Geoarchaeology

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WESTGATE HOUSE, RUPERT STREET, BRISTOL BS1: GEOARCHAEOLOGICAL ASSESSMENT

Prepared for Bristol and Region Archaeological Services

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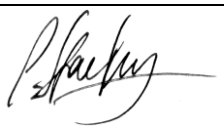
01	18/09/14	F	Phil Stastney		Phil Stastney	
*I – Internal draft; E – External draft; F - Final						

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SUMMARY

In August 2014, three boreholes were drilled in the basement of Westgate House (formerly Electricity House), Rupert Street, Bristol by Hydrock. At the request of BaRAS, ARCA carried out a geoarchaeological assessment of sediments recovered in the three boreholes.

Bedrock of the Mercia Mudstone Group (MMG) was encountered at the base of all three boreholes, outcropping at between -6.50m OD and -3.10m OD. In WGH BH2, the MMG was unconformably overlain by 2m of gravels of the Pleistocene Avon Formation, which was in turn unconformably overlain by Holocene alluvial/intertidal sediments of Alluvium 2 (an informal subdivision of the Wentlooge Formation). In WGH BH1 and WHG BH3, the MMG was directly overlain by Alluvium 2. Alluvium 2 comprised sands, gravels, and silt/clay strata interbedded with fine sands up to 2.30m thick. These strata appear to have been at least initially deposited in a freshwater environment, possibly during the Early Holocene. In all three boreholes, Alluvium 2 was unconformably overlain by deposits of reddish brown poorly sorted strata up to 3.25m thick, which are likely to represent reworked MMG (e.g. colluvium). The colluvium was in turn overlain by further silt/clay strata of the Wentlooge Formation (Alluvium 1), which were deposited in an intertidal environment. The sedimentary sequence at the site was capped by deposits of Made Ground which are most likely part of the present structure at the site which was built in the 1930s. The excavation of the present basement at the site most likely truncated the Holocene alluvial/intertidal sequence.

Whilst Alluvium 2 and Alluvium 1 were assessed as being of low to moderate palaeoenvironmental potential, no further works were recommended as to the lack of material suitable for ^{14}C dating prevents any chronological control. All other strata were of low archaeological and palaeoenvironmental potentials.

1. INTRODUCTION

1.1 In August 2014 four geotechnical boreholes were drilled in the basement of Westgate House (formerly known as Electricity House), Rupert Street, Bristol (henceforth 'the site') by Hydrock. On the 2nd September 2014, at the request of Bristol and Region Archaeological Services (BaRAS), ARCA carried out a geoarchaeological assessment of the sediments recovered in the core samples from the boreholes drilled at the site.

1.2 This document assesses the stratigraphic sequence beneath Westgate House, Rupert Street, Bristol. It 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 assessed A bibliography and an appendix containing lithological descriptions of the borehole stratigraphy completes the document.

1.3 The site lies in central Bristol and is centred on NGR ST 58700 73160. The site is bounded by Rupert Street to the west, Christas Street to the north-east, and Quay street to the south-east (Figure 1). The site lies at c. +9m OD and is at the base of St Michael's Hill which rises towards the north-west.

1.4 The British Geological Survey (BGS) map the site as lying on rock of the Redcliffe Sandstone Member, part of the Mercia Mudstone Group (MMG), a Triassic deposit dating from 250-200 my BP (BGS 2014). However, an unconformable boundary is mapped to the immediate west and south-west of the site beyond which rock of the Carboniferous Quartzitic Sandstone Formation (QSF) (326-314 my BP) outcrops. The BGS map Holocene tidal flat deposits overlying the bedrock, in turn sealed by Made Ground. The site is thought to occupy a former valley of the River Frome.

1.5 A geoarchaeological assessment of the site of the former Magistrates' Court, on the other side of Christmas Street immediately to the north-east of the site was carried out by ARCA in 2014 (Stastney 2014a). At that site bedrock of the QSF was encountered in the western parts of the site outcropping at between -0.59m OD and +0.83m OD, overlain by up to 5m of silts and clays of the Holocene Wentlooge Formation and sealed by Made Ground; in the eastern part of the site bedrock of the

MMG outcropped at +6.99m OD and was unconformably overlain by Made Ground. Two surveys carried out near to the junction of the former River Frome and the River Avon at Broad Quay and Queen Square, c.500m to the south, encountered rock of the Mercia Mudstone Group (MMG) at the base of the sequence. These strata were in turn overlain by Late Pleistocene Gravels of the Avon Formation, alluvial/intertidal sediments of the Holocene Wentlooge Formation (c.8-9m thick) and Made Ground (Stastney 2014b, Wilkinson 2007). A large-scale borehole survey of the Broadmead development, c.500 to the east, encountered c.5-8m of Wentlooge Formation sediments overlying MMG bedrock, with a basal peat in some boreholes dating from the Late Mesolithic to Early Neolithic[1] (Wilkinson and Head 2008). A series of investigations in the Canon's Marsh area, c.800m to the south-west of the site, revealed widespread peat formation in the area dating to the Neolithic[2] at the Cabot House, Deanery Road and Anchor Road sites (Cox *et al.* 2006, Stastney and Batchelor 2014, Wilkinson *et al.* 2002, 2009).

