ENVIRONMENTAL REMAINS FROM A BOREHOLE SURVEY AT THE W. PROSSER SCRAP YARD, CHEQUERS LANE, WORCESTER, WORCESTERSHIRE

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Contents

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Part 1 Project summary

An archaeological borehole survey was undertaken at the W. Prosser scrap yard, Chequers Lane, Worcester (NGR SO 841 549).

The investigation was undertaken on behalf of CgMs Consulting, and their client the University of Worcester as part of an agreed programme of mitigation works.

Two boreholes were sunk using a percussive auger rig to recover continuous/windowless cores with the aim of sampling alluvial and/or organic deposits that could be assessed for environmental remains and their potential for geoarchaeological analysis.

The geoarchaeological assessment encountered the weathered surface of the Sidmouth Mudstone Formation in the base of Borehole 2 and gravels of the Power House Member, a unit of probable Late Devensian date, in the bottom of Borehole 1. These were overlain by iron stained, structureless silts and clays which were probably formed within a seasonally inundated floodplain. These were in turn overlain by continuously waterlogged alluvial silts and clays containing lenticular organic mud beds which are likely to have formed within a channel or channel margin environment.

Three samples were selected from the channel/channel margin deposits for AMS radiocarbon dating to accompany the pollen analysis with a basal date of Cal BC 2300 to 2120 AND Cal BC 2090 to 2040 (Beta-286993) and Cal BC to 1650 (Beta-286991) at the top indicating that the sediment was accumulating during the early to mid-Bronze Age. At the base of the sequence, the pollen analysis indicated an herbaceous-rich floodplain environment with pockets of alder carr and a mixed lime-dominated woodland on the floodplain margins/terraces. As the sequence progresses, the Lime Decline is identified indicating clearance of the mixed deciduous woodland on the floodplain margins for agriculture. This clearance is accompanied by a decline in alder, a trend witnessed at several other sites within the Severn Valley, further indicating the deforestation of the landscape by humans.

An undated layer of iron smelting debris/slag with interbedded waterlogged organic layers sealed this alluvial unit. Due to similar morphology, stratigraphic position and elevation when compared to similar deposits identified at Newport Street and The Butts on the eastern bank of the river, this layer has been tentatively assigned a Roman date.

A significant quantity (approximately 2.00m) of post-medieval/modern activity was identified, including two *in situ* courses of brick and 19th-20th century artefacts, which truncated and buried the underlying alluvial deposits in both boreholes.

Part 2 Detailed report

1. Background

1.1 Reasons for the project

An archaeological borehole survey was undertaken at the W. Prosser scrap yard, Chequers Lane, Worcester (NGR SO 841 549; Fig 1) for CgMs Consulting and on behalf of their client the University of Worcester as part of an agreed programme of mitigation works

1.2 Project parameters

The project conforms to relevant sections of the *Standard and guidance for an archaeological watching brief* (IfA 2008), *Statement of standards and practices appropriate for archaeological fieldwork in Worcester* (WCC 1999) and the *Manual of Service practice: fieldwork recording manual* (CAS 1995).

In addition, the sampling and environmental analysis conforms to relevant sections of *Environmental Archaeology: a guide to the theory and practice of methods, from sampling and recovery to post-excavation* (English Heritage 2002) and *Environmental archaeology and archaeological evaluations* (AEA 1995).

The project also conforms to a project proposal (including detailed specification) which was produced (HEAS 2010).

1.3 Aims

The aims of this archaeological assessment were:

- to describe and assess the significance of the heritage asset with archaeological interest;
- to establish the nature, importance and extent of the archaeological site;
- to assess the impact of the proposed development on the archaeological site

In particular, the research priorities and aims as identified in "*An archaeological resource assessment and research framework for the city of Worcester*" (WCMAS 2007) should be considered. Within the scope of this project, they include the following, although this list is not exhaustive:

- The dating, character and origins of Severn alluviation (RP1.3)
- Location and characterisation of palaeochannels of the Severn (RP1.4)
- Investigation and mapping of Holocene terraces and alluvium (RP1.8)
- Investigation of Holocene flooding (RP1.9)
- Understanding of the hydrological system and identification of areas of potential and preservation (RP1.10)
- Environmental change in Worcester's hinterland (RP7.21)

In addition, priorities for research as identified within the West Midlands Research Framework (Hurst and Jackson 2002; White, 2002; Greig, 2007a)

- To identify, analyse and make available detailed reference pollen diagrams with long chronological sequences
- To identify and analyse environmental evidence from river valleys with suitable palaeochannel deposits and concentrations of prehistoric activity
- To study the history of river valley alluviation as this is strongly linked to human activity, especially woodland clearance.
- To study the regional and local environmental setting of settlement and ceremonial sites
- To integrate an understanding of the geo-environmental contexts of prehistoric economies and social life with interpretations of the material culture evidence.
- 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.

- 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 PPG16 environment.

2. Methods

2.1 Documentary search

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

Cartographic sources

- Young, G, 1779, Map of the City of Worcester
- Bentley 1840, map of the City of Worcester
- Ordnance Survey 1887, 1905, 1930, 1938 (extracts from) *Worcestershire* SO 85NE, 1:5000

2.2 Fieldwork methodology

2.2.1 Fieldwork strategy

A detailed specification has been prepared by the Service (HEAS 2010) and approved by James Dinn, planning archaeologist for Worcester City Council

The borehole survey was undertaken on 6 August 2010 with subsequent fieldwork to obtain OD heights occurring on 12 October 2010. The site reference number and site code is WCM 101827

Two boreholes were sunk which continued the north-east to south-west transect which was undertaken in the earlier work at the fruit and vegetable market (Daffern 2010). The boreholes were sunk using a Competitor mini-tracked percussive auger rig to recover continuous/windowless cores of *c*100-80mm 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.

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 Geoarchaeology methodology, by Keith Wilkinson

The cores were passed to ARCA on 24 August 2010 and were studied in the laboratory between 1 and 2 October 2010. The plastic sleeves containing the cores were slit open and the retained sediments cleaned to expose a fresh face, photographed and then described according to standard geological criteria (Tucker 1982, Jones *et al* 1999, Munsell Color 2000). The resultant lithological data were input into a database of the geological utilities program Rockworks v 2006 (RockWare 2008) and this used to generate the tabular data included in Appendix 1. Sub-samples were taken from cores of Borehole 2 for palynological assessment and radiocarbon dating, and were passed to WHEAS for examination.

2.4 Environmental archaeology methodology

2.4.1 Sampling policy

The environmental sampling strategy conformed to standard Service practice (CAS 1995; appendix 4). The sampling of material for radiocarbon dating and pollen analysis was undertaken by staff at ARCA during the geoarchaeological analysis.

2.4.2 Radiocarbon dating methodology

Three samples were submitted for Accelerated Mass Spectrometry (AMS) dating to Beta Analytic Inc.

Three samples were taken from 2.50 – 2.51m, 3.50 – 3.51m and 3.80 – 3.81m below ground surface (BGS) in Borehole 2 and were all taken from a grey alluvial silt stratum.

2.4.3 **Palynological remains**

Six pollen samples of 2cm^3 taken from Borehole 2 were selected for assessment, the exact depths of which are given within the results section below, these were selected based upon their position in the sequence to give an even spread whilst attempting to address questions of preservation raised in the geoarchaeological analysis.

The 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 2.

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 Kirk *et al* (2008) and Grant-Smith (2000).

2.5 The methods in retrospect

The methods adopted allow a high degree of confidence that the aims of the project have been achieved.

3. Topographical and archaeological context

No Scheduled Ancient Monuments, Registered Battlefields or Registered Parks or Gardens occur within the site boundaries.

The archaeological background of the site environs has been extensively discussed by Lockett and Jones (2001), Archaeological Solutions (2005) and Patrick (2010) during work undertaken on the fruit and vegetable market which lies immediately to the north-east and therefore no further background will be provided here. Also, as a full discussion regarding the topography and stratigraphy is given below by Wilkinson (Section 4.1.1), it will not be discussed here.

No previous archaeological investigation has occurred upon the site although the fruit and vegetable market has previously been subject to four phases of archaeological investigation, an evaluation (Lockett and Jones 2001), a watching brief (Vaughan 2008), a desk-based assessment (Archaeological Solutions 2005) and an archaeological borehole survey (Daffern 2010). The evaluation produced a residual Mesolithic flint scraper and a residual sherd of Roman Severn Valley ware pottery from alluvial deposits which underlay the modern and post-medieval deposits which cover the entirety of the site.

The geoarchaeological assessment associated with the borehole survey encountered gravels of a probable Late Devensian date in the bottom of all of the boreholes. These were overlain by undisturbed organic muds which are interpreted as being deposited in a seasonally inundated floodplain. Alluvial silts were also identified in the lower, undisturbed sections of the sequence, which were interpreted as being deposited within a channel or channel margin environment.

The radiocarbon dating of these channel/channel margin deposits produced an early Neolithic date (3640 to 3500 cal BC and 3440 to 3380 cal BC, Beta-281895). This compared favourably with the pollen analysis which indicated that pre-Lime Decline wildwood was still present upon the raised terraces, with the immediate floodplain environment being a combination of wet woodland such as alder and willow carr, interspersed with patches of wet grassland and "scrubby" ground.

