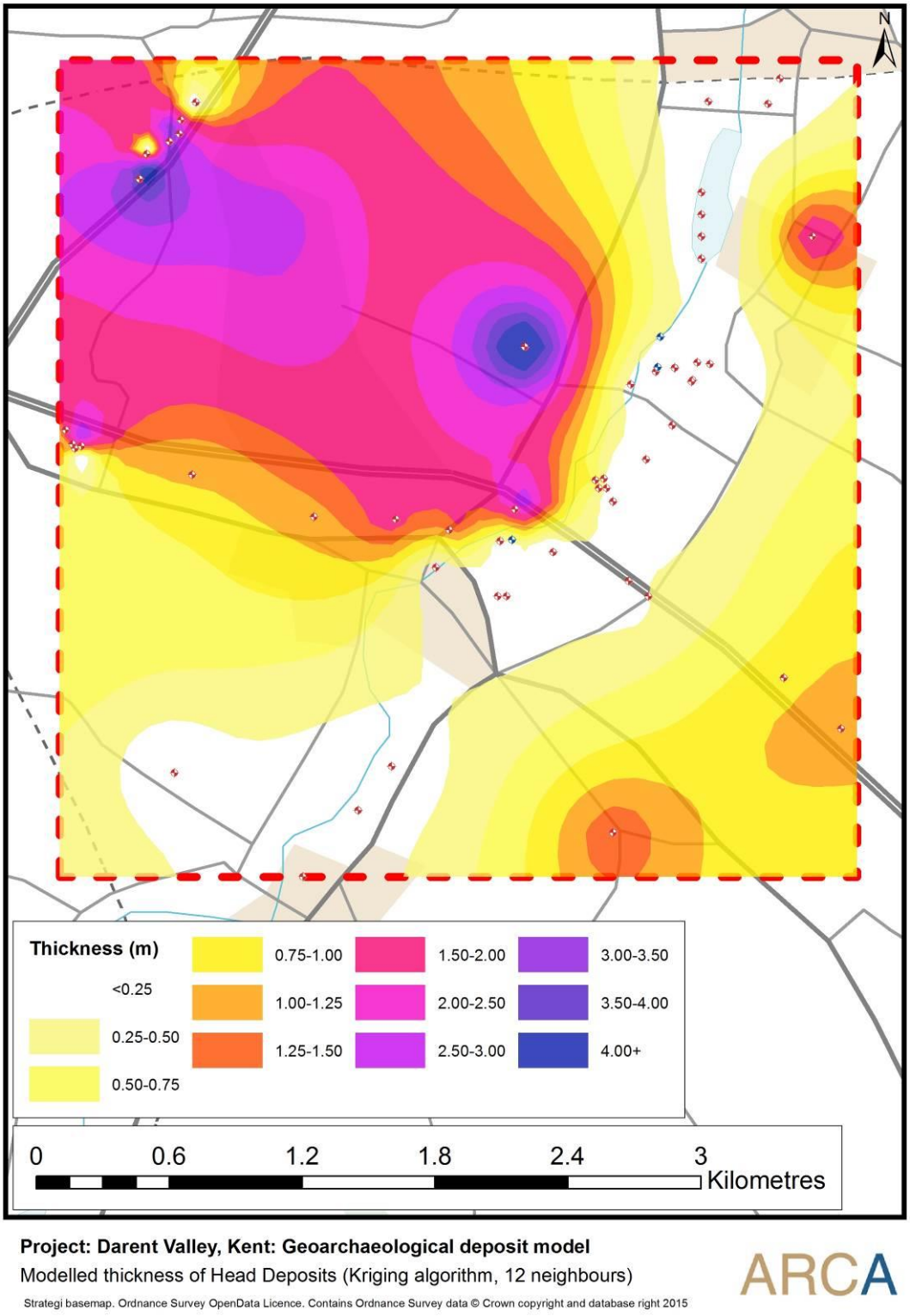

Figure 11: Modelled thickness of Head.