1.6 The objectives of the geoarchaeological project at the site were to:

1.6.1 Determine the Holocene sedimentary sequence on the site.

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

1.6.3 Make recommendations for further investigation of high potential strata at later project stages.

2. METHODOLOGY

2.1 Four boreholes we drilled at the site by a ground investigation contractor under the supervision of Hydrock using a Pioneer drilling rig. Borehole locations were recorded by Hydrock operatives. The elevation of the top of the boreholes was estimated based on the depth of the basement in which the boreholes were drilled (3.50m) below street level (c. +9.00m OD). Sediment samples from the boreholes were recovered in plastic liners. Samples were taken to Hydrock's Almondsbury office where the liners were split and where they were photographed

[1] E.g. Beta 229909 (4080±50 BP) at 5.445m BGL and Beta 245642 (5430±40 BP) at 6.805m BGL in ARCA BM BH7.

[2] Wood charcoal from Cabot House Wk 25622 (4100±31 BP); peat from Deanery Road Wk 10946 (4594±63 BP) and Wk 10947 (5174±61 BP); peat from Anchor Road GU 32161 (4701±29 BP) and GU 32162 (5261±29 BP).

and described by ARCA geoarchaeologists using standard geological criteria (Tucker 1982, Jones *et al.* 1999, Munsell Color 2000). Full stratigraphic descriptions are presented in Appendix 1.

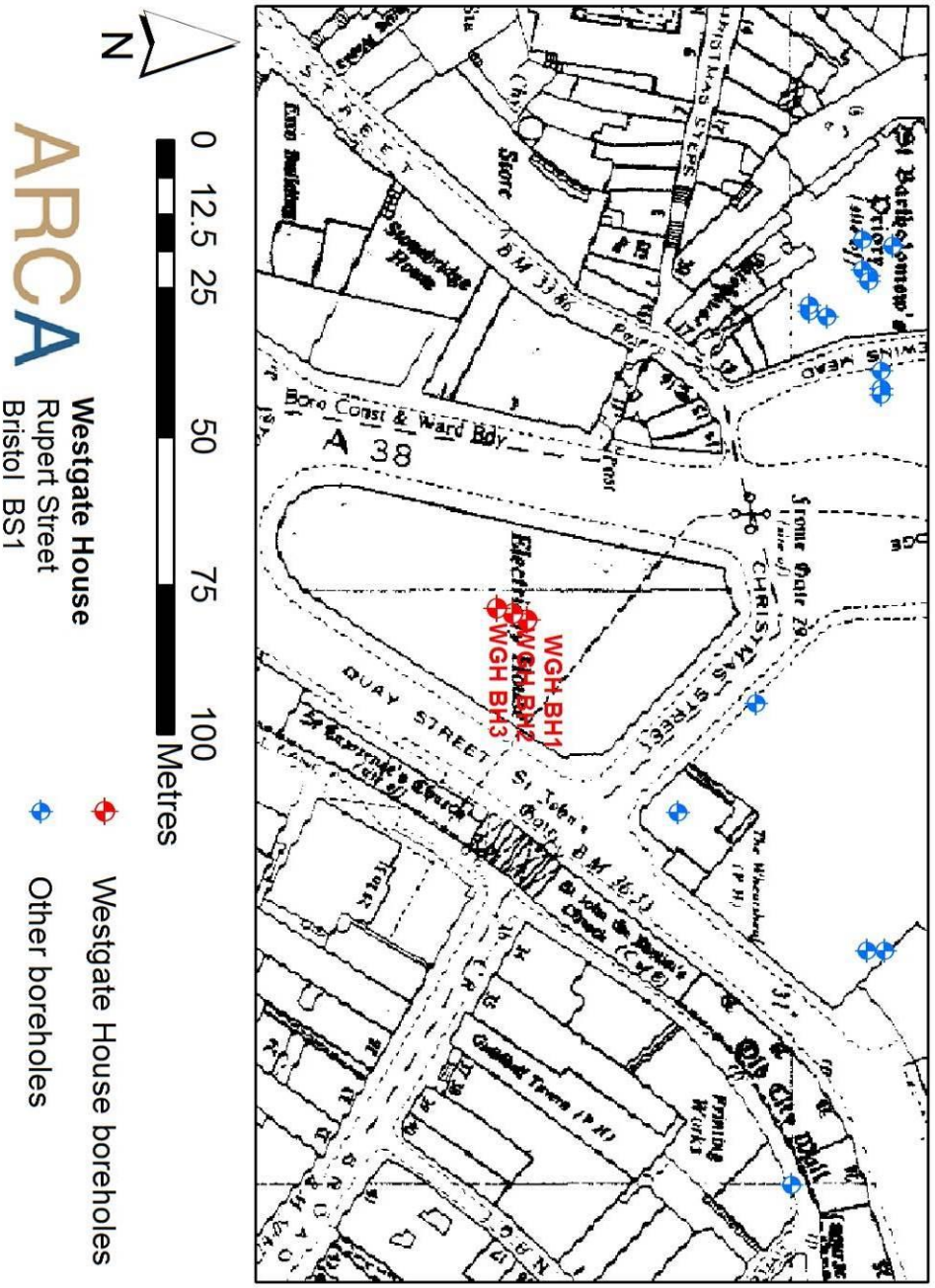

Figure 1: Location of boreholes on the site.