Overlying this, a single, well preserved sherd of Roman Severn Valley ware with organic sediment from the same depth being radiocarbon dated to Cal AD 210 to 390 (Beta-281896). Undated cultural remains were identified included a possible midden deposit and a burnt clay surface which indicated the potential for *in situ* archaeological remains on the site.

All of the deposits encountered during the borehole survey were sealed by at least 1.5m of made ground with a maximum overburden depth of 3.76m.

In addition, a Palaeolithic hand axe has been recovered *c* 20m to the north-west of the site (WCM 100695) at the Hylton Road trading estate.

4. Results

4.1 Geoarchaeology, by Keith Wilkinson

There was an average 10% sediment loss/compression in each of the boreholes. Therefore the depths quoted in the text that follows are accurate to an estimated ±0.1-0.2m. Full lithological descriptions are appended as Appendix 1.

4.1.1 Stratigraphy

The Scrap Yard site lies 190m to the west of the River Severn and is mapped by the British Geological Survey as lying on Quaternary Alluvium accumulating on the Severn floodplain. 'Alluvium' technically includes all deposits accreting in fluvial environments, but in practice the British Geological Survey use the term as a surrogate for Holocene channel and floodplain deposits. Maddy (1999) ascribes alluvium of the River Severn floodplain to the Elmore Member of the Severn Valley Formation. The alluvium at the Scrap Yard site overlies sediments of the Sidmouth Mudstone Formation (in previous geological maps of Worcester the Sidmouth Mudstone Formation has been incorporated within the Triassic Mercia Mudstone Group), which deposits also occur as surface outcrops *c* 460m to the east and 80m to the west of the Scrap Yard site (ie the Severn has cut down through these sediments in the Late Pleistocene to carve out its present channel and floodplain). Sands and gravels of the Late Pleistocene Worcester Member (Severn Valley Formation) outcrop immediately to the west of Borehole 2.

Strata recovered in the borehole cores comprise the weathered surface of the Sidmouth Mudstone Formation, ?Pleistocene sands and gravels, Holocene alluvium (channel and floodplain deposits), possible archaeological deposits and recent made ground. In the text below the stratigraphy is reviewed in stratigraphic order while the lithological data are plotted graphically in Figure 5.

Sidmouth Mudstone Formation

Dark reddish brown cohesive and blocky clays with veins of green grey clay were found outcropping in Borehole 2 below 11.3m OD. These strata are almost certainly the weathered surface of the Sidmouth Mudstone Formation. The presence of such deposits beneath alluvium and without a capping of sand and gravel strata suggest that there is a gap in the western part of the Scrap Yard site between the outcrop of the floodplain terrace (eg as evidenced in Borehole 1) and the older Worcester Member to the west (*contra* British Geological Survey data).

?Pleistocene gravels

Matrix-supported gravels of rounded and sub-rounded quartzite and sandstone clasts contained within a silt and clay matrix were found below 11.4m OD in Borehole 1. This elevation for the alluvium/gravel contact is similar to that recorded in Hylton Road (P3516) Borehole 1 which is in turn lower than the contact in other boreholes from that site (Wilkinson 2010). A palaeochannel has been postulated in the westerly margin of the Hylton Road site, a feature that seems to continue into the Scrap Yard site. The gravel strata encountered in both the Scrap Yard and Hylton Road boreholes is likely to form part of the Power House Member, a unit that was deposited in the Devensian Late Glacial (Maddy 1999).

Holocene fine-grained alluvium

Alluvial silts and clays (Elmore Member) were found conformably overlying the gravels in Borehole 1 at 11.4m OD and overlying weathered Sidmouth Mudstone Formation clays with an undetermined contact at 11.8m OD in Borehole 2. The former conformable contact is likely to be the result of the silts and clays forming the interstitial fill of the uppermost gravel strata. As previously noted at Hylton Road the basal fine-grained alluvial strata comprise heavily iron stained and structureless silts and clays. The iron stains are the result of redox processes, ie fluctuations in the height of the water table, and are therefore post-depositional. The iron stained silts and clays are conformably overlain by grey brown alluvial silts and clays that lack iron stains, but which instead contain occasional fine lenticular organic mud beds demonstrating continuous waterlogging since deposition. As previously noted at Hylton Road these data suggest the redox processes witnessed by the iron staining of lower fine-grained beds must have operated prior to the deposition of the grey brown alluvial silts and clays. Therefore it would seem likely that the iron-stained silts and clays were deposited on a seasonally inundated floodplain (Wilkinson 2010). The grey brown silts and clays on the other hand are likely to have formed within a channel or in a channel marginal environment given the lack of iron stains and the preservation of bedding structures. Presently available evidence from Hylton Road suggests that these alluvial strata date between the Neolithic and Roman periods (N Daffern pers comm).

?Archaeological deposits

Probable archaeological deposits were found conformably overlying the fine-grained alluvium at 13.2-13.6m OD in Borehole 2, but were lacking from Borehole 1. Unlike Hylton Road where midden-like deposits were found in a similar stratigraphic position, but at lower elevations (Wilkinson 2010), the Scrap Yard archaeological strata comprise iron smelting debris (slag) with interbedded waterlogged organic layers. This smelting debris appears similar in morphology, stratigraphic position and elevation to those previously encountered on the eastern bank of the Severn at Newport Street (Wilkinson 2006a) and The Butts (Wilkinson 2006b). It is possible that the slag layer and organic archaeological strata in Scrap Yard Borehole 2 are lateral equivalents of the Romano-British occupation strata noted at Hylton Road (Wilkinson 2010).

Made ground

Deposits resulting from post-medieval use of the Scrap Yard site are found in the top of both boreholes. The made ground comprises fragmented bricks, cinders, hard core and diamict in which these constructional materials are mixed with silts and clays derived from imported soils. Two *in situ* courses of bricks from a former wall were encountered 0.15m below the ground surface in Borehole 2. Artefacts noted within the made ground (see Appendix 1 for details) suggests deposition in the 19-20th centuries.

4.1.2 Assessment

The weathered Sidmouth Mudstone Formation noted at the base of Borehole 2 dates from the Triassic period, long before the evolution of the Hominidae family. These deposits therefore have NO archaeological or palaeoenvironmental potential.

The gravels noted at the base of Borehole 1 are likely to have formed in a braided river environment in the Devensian Late Glacial period. Although people were present in England for much of the Late Glacial, they are unlikely to have frequented such a high energy fluvial environment. No organic preservation was noted in the gravels. For these reasons the gravels are assessed as having LOW archaeological and palaeoenvironmental potentials.

The fine-grained alluvium of the Elmore Member probably accumulated initially in a floodplain and then a channel or channel marginal environment. The only cultural material present in these deposits were charcoal fragments which represent secondary depositions relating to activity at an unknown location along the river bank. The fine-grained alluvium thus has a LOW archaeological potential. The oxidised silts and clays at the base of the fine-grained sequence are unlikely to contain well preserved waterlogged plant macrofossils (none were visible as the cores were being studied). However, the channel/channel marginal deposits that overlie the oxidised sediment do contain waterlogged plant remains and the potential for providing useful palaeoenvironmental and palaeoeconomic data is likely to be high. Collectively the fine-grained alluvium is therefore assessed as having MODERATE to HIGH palaeoenvironmental potential.

The probable archaeological deposits noted in Borehole 2 represent industrial activity – possibly of Roman date. It is unclear where the metalwork detritus noted in Borehole 2 originated, but there is good evidence from Worcester to suggest that slag was moved considerable distances from the primary iron production sites. The metalworking deposits are classified as having a HIGH archaeological potential, not least because organic preservation within these same deposits also appears good. The ?archaeological deposits are also classified as having a HIGH palaeoenvironmental potential.

The made ground is likely to have accumulated mostly within the last 200 years and is better assessed by conventional archaeological works rather than in boreholes. It has a LOW palaeoenvironmental potential.

4.2 Radiocarbon dating

4.2.1 Results

Three samples were submitted to Beta Analytic Inc for Accelerator Mass Spectrometry (AMS) radiocarbon dating. The results of which are contained in Table 1. The full radiocarbon report is appended as Appendix 3.

The samples were taken from within the fine-grained alluvium which was sealed by the slag layer and are therefore likely to be undisturbed, *in situ* deposits.

The lower two samples (3.50-3.51m and 3.80-3.81m) were both sufficiently organic to produce both an organic sediment fraction and a plant macrofossil (3.50-3.51m) or wood fraction (3.80-3.81m). Unfortunately, due to budgetary limitations, both fractions could not be dated and therefore the plant macrofossil and wood fractions were selected for dating as they are more likely to represent a more unique event and therefore provide a "tighter" date (R Hatfield, Beta Analytic pers comm, 5 November 2010).