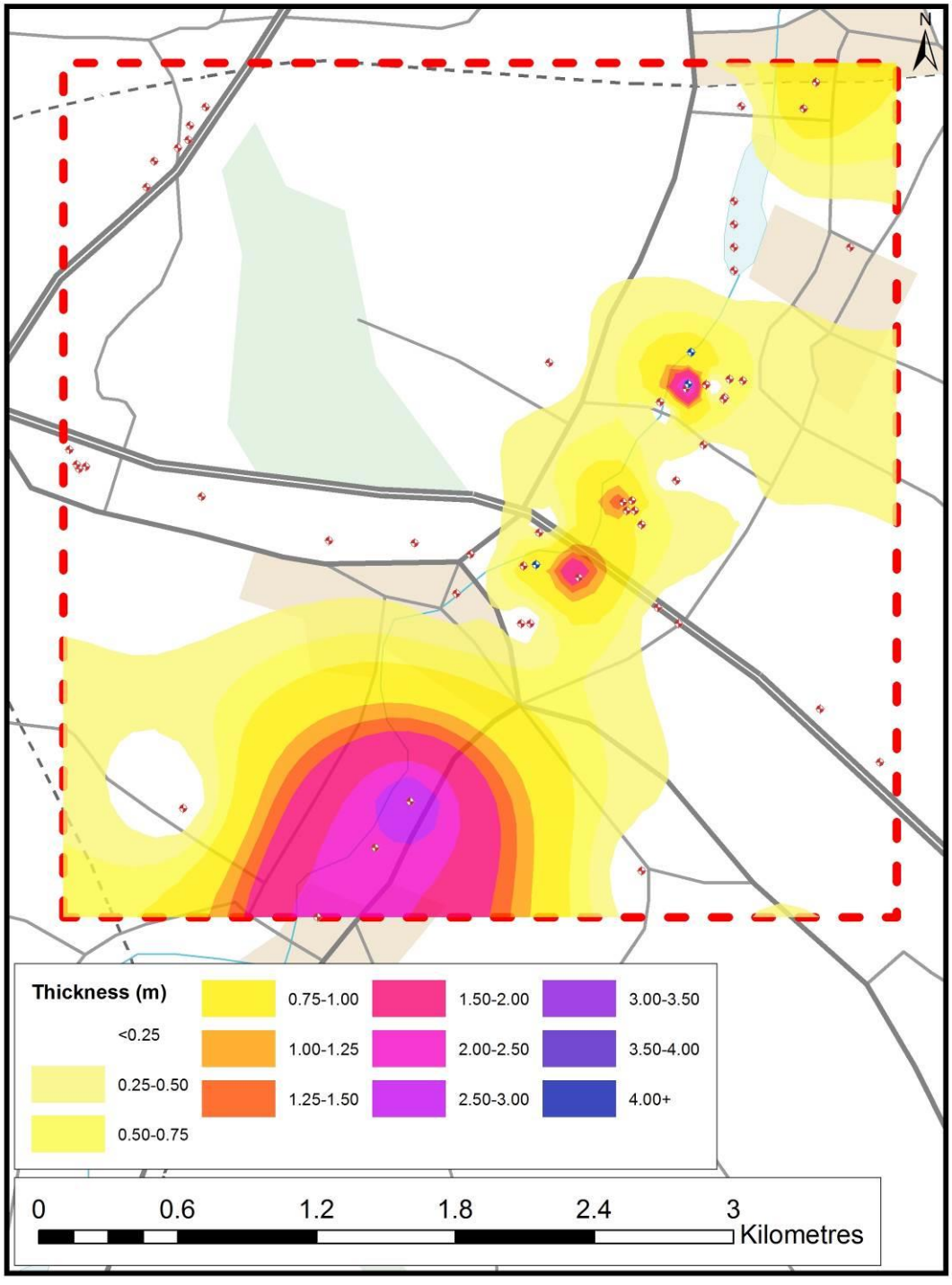

Figure 12: Modelled thickness of Alluvium.

