ASSESSMENT OF ENVIRONMENTAL REMAINS FROM A BOREHOLE SURVEY AT DROITWICH GARAGE, ST GEORGE SQUARE, DROITWICH, WORCESTERSHIRE

Nicholas Daffern

With contributions by Alan Clapham, Laura Griffin, Tom Vaughan and Simon Woodiwiss and Ground Investigation Specialists (GIS)

Illustrated by Carolyn Hunt

18 November 2011
Revised 22 November 2011

Historic Environment and Archaeology Service,
Worcestershire County Council,
Woodbury,
University of Worcester,
Henwick Grove,
Worcester WR2 6AJ

Project 3767
Report 1878
SM 30097
SMC S00020526
WSM 46049

Contents

Assessment of environmental remains from a borehole survey at Droitwich Garage, St George Square, Droitwich, Worcestershire

Nicholas Daffern
With contributions by Alan Clapham, Laura Griffin, Tom Vaughan and Simon Woodiwiss and Ground Investigation Specialists (GIS)

Part 1 Project summary

An archaeological borehole survey was undertaken at Droitwich Garage, St George Square, Droitwich, Worcestershire (NGR SO 9022 6346). The borehole survey and environmental assessment were undertaken on behalf of CgMs in response to potential development occurring on the site.

An archaeological assessment and analysis (CgMs 2011) indicated that the development site lies within a monument (SM 30097) scheduled under the Ancient Monuments and Archaeological Areas Act 1979 considered to include a heritage asset with archaeological interest (HA 1020256). Scheduled monument consent for the works reported here has been issued (English Heritage reference S00020526, 12 October 2011).

The assessment revealed significant quantities (up to 6.5m) of levelling deposit consisting of post-medieval clinker, coal fuel ash and brickwork relating to the dumping of industrial waste produced during salt production and attempts to level the site as a result of subsidence caused through the extraction of brine. Artefacts recovered were consistently late 18th century onwards in date therefore supporting this post-medieval character. The site's 20th century use as a garage was also readily evident through the frequent identification of hydrocarbons within the deposits, particularly in the north-west of the site.

Underlying the post-medieval levelling deposit were alluvial deposits which were similar in appearance to those that had been encountered during previous investigations both on this site and within the wider landscape which had identified it as being Anglo-Saxon/early medieval in origin although unfortunately no datable material could be obtained from the alluvium to confirm this previous dating and palynological assessment proved unsuccessful due to apparent disturbance of the sediments

Despite the domination of post-medieval material and the lack of archaeological material pre-dating the post-medieval subsidence and dumping, borehole 2 produced an apparently uncontaminated organic sediment sample which was submitted for radiocarbon dating and produced a middle to late Neolithic date of Cal BC 2850 to 2810 AND Cal BC 2740 to 2720 AND Cal BC 2700 to 2480 (Beta-309383).

Part 2 Detailed report

1. Background

1.1 Reasons for the project

An archaeological borehole survey was undertaken at Droitwich Garage, St George Square, Droitwich, Worcestershire (NGR SO 9022 6346). The borehole survey and environmental assessment were undertaken on behalf of CgMs in response to potential development occurring on the site. An archaeological assessment and analysis (CgMs 2011) indicated that the development site lies within a monument (SM 30097) scheduled under the Ancient Monuments and Archaeological Areas Act 1979 considered to include a heritage asset with archaeological interest (HA 1020256). Scheduled monument consent for the works reported here has been issued (English Heritage reference S00020526, 12 October 2011).

1.2 Project parameters

The project conforms to relevant sections of the *Standard and guidance for an archaeological watching brief* (IfA 2008) and the *Manual of Service practice: fieldwork recording manual* (CAS 1995).

In addition, the sampling, geoarchaeology and environmental analysis conform to relevant sections of *Environmental Archaeology: A guide to the theory and practice of methods, from sampling and recovery to post-excavation* (English Heritage 2011), *Geoarchaeology: Using earth sciences to understand the archaeological record* (English Heritage 2007) and *Environmental archaeology and archaeological evaluations* (AEA 1995).

The project also conforms to a project proposal (including detailed specification) which was produced (HEAS 2011).

1.3 Aims

The aims of this archaeological assessment were to:

1) Recover environmental remains and material suitable for radiocarbon dating
2) Establish the full depth of salt-working waste and investigate the presence/absence of any earlier archaeological deposits beneath the waste deposits
3) Provide information regarding the type and nature of contamination to guide future works
4) Locate archaeological deposits which have previously been recorded at a shallow depth and enhance the deposit model created by CgMs
5) To investigate the nature of prehistoric impact upon woodland to determine the date when settlement and/or industrial activity commences
6) Investigate the environmental impact of prehistoric, Roman, Anglo-Saxon and medieval industrial activity
7) Retrieve plant macrofossil fragments associated with the salt-working to identify whether there is any indication of preference for certain species as fuel, whether woodland management occurred to support this preference and how this varied over time
8) Investigate the nature of prehistoric, particularly Iron Age, settlement in Droitwich as it is unclear how extensively settled the area was with Buteux and Hurst (1996, 9) hypothesising that there was no permanent settlement during the Iron Age and salt production was seasonal.

9) Identify alluvial deposits dating from the Roman period to assist in mapping the location of the River Salwarpe to aid understanding of the layout of the Roman town and its bridging points

10) Investigate the nature of the Salwarpe alluvium identified during previous borehole investigation (Wilkinson 2006)

11) Identify environmental indicators of Anglo-Saxon activity to support the documentary and artefactual evidence from this period (Buteux and Hurst 1996, 12-13)

In addition, priorities for research as identified within the West Midlands Research Framework (White 2002; Greig 2007) are:

12) To identify, analyse and make available detailed reference pollen diagrams with long chronological sequences

13) To identify and analyse environmental evidence from river valleys with suitable palaeochannel deposits and concentrations of prehistoric activity

14) To study the history of river valley alluviation as this is strongly linked to human activity, especially woodland clearance.

15) To study the regional and local environmental setting of settlement and ceremonial sites

16) To integrate an understanding of the geo-environmental contexts of prehistoric economies and social life with interpretations of the material culture evidence.

17) To integrate an understanding of the geo-environmental contexts of the Romano-British economy and social life with interpretations of the material culture evidence (including eco-factual materials) in an attempt to map the technical and industrial developments during the period.

18) To determine the most appropriate methodologies for detecting the cultural material, ecofactual, and structural evidence for the transitional phase at the end of the Roman period within the context of the PPS5 (DCLG 2010) environment.

2. Methods

2.1 Documentary search

Prior to fieldwork commencing a search was made of the Worcestershire Historic Environment Record (HER). In addition to the sources listed in the bibliography the following were also consulted:

Cartographic sources

- 17th century. Map of the borough of Wych. Tracing of the 17th century map of the town
- 1786 Karver *et al*, Map of the town and borough of Droitwich drawn according to a perambulation of the same taken in the year 1786
- 1840 Tithe map for St Peters parish, Droitwich.
- 1885 Ordnance Survey, 1st edition, sheet XXII.14, 1:2,500 (25")

2.2 Fieldwork methodology

2.2.1 Fieldwork strategy

A detailed specification has been prepared by the Service (HEAS 2011).

The fieldwork was undertaken between 19 October and 1 November 2011. The site reference number and site code is WSM 46049.

Six shell and auger boreholes (BH 1-6) and two rotary holes (RH2 and RH6) were sunk for geotechnical purposes whilst four window samples (WS2, WS4, WS5 and WS6) were sunk for archaeological purposes. The latter remained sealed and were taken off site for archaeological recording and sampling. Borehole, rotary holes and window sample locations are shown in Figure 2. All intrusive works were monitored by staff of the Service.

The numbering system for these works was based upon the methodology provided by GIS (2011) with arbitrary numbers being provided for the boreholes (BH) and the window sample (WS) and rotary borehole (RH) numbers being assigned based upon their proximity to these boreholes to allow ease of cross referencing during post-excavation.

The window samples were sunk using a mini-tracked percussive auger rig to recover continuous cores of c100-80mm in diameter and 1m length with the aim of sampling alluvial and/or organic deposits that could be assessed for environmental remains and their potential for geoarchaeological analysis. Where possible, the boreholes were cased to ensure contamination was prevented.

2.2.2 Structural analysis

All fieldwork records were checked and cross-referenced. Analysis was effected through a combination of structural, artefactual and ecofactual evidence, allied to the information derived from other sources.

2.3 Archaeological recording

The sealed boreholes were opened by the author for archaeological recording and recovery of artefactual and environmental evidence, the results of which are described in Appendix 1.

2.4 Artefact methodology

2.4.1 Artefact recovery policy

The artefact recovery policy conformed to standard Service practice (CAS 1995; appendix 2).

2.4.2 Method of analysis

All hand-retrieved finds were examined. They were identified, quantified and dated to period.. All information was recorded on pro forma sheets.

The pottery and ceramic building material was examined under x20 magnification and recorded by fabric type and form according to the fabric reference series maintained by the service (Hurst and Rees 1992 and www.worcestershireceramics.org).

2.5 Environmental archaeology methodology

2.5.1 Sampling policy

The environmental sampling strategy conformed to standard Service practice (CAS 1995; appendix 4) and relevant sections of *Environmental Archaeology: A guide to the theory and practice of methods, from sampling and recovery to post-excavation* (English Heritage 2011), *Geoarchaeology: Using earth sciences to understand the archaeological record* (English Heritage 2007) and *Environmental archaeology and archaeological evaluations* (AEA 1995).

The sampling of material for radiocarbon dating and pollen analysis was undertaken during the archaeological recording.

2.5.2 Archaeological recording of deposits

Archaeological recording of deposits was undertaken by the author and consisted of cores being slit open and a fresh sediment face being exposed, photographed and then described according to the standard recording methodology as outlined in the *Manual of Service practice: fieldwork recording manual* (CAS 1995), *Geoarchaeology: Using earth sciences to*

understand the archaeological record (English Heritage 2007) and *The description and analysis of quaternary stratigraphic field sections* (Jones *et al* 1999).

Sampling of material for radiocarbon dating, plant macrofossil and pollen assessment and recovery of all finds occurred once recording of deposits had been completed.

2.5.3 Radiocarbon dating methodology

One sample was submitted for Accelerated Mass Spectrometry (AMS) dating to the Beta Analytic Ltd radiocarbon dating laboratory.

No other material was submitted for radiocarbon dating due to the unsuitability of the material either through doubts regarding its provenance and/or age and the lack of short-lived wood species.

The sample was an organic sediment taken from alluvium encountered 6.20m below ground surface (BGS)/ 23.10m AOD in Borehole 2

All calibrated date ranges cited in the text are those for 95% confidence.

2.5.4 Palynological remains

In total, twelve pollen sub-samples of $2cm^3$ were selected for palynological assessment; the results of six of these samples, three from WS2 and three from WS4, the exact depths of which are given within the results section below, will be reported upon here. These were selected based upon their position in the sequence and their perceived potential for the preservation of palynological remains.

The sub-samples were submitted to the laboratories of the Department of Geography and Environment at the University of Aberdeen for chemical preparation following standard procedures as described by Barber (1976) and Moore *et al* (1991). The full methodology is described in Appendix 5.

Where preservation allowed, pollen grains were counted to a total of 150 land pollen grains (TLP) for assessment purposes using a GS binocular polarising microscope at x400 magnification. Identification was aided by using the pollen reference slide collection maintained by the Service, and the pollen reference manual by Moore *et al* (1991). Nomenclature for pollen follows Stace (2010) and Bennett (1994).

Fungal spores and parasite ova were noted with rapid identification being undertaken to genus level. Identifications were aided through reference material maintained by the Service and reference manuals by Kirk *et al* (2008) and Grant-Smith (2000).

2.5.5 Wood identification, by Alan Clapham

The cell structure of all the non-oak identification samples was examined in three planes under a high power microscope and identifications were carried out using reference texts (Schweingruber 1978, Brazier and Franklin 1961 and Hather 2000) and reference slides housed at the Worcestershire Historic Environment and Archaeology Service.

2.6 The methods in retrospect

It has previously been noted by Woodiwiss (2006, 9) that the effects of subsidence have an adverse impact upon the ability to access the deepest deposits in certain areas of the site with this being an issue once again with 9m of stratigraphy being encountered in borehole 1.

Similarly, the type of deposits encountered has an effect on the ability to recover samples. Several of the deposits (post-medieval clinker, sand and gravels) were too loose to be adequately recovered resulting in voids and gaps within the sequences that could only be reconstructed through comparison of notes across the boreholes and window samples. Unfortunately this method may not account for very localised variations within the deposits, the presence of which has previously been illustrated by the work of Woodiwiss (2006) and by comparing the results of that work and those contained within this assessment.

In WS6, the post-medieval levelling deposit consisting of clinker, fuel waste and brick rubble caused a refusal of the drilling rig and trapped the casing and the sampler underground eventually requiring jacks applying 24 tonnes of force to remove the trapped machinery. Similarly in WS4, the sheer quantity of in-situ and dumped brickwork again trapped the casing causing a segment of the steel casing to shear and break.

3. Topographical, geological and modern context, by Tom Vaughan, Simon Woodiwiss and Nicholas Daffern

3.1 Topography

The site comprises a sub-rectangular area of approximately 0.3ha on the north-west corner of St George's Square. It lies less than 0.5km to the north-east of Droitwich Spa town centre within the parish of St Peters (Fig 1).

The site is largely flat, at a height of approximately 29m AOD, although with a slight rise up to the north. It is bounded by roads to the south and east, and by Vines Park to the north and west. The canalised River Salwarpe lies c 20m to the north, flowing from east to west and eventually joining the River Severn 7km to the south-west, just north-west of Worcester. The site lies within the floodplain of the river, and is considered to be at risk of flooding (Worcestershire County Council Corporate GIS and Mapping Flood Data 2000).

3.2 Geology and soils

The underlying geology of the site is that of the Droitwich Halite member of the Mercia Mudstone group overlain by fluvioglacial gravels, archaeological deposits and levelling deposit.

The soils of the site are unsurveyed in the Soil Survey of England and Wales (1986) however to the north the soils along the River Salwarpe are of the Compton soil series (813), with adjacent soils of the Whimple series (572). The former comprises reddish pelo-alluvial gleyed mottled clays developed from river alluvium above permanently waterlogged grey clay. The latter comprises stagnogleyic argillic brown earths developed in thin loamy or silty drift over reddish clayey parent material (Soil Survey of England and Wales 1986).

3.3 Modern context

It is presently occupied by a two main buildings an L-shaped store along the west boundary with an additional toilet block within the angle, plus a two-storey antiques shop on the corner of Saltway and Queen Street. The forecourt and garage areas are covered by tarmac throughout. Access is via Queen Street.