Borehole number and depth	Material	Laboratory code	Measured Age	13C/12C	Conventional Age	OxCal calibrated age (95.4% probability or 2 sigma)
Borehole 2: 2.50 – 2.51m	Organic Sediment	Beta -286991	3470 ± 40 BP	-26.7 o/oo	3440 ± 40 BP	Cal BC 1880 to 1650 (Cal BP 3830 to 3600)
Borehole 2: 3.50 – 3.51m	Plant macrofossil fraction	Beta -286992	1740 ± 40 BP	-26.5 o/oo	1720 ± 40 BP	Cal AD 230 to 410 (Cal BP 1720 to 1540)
Borehole 2: 3.80 – 3.81m	Wood fraction	Beta-286993	3820 ± 40 BP	-28.2 o/oo	3770 ± 40 BP	Cal BC 2300 to 2120 (Cal BP 4250 to 4070) AND Cal BC 2090 to 2040 (Cal BP 4040 to 3990)

Table 1 Radiocarbon dating results

4.2.2 Discussion

The results of the radiocarbon dating provided an early-Bronze Age date (Cal BC 2300 to 2120 AND Cal BC 2090 to 2040; Beta-286993) for the base of the channel/channel margin and an early to middle-Bronze Age date (Cal BC 1880 to 1650; Beta-286991) for the top of the deposits. Unfortunately, a Roman date (Cal AD 230 to 410; Beta-286992) was obtained from 3.50-3.51m BGS.

This divergent date is obviously problematic and explanation of its presence at this time must be based upon hypothesis. The geoarchaeological assessment did not identify signs of disturbance indicating that later truncation has not occurred leaving two remaining explanations.

The first is that the material is an in-situ Roman deposit and the overlying Bronze Age dated material (Beta-286991) represents reworked material although the author believes this explanation is unlikely given that the basal early-Bronze age date (Beta-286993) comes from the same deposit as the Roman radiocarbon date (Beta-286992) and as there is no break in the deposit it would suggest a continuously deposited sequence which would require unfeasibly low sedimentation rates (0.013cm sediment per year or 1cm of sediment deposited every 76 years).

The second and more likely explanation is that the material selected from 3.50-3.51m BGS is Roman contamination, possibly from the metalworking waste layer, that was disturbed and inadvertently entered the sequence during the sinking of Borehole 2 and that the main channel/channel margin sequence is of early to middle-Bronze Age date.

4.3 Pollen analysis

The palynological evidence recovered is summarised in Table 2 and Figure 6.

2.48 – 2.49m

Pollen preservation and concentrations in this sample were moderate to good with the complete assessment count being achieved.

Herbaceous species dominated the sample contributing 88% TLP with Poaceae indet (indeterminate grasses) being the dominant contributor (38% TLP) although *Solidago virgaurea*-type (daisies/goldenrods) pollen was also frequently identified (15% TLP). Herbaceous species diversity from this sample was high with frequent identifications of species whose contribution was less than 5% TLP, these included *Achillea*-type (yarrows/chamomiles), Apiaceae (carrot family), *Cichorium intybus*-type (chicory/dandelion), Cyperaceae undiff (sedges), *Littorella uniflora* (shoreweed), *Ranunculus acris*-type (meadow buttercup), *Plantago lanceolata* (ribwort plantain), *Primula veris*-type (cowslip/primrose), *Rumex acetosa* (common sorrel), *Saxifraga granulata*-type (meadow saxifrage), *Valeriana dioica* (marsh valerian) and *Valeriana officinalis* (common valerian) amongst others.

Of note were the presence of *Cerealia* indet (indeterminate cereal) and *Avena/Triticum*-type (oat/wheat) pollen.

Heaths from this sample (and from the sequence as a whole) were represented by a solitary grain of Calluna vulgaris (heather) pollen.

Trees and shrubs represented 11% TLP with none contributing greater than 3 % TLP. Species identified were *Alnus glutinosa* (alder), *Betula* (birch), *Corylus avellana*-type (hazel/bog-myrtle), *Ilex aquifolium* (holly), *Pinus sylvestris* (Scot's pine), *Quercus* (oak), *Salix* (willow) and *Ulmus* (elm).

No aquatic species were identified from this sample although spores of *Polypodium* (polypody), *Pteridium aquilinum* (bracken) and *Pteropsida* (mono) indet (ferns) were present.

2.68 – 2.69m

Pollen preservation was once again moderate to good although concentrations were lower within this sample than the previous. Despite this, a complete 150 TLP grain count was completed.

Once again, herbaceous species dominated the sample (81% TLP) with Poaceae indet again the main contributor (39% TLP) with *Solidago virgaurea*-type (9% TLP), Lactuceae undiff (chicory/dandelion/sow-thistle) (8% TLP) and Cyperaceae undiff (7% TLP) also making significant contributions although, overall, diversity of herbaceous species was lower within this sample than the previous. Lesser contributions of herbaceous pollen were also made by *Daphne* sp (spurge-laurel/mezereons), *Arctium*-type (burdocks/saw-worts), Saxifragaceae (saxifrage family) and *Urtica dioica* (stinging nettle) although these contributions were at ≤4% TLP.

Tree and shrub pollen was once again in the minority of species identified (19% TLP) with greater contributions by *Alnus glutinosa* and *Salix* than in the previous sample (7% TLP) although it should be noted that the majority of the *Salix* grains were clumped together possibly indicating that a part of the parent material i.e. a catkin, had entered the deposit and thereby increasing its relative contribution. Grains of *Corylus avellana*-type, *Pinus sylvestris* and *Quercus* were once again present.

Aquatic species identified within this sample included Lemnaceae (duckweed family), *Nymphaea alba* (white water-lily) and *Potamogeton natans*-type (broad-leaved pondweed) with the spores of *Polypodium*, *Pteridium aquilinum* and *Pteropsida* (mono) indet once again being identified.

3.48 – 3.49m

Preservation and concentrations of pollen within this sample were excellent allowing the assessment count to be achieved with ease.

77% TLP of pollen grains identified within this sample were of herbaceous species with 44% TLP of this figure being Poaceae indet. Remaining species identified included *Cichorium intybus*-type, Cyperaceae undiff, *Filipendula* (meadowsweet), Lactuceae undiff, *Plantago lanceolata*, *Ranunculus acris*-type, *Rumex acetosa*, *Rumex acetosella* (sheep's sorrel), *Sagina* sp (pearlworts), *Silene dioica*-type (red campion) and *Urtica dioica* although they were in lesser quantities with none contributing greater than 6% TLP. In addition, grains of *Cerealia* indet and *Avena/Triticum*-type (oat/wheat) were once again identified.

Tree and shrub species was in slightly higher quantities than the previous two samples contributing 23% TLP) with the majority of this being grains of *Alnus glutinosa* (9% TLP) although grains of *Betula*, *Corylus avellana*-type, *Fraxinus excelsior* (ash), *Pinus sylvestris*, *Quercus*, *Salix* and *Tilia cordata* (small-leaved lime).

The sole aquatic from this sample was Nuphar sp (yellow water-lily) whilst spores of *Polypodium*, *Pteridium aquilinum* and *Pteropsida* (mono) indet were once again present.

3.68 – 3.69m

Preservation and concentrations of pollen within this sample were once again excellent and therefore the 150 TLP grain count was once again completed.

In this sample, herbaceous species were in lower quantities than those previously assessed contributing 36% TLP with grains of Poaceae indet (17% TLP) being the most frequently identified. Grains of *Urtica dioica*, Cyperaceae undiff, *Cichorium intybus*-type, *Solidago virgaurea*-type, *Filipendula* and *Pinguicula* sp (butterworts) were also identified.

The pollen of tree and shrub species increased greatly in this sample and contributed 64% TLP. *Alnus glutinosa* was the dominant contributor (17% TLP) although *Tilia cordata* (13% TLP) and *Corylus avellana*-type (8% TLP) also made significant contributions. Additional species identified were *Betula*, *Quercus*, *Salix* and *Ulmus*.

Sparganium erectum (branched bur-reed) was the sole aquatic identified whilst *Polypodium* was the solitary spore producing species identified.

3.92 – 3.93m

Polliniferous material was virtually absent from this sample with solitary grains of Poaceae indet, *Polypodium*, *Pteridium aquilinum* and *Pteropsida* (mono) indet being identified from the scanning of two slides.

4.50 – 4.51m

Similarly to the previous sample, preservation and concentration of remains within this sample was extremely poor with only three pollen grains, Poaceae indet, Lactuceae undiff and *Urtica dioica,* and the spores of *Polypodium* and *Pteropsida* (mono) indet, being identified.

Parasite ova and Fungal Spores

The fungal spores of *Chaetomium* sp and *Cladosporium* sp were infrequently identified from the upper four samples (2.48 – 3.69m). Both genera are ubiquitous within the atmosphere and soils although both are commonly found on plant debris with *Cladosporium* sp particularly prevalent upon dead herbaceous and woody plants.

No parasite ova were identified during the assessment and, given the date and nature of the deposits i.e. alluvial sediments, this was unsurprising.