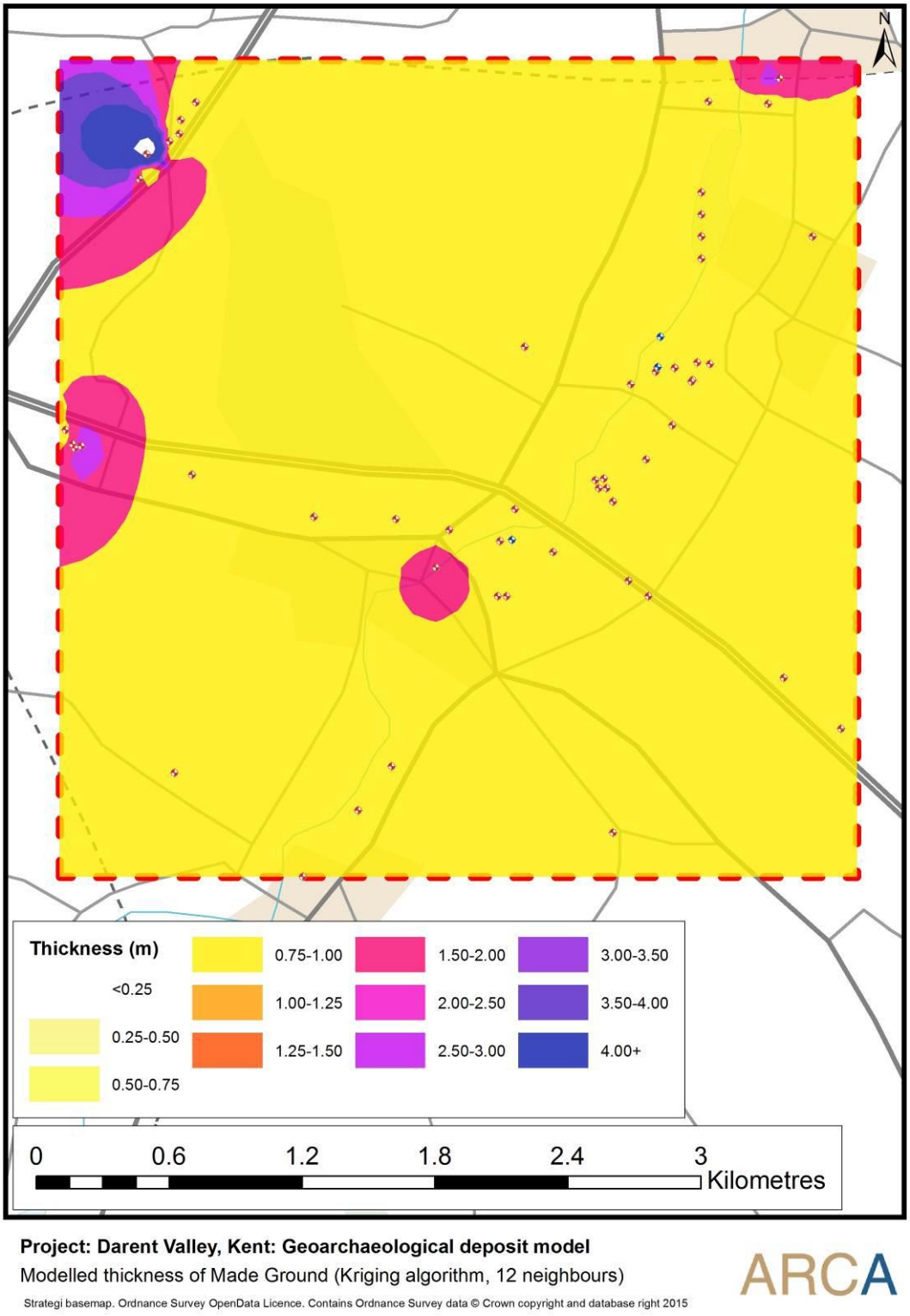

Figure 13: Modelled thickness of Made Ground.

4.2 Archaeological and palaeoenvironmental significance

4.2.1 Given the Cretaceous age of the Seaford Chalk Formation, these strata are of NO archaeological or palaeoenvironmental significance. Similarly given their Palaeocene age, the Thanet Formation and Lambeth Group have NO archaeological or palaeoenvironmental significance.

4.2.2 Terrace Gravel deposits are assessed as being of LOW archaeological potential given that these strata formed on a high-energy braid plan on which humans are unlikely to have been active. There is some potential for the recovery of lithic artefacts from these deposits, but any artefacts are likely to have been reworked.

4.2.3 The Terrace Gravels are assessed as being of LOW palaeoenvironmental potential; although fine-grained beds which may contain palaeoenvironmental indicators (e.g. faunal remains, molluscs etc.) do occur within such strata, no such beds or any specific indicators were noted in any of the records within the Study Area.

4.2.4 Head deposits are assessed as being of LOW archaeological and palaeoenvironmental potentials. Such strata may contain palaeoenvironmental indicators (such as molluscs), but no such indicators were noted, and any artefacts contained within these strata are likely to have been reworked.

4.2.5 Alluvium within the Study Area is assessed as being of LOW to MODERATE archaeological potential. There is some potential for the recovery of reworked artefacts and/or evidence of occupation of the floodplain of the Darent, although no specific indicators were noted in any of the records. The absence of evidence for waterlogged and/or organic strata in the purposive geoarchaeological boreholes may restrict the potential of these strata. However, it must be stressed that the present works alone do not provide an adequate means of fully assessing the potential of all alluvial strata within the Study Area.