The study area lies within the eastern end of a Scheduled Ancient Monument (SAM 30097, scheduled under the Ancient Monuments and Archaeological Areas Act 1979). This comprises the flood plain of the River Salwarpe, presently Vines Park, plus adjacent plots (Section 4 below).

During the final phase of exploitation of salt in this area (19th century) the extraction of salt ceased in Droitwich itself and was moved northwards to Stoke Works. This had the effect of introducing unsaturated brine to the salt beds below the town, which were then dissolved, causing subsidence (Poole and Williams 1981). The subsidence is most dramatically demonstrated by the westwards view along High Street from Queen Street, where the road level drops and many buildings are leaning. A clue that the development site is affected by subsidence is the historic documentation of the locks just to the north being periodically repaired and raised to counter subsidence in 1875-6 and 1903 (George 1905). The extent of subsidence is, however, imprecisely known.

3.4 Previous investigations

The site has been subject to two previous archaeological investigations; Vaughan and Darch (2003) and Woodiwiss (2006) with the latter also involving borehole investigation and a programme of monitoring of the burial environment.

A geotechnical investigation has also previously been undertaken (Rskensr 2004).

4. Results

4.1 Archaeological recording of deposits

The window sample logs are appended as Appendix 1

The majority of the deposits identified during borehole works could be assigned to post-medieval and modern levelling deposits associated with the dumping of industrial waste from salt production and the levelling of the site in the 20th century with the greatest depth being identified in BH1 where levelling deposit was identified down to 6.50m BGS/21.94m AOD. This levelling deposit consisted of reworked/redeposited Mercia Mudstone marl, brick, clinker and towards the top of the sequence, concrete and asphalt, in an ash-rich sand matrix.

One of the characteristic elements of the deposits, particularly to the north and west of the site was extensive contamination by hydrocarbons which, in BH1 in particular, had saturated much of the industrial waste but also contaminated the upper surfaces of the underlying alluvium.

Preservation in the southern half of the site was significantly poorer than was expected due to the shallow nature of the deposits with geology being encountered at 2.80m BGS/25.77m AOD in WS5 and 4.90m BGS/23.59m AOD in BH6. Coupled with this is the extensive disturbance witnessed in this area through development on the Saltway frontage which, from cartographic evidence (Woodiwiss 2006, 12), is known to have been occurring since at least the 17th century although given the location of the site beside a major route way it can be expected that development in this area was occurring much earlier than the cartographic sources indicate.

Alluvium was frequently identified in the majority of the boreholes and window samples but frequently exhibited signs of disturbance and/or contamination by the overlying clinker or hydrocarbons.

The alluvium identified in WS4 and BH4 between 23.65m – 22.65m AOD although appearing suitable for palaeoenvironmental potential was unproductive for palynological remains and plant macrofossils and appears to have been contaminated and disturbed in the post-medieval/modern period.

The alluvium in BH6 between 24.49m – 23.99m AOD although appearing similar in character to the blue/grey alluvium identified in previous investigations (Hurst 1997; Woodiwiss 2006) was unsuitable for palaeoenvironmental assessment due to the sterility of the clay and frequency and coarseness of the gravels.

Alluvium that appeared to be undisturbed and with the highest potential for palaeoenvironmental assessment was identified in WS2 at 22.16m – 22.00m AOD and BH2 at 23.10 – 22.50m AOD and exhibited the similar grey colouration that has previously been observed in previous investigations in the area (Hurst 1997; Woodiwiss 2006).

Despite this alluvium providing an earlier radiocarbon date and lying at a higher level AOD than was previously identified in the investigation by Woodiwiss (2006), it is hypothesised that this alluvium is in-situ and has been have been protected from later disturbance due to a buffer zone provided by the road and crossing point which was not afforded to the western parts of the site. This is based upon the postulated Roman road system, historical mapping and the toponymical evidence (Woodiwiss 2006, 10-12) which indicate that there has been a fording/bridging point located immediately to the east of the site, presently Chapel Bridge, for a considerable period of time and later development have respected this early thoroughfare.

This hypothesis is further reinforced by the evidence from Upwich where the marker horizon of Anglo-Saxon alluvium was identified between 26.78m and 26.15m AOD whereas the alluvium in the present investigation was over 3 metres below this (23.10m AOD). It is therefore suggested that the blue/grey alluvium that has typically been assigned to the Anglo-Saxon alluviation of the Salwarpe floodplain is likely to be characteristic of alluviation of this area through history and prehistory.

There is potential for preserved alluvium in BH1 between 21.64m – 20.04m AOD below the dumped industrial waste and hydrocarbon contamination and it was unfortunate that a stratified bulk sample could not be recovered to assess its potential for palaeoenvironmental preservation.

The alluvium was underlay either by alluvial gravels or lay unconformably upon the marl representing the upper reworked surface of the Mercia Mudstone Group. The greatest abundance of these gravels was identified at the northern end of the site, particularly in WS2 where the coarse nature of the gravels caused a refusal resulting in the drilling to be halted at 6.70m BGS/22.00m AOD.

4.2 Geotechnical summary, by Ground Investigation Specialists (GIS)

The percussive and rotary borehole logs are appended as Appendices 2 and 3 respectively

The boreholes revealed the site to be underlain by made ground (consisting for the most part of very loose sandy ash with brick and concrete fragments) which ranged in thickness from 2.0 to 6.5m increasing in a northerly direction. Underlying the made ground were layers of soft dark organic silt and denser sandy gravel which together varied in thickness between 1.0 and 5.7m, also increasing towards the northern end of the site.

These alluvial soils extended to depths ranging from 3.1m in Borehole 5 to 9.0m in Borehole 1, where they were underlain by highly weathered mudstones and occasional sandstones consistent with the Droitwich Halite Member of the Mercia Mudstone Group. With increasing penetration the unit became less weathered and stronger; containing bands of siltstone and deposits of halite. A relatively high groundwater table is present below the site varying in depth from 0.80 to 1.80m.

In some areas the superficial soils and groundwater are contaminated with hydrocarbons, most notably in Boreholes 1, 3, and 6.

4.3 Radiocarbon dating, by Beta Analytic Ltd and Nicholas Daffern

4.3.1 Results

One sample was submitted to Beta Analytic Ltd for Accelerator Mass Spectrometry (AMS) radiocarbon dating. The results of which are contained in Table 1. The full radiocarbon report is appended as Appendix 4. All calibrated date ranges cited in the text are those for 95% confidence.

Despite the recovery of wood from within the alluvium, this material was not submitted for radiocarbon dating due to it being oak and therefore potentially long-lived which would result in a date that is unlikely to reflect the true date of the deposit. Also given the conclusions of the wood assessment (section 5.5 below) it was concluded that submitting the retrieved wood would not be a productive use of resources.

Laboratory code	Borehole number and depth (m OD)	Material	13C/12C	Radiocarbon Age BP	OxCal calibrated age (95.4% probability or 2 sigma)
Beta-309383	BH2: 6.20m BGS/ 23.10m AOD	Organic sediment	-25.1 o/oo	4060 +/- 40 BP	Cal BC 2850 to 2810 (Cal BP 4800 to 4760) AND Cal BC 2740 to 2720 (Cal BP 4690 to 4680) AND Cal BC 2700 to 2480 (Cal BP 4640 to 4420)

Table 1 Radiocarbon dating results

4.3.2 **Discussion**

The result of the radiocarbon dating, providing a middle to late Neolithic date of Cal BC 2850 to 2810 AND Cal BC 2740 to 2720 AND Cal BC 2700 to 2480 (Beta-309383), was somewhat earlier than was expected given the previous Anglo-Saxon and early medieval dating of alluvial deposits in this area (Table 2).

It is noteworthy that the source of this material was at the top of the alluvium in BH2 and therefore there is potentially a further 0.60m of prehistoric alluvium lying below this point.

A possible explanation for this earlier than expected date may relate to the location of the borehole and the "buffer zone" provided by the crossing point as was described in Section 4.1 although an alternative explanation of this early date which is related to the material selected for radiocarbon dating.

In the absence of suitable plant macrofossil material a bulk organic sediment sample was selected for dating and recent work by Meadows et al (2011) has suggested that when compared to the dating of plant macrofossils, organic samples can be "systematically biased towards older ages" (Meadows et al 2011, 34). This is explained by the statement that:

> the humified organic material dated could have been derived, in part, from reworked plant remains and from remains of submerged species, and may also have significant intrinsic ages both because the sediment in the bulk sample may have taken a number of years to accumulate, and because its organic content may in part be derived from decomposed wood from long-lived species. (Meadows et al 2011, 32)

It is known that prehistoric organic deposits do lie upstream of the present site with Mesolithic deposits having been identified and radiocarbon dated at Impney (Williams et al 2005, 8-9) and therefore there is potential for reworked organic material to be transported and incorporated into the alluvium at the present site.

Even if this latter explanation were the cause of this earlier than expected date, the offset of earlier, reworked material would not be sufficient to cause bulk organic sediment of Anglo-Saxon date to produce a Neolithic date and therefore it must be presumed that the deposit is prehistoric in date.

Location	Context/ Depth	Laboratory code	Material	OxCal calibrated age (95.4% probability or 2 sigma)	Bibliographic source
Upwich	2189	UB3194	charcoal	689 to 801 Cal AD	Hurst 1997
Upwich	3047	HAR912	charcoal	600 to 660 Cal AD	Hurst 1997
Upwich	3049	HAR9123	charcoal	440 to 625 Cal AD	Hurst 1997
Upwich	3059	HAR9120	charcoal	445 to 600 Cal AD	Hurst 1997

Location	Context/ Depth	Laboratory code	Material	OxCal calibrated age (95.4% probability or 2 sigma)	Bibliographic source
Upwich	3061	HAR9121	charcoal	415 to 555 Cal AD	Hurst 1997
Upwich	3070	HAR9118	charcoal	425 to 590 Cal AD	Hurst 1997
Upwich	3088	HAR9119	charcoal	555 to 650 Cal AD	Hurst 1997
Upwich	3635	UB3195	wood	686 to 788 Cal AD	Hurst 1997
Upwich	3747	UB3196	charcoal	442 to 598 Cal AD	Hurst 1997
Upwich	3748	UB3197	charcoal	542 to 607 Cal AD	Hurst 1997
Upwich	3807	HAR9124	charcoal	560 to 655 Cal AD	Hurst 1997
Upwich	3821	HAR9125	charcoal	340 – 530 Cal AD	Hurst 1997
Vines Park BHCP 100	21.29m – 21.19m AOD	Beta – 217621	wood	Cal AD 980 to 1060 (Cal BP 970 to 890) AND Cal AD 1080 to 1150 (Cal BP 860 to 800)	Woodiwiss 2006

Table 2 Radiocarbon results from previous investigations within the area

4.4 Artefact analysis, by Laura Griffin

The artefactual assemblage recovered is summarised in Table 3.

Due to the nature/methodology of the investigation, recovery of finds was unlikely; however, a small group of artefacts was retrieved during the works.

Overview of artefactual evidence

The finds from this site were all consistent with the discarding of domestic and building materials, none of which were earlier than late post-medieval in date.

Period	Material	Borehole	Depth (BGS)	Count	Weight (g)
Late 18th century onwards	Brick	WS2	4.00m	4	48g
Late 18th century onwards	Brick	WS2	5.10m	3	44g
Late 18th century onwards	Roof tile	BH4	4.00m – 4.40m	2	66g
Late 18th century onwards	Clay pipe	BH4	4.60m	1	2
Late 18th century onwards	Brick	WS4	3.70m	5	749g
Late 18th century onwards	Brick	WS5	2.29m	1	13g
Late 18th century onwards	Brick	BH6	4.00m	1	1388g

Table 3 Quantification of the assemblage

4.5 Wood identification, by Alan Clapham and Nicholas Daffern

Multiple fragments of wood were recovered during the borehole works upon the site, particularly from WS2 and BH2.

All of the wood samples examined were identified as *Quercus* (oak) with the exception of the deepest sample retrieved from 6.30m BGS/22.40m AOD in WS2; this sample was identified as a conifer.

Evidence for working of the wood was relatively frequent with definite tooling and cut marks particularly from the wood between 24.64m – 24.07m AOD in WS2 but due to the constraints of this assessment, no attempt has been made to qualify the nature of this working for which specialist examination would be required.

The preservation of the wood was generally very good with little or no evidence for chemical, biological or mechanical decay and no mineralization of the sample was apparent. The wood structure itself was still fibrous indicating that little or no degradation of the tissues had occurred.

There was little or no indication of skewing, warping or compression upon the sample with the structure of the sample still evident and "fresh" on both the interior and, more notably, the outer margins.

The lack of decay to the outer margins of the wood is particular notable as "decay always starts from the outside and moves towards the inside. Artefacts therefore often consist of a well preserved inner core surrounded by a decayed soft outer layer. Degraded waterlogged wooden artefacts may be much more fragile than they first appear. Indeed, if of any size, they are unlikely to be able to bear their own weight once removed from the ground. Loss of water from the most degraded outer surface begins as soon as the wood is exposed during excavation" (English Heritage, 2010).

This description of archaeological wood is dissimilar to the traits exhibited by the wood fragments retrieved from Droitwich whose outer layer was still very robust and was resistant enough to withstand cutting with a razor blade, the standard thin sectioning method used for archaeological wood.

The lack of skewing, warping or compression upon the samples, a feature typically witnessed in wood from archaeological contexts especially those from great depth, is of great interest as this process can commence immediately upon deposition of organic remains and therefore the absence of these processes indicates a relatively short burial period especially given the great depths from which these samples were obtained.

It is therefore concluded that the wood encountered in this assessment is either intrusive and have been driven into the deposits or they are deliberately dumped as a component of the salt working waste and/or levelling of the site.

4.6 Palynological remains

Palynological remains within the sub-samples taken from WS2 (23.52m AOD, 23.40m ADO and 23.22m AOD) and WS4 (24.63m AOD, 24.60m AOD and 24.54m AOD) were very poorly preserved and in low abundance. Grains were frequently encountered exhibiting signs of mechanical damage and/or degradation. Delcourt and Delcourt (1980) state that the former will be caused by either physical transport of the grains or syn-depositional and post-depositional compaction within the sediments whilst the latter will be caused by chemical oxidation within aerial and sub-aerial environments. It is therefore likely that there has been a great deal of disturbance to these deposits either during their initial formation or more likely at a latter date by post-medieval and modern activity upon the site.

Due to the poor preservation and low abundance exhibited by these samples, no further reference will be made to them.

A further six samples were submitted for processing, the results of this work will be forthcoming as an addendum to this work

5. Publication summary

The Service has a professional obligation to publish the results of archaeological projects within a reasonable period of time. To this end, the Service intends to use this summary as the basis for publication through local or regional journals. The client is requested to consider the content of this section as being acceptable for such publication.