Latin Name	Family	Common Name(s)	2.48-2.49m (BH2)	2.68-2.69m (BH2)	3.48-3.49m (BH2)	3.68-3.69m (BH2)	3.92-3.93m (BH2)	4.50-4.51m (BH2)
Alnus glutinosa	Betulaceae	alder	5	10	16	61		
Betula	Betulaceae	birch	2		3	3		
Fraxinus excelsior	Oleaceae	ash			1			
Pinus sylvestris	Pinaceae	Scot's pine	2	2	2			
Quercus	Fagaceae	oak	2	2	5	4		
Tilia cordata	Malvaceae	small-leaved lime			3	22		
Ulmus	Ulmaceae	elm	1			1		
Corylus avellana-type	Betulaceae	hazel	2	4	7	13		
Ilex aquifolium	Aquifoliaceae	holly	1					
Salix	Salicaceae	willow	2	11	4	1		
Calluna vulgaris	Ericaceae	heather	1					
Poaceae undiff	Poaceae	grass	60	60	79	27	1	1
Cerealia indet	Poaceae	indeterminate cereal	2		4			
Avena/ Triticum-type	Poaceae	oat/wheat	1		1			
Achillea-type	Asteraceae	yarrows/ chamomiles	1					
Apiaceae	Apiaceae	carrot family	4	1				
Arctium-type	Asteraceae	burdocks/ saw-worts	1	1				
Caryophyllaceae	Caryophyllaceae	pink family	1		2	1		
Chenopodioideae	Amaranthaceae	goosefoot subfamily	3	1				
Cichorium intybus-type	Lactuceae	chicory/dandelion	7	4	10	5		
Cirsium-type	Asteraceae	thistles	2	1	1			
Cyperaceae undiff	Cyperaceae	sedge	6	11	3	5		
Daphne	Thymelaeaceae	spurge-laurel/ mezereons		1				
Filipendula	Rosaceae	meadowsweet	1	1	4	2		
Lactuceae undiff	Asteraceae	chicory/dandelion/sow-thistle	3	12	5	2		1
Littorella uniflora	Plantaginaceae	shoreweed	1					
Pinguicula sp	Lentibulariaceae	butterworts				1		
Plantago lanceolata	Plantaginaceae	ribwort plantain	3	2	5			
Primula veris-type	Primulaceae	cowslip/ primrose	2					
Ranunculus acris-type	Ranunculaceae	meadow buttercup	4	2	5	1		
Rosaceae	Rosaceae	Rose family	1	1	2	1		
Rumex acetosa	Polygonaceae	common sorrel	3		4			
Rumex acetosella	Polygonaceae	sheep's sorrel	1		3	1		
Sagina sp	Caryophyllaceae	pearlworts			1			
Saxifraga granulata-type	Saxifragaceae	meadow saxifrage	1					
Saxifragaceae	Saxifragaceae	saxifrage family	2	5	2	1		
Silene dioica-type	Caryophyllaceae	red campion			1			
Solidago virgaurea-type	Asteraceae	daisies/ goldenrods	24	14	1	3		
Urtica dioica	Urticaceae	stinging nettle		6	5	7		1
cf *Urtica urens*	Urticaceae	small nettle			1			
Valeriana dioica	Valerianaceae	marsh valerian	3			1		

Valeriana officianilis	Valerianaceae	common valerian	2					
		TLP Grains counted	**157**	**152**	**180**	**163**	**1**	**3**
Lemnaceae	Lemnaceae	Duckweed family		2				
Nuphar sp	Nymphaeaceae	yellow water-lily			1			
Nymhaea alba	Nymphaeaceae	white water-lily		1				
Potamogeton natans-type	Potamogetonaceae	broad-leaved pondweed		1				
Sparganium erectum	Typhaceae	branched bur-reed				1		
Polypodium	Polypodiaceae	polypody	3	7	4	1	1	1
Pteridium aquilinum	Dennstaedtiaceae	bracken	3	5	3		1	
Pteropsida (mono) indet		ferns	1	8	4		1	3

Table 2 Results of pollen analysis

5. Synthesis

5.1 Late Pleistocene

The solitary deposit associated with this period are the matrix- and clast-supported gravels of the Power House Member deposited in the Devensian Late Glacial (Maddy 1999) encountered at the base of Borehole 1. Due to the date of the deposits, either the last Glacial Maximum (25,000 – 16,000 BP) or the Younger Dryas/ Loch Lomond stadial (11,000-10,000 BP), it is unlikely that these deposits will produce evidence of human activity as it is during these periods that much of Britain was abandoned due to the cold climate with occupation being focused in the south of the country and even if human occupation was occurring within this region, occupation of high energy fluvial environments such as that indicated within the geoarchaeological assessment is unlikely.

The only evidence for the Late Upper Palaeolithic from the West Midlands comes from King Arthur's Cave, Herefordshire from which Creswellian Points (*c* 12,500 and 12,000 BP) were recovered (Myers 2007, 25) and due to the active nature of glacial fluvial systems it is unlikely that any *in situ* archaeological material of this period would be encountered.

5.2 Bronze Age

The lower margins of the channel/channel marginal silts were dated to the early-Bronze Age (Cal BC 2300 to 2120 AND Cal BC 2090 to 2040; Beta-286993) although there was approximately a further 0.30m of silt underlying this deposit suggesting that accumulation of the deposit may have began in the late Neolithic.

Pollen evidence supports the early-Bronze Age date of this feature as the lowest productive pollen sample (3.68-3.69m) contained high quantities of lime pollen (13% TLP) indicating a pre-lime decline environment, the same percentage as identified by Brown (1988) at Wilden Marsh. This figure also compares favourably with the pollen analysis previously undertaken at the Fruit and Vegetable Market (Daffern 2010) which, although being early Neolithic in date, contained a similar figure (16% TLP) indicating that there is continuity of lime woodland flanking the Severn Valley throughout the Neolithic and into the Bronze Age supporting the work of Brown (1982, 1988) at Ashmoor Common, Callow End, Ripple Brook and Wilden Marsh, Worcestershire, Greig (unpublished) at Cookley and Head and Daffern (forthcoming) from Clifton which show that lime was a considerable, if not dominating component of the wildwood in the Neolithic.

Interestingly, a feature of the sequence retrieved from the present site that was absent from the work undertaken at the Fruit and Vegetable market is the presence of the lime decline itself within the pollen diagram (Figure 6). This anthropogenic decline is diachronous throughout Britain (Turner 1962) and is thought to have occurred due to the clearance of fertile soils, the preferable habitat of limes, for agriculture. This is somewhat supported by the limited presence of unidentifiable cereal and *Triticum*-type pollen during the analysis.

Despite its occurrence being variable throughout Britain, within the West Midlands it consistently occurs in the late-Neolithic or early-Bronze Age, eg *c* 2000-2250 cal BC at Wellington, Herefordshire (Greig 2007b) and Clifton, Worcestershire (Head and Daffern forthcoming) and *c* 2300-2850 cal BC at Cookley, Worcestershire (Greig forthcoming), a trend which is exhibited in the sequence from the present site where it occurs *c* 2000 cal BC although further dating would be required to refine this figure.

A similar decline event that has been identified within the sequences from the present site and others within the Severn Valley of Worcestershire and Gloucestershire is that of alder. Brown (1988, 432) states that this decline has been identified at Wilden Marsh, Ashmoor Common, Longney, Callow End and Ripple Brook and attributes the clearance to deforestation by man although the alder decline within the Scrap Yard sequence appears to occur earlier (3770-3440 BP) than that previously witnessed (3100 – 2500 BP) so the decline in the current sequence may represent an earlier fluctuation within alder levels which is related to fluvial or climatic variations although human disturbance is not ruled out.

The presence of both of these anthropogenic clearances helps to indicate that the Roman date (Cal AD 230 to 410; Beta-286992) retrieved from 3.50-3.51m BGS in Borehole 2 is erroneous and likely to originate through contamination as both of these events are associated with the late-Neolithic or Bronze Age within the Severn Valley and the wider West Midlands.

The upper radiocarbon sample taken from Borehole 2 (2.50-2.51m BGS) produced a later early-Bronze Age date (Cal BC 1880 to 1650; Beta-286991). The geoarchaeological analysis of this deposit indicates that this deposit was formed within a channel or channel marginal environment and is *in situ* due to the presence of bedding structures.

The pollen analysis indicated that an open, post-Lime Decline landscape has formed with much of the terrace and higher ground deciduous woodland having been cleared, probably as a result of agriculture as indicated by the limited presence of cereal pollen. The floodplain environment consisted of herbaceous-rich grassland with limited stands of willow and alder carr.

The presence of these deposits shows that the sequence is long lived with the environs being fluvially active until at the middle Bronze Age before a shift within the depositional regime occurs with the halting of sedimentation.

This change can most likely be attributed to the migration of the active channel away from the scrap yard site towards the present course of the Severn and this in turn can be linked to the climatic deterioration that is witnessed in many locations throughout Britain from the middle Bronze Age onwards (Knight and Howard 2004; Macklin *et al* 2005; Brown 2008). This deterioration resulted in the climate becoming cooler and wetter and as a result river discharge would have increased causing greater channel mobility and incision.

5.3 Roman

Despite no artefactual remains being retrieved during the assessment, the iron smelting/slag deposit identified within Borehole 2 has been preliminarily assigned a Roman date due to the similarity as regards morphology and stratigraphic position with similar deposits identified at Newport St and The Butts during previous geoarchaeological investigations (Wilkinson 2006a, 2006b). This deposit, if it is Roman in date, is of interest as no evidence for large scale Roman smelting or iron working has been identified on the western bank of the River Severn within the city (H Dalwood pers comm) and this therefore raises the question of where did the slag originate and what purpose did it serve?

Unfortunately, due to the nature of the investigation, comments regarding the full extent of this deposit cannot be made although due to the thickness of this debris (0.27m depth) and its similarity to previously identified layers, it would appear that this may be a substantial deposit whose function may have been to raise the ground level and provide a consolidated ground surface to allow access to the river.