4.2.6 The Alluvium within the three purposive geoarchaeological boreholes (ARCA BH1, ARCA BH2, and ARCA BH3) are assessed as being of LOW to MODERATE palaeoenvironmental potential. A single mollusc shell (*Trichia* sp.) was noted in the sands near the base of ARCA BH1. Although pollen may be preserved in these fine-grained alluvial strata, preservation is likely to be highly variable given that these strata appear to have undergone

some oxidation. The lack of organic strata and material suitable for ^{14}C dating further restricts the potential of these strata. Bearing in mind the variable detail in recording of alluvium in the BGS records, this assessment is provisionally applied to all Alluvium strata in the Study Area.

4.2.7 Made Ground in the Study Area as a whole are assessed overall as being of LOW archaeological potential, since these strata appear to generally comprise deposits related to modern construction activity. However, the term 'Made Ground' may be applied to archaeological deposits of any age, and the present works do not provide an adequate means of fully assessing the potential of all such strata within the Study Area.

4.2.8 Made Ground strata are assessed as being of LOW palaeoenvironmental potential since proxy indicators are likely to be poorly preserved and of unknown provenance in such mixed deposits.

5. ACKNOWLEDGEMENTS

5.1 ARCA would like to thank Claire Hallybone and Jamie Riches of Thames Water for help during the course of this project.

5.2 Geoarchaeological boreholes were drilled by Nick Watson and Phil Stastney.

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APPENDIX 1: ARCA BOREHOLE LOCATIONS AND LITHOSTRATIGRAPHY

Bore	Easting	Northing	Elevation (m OD)	Total Depth (m)
ARCA BH1	555713.10	168145.40	25.90	1.00
ARCA BH2	555701.90	168008.40	26.00	1.00
ARCA BH3	555043.70	167224.80	31.00	2.10

Bore	Top	Base	Lithology	Comments
ARCA BH1	0.00	0.07	No recover	Void
ARCA BH1	0.07	0.38	Sandy silt	Grass over 7.5 YR 2.5/1 Black soft slightly fine sandy silt/clay with rare subangular flint granules. Roots throughout. Grading into:
ARCA BH1	0.38	0.50	Fine sand	7.5 YR 4/3 Brown fine silty sand with rare subrounded granular to fine-pebble sized chalk and flint and frequent Fe/Mn oxide granules. Possibly very faintly laminated. Grading into:
ARCA BH1	0.50	0.86	Fine sand	7.5 YR 4/2 Brown silty sand becoming coarse sand with depth. Occasional charcoal granules and flecks of CBM. Single shell of *Trichia* sp. Diffuse boundary to:
ARCA BH1	0.86	1.00	Sand and gravel	7.5 YR 4/4 Brown poorly sorted angular to subrounded gravel of flints with some coarse sand. End of BH.
ARCA BH2	0.00	0.20	No recover	Void
ARCA BH2	0.20	0.48	Silt/clay	Grass over 10 YR 3/2 Very dark greyish brown silt/clay. Grading into:
ARCA BH2	0.48	0.70	Silt/clay	10 YR 4/2 Dark greyish brown silt/clay with roots throughout and some Fe oxide mottles. Rare subrounded chalk and flint pebbles. Sharp boundary to:
ARCA BH2	0.70	1.00	Sand and gravel	10 YR 5/2 Greyish brown poorly sorted clast-supported gravel of angular flints. End of BH.
ARCA BH3	0.00	0.15	No recover	Void

Bore	Top	Base	Lithology	Comments
ARCA BH3	0.15	0.30	Silt/clay	10 YR 3/2 Very dark greyish brown soft silt/clay. Sharp boundary to:
ARCA BH3	0.30	0.36	Made Ground	Grey concrete. Sharp boundary to:
ARCA BH3	0.36	0.77	Silt/clay	10 YR 4/2 Dark greyish brown very firm silt/clay with occasional subrounded flint pebbles. Sharp boundary to:
ARCA BH3	0.77	0.86	Sandy silt	10 YR 4/3 Brown stiff very sandy silt/clay. Diffuse boundary to:
ARCA BH3	0.86	1.44	Silt/clay	10 YR 3/4 Dark yellowish brown silt/clay with occasional subangular flint granules and pebbles increasing with depth. Diffuse boundary to:
ARCA BH3	1.44	2.10	Sand and gravel	10 YR 3/4 Dark yellowish brown very dense poorly sorted gravel of subangular flint pebbles with a little 10 YR 5/2 Greyish brown sandy clay matrix. End of BH.