An archaeological borehole survey was undertaken at Droitwich Garage, St George Square, Droitwich, Worcestershire (NGR SO 9022 6346). The borehole survey and environmental assessment were undertaken on behalf of CgMs in response to potential development occurring on the site.

An archaeological assessment and analysis (CgMs 2011) indicated that the development site lies within a monument (SM 30097) scheduled under the Ancient Monuments and Archaeological Areas Act 1979 considered to include a heritage asset with archaeological interest (HA 1020256). Scheduled monument consent for the works reported here has been issued (English Heritage reference S00020526, 12 October 2011).

The assessment revealed significant quantities (up to 6.5m) of levelling deposit consisting of post-medieval clinker, coal fuel ash and brickwork relating to the dumping of industrial waste produced during salt production and attempts to level the site as a result of subsidence caused through the extraction of brine. Artefacts recovered were consistently late 18th century onwards in date therefore supporting this post-medieval character. The site's 20th century use as a garage was also readily evident through the frequent identification of hydrocarbons within the deposits, particularly in the north-west of the site.

Underlying the post-medieval levelling deposit were alluvial deposits which were similar in appearance to those that had been encountered during previous investigations both on this site and within the wider landscape which had identified it as being Anglo-Saxon/early medieval in origin although unfortunately no datable material could be obtained from the alluvium to confirm this previous dating and palynological assessment proved unsuccessful due to apparent disturbance of the sediments

Despite the domination of post-medieval material and the lack of archaeological material pre-dating the post-medieval subsidence and dumping, borehole 2 produced an apparently uncontaminated organic sediment sample which was submitted for radiocarbon dating and produced a middle to late Neolithic date of Cal BC 2850 to 2810 AND Cal BC 2740 to 2720 AND Cal BC 2700 to 2480 (Beta-309383).

The Service would like to thank the following for their kind assistance in the successful conclusion of this project, Cathy Patrick (CgMs), Tony Fleming and Lisa Moffett (English Heritage), Simon Woodiwiss (WHEAS) and Tom McLaren (GIS).

6. Personnel

The fieldwork and report preparation was led by Nicholas Daffern. The project manager responsible for the quality of the project was Simon Woodiwiss. Fieldwork was undertaken by Nicholas Daffern and Andrew Mann, finds analysis by Laura griffin, environmental analysis by Nicholas Daffern and Alan Clapham, geoarchaeological/geotechnical recording by Nicholas Daffern and Ground Investigation Specialists and illustration by Carolyn Hunt. The report was edited by Simon Woodiwiss.

7. Bibliography

Association for Environmental Archaeology, 1995 *Environmental archaeology and archaeological evaluations. Recommendations concerning the environmental component of archaeological evaluations in England*, Working Papers of the Association for Environmental Archaeology, **2**

Barber, K E, 1976 History of vegetation, in S Chapman (ed) *Methods in plant ecology*, Oxford: Blackwell Scientific Publications, 49-52

Bennett, K D, 1994 *Annotated catalogue of pollen and pteridophyte spore types of the British Isles*, unpublished report, Department of Plant Sciences, University of Cambridge

Blewitt, L, and Field, R, 1994 *Droitwich, a pictorial history*, Phillimore

Brazier, J D, and Franklin, G L, 1961 *Identification of hardwoods: a microscope key*, Dept of Scientific and Industrial research, Forest Products Research Bulletin, **46,** Her Majesties Stationary Office, London

Buteux, V and Hurst, D, 1996 *Archaeological Assessment of Droitwich*, Hereford and Worcester, County Archaeological Service, Hereford and Worcester County Council, report 312

CAS, 1995 (as amended) *Manual of Service practice: fieldwork recording manual*, County Archaeological Service, Hereford and Worcester County Council, report **399**

CgMs, 2011 *Archaeological Assessment at Droitwich Garages, St Georges Square, Droitwich*, unpublished report

DCLG 2010 *Planning Policy Statement 5: Planning for the historic environment*, Department for Communities and Local Government

DCLG/DCMS/EH 2010 *PPS5 Planning for the historic environment: historic environment planning practice guide*, Department for Communities and Local Government/Department for Culture, Media and Sport/English Heritage

Delcourt, P A and Delcourt H R 1980 Pollen preservation and Quaternary environmental history in the southeastern United States, *Palynology*, **4**, 215-231

English Heritage 2007 *Geoarchaeology: Using earth sciences to understand the archaeological record*, Swindon: English Heritage Publishing

English Heritage, 2010 *Waterlogged Organic Materials Guidelines (Draft)*, Available: http://www.english-heritage.org.uk/content/publications/docs/waterlogged-organic-materials-guidelines-draft.pdf, Accessed: 18 November 2011

English Heritage 2011 *Environmental Archaeology: A guide to the theory and practice of methods, from sampling and recovery to post-excavation*, Swindon: English Heritage Publishing

George, W, 1905 *A short description of the Worcester and Birmingham, the Droitwich, and the Droitwich Junctions canals, which represent the northern sections of the Sharpness New Docks and Gloucester and Birmingham Navigation, showing their levels and connections with other canals, and describing their works and the principal features connected therewith*, WCRO BA 3762/144 ref 8991

GIS, 2011 *Method statement for borehole investigation at Droitwich Garages, St Georges Square, Droitwich*, unpublished report, Ground Investigation Specialists Ltd

Grant-Smith, E, 2000 *Sampling and identifying allergenic pollens and molds: An illustrated identification manual for air samplers*, San Antonio, Texas: Blewstone Press

Greig, J, 2007 Priorities in Mesolithic, Neolithic and Bronze Age environmental archaeology in the West Midlands in P Garwood (ed) *The undiscovered country: the earlier prehistory of the West Midlands,* Oxford: Oxbow Books

Hather, J G, 2000 *The identification of the Northern European hardwoods: a guide for archaeologists and conservators,* Archetype Publications Ltd

HEAS 2011 *Proposal for archaeological monitoring and the assessment of environmental remains at Droitwich Garage, St Georges Square, Droitwich*, Worcestershire, Historic Environment and Archaeology Service, Worcestershire County Council, unpublished document dated 07 October 2011, **P3767**

Hurst, J D, and Rees, H, 1992 Pottery fabrics; a multi-period series for the County of Hereford and Worcester, in Woodiwiss, S G (ed), *Iron Age and Roman salt production and the medieval town of Droitwich*, CBA Res Rep, **81**

Hurst, J D, 1997 A multi-period salt production site at Droitwich: Excavations at Upwich, CBA Res Rep, **107**

Hurst, J D, 2006 *Roman Droitwich: Dodderhill fort, Bays Meadow villa and roadside settlement*, CBA Res Rep, **146**

IfA 2008 Standard and guidance for an archaeological watching brief, Institute for Archaeologists

Jones, A P, Tucker, M E, and Hart, J K, 1999 Guidelines and recommendations, in A P Jones, M E, Tucker and J K, Hart (eds), *The description and analysis of Quaternary stratigraphic field sections*, London: Quaternary Research Association technical guide **7**, 27-76

Kirk, P M, Cannon, P F, Minter D W and Stalpers J A, 2008 *Dictionary of the fungi 10th Edition*, Wallingford: CABI Publishing

Mawer, A, and Stenton, F M, 1927 *The place-names of Worcestershire*, Cambridge University Press, London

Meadows, J, Bronk Ramsey, C, Cook, G, Jackson, R and Toms, P, 2011 Radiocarbon dating of palaeochannel fills, in R Jackson, A Mann and T Roberts (eds) *Evaluating and enhancing the geoarchaeological resource of the lower Severn Valley*, Historic Environment and Archaeology Service, Worcestershire County Council, Internal Report, **1819**

Moore, P D, Webb, J A, and Collinson, M E, 1991 *Pollen analysis, (2nd edition)*, Oxford: Blackwell Scientific Publications.

Poole, E G, and Williams, B J, 1981 *The Keuper saliferous beds of the Droitwich area*, Institute of Geological Sciences, report **81/2**

Rskensr, 2004 *Site investigation, St Georges Square, Droitwich Garage*, Droitwich, RSK ENSR Ltd, **21729-1 (00)**

Schweingruber, F H, 1978 *Microscopic wood anatomy: structural variability of stems and twigs in recent and subfossil woods from Central Europe*, Swiss Federal Institute of Forestry Research

Soil Survey of England and Wales, 1986 *Soils of Worcester and the Malverns district*, sheet 150, scale 1:50,000

Stace, C 2010 *New flora of the British Isles (3rd edition)*, Cambridge: Cambridge University Press

Thorn, F, and Thorn, C, 1982 *Domesday Book - Worcestershire*, Chichester

Vaughan, T, and Darch, E, 2003 *Archaeological evaluation at Droitwich Garage, Droitwich, Worcestershire*, Archaeology Service, Worcestershire County Council, report **1160**, http://public.worcestershire.gov.uk/sites/archaeology/Reports/wr2402.pdf

VCH I, Page, W (ed), 1913 *Victoria History of the County of Worcestershire*, **I**

VCH III, Page, W (ed), 1913 *Victoria History of the County of Worcestershire*, **III**

White, R (ed), 2002 *Research issues in the Roman period in the West Midlands: LPRIA to sub-Roman*, West Midlands Regional Framework for Archaeology, http://www.iaa.Boreholeam.ac.uk/research/projects/wmrrfa/seminar3/index.shtml, Accessed 15 November 2011

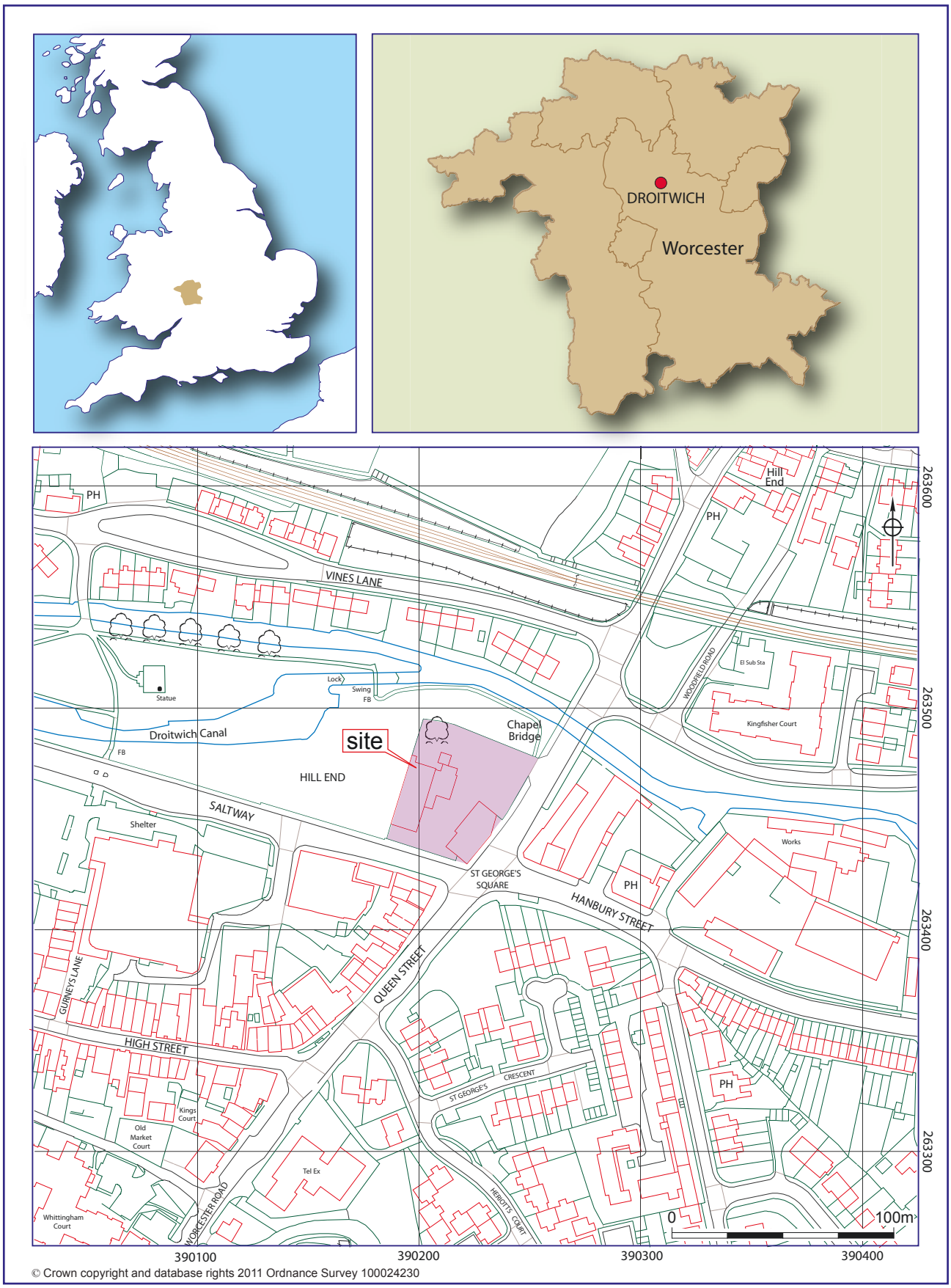
Wilkinson, K, 2006 Streets Garage, Droitwich: A geoarchaeological study of borehole stratigraphy, ARCA report number 0607-1, in S Woodiwiss, *Evaluation at Street's Garage, Droitwich, Worcestershire*

Williams, P, Hurst, D, Pearson, E, and Greig, J, 2005 *Watching brief and building recording at Impney Farm, Dodderhill, Worcestershire*, Historic Environment and Archaeology Service, Worcestershire County Council, report **991**, http://public.worcestershire.gov.uk/sites/archaeology/Reports/wr9874.pdf