2.2 Lithological descriptions and positional data from the site were combined with lithological data from previous geotechnical and geoarchaeological boreholes from central Bristol within a RockWorks database (RockWare 2013). The RockWorks software package was then used to plot the lithological and stratigraphic cross sections (Figure 2 and Figure 3).

2.3 The geoarchaeological archive from the site consists of digital records (photographs of the cores, lithological descriptions and RockWorks database entries) retained on the University of Winchester server.

3. BOREHOLE STRATIGRAPHY

3.0.1 Six major stratigraphic units (formal and informal formations and members) present at the site were revealed in the borehole stratigraphy of the three boreholes drilled during the present works (see Figure 2 and Figure 3). These are reviewed below in chronological order.

3.0.2 'Alluvium 2' and 'Alluvium 1' are informal terms for major stratigraphic units in central Bristol defined by Wilkinson *et al.* (2013) both of which may be assigned to the Wentlooge Formation (*sensu* Allen and Rae 1987), but are discussed separately below.

3.0.3 The stratigraphic and lithological data are plotted graphically in Figure 2 and Figure 3, respectively. Full lithological descriptions from the three boreholes at the site are included as Appendix 1.

3.1 Mercia Mudstone Group

3.1.1 The Mercia Mudstone Group (MMG) dates from the Middle Triassic (c. 230 my BP) and formed in a series of alluvial fans emanating from the Mendips and Bristol coalfields (Green 1992, 78). The MMG therefore comprises sand and conglomerate facies, but as the name suggests is primarily made up of silts and clays.

3.1.2 The MMG was encountered at the base of all three boreholes at the site and outcrops at -4.30m OD in WGH BH1, -6.50m OD in WGH BH2, and at -3.10m OD in WGH BH3.

3.1.3 MMG bedrock at the site is represented by reddish brown sands overlying reddish grey mudstone.

3.1.4 The MMG is unconformably overlain by Quaternary sediments in all three boreholes: by gravels of the Pleistocene Avon Formation in WGH BH2, and where the latter is absent in WGH BH1 and WGH BH2 by sediments of the Holocene Wentlooge Formation (Alluvium 2).