It may be hypothesised that, due to the lack of evidence for metalworking on western bank the river, the debris was transported across from the eastern bank although if the deposit is similar in scale to those identified at Newport St and The Butts, this would appear quite a substantial undertaking whose effort may outweigh the rewards especially given that the excavations at St John's (Wainwright 2010) appear to indicate that the western bank was more rural/agricultural rather than industrial in character.

One speculative hypothesis for this is that there could be a river crossing of Roman date within this area. This has previously been hypothesised through the projection of the known road layout from the eastern bank towards the River Severn as identified at The Butts (Burrows and Cutler 2004, S Sworn pers comm), and therefore the deposition of the slag layer might relate to such a crossing although without a larger area being exposed, this must remain a tentative theory.

An alternative explanation may be that the upper, thickest slag layer represents a metalled road surface similar to that identified at Newport Street. The sequence is very similar to that identified within Borehole 2 with Davenport (forthcoming) describing it thus "The site occupied the flood plain of the Severn and was subject to periodic inundation leading to the deposition of alluvial clays. These were already a cleared agricultural/pastoral landscape by the late Bronze Age or Early Iron Age."

"Alluviation continued into the Roman period and massive amounts of iron working slag were thrown on to the flood plain. Thin lenses of alluvial clay were interleaved with these slag deposits and finally a road was laid across the deposits made largely of slag. The interleaved layers are quite mixed, with charcoal and small pieces of slag, indicating, as does the interleaving, that the alluvial clays were collecting other materials of anthropogenic origin before deposition."

5.4 Post-medieval/modern

Material of post-medieval/modern origin was encountered in both boreholes with overburden/made ground being identified to a depth of 2.17m BGS in Borehole 1 and 2.00m BGS in Borehole 2.

There is also the possibility of truncation due to the extraction of clay associated with the brick yards as shown on Young's 1779 map, although the exact location of these is difficult to pinpoint.

Much of the made ground/overburden will be due to the requirement to stabilize prior to construction and raise the ground above standing water level as the 1849 Board of Health Inquiry report describes the site environs as "... partially inhabited lands in St Clement's beyond the river, are also low, marshy and entirely undrained. ... The lowest part of St Clement's is not the river bank, but a sort of valley parallel to the river, and 200 yards from it" (J Dinn pers comm). This statement would tend to suggest that the relict channels were still identifiable within the topography and would have "reactivated" during flood events. This statement is supported by the first and second edition OS map (Figures 3 and 4) which show that land to the rear of Chequers Lane was still liable to flooding after the development of the Hylton Road frontage.

An additional point of interest is the presence of two *in situ* courses of brick from a former wall 0.15m BGS in Borehole 2. No buildings are shown on the 1st or 2nd edition OS maps (Figures 3 and 4) so these bricks most likely represent a section of the boundary wall which is shown entering the site area from the north-east on the 1st or 2nd edition OS maps.

5.5 Undated deposits

The fine grained alluvium of the Elmore Member and the basal fine-grained alluvial strata comprising of heavily iron stained and structureless silts and clays both remain undated but both have been considered as having low archaeological potential.

6. Significance

The *Archaeological resource assessment and research framework for the city of Worcester* (WCMAS 2007, 17) states that "To date, then, there is little (probably no) stratified evidence for earlier prehistoric activity in Worcester" and therefore the identification of early Bronze Age channel/channel margin deposits is of great significance, especially in light of the Neolithic deposits from the earlier works at the Fruit and Vegetable Market as it would appear that this area can provide a cross-section of the early – middle Holocene development of the River Severn which has high potential as regards palaeoenvironmental and geoarchaeological remains.

This deposit has greatly assisted and has further potential in addressing certain aims as outlined in the resource assessment (*ibid*.)

- The dating, character and origins of Severn alluviation (RP1.3)
- Location and characterisation of palaeochannels of the Severn (RP1.4)
- Investigation and mapping of Holocene terraces and alluvium (RP1.8)
- Investigation of Holocene flooding (RP1.9)
- Understanding of the hydrological system and identification of areas of potential and preservation (RP1.10)
- Identification of stratified Neolithic – early Bronze Age remains in the city centre (RP2.3)
- Environmental change in Worcester’s hinterland (RP7.21)

Of additional importance is the presence of the iron slag layer layer though to be of Roman date which is comparable to those previously identified on the eastern bank of the River Severn. The function of this slag layer is unclear, especially given its location on the western bank away from the "normal" area of substantial Roman industrial activity and therefore understanding the reasoning behind its deposition should be a matter of considerable importance, especially if the hypothesis of the slag layer representing a metalled surface of a road or riverside access.

It would appear from the limited intrusive works that have occurred during the current works that this dumped material has the potential to be extensive and therefore may contribute to additional aims as outlined in the resource assessment (*ibid*)

- Roman road network (RP3.7)
- Dumping of Roman iron slag (RP3.8)

- Potential Roman bridge (RP3.9)
- Origins of the Roman iron industry (RP3.19)
- Roman iron industry – production sites (RP3.20)
- Roman iron industry – raw materials including fuel (RP3.21)

7. Conclusions

The assessment identified deposits of archaeological, geoarchaeological and palaeoenvironmental significance although these were sealed by extensive quantities (at least 2.0m) of modern overburden.

The fine grained alluvium, in particular the channel fill/ margin silts, has been assigned a HIGH potential for further palaeoenvironmental and geoarchaeological analysis based upon the good preservation of palynological remains. The early Bronze Age pollen sequence retrieved from the channel/ channel margin deposits has the potential to improve and refine the dating and our understanding of the Lime Decline and evolution of agriculture within the Severn Valley thus making this deposit of great regional significance.

The metalworking layer whilst currently undated would appear to be Roman in date given the presence of similar deposits as regards morphology and stratigraphic location on the eastern bank. This deposit is classified as having HIGH archaeological potential and the preservation of plant macrofossil remains would assist not only in the dating of the deposit through providing material for an additional programme of radiocarbon dating but would offer information regarding the vegetation at the time of deposition., This deposit is also significant as its presence away from the normal foci of industrial activity cannot be explained and therefore establishing the extent and function of the deposit is of local importance.

Overall, it is proposed that the deposits identified during the assessment can provide a long-lived sequence with HIGH potential to inform the geoarchaeological, palaeoenvironmental and archaeological history of not only the western bank of the Severn, but of the city and potentially the wider region.

8. 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 the W. Prosser scrap yard, Chequers Lane, Worcester (NGR SO 841 549).

The investigation was undertaken on behalf of CgMs Consulting, and their client the University of Worcester as part of an agreed programme of mitigation works.

Two boreholes were sunk using a percussive auger rig to recover continuous/windowless cores with the aim of sampling alluvial and/or organic deposits that could be assessed for environmental remains and their potential for geoarchaeological analysis.

The geoarchaeological assessment encountered the weathered surface of the Sidmouth Mudstone Formation in the base of Borehole 2 and gravels of the Power House Member, a unit of probable Late Devensian date, in the bottom of Borehole 1. These were overlain by iron stained, structureless silts and clays which were probably formed within a seasonally inundated floodplain. These were in turn overlain by continuously waterlogged alluvial silts and clays containing lenticular organic mud beds which are likely to have formed within a channel or channel margin environment.

Three samples were selected from the channel/channel margin deposits for AMS radiocarbon dating to accompany the pollen analysis with a basal date of Cal BC 2300 to 2120 AND Cal BC 2090 to 2040 (Beta-286993) and Cal BC to 1650 (Beta-286991) at the top indicating that the sediment was accumulating during the early to mid-Bronze Age. At the base of the sequence, the pollen analysis indicated an herbaceous-rich floodplain environment with pockets of alder carr and a mixed lime-dominated woodland on the floodplain margins/terraces. As the sequence progresses, the Lime Decline is identified indicating clearance of the mixed deciduous woodland on the floodplain margins for agriculture. This clearance is accompanied by a decline in alder, a trend witnessed at several other sites within the Severn Valley, further indicating the deforestation of the landscape by humans.

An undated layer of iron smelting debris/slag with interbedded waterlogged organic layers sealed this alluvial unit. Due to similar morphology, stratigraphic position and elevation when compared to similar deposits identified at Newport Street and The Butts on the eastern bank of the river, this layer has been tentatively assigned a Roman date.

A significant quantity (approximately 2.00m) of post-medieval/modern activity was identified, including two *in situ* courses of brick and 19th-20th century artefacts, which truncated and buried the underlying alluvial deposits in both boreholes.

9. Acknowledgements

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10. Personnel

The fieldwork and report preparation was led by Nick Daffern. The project manager responsible for the quality of the project was Tom Vaughan. Fieldwork was undertaken by Nick Daffern and Emily Beales, geoarchaeological analysis by Keith Wilkinson, environmental analysis by Nick Daffern and illustration by Carolyn Hunt.