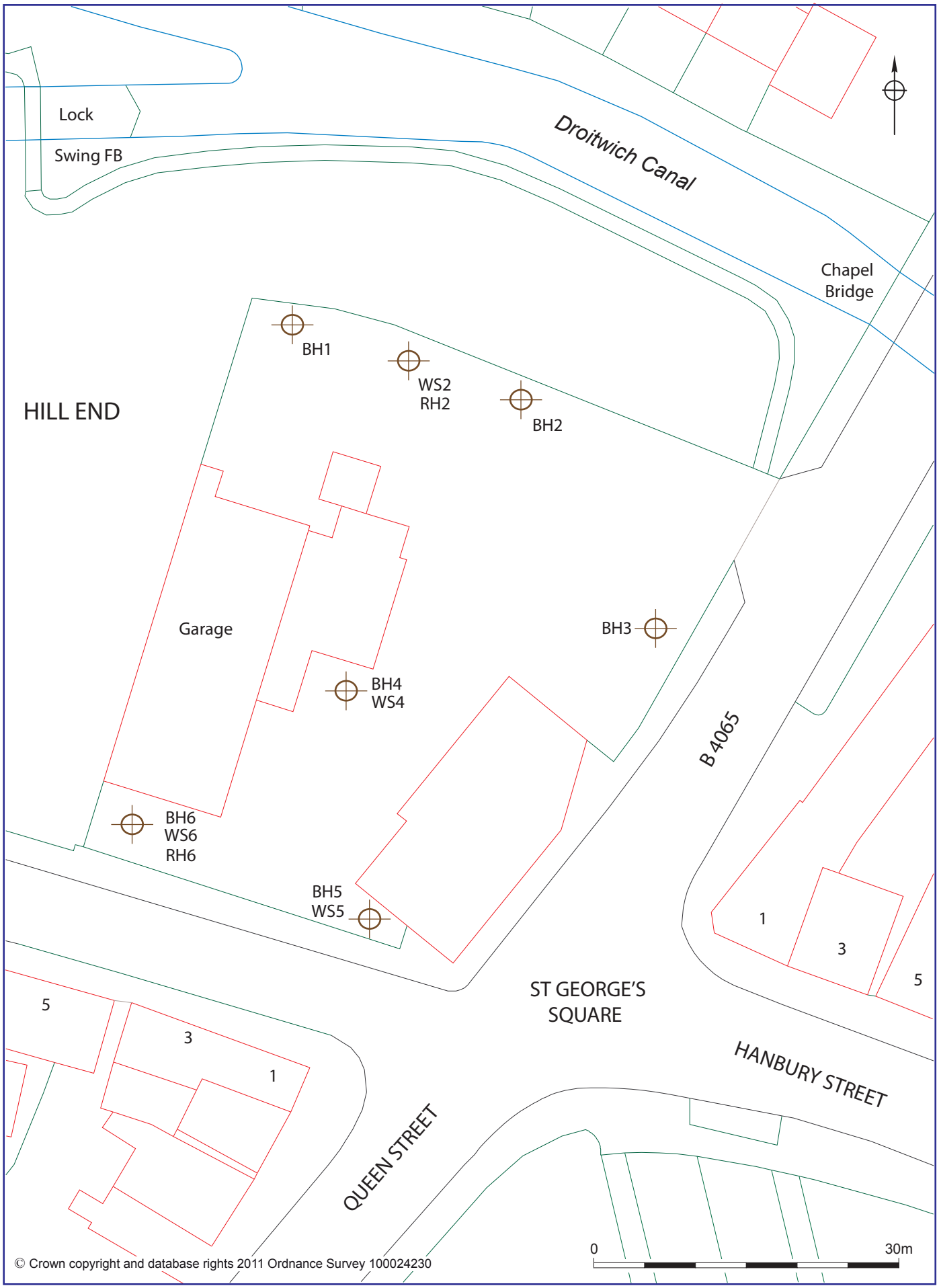
Woodiwiss, S G (ed),1992 Iron Age and Roman salt production and the medieval town of Droitwich, CBA Res Rep, **81**

Woodiwiss, S 2006 *Evaluation at Street's Garage, Droitwich, Worcestershire, Worcestershire*, Historic Environment and Archaeology Service, Worcestershire County Council, report **1438**, http://public.worcestershire.gov.uk/sites/archaeology/Reports/WR11273.pdf

Figures



Location of the site *Figure 1*



Location of boreholes

Figure 2

Plates

Plate 1 Sinking of Window Sample 4, looking north-west

Plate 2 Sinking of Window Sample 6, looking north-east

Plate 3 Sinking of Borehole 1, looking south-east

Plate 4 Sinking of Rotary Hole 2, looking north-west

Appendix 1 Window sample (WS) descriptions

Window Sample 2

Top of borehole height above ordinance datum – 28.70m AOD

Maximum depth: 6.70m

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 0.40m	28.70m – 28.30m	Levelling deposit	Firm, mid – dark brown clayey silt with frequent CBM and concrete fragments
0.40m – 1.80m	28.30m – 26.90m	Levelling deposit	Friable yet firm, dark brown silty sand with frequent CBM fragments and clinker and occasional angular – sub rounded gravels
1.80m – 2.30m	26.90m – 26.40m	Levelling deposit	Pliable, dark greyish brown silty, sandy clay with occasional rounded – sub rounded gravels and occasional clinker and CBM
2.30m – 3.00m	26.40m – 25.70m	Disturbed/ redeposited alluvium	Pliable, dark blackish/greyish brown sandy silt with frequent rounded – angular gravels and occasional clinker and CBM fragments
3.00m – 3.60m	25.70m – 25.10m	Redeposited natural marl	Firm, light – mid reddish pink marl – redeposited weathered Mercia Mudstone marl
3.60m – 3.80m	25.10m – 24.90m	Disturbed/ redeposited alluvium	Wet, pliable, light – mid grey coarse silty sand with frequent angular – sub angular stones and pebbles and occasional CBM fragments and flecks
3.80m – 4.00m	24.90m – 24.70m	Dumped industrial waste	Friable but firm, dark greyish black coarse sand, clinker, coal and fuel ash
4.00m – 4.06m	24.70m – 24.64m	Stone	Light – mid grey sandstone block
4.06m – 4.63m	24.64m – 24.07m	Wood	Firm, dark greyish black worked wood with occasional – frequent coarse sand
4.63m – 5.00m	24.07m – 23.70m	VOID	
5.00m – 5.17m	23.70m – 23.53m	Dumped industrial waste	Friable but firm, dark greyish black coarse sand, clinker, coal and fuel ash
5.17m – 5.21m	23.53m – 23.49m	Disturbed alluvium	Pliable, dark greyish black clayey silt mildly contaminated by overlying industrial
5.21m – 5.51m	23.49m – 23.19m	?Disturbed Alluvium	Firm, pliable, light – mid pinkish, greyish brown clayey silt with occasional – frequent dark mottles
5.58m – 6.00m	23.19m – 22.70m	VOID	
6.00m – 6.54m	22.70m – 22.16m	Dumped industrial waste – tumble?	Friable but firm, dark greyish black coarse sand, clinker, coal and fuel ash

Below ground surface depth	Height OD	Classification	Description
6.54m – 6.70m	22.16m – 22.00m	Alluvium	Firm, pliable, light – mid pinkish, greyish brown clayey silt with occasional – frequent dark mottles
REFUSAL DUE TO RIVER COBBLES/ COARSE GRAVEL			

Window Sample 4

Top of borehole height above ordinance datum – 28.65m AOD

Maximum depth: 4.41m

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 0.18m	28.65m – 28.47m	Levelling deposit	Tarmac
0.18m – 0.29m	28.47m – 28.36m	Structural	Firm, mid reddish pink post-medieval/modern brick
0.29m – 0.82m	28.36m – 27.83m	Structural	Firm, light – mid orange post-medieval/modern brick
0.82m – 2.23m	27.83m – 26.42m	Structural	Firm, dark reddish pink post-medieval/modern brick. Strong hydrocarbon odour
2.23m – 2.40m	26.42m – 26.25m	Levelling deposit	Friable, light creamish grey occasionally silty coarse sand. Frequent angular – sub angular fragmented brick and CBM. Strong hydrocarbon odour
2.40m – 2.76m	26.25m – 25.89m	Levelling deposit/ demolished structure?	Firm yet occasionally friable mid pinkish red broken brickwork. Strong hydrocarbon odour
2.76m – 3.00m	25.89m – 25.65	VOID	
3.00m – 3.76m	25.65m – 24.89m	Dumped industrial waste	Firm black brickwork, coarse sand and clinker. Very strong hydrocarbon odour and staining
3.76m – 4.00m	24.89m – 24.65m	VOID	
4.00m – 4.21m	24.65m – 24.44m	Alluvium	Pliable, light – mid grey silty clay with frequent rounded – sub rounded gravel and cobbles. Frequent orange Mercia Mudstone mottling. Possible hydrocarbon contamination, very faint odour
4.21m – 4.41m	24.44m – 24.24m	Geology	Firm reddish orange marl - upper weathered surface of Mercia Mudstone
END OF BOREHOLE - IN NATURAL			

Window Sample 5

Top of borehole height above ordinance datum – 28.57m AOD

Maximum depth: 4.00m

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 0.19m	28.57m – 28.38m	Levelling deposit	Tarmac
0.19m – 0.78m	28.38m – 27.79m	Levelling deposit	Light orange brick rubble and mortar
0.78m – 1.43m	27.79m – 27.14m	Dumped industrial waste	Soft, friable, dark brownish black sandy silty clay with frequent clinker, CBM, coal and fuel ash
1.43m – 2.28m	27.14m – 26.29m	Dumped industrial waste	Soft, friable, dark – mid greyish brown/black silty clay with frequent clinker, CBM, coal and fuel ash
2.28m – 2.54m	26.29m – 26.03m	Dumped industrial waste	Firm yet pliable, dark – mid greyish black silty clay with frequent clinker, coal, fuel ash and occasional CBM
2.54m – 2.71m	26.03m – 25.86m	Dumped industrial waste	Wet, firm yet pliable, dark black silty clay with frequent clinker coal, fuel ash and occasional rounded – sub angular pebbles
2.71m – 2.80m	25.86m – 25.77m	Alluvium	Firm yet pliable, light – mid grey silty clay with occasional rounded – sub rounded pebbles
2.80m – 2.95m	25.77m – 25.62m	Disturbed geology	Firm, dirty pinkish orange brown clayey marl – upper weathered surface of Mercia Mudstone
2.95m – 4.00m	25.62m – 24.57m	Geology	Firm, blocky, pinkish reddish orange marl - upper weathered surface of Mercia Mudstone
END OF BOREHOLE - IN NATURAL			

Window Sample 6

Top of borehole height above ordinance datum – 28.49m AOD

Maximum depth: 2.80m

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 0.21m	28.49m – 28.28m	Levelling deposit	Tarmac
0.21m – 0.37m	28.28m – 28.12m	Levelling deposit	Concrete
0.37m – 0.47m	28.12m – 28.02m	Levelling deposit	Friable, light – mid grey fine sandy disintegrated concrete with frequent rounded – sub angular pebbles and angular – sub angular concrete and CBM fragments

Below ground surface depth	Height OD	Classification	Description
0.47m – 0.61m	28.02m – 27.88m	Structural	Light orange brick
0.61m – 0.74m	27.88m – 27.75m	Levelling deposit	Friable, mid brownish grey fine sandy silt with frequent CBM fragments, bioturbation and rootlets
0.74m – 1.00m	27.75m – 27.49m	Structural	Light pinkish orange brick. Becomes more degraded and disintegrated with depth
1.00m – 1.22m	27.49m – 27.27m	Dumped industrial waste	Friable, black moderately coarse sand, coal ash and clinker with occasional CBM, mortar, pebbles and rare glass
1.22m – 1.38m	27.27m – 27.11m	Redeposited natural marl	Firm, mid pinkish reddish orange silty clay marl
1.38m – 1.51m	27.11m – 26.98m	Dumped industrial waste	Friable, mid – dark grey fine – coarse gritty sand with frequent angular – sub angular CBM and stone fragments
1.51m – 1.69m	26.98m – 26.80m	Dumped industrial waste	Loose, friable, dark black clinker and coal ash. Strong hydrocarbon odour
1.69m – 2.00m	26.80m – 26.49m	Dumped industrial waste	Firm, dark black clinker and coal ash. Strong hydrocarbon odour
2.00m – 2.60m	26.49m – 25.89m	Dumped industrial waste	Firm, dark black coarse sandy clicker and coal ash and occasional mortar, stone and CBM fragments. Strong hydrocarbon odour
2.60m – 2.80m	25.89m – 25.69m	Redeposited natural marl	Very firm dirty pinkish orange brown clayey marl
REFUSAL DUE TO HEAVILY COMPACTED NATURE OF DEPOSIT			

Appendix 2 Archaeological borehole (BH) descriptions

Borehole 1

Top of borehole height above ordinance datum –28.44m AOD

Maximum observed depth: 11.50m

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 0.10m	28.44m – 28.34m	Topsoil	Mid orangish brown clayey silt. Frequent angular – sub angular CBM fragments
0.10m – 6.20m	28.34m – 22.24m	Heavily contaminated industrial waste	Dark blackish grey silty ash and clinker. Very heavily contaminated by diesel and/or oil
6.20m – 6.80m	22.24m – 21.64m	Contaminated alluvium	Pliable, dark brownish grey silty clay. Strong hydrocarbon odour
6.80m – 8.40m	21.64m – 20.04m	Alluvium	Pliable, dark greyish black sandy silt
8.40m – 11.30m	20.04m – 17.14m	Natural sand and gravels	Friable, mid yellowish brown silty sand. Frequent rounded – sub rounded gravels
11.30m – 11.50m	17.14m – 16.94m	Natural sand and gravels	Loose, rounded – sub rounded gravel with occasional coarse sand
11.50m	16.94m	Geology	Firm reddish orange marl - upper weathered surface of Mercia Mudstone

Borehole 2

Top of borehole height above ordinance datum –29.30m AOD

Maximum observed depth: 11.00M

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 1.80m	29.30m – 27.50m	Topsoil/ levelling deposit	Pliable, clay silt and rubble
1.80m – 2.00m	27.50m – 27.30m	Redeposited alluvium/ gravels	Soft, brownish grey silt and rounded – sub angular gravels
2.00m – 4.60m	27.30m – 24.70m	VOID/ UNRECORDED	
4.60m – 5.80m	24.70m – 23.50m	Dumped industrial waste	Mid – dark blackish grey silts, gravels, clinker and ash
5.80m – 6.20m	23.50m – 23.10m	Disturbed alluvium	Soft black silts with occasional clinker. Occasional worked wood
6.20m – 6.80m	23.10m – 22.50m	Alluvium	Soft, pliable mid greyish brown silts
6.80m –	22.50m –	Alluvium and	Dark grey silty rounded – sub rounded gravels with occasional

Below ground surface depth	Height OD	Classification	Description
11.00m	18.30m	gravels	angular – sub angular fragments of Mercia Mudstone
11.00m	18.30m	Natural gravels	Dark grey, fine rounded – sub rounded gravels
NO RECOVERY BEYOND THIS POINT			