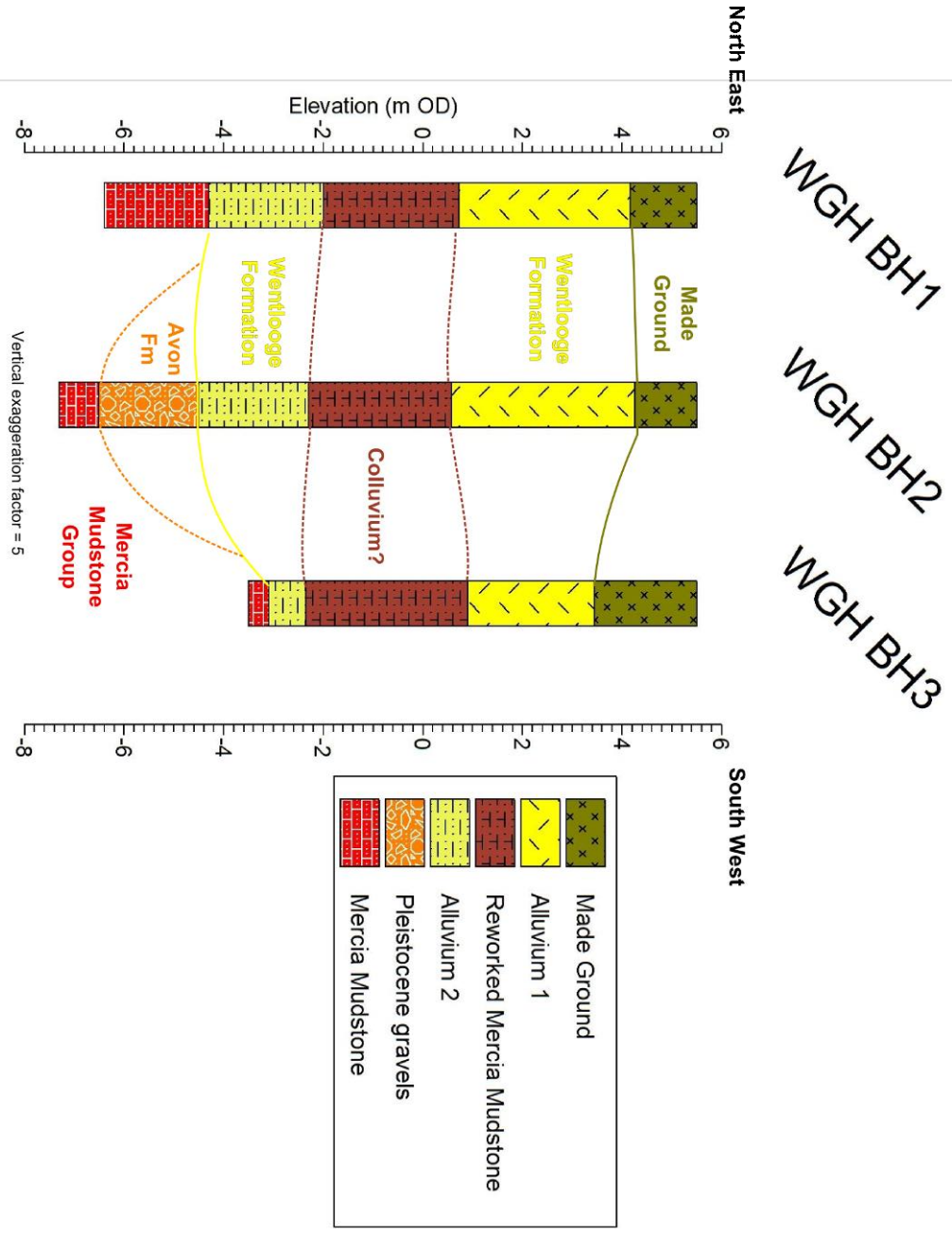

Figure 2: NE to SW stratigraphic cross section.

3.2 Avon Formation

3.2.1 Deposits of fluvial gravel were encountered above the MMG in WGH BH2 outcropping between -6.50m OD and -4.50m OD. The gravels are likely to be part of an as yet unnamed member of the Avon Formation, a series of terrace gravels dating to the Late Pleistocene (Campbell *et al.* 1999).

3.2.2 Given the low elevation of their outcrop, the Avon Formation gravels encountered at the site are likely to date from the latest part of the Late Pleistocene, i.e. the Devensian Late Glacial. Campbell et al. (1999) and Bates (2003) suggest that the Barhampton Member, which is at 3m above the present river level, is of Marine Isotope Stage (MIS) 6 date or earlier, and therefore as the gravels seen at the site outcrop below river level, they must be later (MIS 5e-2, i.e. 130-14 Kya). Avon Formation gravels have been found outcropping on a number of sites in central Bristol at similar elevations to those at the site, including at Queen Square (Stastney 2014b), Broad Quay (Wilkinson 2007), Harbourside (Wilkinson and Tinsley 2005), Broadmead (Yendell and Stafford 2005, Wilkinson 2013) and Avon Fire Station (Stastney 2014c).

3.2.3 The Avon Formation at the site was only encountered in WGH BH2 and appears to fill a local undulation in the underlying MMG.

3.2.4 The Avon Formation strata encountered in WGH BH2 consist of reddish brown to dark greyish brown poorly sorted gravels of subangular to subrounded granule to pebble-sized clasts of various lithologies.

3.2.5 The Avon Formation is (presumably unconformably) overlain by Holocene alluvial/intertidal sediments of the Wentlooge Formation (Alluvium 2).