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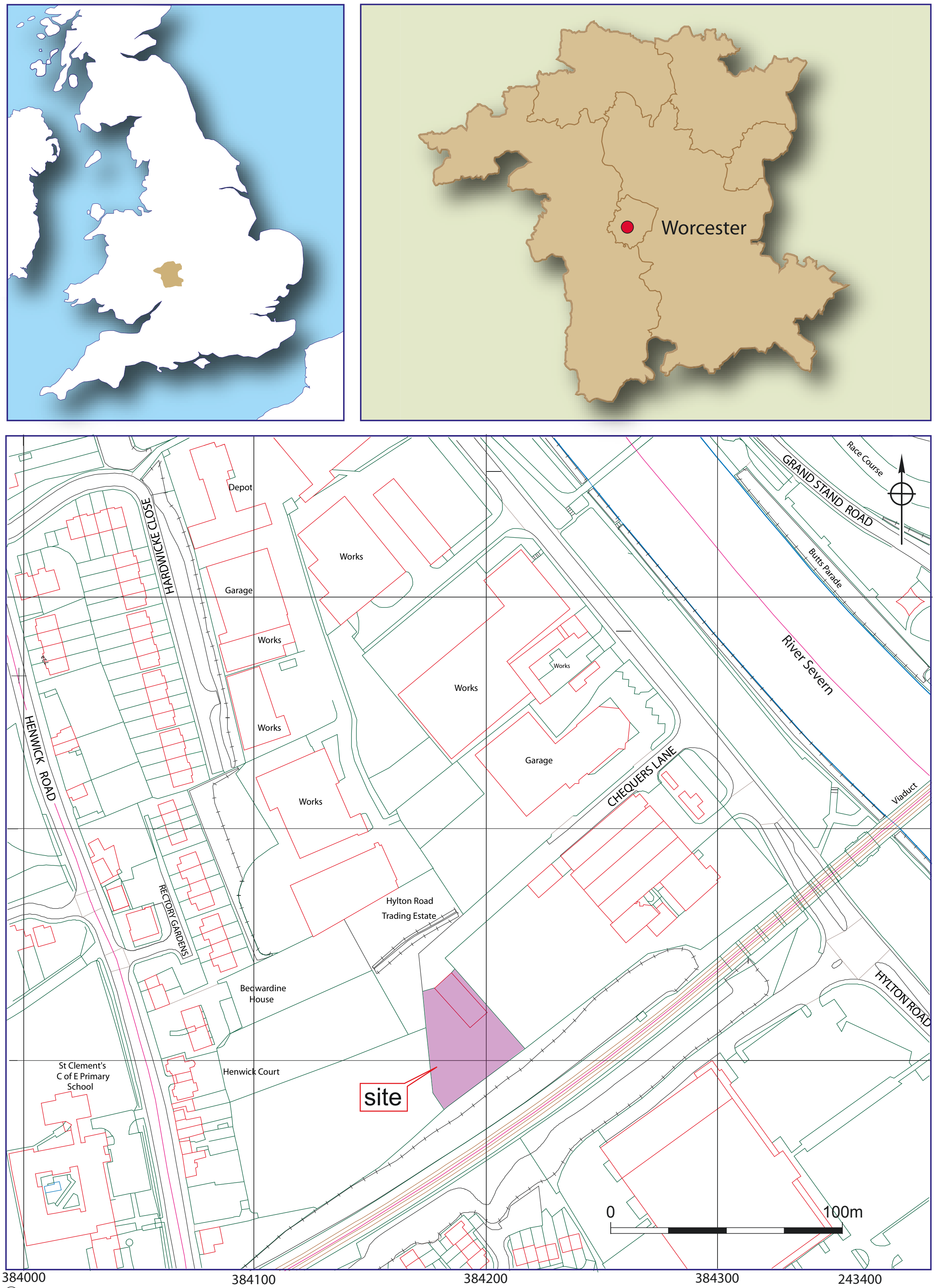
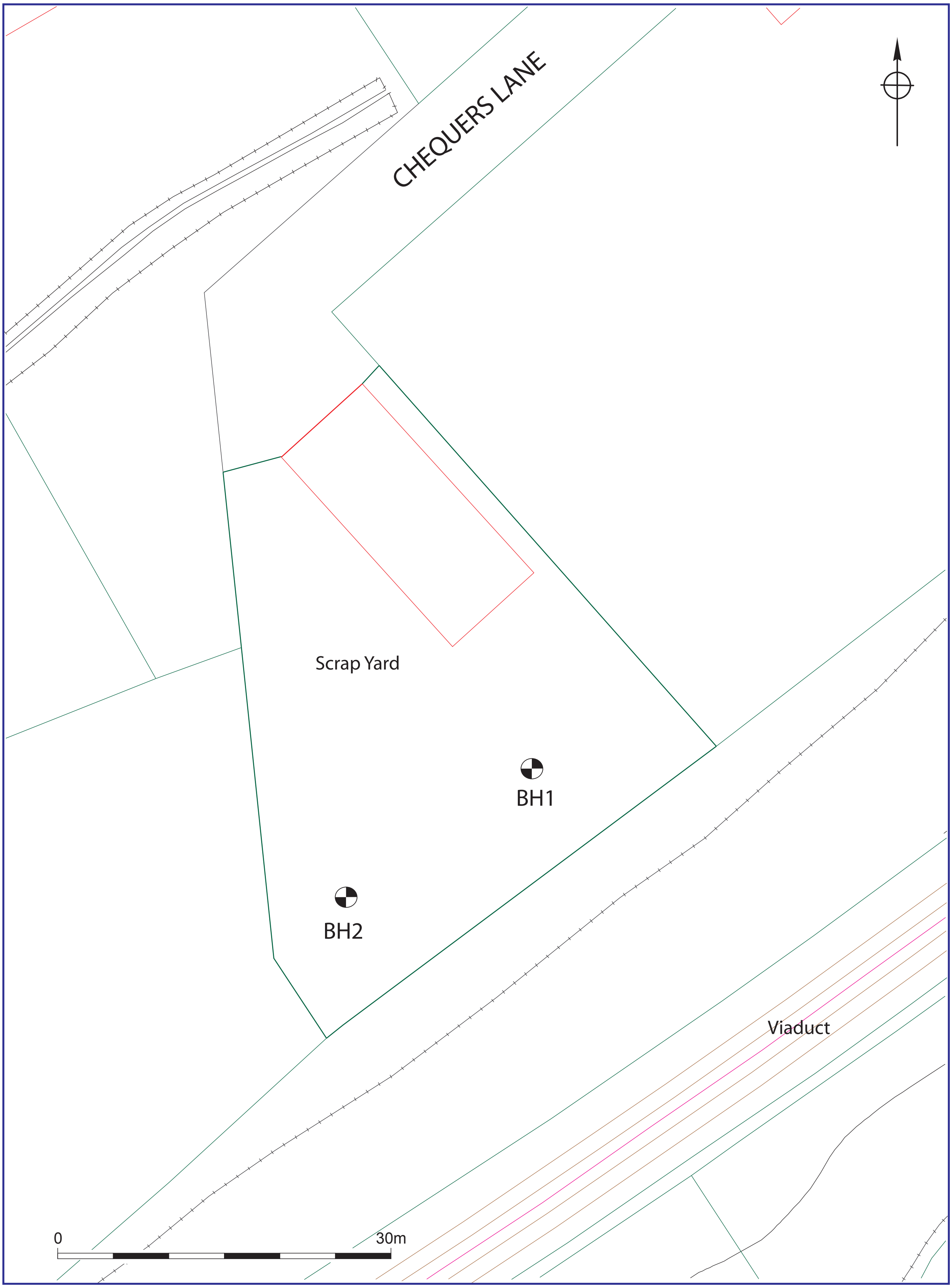
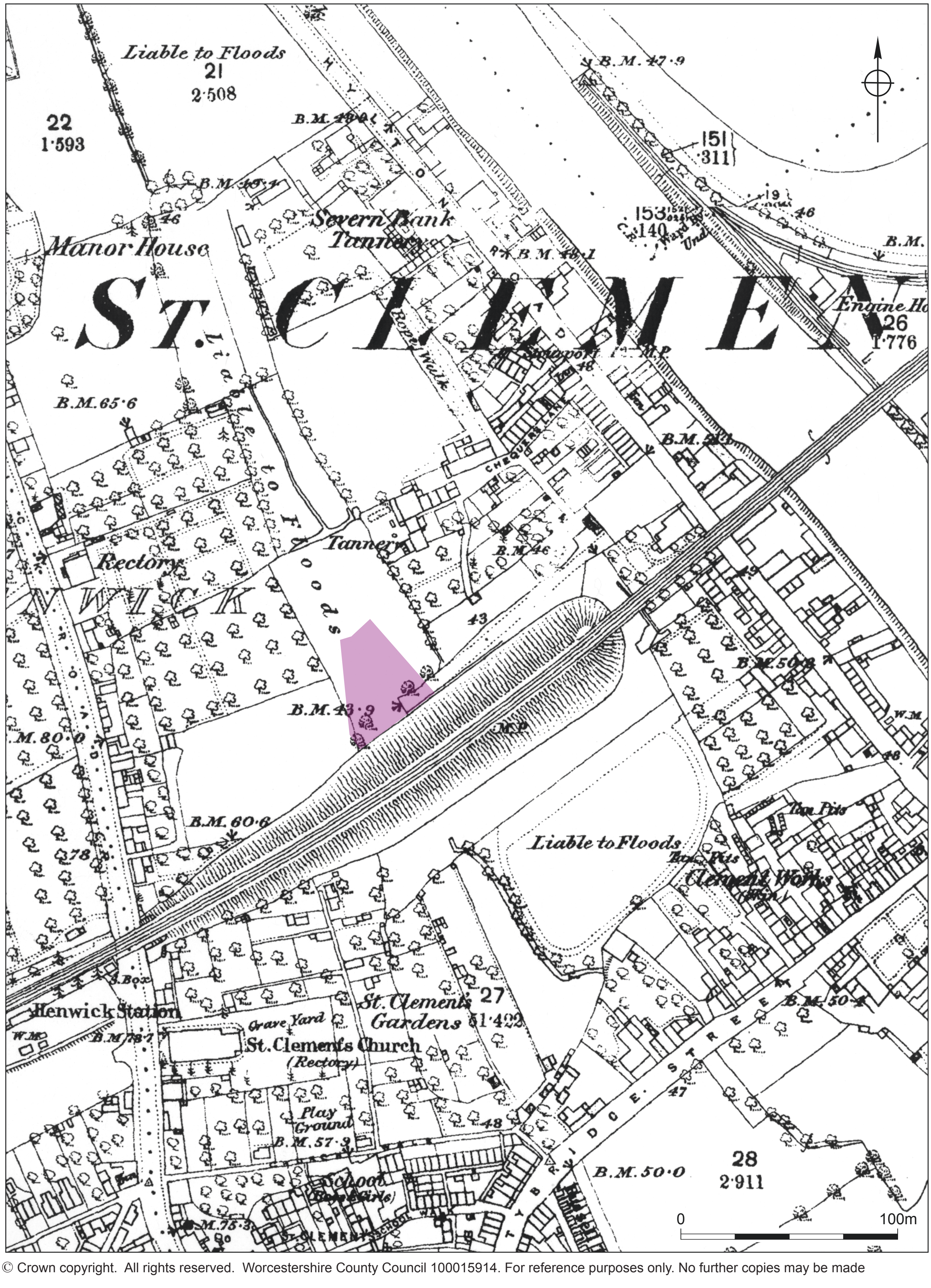
Figures