Borehole 3

Top of borehole height above ordinance datum – 29.09m AOD

Maximum observed depth: 6.90m

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 0.40m	29.09m – 28.69m	Levelling deposit	Coarse sand, angular brick and sandstone fragments
0.40m – 1.80m	28.69m – 27.29m	Levelling deposit	Dark brown sandy clay. Frequent angular – sub angular CBM, sandstone and concrete fragments
1.80m – 3.00m	27.29m – 26.09m	Dumped industrial waste	Dark black silty, clayey ash, charcoal and clinker. Occasional small fragments of CBM. Hydrocarbon odour
3.00m – 3.30m	26.09m – 25.79m	VOID/UNRECORDED	
3.30m – 3.80m	25.79m – 25.29m	Redeposited natural marl?	Firm and cohesive, red sandy clay, appears sterile
3.80m – 4.20m	25.29m – 24.89m	Disturbed alluvium?	Soft but cohesive, brown gritty sandy clay with occasional charcoal flecks
4.20m – 4.50m	24.89m – 24.59m	Disturbed alluvium?	Becomes siltier at 4.20m
4.50m – 5.00m	24.59m – 24.09m	Disturbed alluvium?	Becomes greyer/bluer at 4.50m
5.00m – 5.50m	24.09m – 23.59m	Redeposited natural marl?	Firm, sterile, orange clay/marl and rounded gravels.
5.50m – 6.90m	23.59m – 22.19m	Natural gravels	Clean rounded – sub rounded gravels
6.90m	22.19m	Geology	Firm reddish orange marl - upper weathered surface of Mercia Mudstone

Borehole 4

Top of borehole height above ordinance datum – 28.65m AOD

Maximum observed depth: 6.30m

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 3.20m	28.65m – 25.45m	Levelling deposit	Firm, pliable, orangish brown silty clay containing concrete and CBM
3.20m – 4.00m	25.45m – 24.65m	Disturbed alluvium?	Loose, dark brown silty, sandy clay with occasional rounded – sub angular gritty gravels. Slightly organic in appearance. Becomes very gravelly towards base
4.00m – 5.00m	24.65m – 23.65m	Disturbed alluvium	Firm and cohesive silty clay, occasional rounded gravels and occasional CBM fragments
5.00m – 5.30m	23.65m – 23.35m	Alluvium	Light – mid grey silty clay with occasional small rounded 0 sub rounded gravels
5.30m – 6.00m	23.35m – 22.65m	Alluvium	Mid – light brown silty clay
6.00m – 6.30m	22.65m – 22.35m	Alluvium and gravels	Firm and cohesive sandy clay marl and occasional – frequent fragments of Mercia Mudstone
6.30m	22.35m	Geology	Firm, reddish orange marl - upper weathered surface of Mercia Mudstone

Borehole 5

Top of borehole height above ordinance datum – 28.57m AOD

Maximum observed depth: 2.50m

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 0.50m	28.57m – 28.07m	Levelling deposit	Brick and mortar
0.50m – 1.40m	28.07m – 27.17m	Dumped industrial waste	Soft, brownish black silt with frequent CBM, clinker and fuel ash
1.40m – 2.00m	27.17m – 26.57m	Levelling deposit	Soft, greyish brown silty clay with occasional mortar and CBM flecks and fragments
2.00m – 2.50m	26.57m – 26.07m	Alluvium	Firm, brown alluvial silty clay
2.50m	26.07m	Geology	Firm, red clay marl with occasional – frequent blue/gleyed clay veins - upper weathered surface of Mercia Mudstone

Borehole 6

Top of borehole height above ordinance datum – 28.49m AOD

Maximum observed depth: 5.60m

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 0.50m	28.49m – 27.99m	Levelling deposit	Brick and mortar
0.50m – 1.40m	27.99m – 27.09m	Dumped industrial waste	Soft, brownish black silt with frequent CBM, clinker and fuel ash. Heavily contaminated by diesel and/or oil
1.40m – 2.00m	27.09m – 26.49m	Levelling deposit	Soft, greyish brown silty clay with occasional mortar and CBM flecks and fragments. Heavily contaminated by diesel and/or oil
2.00m – 3.00m	26.49m – 25.49m	Disturbed alluvium	Soft, brown silty sandy clay with frequent concrete, brick, CBM and mortar
3.00m – 4.00m	25.49m – 24.49m	Disturbed alluvium	Soft, dark brown gritty silty clay with occasional brick and CBM fragments
4.00m – 4.50m	24.49m – 23.99m	Alluvium	Bluish grey clay with frequent rounded - sub angular pebbles and gravels
4.50m – 4.90m	23.99m – 23.59m	Natural gravels	Rounded – sub rounded gravels with occasional sand
4.90m – 5.00m	23.59m – 23.49m	Disturbed geology	Firm, grey marly clay
5.00m – 5.20m	23.49m – 23.29m	Geology	Firm reddish orange marl - upper weathered surface of Mercia Mudstone
5.20m – 5.60m	23.29m – 22.89m	Geology	Very firm, blocky reddish orange marl - upper weathered surface of Mercia Mudstone

Appendix 3 – Archaeological Rotary Borehole (RH) descriptions

Rotary Borehole 2

Top of borehole height above ordinance datum – 28.70m AOD

Maximum observed depth: 25.00m

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 0.60m	28.70m – 28.10m	Levelling deposit	Hardcore/ tarmac
0.60m – 5.00m	28.10m – 23.70m	Dumped industrial waste	Clinker and industrial waste
5.00m – 6.80m	23.70m – 21.90m	Alluvium	Mid – dark brownish grey silty clay
6.80m – 8.50	21.90m – 20.20m	Natural gravels	Cobbles and very dense gravels
8.50m - 25.00m	20.20m – 3.70m	Geology	Weathered Mercia Mudstone

Rotary Borehole 6

Top of borehole height above ordinance datum – 28.49m AOD

Maximum observed depth: 20.50m

Main deposit description

Below ground surface depth	Height OD	Classification	Description
0.00m – 0.50m	28.49m – 27.99m	Levelling deposit	Brick and mortar
0.50m – 2.00m	27.99m – 26.49m	Dumped industrial waste	Soft, brownish black silt with frequent CBM, clinker and fuel ash. Heavily contaminated by diesel and/or oil
2.00m – 4.00m	26.49m – 24.49m	Disturbed alluvium	Soft, dark brown gritty silty clay with occasional brick and CBM fragments
4.00m – 4.90m	24.49m – 23.59m	Natural gravels	Rounded – sub rounded gravels with occasional sand
4.90m – 20.50m	23.59m – 7.99m	Geology	Weathered Mercia Mudstone

Appendix 4 Geotechnical borehole (BH) descriptions

GROUND INVESTIGATION SPECIALISTS LIMITED

BOREHOLE RECORD (DRAFT)	BORING COMMENCED: 20.10.11 BORING COMPLETED: 24.10.11 GROUND LEVEL:	TYPE OF BORING: Cable Percussive DIAMETER OF HOLE: 200 – 150mm BOREHOLE CASING: 200mm to 7.20m; 150mm to 11.40m	CLIENT: Churchill Retirement Living Ltd ENGINEER: Armstrong Burton Structures Ltd CONTRACT: Droitwich Garage, Droitwich	**BOREHOLE: 1** SHEET: 1 OF 2 JOB NO: 1085

DRILLING | SAMPLES | RESULTS OF TESTS

DESCRIPTION OF STRATA	LEGEND	WATER LEVEL	THICK-NESS	DEPTH	REDUCED LEVEL	DEPTH	TYPE	INDEX PROPERTIES 'N' VALUE	M/C %	LL %	PL %	PI	DENSITIES WET (kg/m³)	DRY (kg/m³)	STRENGTH TESTS TYPE	COHESION (kN/m²)	ANGLE OF INTERNAL FRICTION (degrees)	IN-SITU CHEMICAL AND OTHER TESTS AND REMARKS (SPT Blows)
				GL														
Made ground (dark brown silty sandy TOPSOIL with occasional brick fragments and rounded gravel).			0.30	0.30														Service Inspection pit dug to 1.20m in 1 hour
Made ground (dark grey slightly silty ashy SAND and fine to coarse angular GRAVEL sized fragments of ash with occasional peat fragments).			0.60			0.50	E1											PID at 0.50m = 0 ppm
		▽		0.90		1.00	E2											PID at 1.00m = 48.9 ppm
Made ground (very loose dark grey very silty fine to coarse angular GRAVEL sized fragments of ash). Includes strong hydrocarbon odour and multicoloured staining.		▽		1.20		1.20	C3	1 BLOW FOR 450 mm PENETRATION										(1. -. -. -. -. -)
						1.50	D4											PID at 1.50m = 39.1 ppm
						2.00	C5	2										(1. -. 1. -. -. 1)
Includes coarse brick and wood fragments below 3.00m.						3.00	C6	2										(2. 1. 1. -. -. 1)
			5.60			3.50	D7											PID at 3.50m = 5.9 ppm
No soils recovered from 2.0 – 3.0m and 4.0 – 5.0m.						4.00	C8	2										(1. 1. 1. -. 1. -)
						5.00	C9	3 BLOWS FOR 450 mm PENETRATION										(1. 1. -. -. -. 1)
						5.50	D10											PID at 5.50m = 0 ppm
						6.20	D11											PID at 6.20m = 0 ppm
Soft dark grey organic SILT. (ALLUVIUM)			0.30	6.50		6.50	C12	9										(4. 2. 1. 1. 1. 6)
				6.80		6.80	D13											
Firm grey-brown sandy clayey gravelly SILT. (ALLUVIUM)		▲	2.20	7.00														
Includes grey organic pockets and wood fragments below 7.80m.						7.80	D14											PID at 7.80m = 0 ppm
BOREHOLE CONTINUED…/				8.00														

GROUNDWATER OBSERVATIONS:

Water struck at 1.20m. Rose to 0.90m after 20 minutes.

▼ - Final groundwater level
▽ - Groundwater first struck
▲ - Standpipe
● - Piezometer

W - Water Sample
D - Small Disturbed Sample
E - Environmental Sample Suite
U - Undisturbed Sample

M/C - Natural Moisture Content
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index

'N' - Standard or Cone Penetration Test Result
T - Undrained Triaxial
M - Multi-stage Undrained Triaxial

S - Standard Penetration Test
C - Cone Penetration Test
V - Vane Test
SO_3 - Soluble Sulphate Analysis

GROUND INVESTIGATION SPECIALISTS LIMITED

BOREHOLE RECORD (DRAFT)					BOREHOLE: 1
	BORING COMMENCED: 20.10.11	TYPE OF BORING: Cable Percussive	CLIENT: Churchill Retirement Living Ltd		
	BORING COMPLETED: 24.10.11	DIAMETER OF HOLE: 150mm	ENGINEER: Armstrong Burton Structures Ltd		SHEET: 2 OF 2
	GROUND LEVEL:	BOREHOLE CASING: 11.40m	CONTRACT: Droitwich Garage, Droitwich		JOB NO: 1085

DRILLING | SAMPLES | RESULTS OF TESTS

DESCRIPTION OF STRATA	LEGEND	WATER LEVEL	THICK-NESS	DEPTH	REDUCED LEVEL	DEPTH	TYPE	INDEX PROPERTIES 'N' VALUE	M/C %	LL %	PL %	PI	DENSITIES WET (kg/m³)	DRY (kg/m³)	STRENGTH TESTS TYPE	COHESION (kN/m²)	ANGLE OF INTERNAL FRICTION (degrees)	IN-SITU CHEMICAL AND OTHER TESTS AND REMARKS (SPT Blows)
BOREHOLE CONTINUED…/				8.00		8.00	S15	13										(1. 2. 2. 4. 4. 3)
Firm grey-brown and grey sandy clayey gravelly organic SILT with some wood fragments. (ALLUVIUM) Driller noted wood obstruction at 8.80m.			2.20															PID at 8.00m = 0 ppm
				9.00		9.00	S16	4										(1. -. 1. 1. 1. 1) PID at 9.00m = 0 ppm
Very soft to soft reddish brown very silty sandy CLAY. (Reworked DROITWICH HALITE MEMBER)			2.30															Chiselled from 9.00 – 9.40m for ½ hour
						11.00	C17	25										(1. -. 4. 6. 8. 7)
Very weak red and grey MUDSTONE. (driller's description) (DROITWICH HALITE MEMBER)			0.20	11.30		11.50	D18											PID at 11.50m = 0 ppm
Very weak to weak red-brown muddy fine to medium grained fairly well cemented SANDSTONE. (DROITWICH HALITE MEMBER)			0.30	11.80														
Very weak red-brown and occasional tea-green silty MUDSTONE. Recovered as medium grained sand to fine gravel sized lithorelicts. (Highly weathered DROITWICH HALITE MEMBER)			0.37	12.17		11.90	S19	50 BLOWS FOR 120mm PENETRATION										(11. 13. 28. 22 for 45mm) PID at 11.90m = 0 ppm
BOREHOLE COMPLETE Sealed with bentonite/ cement grout from 12.17 – 7.00m. Soil gas monitoring standpipe installed to 7.00 m. Slotted screen from 7.00 – 1.00m. Plain pipe above sealed with bentonite.																		

GROUNDWATER OBSERVATIONS:

Water at 1.1 m on morning of 24.10.11

▼ - Final groundwater level

▽ - Groundwater first struck

▲ - Standpipe

● - Piezometer

W - Water Sample

B - Bulk Sample

E - Environmental Sample Suite

U - Undisturbed Sample

M/C - Natural Moisture Content

LL - Liquid Limit

PL - Plastic Limit

PI - Plasticity Index

'N' - Standard or Cone Penetration Test Result

T - Undrained Triaxial

M - Multi-stage Undrained Triaxial

S - Standard Penetration Test

C - Cone Penetration Test

V - Vane Test

SO_3 - Soluble Sulphate Analysis

GROUND INVESTIGATION SPECIALISTS LIMITED

BOREHOLE RECORD	BORING COMMENCED: 24.10.11 BORING COMPLETED: 25.10.11 GROUND LEVEL:	TYPE OF BORING: Cable Percussive DIAMETER OF HOLE: 200 – 150mm BOREHOLE CASING: 200mm to 6.20m; 150mm to 10.00m	CLIENT: Churchill Retirement Living Ltd ENGINEER: Armstrong Burton Structures Ltd CONTRACT: Droitwich Garage, Droitwich	**BOREHOLE: 2** SHEET: 1 OF 2 JOB NO: 1085

DRILLING | SAMPLES | RESULTS OF TESTS

DESCRIPTION OF STRATA	LEGEND	WATER LEVEL	THICK-NESS	DEPTH	REDUCED LEVEL	DEPTH	TYPE	INDEX PROPERTIES 'N' VALUE	M/C %	LL %	PL %	PI	DENSITIES WET (kg/m³)	DRY (kg/m³)	STRENGTH TESTS TYPE	COHESION (kN/m²)	ANGLE OF INTERNAL FRICTION (degrees)	IN-SITU CHEMICAL AND OTHER TESTS AND REMARKS (SPT Blows)
				GL														
Made ground (compact brown CLAY/ SILT with rubble). (driller's description)			0.40	0.40		0.40	E1											Service inspection pit dug to 1.20m in 1 hour. PID at 0.40m = 0 ppm
Made ground (compact becoming loose dark brown silty SAND with some fine to coarse angular to rounded gravel sized fragments of brick, ash and quartzite).			1.40			1.00 1.20	E2 C3	5										PID at 1.00m = 0 ppm (3. 3. 2. 1. 1. 1)
		▽1st		1.80		1.80	D4											PID at 1.80m = 0 ppm
Made ground (very soft dark brown and dark grey silty very sandy CLAY with some rounded gravel and angular ash and brick fragments).		▽1st ▲ ▽2nd	0.70	1.90 2.00		2.00	C5	3										(1. -. 1. 1. 1. -)
				2.50		2.50	D6											PID at 2.50m = 0 ppm
Very soft grey-brown very sandy SILT with much fine to occasionally coarse rounded to angular gravel of quartzite, diorite and occasional fine brick fragments. (Disturbed ALLUVIUM)			2.00			3.00	C7	3										(2. 1. 1. -. 1. -. 1)
						4.00	C8	4 BLOWS FOR 450mm PENETRATION										(1. 1. -. 1. -. 1)
				4.50		4.50	D9											PID at 4.50m = 0 ppm
Very loose dark brown silty very sandy fine to coarse angular to sub-rounded GRAVEL of quartzite and diorite. (Disturbed ALLUVIUM)			1.30			5.00	C10	4 BLOWS FOR 450mm PENETRATION										(1. 1. -. -. 1. 1)
						5.00	D11											PID at 5.00m = 0 ppm
				5.80		5.80	D12											PID at 5.80m = 0 ppm
WOOD fragments (possibly worked?) with some very soft dark grey sandy silt. (Disturbed ALLUVIUM)			0.40	6.20		6.20	D13											PID at 6.20m = 0 ppm
Very soft dark brown and dark grey very sandy slightly organic SILT with occasional wood, fine gravel and brick fragments. (Disturbed ALLUVIUM)			0.60	6.80		6.50	S14	15										(1. 1. 1. -. 10. 14) PID at 6.50m = 0 ppm
Dense dark grey slightly silty slightly sandy fine to coarse sub-angular to rounded GRAVEL of various lithologies. (ALLUVIUM)		▲	1.40	7.00		7.50	D15											PID at 7.50m = 0 ppm
				8.20														
BORHEOLE CONTINUED…/																		

GROUNDWATER OBSERVATIONS:

1st water strike at 2.0m. Rose to 1.9m after 20 minutes.