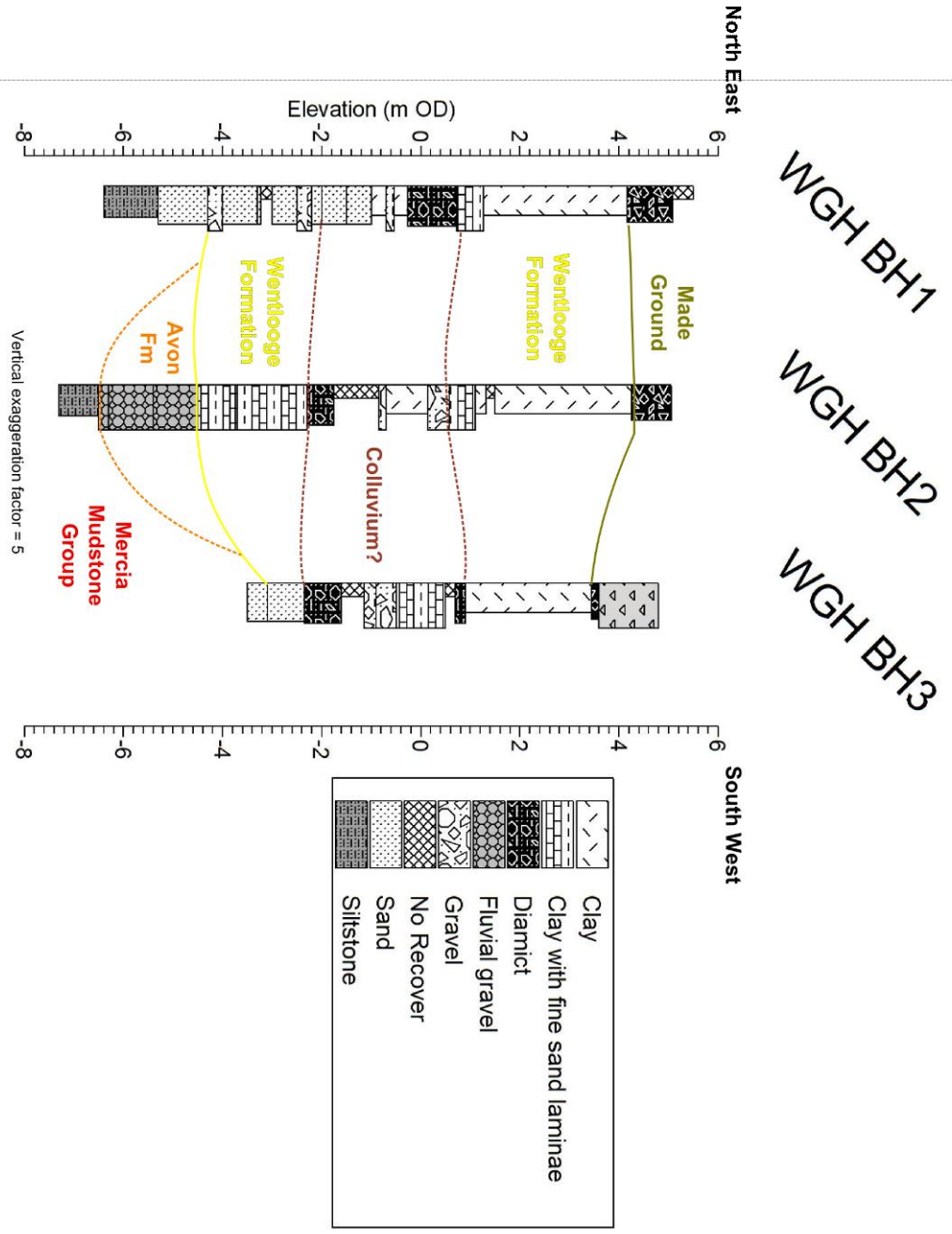

Figure 3: NE to SW lithological cross section.

3.3 Alluvium 2 (Wentlooge Formation)

3.3.1 The Wentlooge Formation is comprised of intertidal and freshwater strata of the Severn Estuary (both mineral and organic), and dates to the beginning of the Holocene to the Roman period (Allen and Rae 1987). Since other Holocene intertidal formations defined by Allen and Rae (1987) only outcrop close to the historic sea defences along the line of the River Severn all the Holocene intertidal/alluvial sediments

encountered at the site are most likely assigned to the Wentlooge Formation. Wentlooge Formation strata at the site outcrop between -4.50m OD and +4.25m OD.

3.3.2 As mentioned previously in Section 3.0.2, both Alluvium 2 and Alluvium 1 are informal subdivisions of the Wentlooge Formation defined by Wilkinson *et al.* (2013) for alluvial/intertidal strata in central Bristol.

3.3.3 'Alluvium 2' is defined by Wilkinson *et al.* (2013) as mineral alluvial/intertidal sediments encountered below peat. Whilst no peat strata were encountered at the site, the term 'Alluvium 2' is used in this report to refer to strata of the Wentlooge Formation encountered below deposits of reworked MMG (possible colluvium) and is therefore roughly analogous to the usage of the term by Wilkinson *et al.* for the lowermost mineral alluvial/intertidal strata of the Wentlooge Formation.

3.3.4 Alluvium 2 was encountered in all three boreholes at the site, outcropping between -4.30m OD and -2.00m OD in WGH BH1, between -4.50m OD and -2.30m OD in WGH BH2, and between -3.10m OD and -2.35m OD in WGH BH3.

3.3.5 Alluvium 2 strata at the site generally consist of very dark grey fine sands, gravels and silt/clays interlaminated with fine sand. Rare fragments of waterlogged wood were encountered within the lower parts of the Alluvium 2 strata in WGH BH1. Alluvium 2 appears to have formed in or close to (at least initially) freshwater channels of the former River Frome – with both channel (gravel) and channel margin (fine sands and silt/clays) facies represented.

3.3.6 In all three boreholes at the site, Alluvium 2 is unconformably overlain by strata of reworked MMG.

3.4 Reworked MMG (colluvium)

3.4.1 In all three boreholes at the site, Alluvium 2 was overlain by a series of generally reddish, poorly sorted, gravelly deposits. Clastic inclusions in these strata are of a variety of lithologies, but are mostly quartzite, generally angular and very poorly sorted, ranging in size from granule to cobble, in a matrix of reddish brown to dark reddish grey silt/clay and sand. Based on these characteristics, these strata have been tentatively interpreted as being composed of material reworked from the MMG although the quartzite inclusions may have been derived

from the QSF which outcrops immediately to the west of the site. These deposits are in places interbedded with dark grey silt/clay strata suggesting a series of episodes of deposition, punctuated by episodes of alluvial deposition.