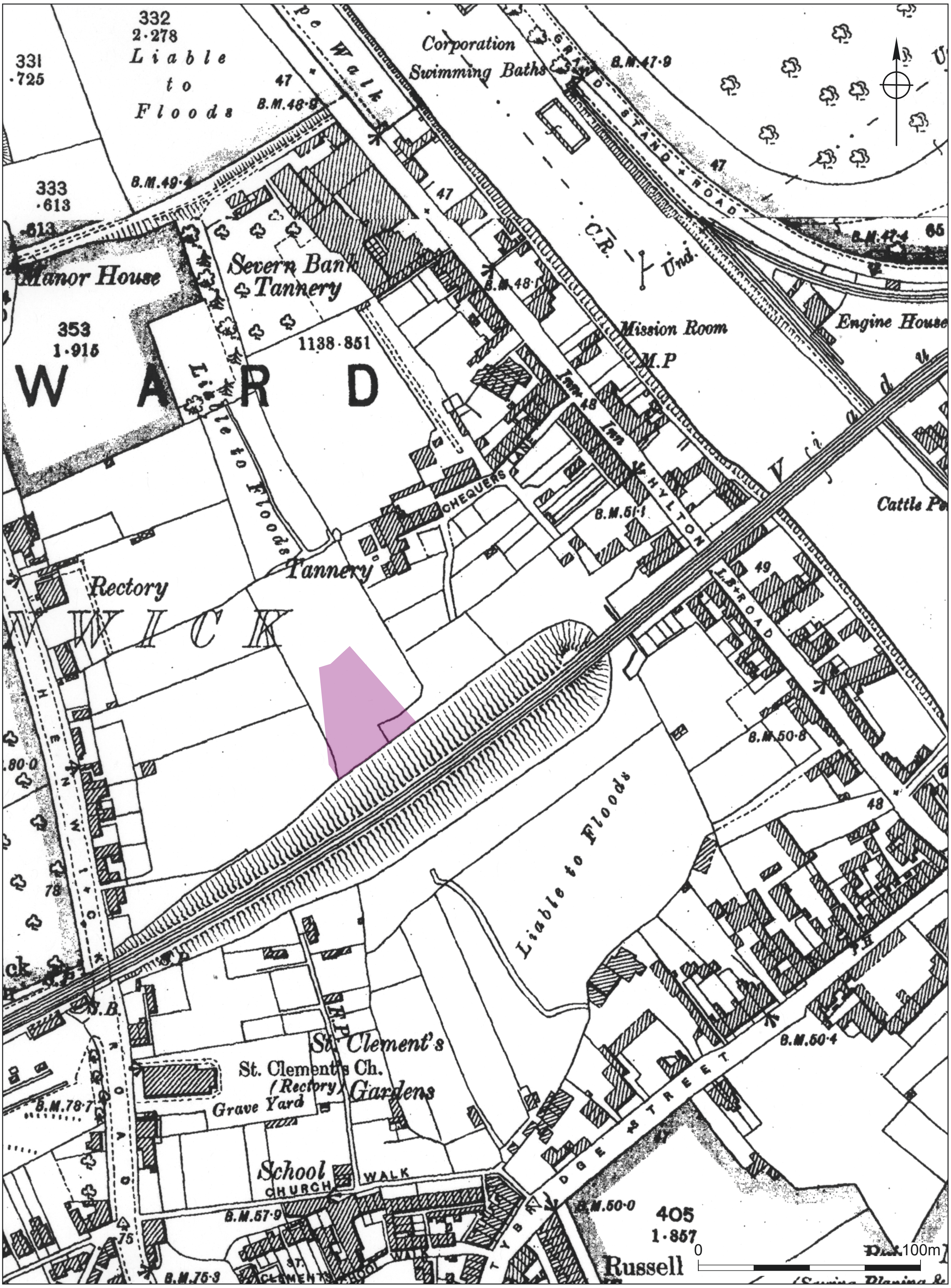
Location of the site *Figure 1*



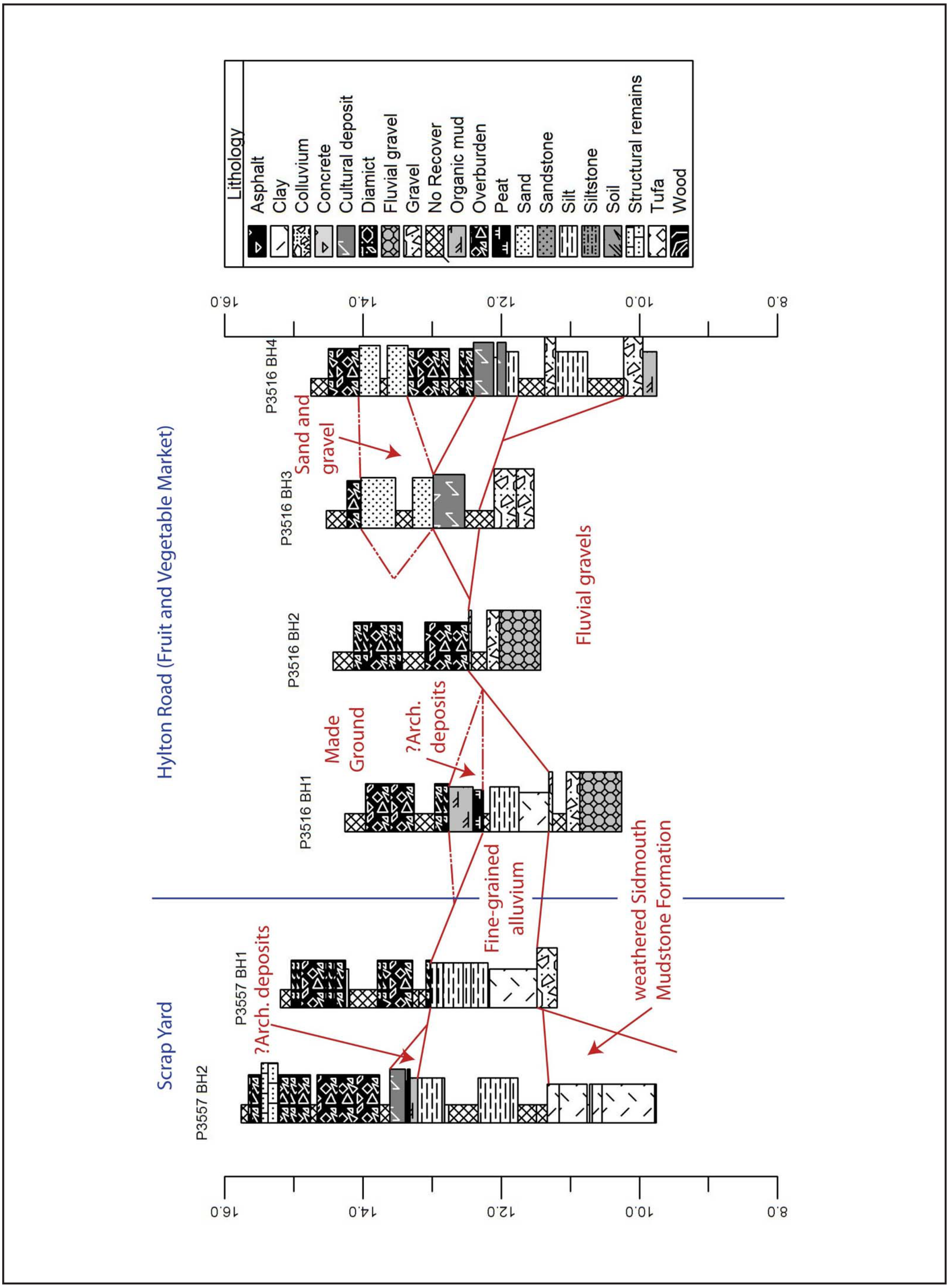
Location of boreholes *Figure 2*



Extract from 1st edition OS, 1888 *Figure 3*

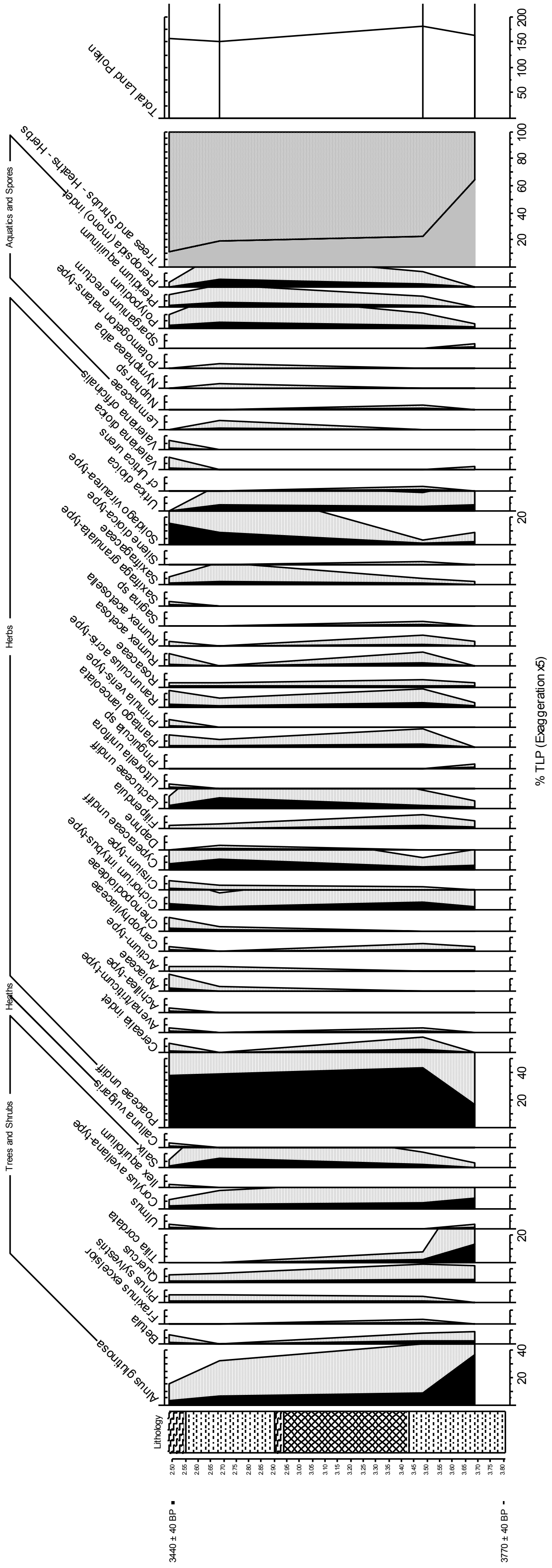


Extract from 1904 OS *Figure 4*



South-west to north-east composite cross section of borehole stratigraphy of Scrap Yard, Chequers Lane and four boreholes from Fruit and Veg Market (by Keith Wilkinson)

Figure 5



Pollen diagram, lithology and ^{14}C dates from borehole 2 at the W. Prosser Scrap Yard, Worcester *Figure 6*

Plates

Plate 1Geotechnical rig sinking Borehole 1

Plate 2 Borehole 1 location shot

Plate 3 Borehole 2 location shot

Plate 4 Site overview

Appendix 1 Lithological descriptions

Bore	Top (m)	Base (m)	Lithology	Description
P3557 BH1	0.00	0.15	No Recover	Void
	0.15	0.22	Overburden	2.5YR2.5/1 Black unconsolidated diamict of sand to pebble sized, angular and poorly sorted lithic fragments. Rare pebble-sized fragments of glass. Large pebble -sized, dark green clasts (metamorphic). Sharp boundary to:
	0.22	0.29	Overburden	10YR3/3 Dark brown semi consolidated diamict of granular sized gravel of brick, charcoal and clastic fragments. Clay content and compaction increases towards the base. Includes a single piece of stringy cotton fabric. Sharp boundary to:
	0.29	0.64	Overburden	10YR3/2 Very dark greyish brown, consolidated silt/clay with frequent granular-sized fragments of charcoal and clasts. Rare pebble-sized brick fragments and shell. Single cobble-sized rock fragment. Granular-sized iron-stained patches. Sharp boundary to:
	0.64	0.68	Overburden	10YR3/3 Dark brown, consolidated sandy silt/clay with moderate granular-sized fragments of brick and plant fibres, and occasional pebble-sized quartzite clasts. Sharp boundary to:
	0.68	0.76	Overburden	10YR3/2 Very dark greyish brown to black gravel of predominantly granular to pebble sized charcoal fragments. Occasional plant root and clast fragments (burnt?). Poorly sorted Sharp boundary to:
	0.76	0.80	Overburden	Red brick cobble together with several fragments of a white china base with a blue pattern
	0.80	0.92	Overburden	10YR3/2 Very dark greyish brown to black gravel of predominantly granular to pebble sized charcoal fragments. Occasional plant root and clast fragments (burnt?). Poorly sorted Sharp boundary to:
	0.92	0.94	Overburden	Grey ash mixed with granular sized crushed white shell coating a layer of charcoal granules. Poorly sorted. Sharp boundary to:
	0.94	0.98	Clay	10YR3/1 Very dark grey consolidated fine sandy silt/ clay with moderate iron oxide staining derived from (?) the occasional sub rounded, pebble sized rock fragments of grey laminated mudstone banded with iron oxide.
	0.98	1.00	No Recover	Void
	1.00	1.40	No Recover	Void