▼ - Final groundwater level

▽ - Groundwater first struck

▲ - Standpipe

● - Piezometer

W - Water Sample

D - Small Disturbed Sample

E - Environmental Sample Suite

U - Undisturbed Sample

M/C - Natural Moisture Content

LL - Liquid Limit

PL - Plastic Limit

PI - Plasticity Index

'N' - Standard or Cone Penetration Test Result

T - Undrained Triaxial

M - Multi-stage Undrained Triaxial

S - Standard Penetration Test

C - Cone Penetration Test

V - Vane Test

SO_3 - Soluble Sulphate Analysis

GROUND INVESTIGATION SPECIALISTS LIMITED

BOREHOLE RECORD					BOREHOLE: 2
	BORING COMMENCED: 24.10.11	TYPE OF BORING: Cable Percussive	CLIENT: Churchill Retirement Living Ltd		SHEET: 2 OF 2
	BORING COMPLETED: 25.10.11	DIAMETER OF HOLE: 150mm	ENGINEER: Armstrong Burton Structures Ltd		JOB NO: 1085
	GROUND LEVEL:	BOREHOLE CASING: 10.00m	CONTRACT: Droitwich Garage, Droitwich		

DRILLING | SAMPLES | RESULTS OF TESTS

DESCRIPTION OF STRATA	LEGEND	WATER LEVEL	THICK-NESS	DEPTH	REDUCED LEVEL	DEPTH	TYPE	INDEX PROPERTIES 'N' VALUE	M/C %	LL %	PL %	PI	DENSITIES WET (kg/m³)	DRY (kg/m³)	STRENGTH TESTS TYPE	COHESION (kN/m²)	ANGLE OF INTERNAL FRICTION (degrees)	IN-SITU CHEMICAL AND OTHER TESTS AND REMARKS (SPT Blows)
BOREHOLE CONTINUED…/				8.20		8.20	D16											PID at 8.20m = 0 ppm
Very weak red-brown and occasional light greenish grey silty MUDSTONE.						8.30	S17	50 BLOWS FOR 155mm PENETRATION										(8. 14. 20. 27. 3 for 5mm) PID at 8.20m = 0 ppm Chiselled from 8.60 – 9.10m for ½ hour
Recovered as fine to medium sand and occasional fine angular gravel sized lithorelicts.						9.50	S18	26										(3. 3. 4. 6. 6. 10) PID at 9.50m = 0 ppm
(Highly weathered DROITWICH HALITE MEMBER)			4.005															
Includes band of moderately strong red-brown and occasional tea-green fine to medium grained well cemented muddy SANDSTONE from 8.20 – 8.30m.						11.00	S19	44										(4. 5. 7. 11. 12. 14) PID at 11.00m = 0 ppm Chiselled from 11.60 – 11.80m for 1 hour
Becomes mostly grey from 9.50 – 11.00m.		▽2nd		11.80		11.80	S20	50 BLOWS FOR 255mm PENETRATION										(11. 13. 15. 14. 14. 7 for 30mm) PID at 11.80m = 0 ppm
				12.205														
BOREHOLE COMPLETE																		
Sealed with bentonite/ cement grout from 12.20 – 7.00m. Soil gas monitoring standpipe installed to 7.00 m. Slotted screen from 7.00 – 1.00m. Plain pipe above sealed with bentonite.																		

GROUNDWATER OBSERVATIONS:

Water at 4.1m on morning of 25.10.11. 2nd water strike at 11.8m. Rose to 2.0m after 20 minutes.

▼ - Final groundwater level
▽ - Groundwater first struck
▲ - Standpipe
● - Piezometer

W - Water Sample
D - Small Disturbed Sample
E - Environmental Sample Suite
U - Undisturbed Sample

M/C - Natural Moisture Content
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index

'N' - Standard or Cone Penetration Test Result
T - Undrained Triaxial
M - Multi-stage Undrained Triaxial

S - Standard Penetration Test
C - Cone Penetration Test
V - Vane Test
SO_3 - Soluble Sulphate Analysis

GROUND INVESTIGATION SPECIALISTS LIMITED

BOREHOLE RECORD	BORING COMMENCED: 26.10.11 BORING COMPLETED: 26.10.11 GROUND LEVEL:	TYPE OF BORING: Cable Percussive DIAMETER OF HOLE: 200 – 150 mm BOREHOLE CASING: 200mm to 3.40m; 150mm to 7.00m	CLIENT: Churchill Retirement Living Ltd ENGINEER: Armstrong Burton Structures Ltd CONTRACT: Droitwich Garage, Droitwich	**BOREHOLE: 3** SHEET: 1 OF 1 JOB NO: 1085

DRILLING | SAMPLES | RESULTS OF TESTS

DESCRIPTION OF STRATA	LEGEND	WATER LEVEL	THICK-NESS	DEPTH	REDUCED LEVEL	DEPTH	TYPE	INDEX PROPERTIES 'N' VALUE	M/C %	LL %	PL %	PI	DENSITIES WET (kg/m³)	DRY (kg/m³)	STRENGTH TESTS TYPE	COHESION (kN/m²)	ANGLE OF INTERNAL FRICTION (degrees)	IN-SITU CHEMICAL AND OTHER TESTS AND REMARKS (SPT Blows)
				GL														
BLACKTOP			0.10	0.10														Service inspection pit dug to 1.00m in 1 hour
Made ground (medium dense red and light brown SAND and fine to coarse angular GRAVEL sized fragments of crushed brick).			1.50			0.50	E1											PID at 0.50m = 0 ppm
						1.00	E2											PID at 1.00m = 0 ppm
						1.00	C3	15										(3. 3. 3. 4. 4. 4)
				1.60														
Made ground (medium dense? dark grey silty ashy SAND and fine to coarse angular GRAVEL sized fragments of ash and brick). Includes moderate hydrocarbon odour.		▽1st ▽	0.60	2.00		1.70	D4											PID at 1.70m = 119 ppm
						2.00	C5	1										(2. 2. 1. -. -. -)
Made ground (very loose dark grey ASH). (driller's description).			1.10	2.20														
No Recovery 2.20 – 3.20m.						3.00	C6	2 BLOWS FOR 450mm PENETRATION										(-. -. -. -. 1. 1)
		▲		3.30														
Dark grey very silty SAND with much fine to coarse angular to rounded gravel of quartzite and occasional mudstone. (ALLUVIUM)			0.50	3.40		3.60	D7											PID at 3.60m = 7.4 ppm
				3.80														
Soft brown and red-brown SILT.						4.00	S8	7										(1. 1. 1. 2. 2. 2)
(ALLUVIUM)																		PID at 4.00m = 2.7 ppm
Becomes brown, slightly organic and includes occasional fine gravel, charcoal/ lignite fragments below 4.70m.		▽2nd ▽	1.80	4.60		4.70	D9											PID at 4.70m = 0 ppm
				4.70		5.00	S10	50 BLOWS FOR 295mm PENETRATION										(1. 3. 9. 11. 14. 16 for 70mm)
																		PID at 5.00m = 0 ppm
				5.60														
Dense multicoloured slightly sandy fine to coarse sub-angular to rounded GRAVEL of various lithologies.						5.80	D11											PID at 5.80m = 0 ppm
(ALLUVIUM)			1.30			6.50	C12	48										(7. 12. 10. 12. 11. 15)
				6.90		7.00	S13	42										(9. 10. 11. 10. 11. 10)
Very weak red-brown silty MUDSTONE. Recovered as fine to coarse grained sand sized lithorelicts.																		PID at 7.00m = 0 ppm
(Highly weathered DROITWICH HALITE MEMBER)			1.56															Chiselled from 7.8 to 8.2m for 1 hour
																		Chiselled at 8.2m for ½ hour – no progress
						8.20	S14	50 BLOWS FOR 135mm PENETRATION										(12. 13 for 50mm, 19, 31 for 60mm)
				8.46														PID @ 8.20m = 0 ppm
BOREHOLE COMPLETE Sealed with bentonite/ cement grout from 8.46 – 3.40m. Soil gas monitoring standpipe installed to 3.40m. Slotted screen from 3.40 – 1.00m. Plain pipe above sealed with bentonite.																		

GROUNDWATER OBSERVATIONS:

1ST water strike at 2.2m. Rose to 2.0m after 20 minutes. 2nd water strike at 4.7m. Rose to 4.6m after 20 minutes.

▼ - Final groundwater level
▽ - Groundwater first struck
▲ - Standpipe
● - Piezometer

W - Water Sample
D - Small Disturbed Sample
E - Environmental Sample Suite
U - Undisturbed Sample

M/C - Natural Moisture Content
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index

'N' - Standard or Cone Penetration Test Result
T - Undrained Triaxial
M - Multi-stage Undrained Triaxial

S - Standard Penetration Test
C - Cone Penetration Test
V - Vane Test
SO_3 - Soluble Sulphate Analysis

GROUND INVESTIGATION SPECIALISTS LIMITED

BOREHOLE RECORD						**BOREHOLE: 4**
	BORING COMMENCED: 25.10.11	TYPE OF BORING:	Cable Percussive	CLIENT:	Churchill Retirement Living Ltd	SHEET: 1 OF 1
	BORING COMPLETED: 26.10.11	DIAMETER OF HOLE:	200 – 100mm	ENGINEER:	Armstrong Burton Structures Ltd	JOB NO: 1085
	GROUND LEVEL:	BOREHOLE CASING:	200mm to 4.70m; 150mm to 6.00m	CONTRACT:	Droitwich Garage, Droitwich	

DRILLING | SAMPLES | RESULTS OF TESTS

DESCRIPTION OF STRATA	LEGEND	WATER LEVEL	THICK-NESS	DEPTH	REDUCED LEVEL	DEPTH	TYPE	INDEX PROPERTIES 'N' VALUE	M/C %	LL %	PL %	PI	DENSITIES WET (kg/m³)	DRY (kg/m³)	STRENGTH TESTS TYPE	COHESION (kN/m²)	ANGLE OF INTERNAL FRICTION (degrees)	IN-SITU CHEMICAL AND OTHER TESTS AND REMARKS (SPT Blows)
				GL														
BLACKTOP.			0.10	0.10														Service inspection pit dug to 1.20m in 1 hour.
Made ground (very loose grey-brown slightly silty SAND and fine to coarse angular GRAVEL and small COBBLE sized fragments of concrete and increasing brick).						0.50	E1											PID @ 0.50m = 0 ppm
						1.00	E2											PID @ 1.00m = 0 ppm
				1.20		1.20	C3	1										(2.2.1.-.-.-.)
No recovery 1.40 – 3.20 m.		▽		1.40														
			3.10			2.00	C4	3 BLOWS FOR 450mm PENETRATION										(1.1.-.1.-.-.)
						3.00	C5	2										(2.2.1.-.1.-.)
				3.20		3.20	D6											PID @ 3.20m = 0 ppm
Made ground (very loose dark grey ashy SAND and fine to coarse angular GRAVEL sized fragments of ash and occasional brick).			1.40			4.00	C7	Rods sank under self weight										(-.-.-.-.-.-.)
				4.60		4.60	C8	26										(4.6.6.6.6.8.)
						4.60	D9											PID @ 4.60m = 0 ppm
Medium dense dark grey SILT/SAND with some fine to coarse rounded to sub-angular gravel of various lithologies. (ALLUVIUM)			1.50															
						5.50	D10											PID @ 5.50m = 0 ppm
Becomes increasingly gravelly with depth.		▲		6.00		6.00	C11	26										(2.5.6.7.7.6.)
				6.10		6.30	D12											PID @ 6.30m = 0 ppm
Very weak red-brown and occasional grey silty MUDSTONE. - Recovered mostly as fine to coarse sand sized lithorelicts.																		
(DROITWICH HALITE FORMATION)			3.635															(6.6.8.14.19.9 for 20mm)
						8.00	S13	50 BLOWS FOR 245mm PENETRATION										PID @ 8.00m = 0 ppm Chiselled from 8.0 – 8.9m for 1 hour.
						8.90	S14	50 BLOWS FOR 210mm PENETRATION										(11.13.18.17.15 for 60mm) Chiselled from 8.9 – 9.3m for 1 hour. PID @ 8.90m = 0 ppm
						9.30	S15	50 BLOWS FOR 285mm PENETRATION										(6.11.14.15.11.10 for 60mm) PID @ 9.30m = 0 ppm
Borehole Complete. Sealed with bentonite/cement grout from 9.735 – 6.00m. Soil gas monitoring standpipe installed to 6.00m. Slotted screen from 6.00 – 1.00m. Plain pipe above sealed with bentonite.				9.735														

GROUNDWATER OBSERVATIONS:

Water struck at 1.4m. Rose to 1.2m after 20 minutes. Water at 1.8m on morning of 26.10.11.