3.4.2 Deposits of reworked MMG outcrop between -2.00m OD and +0.72m OD in WGH BH1, between -2.30m OD and +0.57m OD in WGH BH2, and between -2.35m OD and +0.90m OD in WGH BH3.

3.4.3 Two alternative hypotheses may explain the deposition of the reworked MMG at the site: deposition of these strata may have been the result of natural colluvial (i.e. "hillwash") processes as material eroded from surrounding cliffs during hiatuses in the accretion of alluvial/intertidal strata; alternatively, these strata may have been deliberately deposited through human action (e.g. levelling deposits). Whilst the level of the outcrop of these strata is consistent across all three boreholes, no direct indicators of human activity (e.g. artefacts or other anthropogenic material) were noted in the reworked MMG deposits, therefore the former hypothesis appears most likely. This would therefore suggest the presence of cliffs exposing MMG or QSF bedrock in the vicinity of the site – St Michael's Hill immediately to the north-west being the most likely candidate.

3.4.4 Reworked MMG strata at the site are unconformably overlain by Alluvium 1.

3.5 Alluvium 1 (Wentlooge Formation)

3.5.1 'Alluvium 1' is defined by Wilkinson *et al.* (2013) as deposits of the Wentlooge Formation encountered below Made Ground.

3.5.2 Alluvium 1 outcrops between +0.72m OD and +4.16m OD in WGH BH1, between +0.57m OD and +4.25m OD in WGH B2, and between +0.90m OD and +3.45m OD in WGH BH3.

3.5.3 Alluvium 1 at the site consists of grey silt/clay with rare black organic spots and rare fine sand laminae most likely deposited in an intertidal environment.

3.5.4 Alluvium 1 is overlain by Made Ground.

3.6 Made Ground

3.6.1 'Made Ground' is a term used by the British Geological Survey to encompass deposits formed as a product of human action (BGS 2014).

3.3.2 Made Ground strata occur at the top of all boreholes on the site. They outcrop above +4.16m OD in WGH BH1, +4.25m OD in WGH BH2, and above +3.45m OD in WGH BH3.

3.3.3 Made Ground strata at the site consist of gravel (hardcore) of a variety of lithologies, including some CBM and cinders. 1.90m of concrete was encountered at the top of WGH BH3, although the gravel hardcore at the other two borehole locations was presumably also overlain by concrete. The Made Ground strata at the site therefore almost certainly relate to the concrete floor of the basement of Westgate House (formerly Electricity House) which was constructed in the 1930s and are therefore of the same date.

4. ASSESSMENT

4.1 Holocene sedimentary sequence

4.1.1 The sequence recovered from the site begins with the gravels of the Avon Formation which were deposited on the braid plain of the Pleistocene River Avon/Frome overlying the undulating surface of the MMG bedrock. Downcutting later occurred (most likely in the Late Glacial stage), after which new alluvial accretion took place in lower energy environments resulting in the deposition of the predominantly sandy strata of Alluvium 2. Given the presence of wood fragments in these strata, it would appear that Alluvium 2 was formed in a freshwater alluvial environment. Following this, erosion of nearby cliffs took place resulting in the deposition of thick deposits of colluvium. The colluvial deposits were, especially towards the top, interbedded with grey clays suggesting episodic intertidal flooding. As relative sea level (RSL) rise continued during the Holocene, the site became subject to more frequent flooding resulting in the deposition of Alluvium 1 in an intertidal environment. Mean High Water Spring Tides during the Medieval period in Bristol have been estimated at a maximum of height of up to +6.70m OD (Jones 1991, 19) whilst the highest outcrop of Alluvium 1 at the site is at +4.25m OD, suggesting that the upper parts of the intertidal strata at the site were truncated by the excavation of

the basement of the present Westgate House. Deposits of Made Ground at the site all appear to relate to the construction of Westgate House during the 1930s, representing the final phase of the sedimentary sequence.

4.2 Archaeological and palaeoenvironmental significance

4.2.1 The MMG has NO archaeological potential and NO palaeoenvironmental potential given the Triassic age of these strata.

4.2.2 The Avon Formation gravels have a LOW archaeological potential. Whilst Palaeolithic artefacts have been found in Avon Formation gravels in other parts of the region, particularly at Shirehampton, these have mostly been recovered from gravels of the Ham Green Member (Bates and Wenban-Smith 2006, 161), which most likely are of MIS 10-12 date (Hunt 2006, 151), and therefore likely to be considerably older than the Avon Formation gravels encountered at the site. As discussed in Section 3.2.2, the gravels encountered at the site are of an as yet unnamed member of the Avon Formation of probable MIS 5e-2 date, the archaeological potential of which is presently unknown. Nevertheless, any artefacts which are present in these gravels are likely to have been reworked.

4.2.3 The Avon Formation has a LOW palaeoenvironmental potential. Although fine-grained deposits which may contain palaeoenvironmental indicators (such as faunal remains) do occur within similar Pleistocene strata, no such deposits or remains were noted at the site.