▼ - Final groundwater level
▽ - Groundwater first struck
▲ - Standpipe
● - Piezometer

W - Water Sample
D - Small Disturbed Sample
E - Environmental Sample Suite
U - Undisturbed Sample

M/C - Natural Moisture Content
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index

'N' - Standard or Cone Penetration Test Result
T - Undrained Triaxial
M - Multi-stage Undrained Triaxial

S - Standard Penetration Test
C - Cone Penetration Test
V - Vane Test
SO_3 - Soluble Sulphate Analysis

GROUND INVESTIGATION SPECIALISTS LIMITED

BOREHOLE RECORD				BOREHOLE: 5
BORING COMMENCED: 27.10.11	TYPE OF BORING: Cable Percussive	CLIENT: Churchill Retirement Living Ltd		SHEET: 1 OF 1
BORING COMPLETED: 27.10.11	DIAMETER OF HOLE: 200 – 150mm	ENGINEER: Armstrong Burton Structures Ltd		JOB NO: 1085
GROUND LEVEL:	BOREHOLE CASING: 200mm to 3.00m; 150mm to 6.00m	CONTRACT: Droitwich Garage, Droitwich		

DRILLING | SAMPLES | RESULTS OF TESTS

DESCRIPTION OF STRATA	LEGEND	WATER LEVEL	THICK-NESS	DEPTH	REDUCED LEVEL	DEPTH	TYPE	INDEX PROPERTIES 'N' VALUE	M/C %	LL %	PL %	PI	DENSITIES WET (kg/m³)	DRY (kg/m³)	STRENGTH TESTS TYPE	COHESION (kN/m²)	ANGLE OF INTERNAL FRICTION (degrees)	IN-SITU CHEMICAL AND OTHER TESTS AND REMARKS (SPT Blows)
				GL														
BLACKTOP.			0.10	0.10														Service inspection pit dug to 1.0m in 1 hour.
Fill (BRICK RUBBLE) (drillers description).			0.20	0.30														
Made ground (very loose to loose dark grey ashy SAND and fine to medium angular GRAVEL sized fragments of ash, brick and foundry brick).		▽	1.50	1.40		0.50	E1											PID @ 0.50m = - 0 ppm
						1.00	E2											PID @ 1.00m = 0 ppm
						1.00	C3	4										(1.2.2.1.-.1.)
		▽		1.80		1.80	D4											PID @ 1.80m = 0 ppm
Made ground (firm dark brown very sandy SILT with some fine coal, charcoal, brick, mudstone and occasional suspected smoking pipe fragments).			0.20	2.00		2.00	C5	1 BLOW FOR 450mm PENETRATION										(1.-.-.-.-.-.)
Very loose dark brown very sandy SILT and fine to coarse sub-angular to rounded GRAVEL of various lithologies. (ALLUVIUM)		▲	1.10	3.00		2.50	D6											PID @ 2.50m = 0 ppm
						3.00	C7	39										(4.4.6.8.10.15.)
				3.10		3.20	D8											PID @ 3.20m = 0 ppm
Very weak red-brown and grey silty MUDSTONE. Recovered mainly as fine to coarse sand sized lithorelicts. (Highly weathered DROITWICH HALITE MEMBER) Recovered as red-brown SILT from 4.00 – 4.45 m and 8.00 – 8.37 m.						4.00	S9	30										(4.4.6.6.8.10.) PID @ 4.00m = 0 ppm
						5.00	S10	35										(6.7.7.8.10.10.) PID @ 5.00m = 0 ppm
			5.27															
						6.50	S11	47										(5.8.8.11.11.17.) PID @ 6.50m = 0 ppm
																		Chiselled from 7.7 – 8.0m for 1 hour
						8.00	S12	50 BLOWS FOR 220mm PENETRATION										(10.14.17.17.16 for 70mm) PID @ 8.00m = 0 ppm
				8.37														
Borehole Complete. Sealed with bentonite/cement grout from 8.37 – 3.00m. Soil gas monitoring standpipe installed to 3.00m. Slotted screen from 3.00 – 1.00m. Plain pipe above sealed with bentonite.																		

GROUNDWATER OBSERVATIONS:

Water struck at 2.0m. Rose to 1.4m after 20 minutes.

▼ - Final groundwater level
▽ - Groundwater first struck
▲ - Standpipe
● - Piezometer

W - Water Sample
D - Small Disturbed Sample
E - Environmental Sample Suite
U - Undisturbed Sample

M/C - Natural Moisture Content
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index

'N' - Standard or Cone Penetration Test Result
T - Undrained Triaxial
M - Multi-stage Undrained Triaxial

S - Standard Penetration Test
C - Cone Penetration Test
V - Vane Test
SO_3 - Soluble Sulphate Analysis

GROUND INVESTIGATION SPECIALISTS LIMITED

BOREHOLE RECORD	BORING COMMENCED: 28.10.11 BORING COMPLETED: 28.10.11 GROUND LEVEL:	TYPE OF BORING: Cable Percussive DIAMETER OF HOLE: 200 – 150 mm BOREHOLE CASING: 200mm – 3.00m; 150mm to 7.30m	CLIENT: Churchill Retirement Living Ltd ENGINEER: Armstrong Burton Structures Ltd CONTRACT: Droitwich Garage, Droitwich	**BOREHOLE: 6** SHEET: 1 OF 1 JOB NO: 1085

DRILLING | SAMPLES | RESULTS OF TESTS

DESCRIPTION OF STRATA	LEGEND	WATER LEVEL	THICK-NESS	DEPTH	REDUCED LEVEL	DEPTH	TYPE	INDEX PROPERTIES 'N' VALUE	INDEX PROPERTIES M/C %	INDEX PROPERTIES LL %	INDEX PROPERTIES PL %	INDEX PROPERTIES PI	DENSITIES WET (kg/m³)	DENSITIES DRY (kg/m³)	STRENGTH TESTS TYPE	STRENGTH TESTS COHESION (kN/m²)	STRENGTH TESTS ANGLE OF INTERNAL FRICTION (degrees)	IN-SITU CHEMICAL AND OTHER TESTS AND REMARKS (SPT Blows)
				GL														
BLACKTOP.			0.10	0.10														Service inspection pit dug to 1.2m in 1 hour
Fill (broken CONCRETE) (drillers description).			0.15	0.25														
Made ground (very loose dark grey ashy SAND with many fine to medium angular gravel sized fragments of ash and occasional brick). Includes occasional concrete fragments below 1.00m. Includes slight to moderate sweet hydrocarbon odour below 1.10m.		∇1st ↑∇	2.75			0.50	E1											PID @ 0.50m = 0 ppm
				1.00		1.00	E2											PID @ 1.00m = 0 ppm
				1.10		1.20	C3	2										(2.3.1.-.1.-.)
						1.30	E4											PID @ 1.30m = 12.2 ppm
		∇2nd				2.00	C5	2 BLOWS FOR 450mm PENETRATION										(1.-.-.-.1.-.)
				2.20		2.20	D6											PID @ 2.20m = 3.8 ppm
						3.00	D7											
				3.00		3.00	S8	1										(2.1.1.-.-.-.)
Made ground (very soft dark grey SILT with much fine to coarse angular ash and brick fragments).			0.90			3.50	D9											PID @ 3.50m = 0 ppm
Stiff dark grey SILT and GRAVEL (drillers description).			0.40	3.90		4.00	C10	45										(4.6.8.9.12.16.)
Very dense SAND and GRAVEL (drillers description).			0.60	4.30														
Soft light grey becoming firm red-brown sandy SILT. (Reworked DROITWICH HALITE MEMBER).			1.10	4.90		5.00	S11	27										(4.7.7.7.6.7.) PID @ 5.00m = 0 ppm
				6.00		6.00	D12											PID @ 6.00m = 0 ppm
		∇2nd																
Very weak red-brown silty MUDSTONE recovered as fine to medium grained sand sized lithorelicts. (DROITWICH HALITE MEMBER)			2.315	6.50		6.50	S13	29										(4.5.6.7.7.9.) PID @ 6.50m = 0 ppm Chiselled from 7.3 – 8.0m for ¾ hour
						8.00	S14	50 BLOWS FOR 245mm PENETRATION										(6.6.9.14.18.9 for 20 mm) PID @ 8.00m = 0 ppm
				8.315														
Borehole to be continued by rotary coring. Sealed with bentonite from 8.315 – 3.00m.																		

GROUNDWATER OBSERVATIONS:

1st water strike at 1.1m. Rose to 1.0m after 20 minutes. 2nd water strike at 6.5m. Rose to 2.2m after 20 minutes.

▼ - Final groundwater level
∇ - Groundwater first struck
▲ - Standpipe
● - Piezometer

W - Water Sample
D - Small Disturbed Sample
E - Environmental Sample Suite
U - Undisturbed Sample

M/C - Natural Moisture Content
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index

'N' - Standard or Cone Penetration Test Result
T - Undrained Triaxial
M - Multi-stage Undrained Triaxial

S - Standard Penetration Test
C - Cone Penetration Test
V - Vane Test
SO_3 - Soluble Sulphate Analysis

Appendix 5 – Geotechnical Rotary Borehole (RH) descriptions

GROUND INVESTIGATION SPECIALISTS LIMITED

CONTRACT: Droitwich Garage, Droitwich		**BOREHOLE No. 2**
CLIENT: Churchill Retirement Living Limited		**SHEET 1 OF 2**
ENGINEER: Armstrong Burton Structures Limited		**JOB No. 1085**
DATES DRILLED: 01/02.11.11	**RIG TYPE: Hans England HE-50**	**DRILLER: MT**
GROUND LEVEL:	**DRILLING METHOD: Rotary Open Hole Air Mist Flush**	**ANGLE: Vertical**

Drilling & Casing Progress	Core Recovery % T	S	R	STRATA DESCRIPTION	Legend	Depth (m)	O.D. Level (m)
				See cable percussion borehole log for details of strata encountered.		12.00	
12.00	3	0	0	Very weak red-brown and occasional light greenish grey silty MUDSTONE. (DROITWICH HALITE MEMBER) Includes bands of weak to medium strong dark red-brown MUDSTONE from 12.00 – 13.50m.			
	F.I. = N/A						
13.50	39	15	0	Becomes interbedded with bands of green-grey SILTSTONE and becomes marbled/streaked with white crystalline halite below 14.19m.			
	F.I. = 8/0.27m						
15.00	94	75	73	Fractures are sub-horizontal, clean and very close to closely spaced. Includes occasional thin (<0.02m thick) highly fractured zones from 13.00 - 14.35m. Becomes highly fractured from 14.35 – 15.32m.			
PW cased to 16m	F.I. = 4/0.56m						
16.50				Borehole continued …/		16.50	

REMARKS:

T = total core recovery
S = solid core recovery
R = rock quality designation

FIG NO.

GROUND INVESTIGATION SPECIALISTS LIMITED

CONTRACT: Droitwich Garage, Droitwich	**BOREHOLE No. 2**
CLIENT: Churchill Retirement Living Limited	**SHEET 2 OF 2**
	JOB No. 1085
DATES DRILLED: 1/2.11.11	**RIG TYPE: Hans England HE-50**
GROUND LEVEL:	**DRILLING METHOD: Rotary Open Hole Air Mist Flush**
	DRILLER: MT
	ANGLE: Vertical

Drilling & Casing Progress	Core Recovery % T	S	R	STRATA DESCRIPTION	Legend	Depth (m)	O.D. Level (m)
				Borehole continued …/			
16.50						16.50	
	98	58	44	Weak dark red-brown MUDSTONE. (DROITWICH HALITE FORMATION) Highly fractured 16.50 – 16.79m. Includes band of interbedded dark red-brown MUDSTONE and greenish grey SILTSTONE marbled with white crystalline halite from 16.79 – 17.30m.			
	F.I. = 6/0.33m						
17.50	35	23	20	Becomes very weak to weak below 17.50m. Moderately to highly fractured from 17.50 – 18.57m with much soft clay bind between lithorelicts.			
	F.I. = 4/0.12m			Includes band of soft red-brown very silty CLAY with some fine to medium angular lithorelicts from 18.74 to 18.90m. (pocket shear vane test at 18.80m = 18 kN/m^2).			
19.00	98	97	95	Becomes medium strong and interbedded with greenish-grey SILTSTONE and marbled with white crystalline halite below 18.90m. Includes sub-horizontal fractures with a little clay on surface at 19.52 and 20.00m.			
	F.I. = 3/1.00m			Less SILTSTONE below 19.64m. Includes less halite below 20.24m. Becomes moderately fractured from 20.37 – 20.40m.			
20.50	74	51	47	Becomes weak to medium strong with increasing halite marbling below 20.80m. Highly fractured 21.15 – 21.35m. Includes tea green flecks below 21.35m. Sub-horizontal fractures are very close to closely spaced and generally clean.			
	F.I. = 3/0.27m						
22.00	100	84	54	Includes occasional sub-horizontal 3-5mm thick former fractures infilled with white crystalline halite below 22.00m, often with refracture below halite containing a little soft clay or small highly fractured zone.			
	F.I. = 4/0.30m						
23.50	80	11	0	Becomes interbedded with irregular bands of tea-green SILTSTONE from 22.42 – 23.30m. Highly fractured 22.88 – 22.93m and 23.00 – 23.17m. Moderately to highly fractured 23.17 – 23.30m. Includes much halite marbling from 23.17 - 23.30m. Highly fractured 23.45 – 23.50m. Moderately fractured 23.80 – 23.89m and 23.95 – 24.14m. Includes much halite marbling below 24.20m.			
	F.I. = 5/0.23m						
						25.00	
25.00				Borehole Complete. Backfilled with bentonite/cement grout.			

REMARKS:

T = total core recovery
S = solid core recovery
R = rock quality designation

FIG NO.

GROUND INVESTIGATION SPECIALISTS LIMITED

CONTRACT: Droitwich Garage, Droitwich		**BOREHOLE No. 6**
CLIENT: Churchill Retirement Living Limited		**SHEET 1 OF 2**
ENGINEER: Armstrong Burton Structures Limited		**JOB No. 1085**
DATES DRILLED: 31.10.11	**RIG TYPE: Hans England HE-50**	**DRILLER: MT**
GROUND LEVEL:	**DRILLING METHOD: Rotary Open Hole Air Mist Flush**	**ANGLE: Vertical**

Drilling & Casing Progress	Core Recovery % T	S	R	STRATA DESCRIPTION	Legend	Depth (m)	O.D. Level (m)
P.W. casing installed GL-8.50m				See cable percussion log for details of strata encountered.			
8.50						8.50	
	47	8	0	Very weak to weak red-brown silty sandy MUDSTONE. (DROITWICH HALITE MEMBER) Includes clean vertical fracture from 8.81 – 8.93m. Includes band of compact friable SAND from 8.93-9.05m.		9.05	
	F.I. = 4/0.10m			Stiff very friable light greenish grey SILT with occasional fine to coarse angular lithorelicts. (completely weathered DROITWICH HALITE MEMBER)		10.00	
10.00				Weak highly fractured red-brown silty MUDSTONE. (DROITWICH HALITE MEMBER)		10.10	
	70	43	43	Stiff friable red-brown clayey SILT with some fine to medium angular lithorelicts and occasional thin tea-green bands. Horizontal fractures are clean and closely spaced. (DROITWICH HALITE MEMBER)		10.77	
	F.I. = 3/0.64m			Very weak red-brown and light grey silty MUDSTONE. (DROITWICH HALITE MEMBER) Highly fractured with a little soft clay in places from 10.77 - 14.03m.			
11.50	27	0	0	Becomes very weak to weak and dark red-brown below 11.50m.			
	F.I. = N/A						
13.00	52	13	0	Becomes very friable and weak and includes some green/ grey SILTSTONE bands below 13.00m.			
	F.I. = 6/0.30m			Becomes less fractured and includes some tea green flecks and sandy pockets below 14.03m. Fractures are very close to closely spaced and clean.			
14.50	15	0	0	Includes highly fractured zones at 14.07 – 14.08 and 14.37 - 14.50m. Recovered as dark red-brown and green-grey fine to coarse grained angular sand sized lithorelicts below 14.50m.			
	F.I. = N/A					16.00	
16.00				Borehole continued …/			

REMARKS:

T = total core recovery
S = solid core recovery
R = rock quality designation

FIG NO.

GROUND INVESTIGATION SPECIALISTS LIMITED

CONTRACT: Droitwich Garage, Droitwich	**BOREHOLE No. 6**
CLIENT: Churchill Retirement Living Limited	**SHEET 2 OF 2**
	JOB No. 1085
DATES DRILLED: 31.10.11	**RIG TYPE: Hans England HE-50**
GROUND LEVEL:	**DRILLING METHOD: Rotary Open Hole Air Mist Flush**
	DRILLER: MT
	ANGLE: Vertical

Drilling & Casing Progress	Core Recovery % T	S	R	STRATA DESCRIPTION	Legend	Depth (m)	O.D. Level (m)
16.00							
	0	0	0				
	F.I. = N/A						
17.50				Weak to occasionally medium strong dark red-brown and green-grey interbedded MUDSTONE and SILTSTONE. (DROITWICH HALITE MEMBER)			
	83	35	35	Highly fractured 17.50 – 17.77m. Recovered as fine to coarse grained sand sized lithorelicts in a silty matrix from 17.77 – 17.88m.			
	F.I. = 3/0.14m			Becomes more competent below 17.88m. Includes uneven rough undulating fracture at 60^0 to horizontal from 18.14 – 18.27m – clean – possibly drilling induced.			
19.00				Includes clean horizontal fractures at 18.14 and 18.27m. Becomes moderately to highly fractured with a little silt in places from 18.27 to 18.61m.			
	93	69	64	Includes small laterally inconsistent pockets of white crystalline halite below 18.61m. Includes clean curving striated fracture at 19.00 to 19.17m and clean sub-horizontal fracture at 19.20m.			
	F.I. = 3/0.20m			Becomes mostly red-brown MUDSTONE with thin streaks of white halite below 19.50m.			
20.50				Includes 2 old 2-3 mm diameter fractures infilled with white crystalline halite at approximately 31^0 to the horizontal at 19.91 – 20.00m and 20.14 – 20.20m. The lower fracture has been reactivated with a little wet clay below the halite infill. Becomes moderately fractured with less halite below 20.26m. Becomes highly fractured from 20.30 – 20.50m.		20.50	
				Borehole Complete.			
				Sealed with bentonite/cement grout from 20.50 – 4.00 m. Soil gas monitoring standpipe installed to 4.00m. Slotted screen 4.00 – 1.00m. Plan pipe above sealed with bentonite.			

REMARKS:

T = total core recovery
S = solid core recovery
R = rock quality designation

FIG NO.

Appendix 6 – Radiocarbon dating (Beta Analytic Ltd)

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Nick Daffern

Report Date: 11/16/2011

University of Worcester

Material Received: 11/8/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 309383	4060 +/- 40 BP	-25.1 o/oo	4060 +/- 40 BP

SAMPLE : P3767/BH2/6.20m
ANALYSIS : AMS-PRIORITY delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION : Cal BC 2850 to 2810 (Cal BP 4800 to 4760) AND Cal BC 2740 to 2720 (Cal BP 4690 to 4680)
Cal BC 2700 to 2480 (Cal BP 4640 to 4420)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.1:lab. mult=1)

Laboratory number: **Beta-309383**

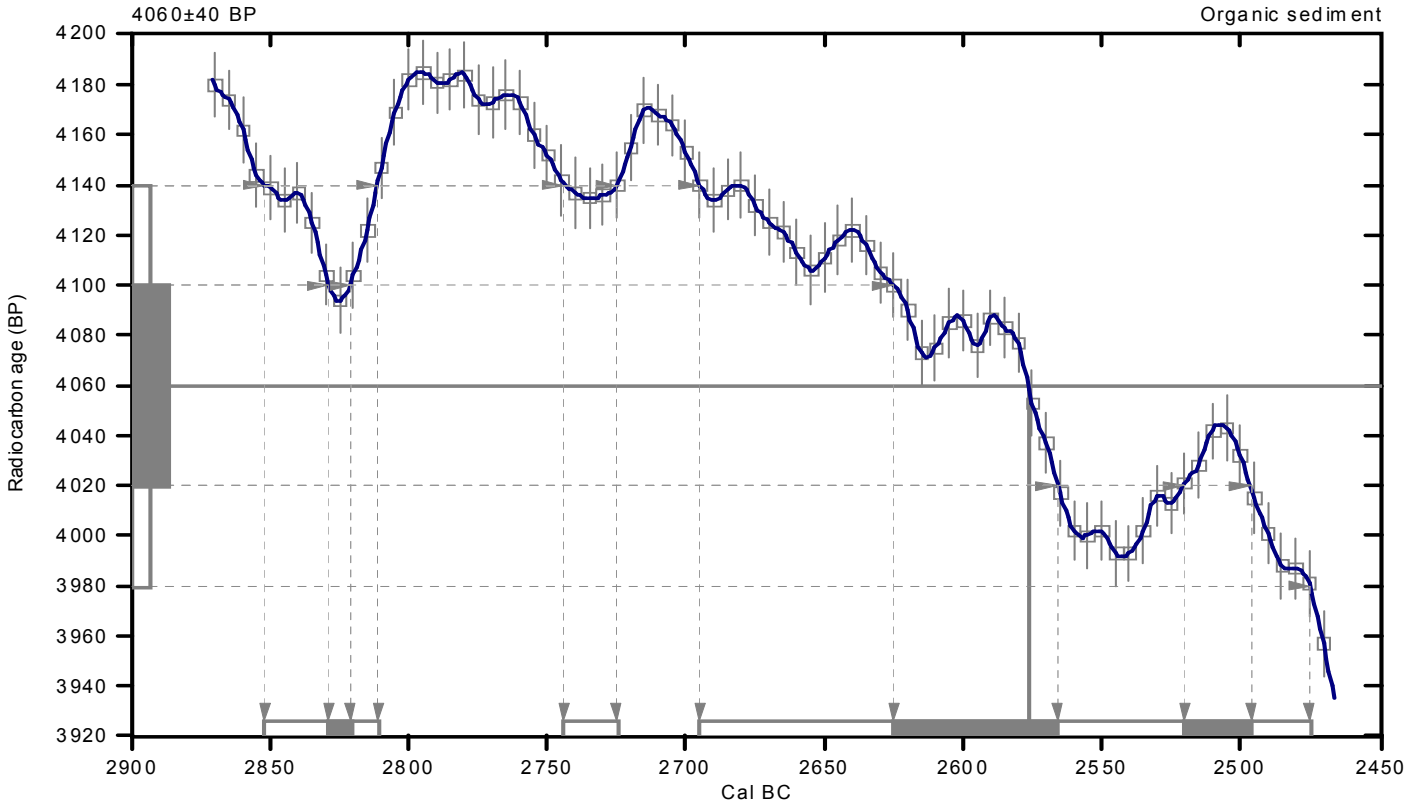
Conventional radiocarbon age: **4060±40 BP**

2 Sigma calibrated results: **Cal BC 2850 to 2810 (Cal BP 4800 to 4760) and**
(95% probability) **Cal BC 2740 to 2720 (Cal BP 4690 to 4680) and**
Cal BC 2700 to 2480 (Cal BP 4640 to 4420)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 2580 (Cal BP 4530)

1 Sigma calibrated results: Cal BC 2830 to 2820 (Cal BP 4780 to 4770) and
(68% probability) Cal BC 2620 to 2570 (Cal BP 4580 to 4520) and
Cal BC 2520 to 2500 (Cal BP 4470 to 4450)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

Appendix 7 - Pollen processing methodology (Tim Mighall, Department of Geography and Environment, University of Aberdeen)

ABSOLUTE POLLEN ANALYSIS: PREPARATION SCHEDULE

PRECAUTIONARY NOTES: All procedures, up to stage 25, should take place in the fume cupboard. Read precautionary notices on fume cupboard before starting. Ascertain whereabouts of First Aid equipment NOW. Please wear laboratory coat, gloves and goggles when dealing with all chemicals. Please organize fume cupboard carefully to maximize workspace. Use the containment trays provided. Always keep the fume cupboard door down as far as practically possible. Make sure the fume cupboard is switched on and functioning correctly.

A) SOLUTION OF HUMIC COMPOUNDS

1) Switch on hotplate to heat water bath. Prepare 12 to 16 samples concurrently.

HCl. is an irritant and can cause burns. Wear gloves. Wash with water if spilt on your skin.

Using a clean spatula, place a known volume or weight of sediment (c. $2cm^3$) and one spore tablet in each 50ml centrifuge tube. Add a few cm^3 of distilled water (enough to cover the pellet and tablets) and a few drops of 2M HCl. Wait until effervescence ceases, then half fill tubes with 10% KOH; place in a boiling water bath for 15 minutes. Stir to break up sediment with clean glass rod. Return HCl and KOH bottles to the chemical cabinet.

2) Centrifuge at 3,000 rpm for 5-6 minutes, ensuring first that tubes are filled to the same level. This applies throughout the schedule (Mark 7 on centrifuge).

3) Carefully decant, i.e. pour away liquid from tube, retaining residue. Do it in one smooth action.

4) Disturb pellet using vortex mixer; add distilled water, centrifuge and decant.

5) Using a little distilled water, wash residue through a fine (180 micron) sieve sitting in filter funnel over a beaker. NB Be especially careful in keeping sieves, beakers and all tubes in correct number order. Wash residue on sieve mesh into petri dish and label the lid. If beaker contains mineral material, stir contents, wait four seconds, then decant into clean beaker, leaving larger mineral particles behind. Repeat if necessary. Clean centrifuge tube and refill with contents of beaker.

6) Centrifuge the tubes and decant.

B) HYDROFLUORIC ACID DIGESTION

***(Only required** if mineral material clearly still present. Otherwise, go to stage 13)*

NB Hydrofluoric acid is extremely corrosive and toxic; it can cause serious harm on contact with eyes and skin. Rubber gloves and mask/ goggles MUST be worn up to and including stage 11. Please fill sink with H_20; have $CaCo_3$ gel tablets ready. Place pollen tube rack into tray filled with sodium bicarbonate.

7) Disturb pellet with vortex mixer. Add one cm^3 of 2M HCl.

8) With the fume cupboard sash lowered between face and sample tubes, very carefully one-third fill tubes with concentrated HF (40%). Place tubes in water bath and simmer for 20 minutes.

9) Remove tubes from water bath, centrifuge and decant down fume cupboard sink, flushing copiously with water.

10) Add $8cm^3$ 2H HCl to each tube. Place in water bath for 5 minutes. Do not boil HCl.

11) Remove tubes, centrifuge while still hot, and decant.

12) Disturb pellet, add distilled water, centrifuge and decant.

C) ACETYLATION

NB Acetic acid is highly corrosive and harmful on contact with skin. Wash with H_20 if spilt on skin.

13) Disturb pellet, add $10cm^3$ glacial acetic acid, and centrifuge. Decant into fume cupboard sink with

water running during and after.

14) Acetic Anhydride is anhydrous. Avoid contact with water. The acetylation mixture can cause severe burns if spilt on skin. Wash with water.

15) Make up 60cm^3 of acetylation mixture, just before it is required. Using a measuring cylinder; mix acetic anhydride and concentrated sulphuric acid in proportions 9:1 by volume. Measure out 54cm^3 acetic anhydride first, then add (dropwise) 6cm^3 concentrated H_2S0_4 carefully, stirring to prevent heat build—up. Stir again just before adding mixture to each tube.

Disturb pellet; then add 7cm^3 of the mixture to each sample.

16) Put in boiling water bath for 1-2 minutes. (Stirring is unnecessary—never leave glass rods in tubes as steam condenses on the rods and runs down into the mixture reacting violently). One minute is usually adequate; longer acetylation makes grains opaque. Switch off hot plate.

17) Centrifuge and decant all tubes into large (1,000ml) beaker of water in fume cupboard. Decant contents of beaker down fume cupboard sink.

18) Disturb pellet, add 10cm^3 glacial acetic acid, centrifuge and decant.

19) Disturb pellet, add distilled water and a few drops of 95% ethanol centrifuge and decant carefully.

D) DEHYDRATION, EXTRACTION AND MOUNTING IN SILICONE FLUID

20) Disturb pellet; add 10cm^3 95% ethanol, centrifuge and decant.

21) Disturb pellet; add 10cm^3 ethanol (Absolute alcohol), centrifuge and decant. Repeat.

22) Toluene is an irritant. Avoid fumes.

Disturb pellet; add about 8cm^3 toluene, centrifuge and decant carefully into 'WASTE TOLUENE' beaker in fume cupboard (leave beaker contents to evaporate overnight).

23) Disturb pellet; then using as little toluene as possible, pour into labelled specimen tube.

24) Add a few drops of silicone fluid - enough to cover sediment.

25) Leave in fume cupboard overnight, uncorked, with fan switched on. Write a note on the fume cupboard *'Leave fan on overnight - toluene evaporation',* and date it. Collect specimen tubes next morning and cork them. Turn off fan.

26) Using a cocktail stick, stir Contents and transfer one drop of material onto a clean glass slide and cover with a cover slip (22mm x 22mm). Label the slide.

27) Wash and clean everything you have used. Wipe down the fume cupboard worktop. Remove water bath from fume cupboard if not needed by the next user. Refill bottles and replace them in chemical cabinets.