4.2.4 The sands and silt/clays of the Wentlooge Formation as a whole (including both Alluvium 2 and Alluvium 1) are assessed as having a LOW archaeological potential since these were deposited in an alluvial/intertidal setting, and there are no specific indicators of human activity.

4.2.5 Alluvium 2 and Alluvium 1 have a LOW to MODERATE palaeoenvironmental potential. Previous investigations of comparable deposits at Deanery Road and Harbourside suggest that pollen is variably preserved in such clastic strata (Wilkinson et al. 2002, Wilkinson and Tinsley 2005). Moreover, the source of the pollen in floodplain/mudflat deposits is difficult to determine. The lack of chronological control further restricts the potential of these strata.

4.2.6 The reworked MMG (possible colluvium) strata are assessed as being of LOW archaeological potential. These strata were most probably deposited as a result of erosion of adjacent hillsides during the Holocene. Whilst artefacts may occur within these sediments, any archaeological material would almost certainly be reworked and there are no specific indicators of human activity.

4.2.6 The reworked MMG strata have a LOW palaeoenvironmental potential since palaeoenvironmental indicators are not likely to be well-preserved in such poorly-sorted clastic sediments, and any such indicators would almost certainly be reworked.

4.2.7 Made Ground strata at the site almost certainly relate to the present building at the site and are therefore assessed as being of LOW archaeological potential, although other methods of assessment (e.g. standing building survey, desk based assessment etc.) may be more appropriate means of assessing the potential of these deposits.

4.2.8 Made Ground strata at the site have NO palaeoenvironmental potential.

5. RECOMMENDATIONS

5.1 No further works are recommended on strata assessed as being of low archaeological and palaeoenvironmental potentials.

5.2 Although palaeoenvironmental indicators may be preserved in Alluvium 2 and Alluvium 1 (albeit variably), no material suitable for ^{14}C dating were noted in the boreholes. In the absence of any chronological control, no further works are recommended.

6. ACKNOWLEDGEMENTS

6.1 ARCA would like to thank John Bryant of BaRAS and Tom Leigh of Hydrock for their help during the course of this project.

6.2 Core samples were described by Nick Watson and David Ashby, the project was managed for ARCA by Phil Stastney.

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APPENDIX 1: BOREHOLE LITHOSTRATIGRAPHY

Borehole	Top	Base	Lithology	Comments
WGH BH1	0.00	0.42	No Recover	Void
	0.42	1.02	Overburden	Very dark grey, poorly sorted, very angular, clast supported gravel of granular to cobble-sized cinder-like clasts. Matrix of fine sand sized particles. Sharp boundary to:
	1.02	1.34	Overburden	10 YR 3/2 Very dark greyish brown, poorly sorted, coarse sand to pebble-sized, angular, clast supported gravel of CBM and rock clasts. Diffuse boundary to:
	1.34	4.24	Clay	5Y 3/1 Very dark grey compact and homogenous silt/clay with black organic spots. Pebble sized lens of poorly humified reed peat at c.2.75m.
	4.24	4.78	Clay with fine sand laminae	5 Y 3/1 Very dark grey compact silt/clay with black organic sports and rare sets of horizontal very fine sand laminae.
	4.78	5.77	Diamict	5 Y 3/1 Very dark grey matrix supported gravel (diamict) of poorly sorted granular to pebble-sized angular clasts of grey quartzite. Matrix of silt clay with rare medium sand-sized mineral grains. (mixture of 2 separate lithologies clasts deposited into the river?)
	5.77	6.03	Clay	5 Y 3/1 Very, dark grey compact and homogenous silt/clay. Sharp boundary to:

Borehole	Top	Base	Lithology	Comments
WGH BH1 (cont.)	6.03	6.20	Gravel	7.5 YR 4/3 Brown clast supported gravel of poorly sorted, granular to pebble-sized angular clasts of quartzite (characteristic red coats of oxide over quartzites). Silt/clay matrix. Sharp boundary to:
	6.20	6.50	Clay	5 Y 3/1 Very dark grey compact and homogenous silt/clay with black organic speckles. Sharp boundary to:
	6.50	7.00	Sand	5 YR 4/3 Reddish brown medium sand. Unknown boundary to:
	7.00	7.50	Sand	as above with a silt/clay fraction and rare pebble to cobble-sized angular quartzite clasts. Unknown boundary to:
	7.50	7.70	Sand	5 Y 3/1 Very dark grey compact and homogenous very fine sandy silt/clay coarsening to fine sand at base. Gradual boundary to:
	7.70	8.00	Gravel	5 YR 5/2 Reddish grey matrix supported gravel of poorly sorted clasts of granular to pebble-sized angular quartzites. Silt/clay matrix.
	8.00	8.50	Sand	5 Y 3/1 Very dark grey very fine sand. Unknown boundary to:
	8.50	8.73	No Recover	Void
	8.73	8.80	Sand	5 Y 3/1 Very dark grey very fine sand. Unknown boundary to:
	8.80	9.50	Sand	as above with horizontally laminated sand and rare waterlogged pebble-sized wood (branch). Sharp boundary to:

Borehole	Top	Base	Lithology	Comments
WGH BH1 (cont.)	9.50	9.80	Gravel	5 Y 3/1 Very dark grey clast supported gravel of poorly sorted granular to cobble-sized angular quartzite clasts. Rare cobble-sized wood (?charred?). Unknown boundary to:
	9.80	10.80	Sand	5 YR 4/3 Reddish brown very coarse sand. Unknown boundary to:
	10.80	11.90	Siltstone	5 YR 5/2 Reddish grey mudstone bedrock.
WGH BH2	0.44	1.25	Overburden	Very dark grey, poorly sorted, very angular, clast supported gravel of granular to cobble-sized cinder-like clasts. Matrix of fine sand sized particles.
	1.25	4.00	Clay	5 Y 3/1 Very dark grey compact and homogenous silt/clay with rare black organic spots. Rare quartzite cobble.
	4.00	4.18	No Recover	Void
	4.18	4.40	Clay	5 Y 3/1 Very dark grey compact and homogenous silt/clay with rare black organic spots.
	4.40	4.93	Clay with fine sand laminae	5 Y 3/1 Very dark grey silt /clay with coarse interbedding of 5 YR 4/2 Dark reddish grey coarse sand. Gradual boundary to:
	4.93	5.36	Gravel	5 YR 3/3 Dark reddish brown clast supported gravel of poorly sorted granular to pebble-sized angular quartzite clasts. Silt/clay matrix. Gradual boundary to:
	5.36	6.20	Clay	5 Y 3/1 Very dark grey silt/clay. Sharp boundary to:
	6.20	6.35	Gravel	Drilled through a quartzite boulder

Borehole	Top	Base	Lithology	Comments
WGH BH2 (cont.)	6.35	7.25	No Recover	Void
	7.25	7.80	Diamict	5 YR 4/4 Reddish brown clast supported gravel of poorly sorted granular to pebble-sized angular clasts of quartzite. Silt /clay matrix. Sharp boundary to:
	7.80	9.25	Clay with fine sand laminae	5 Y 3/1 Very dark grey interlaminated silt/clay and fine sand. Sharp boundary to:
	9.25	10.00	Clay with fine sand laminae	5 Y 3/1 Very dark grey silt/clay interbedded with 5 YR 3/2 Dark reddish brown clast supported gravel of very poorly sorted sand to fine pebble-sized sub rounded quartzite clasts. Unknown boundary to:
	10.00	10.90	Fluvial gravel	5 YR 3/2 Dark reddish brown clast supported gravel of very poorly sorted medium sand to cobble-sized sub angular to sub rounded clasts of various lithologies. Sharp boundary to:
	10.90	11.80	Fluvial gravel	10 YR4/2 Dark greyish brown granular to cobble-sized clasts of drill shattered mudstone (boulder from gravels above?). Sharp boundary to:
	11.80	12.00	Fluvial gravel	5 YR 5/2 Reddish grey well sorted gravel of pebble-sized, subangular clasts of various lithologies. Sharp boundary to:
	12.00	12.80	Siltstone	Mudstone bedrock
WGH BH3	0.70	1.90	Concrete	Concrete
	1.90	2.05	Overburden	5 Y 3/1 Very dark grey clast supported gravel of well sorted pebble-sized sub rounded clasts of unknown lithologies. Silt/clay matrix. (Made ground) Gradual boundary to:

Borehole	Top	Base	Lithology	Comments
WGH BH3 (cont.)	2.05	4.60	Clay	5 Y 3/1 Very dark grey silt/clay with rare black organic spots. Rare horizontal fine sand laminae. Gradual boundary to:
	4.60	4.80	Diamict	5 YR 4/2 Dark reddish grey diamict with sub angular to rounded pebble-sized clasts of unknown lithologies in a dark grey silt/clay matrix. Unknown boundary to:
	4.80	5.00	No Recover	Void
	5.00	6.00	Clay with fine sand laminae	5 Y 3/1 Very dark grey silt/clay with rare horizontal fine sand laminae and black organic spots. Sharp boundary to:
	6.00	6.40	Gravel	5 Y 3/1 Very dark grey clast supported gravel of poorly sorted granular to cobble-sized angular clasts of quartzite. Silt/clay matrix. Sharp boundary to:
	6.40	6.65	Gravel	Drilled through quartzite boulder. Sharp boundary to:
	6.65	7.10	No Recover	Void
	7.10	7.85	Diamict	5 YR 5/3 Reddish brown diamict of silt/clay matrix containing frequent distorted inclusions of 5 Y 4/2 Olive grey silt / clay and granular to cobble-sized angular to sub rounded rock fragments (all quartzite?) . Sharp boundary to:
	7.85	8.60	Sand	5 Y 3/1 Very dark grey fine sand. Unknown boundary to:
	8.60	9.00	Sand	5 YR 4/2 Dark reddish grey clayey medium to coarse sand.