	1.40	1.47	Overburden	10YR3/2 Very dark greyish brown unconsolidated diamict of silt/clay sand with frequent granular to pebble sized charcoal, shell and clast fragments. Rare pebble-sized red brick fragments. Diffuse boundary to:

Bore	Top (m)	Base (m)	Lithology	Description
P3557 BH1	1.47	1.91	Overburden	10YR2/1 Black semi-consolidated silt/clay/fine sand with moderate granular to pebble sized rock fragments distributed throughout.). Frequent granular to cobble sized fragments of slag. Occasional granular-sized plant remains.
	1.91	2.00	No Recover	Void
	2.00	2.10	No Recover	Void
	2.10	2.17	Overburden	2.5Y2.5/1 Black unconsolidated and poorly sorted gravel of granular to pebble sized cinders and light, burnt, stony detritus; iron oxide staining to the cinders. Sandy silt/clay matrix and occasional waterlogged plant fragments. Sharp boundary to:
	2.17	2.26	Silt	Gley 1 2.5/10Y Greenish black silt/clay with occasional fine sand; angular, granular to pebble sized ?brick fragments; and granular sized charcoal fragments. Discontinuous band of granular to fine pebble sized charcoal fragments. Diffuse boundary to:
	2.26	2.35	Silt	5Y3/2 Dark olive grey silt/clay with occasional fine sand, granular sized plant fragments and rare granular sized sandstone fragments. Occasional rounded quartzite pebbles. Diffuse boundary to:
	2.35	2.64	Silt	Gley 1 3/5GY Very dark greenish grey normally bedded silt/clay with rare fine sand and frequent granular sized humic fragments. Occasional very fine vertical root channels and rare, fine pebble sized sandstone fragments. Diffuse boundary to:
	2.64	2.75	Silt	Gley1 3/10Y Very dark greenish grey reverse bedded silt/clay faintly mottled yellow and light brown. Frequent fine sand decreasing towards the base. Occasional granular sized charcoal fragments. Gradual boundary to:
	2.75	3.00	Silt	Gley1 5/5G Greenish normally bedded silt/clay mottled 10YR4/6 dark yellowish brown with occasional fine sand increasing in frequency towards the base where the coarse grains form oxide nuclei.
	3.00	3.02	No Recover	Void
	3.02	3.71	Clay	!0YR4/6 Dark yellowish brown (oxidised) silt/clay with Gley 1 5/5GY greenish grey (reduced) colour around very fine vertical root holes. Well sorted. Diffuse boundary to:
	3.71	4.00	Gravel	7.5YR3/4 Dark brown matrix-supported, gravel of well rounded coarse grained, pebble-granular-sized, red sandstones, siltstones, quartzites in a silt//clay matrix.

Bore	Top (m)	Base (m)	Lithology	Description
P3557 BH2	0.00	0.10	No Recover	Void
	0.10	0.15	Overburden	2.5YR3/1 Very dark grey diamict of granular to pebble sized angular carbonate fragments coated by clay. Single pebble-sized glass fragment. Sharp boundary to:
	0.15	0.27	Overburden	Unconsolidated gravel of cobble sized sandstone and crushed brick. Contains a single fragment of plastic. Sharp boundary to:
	0.27	0.29	Overburden	2.5YR2.5/1 Black clast-supported gravel of granular to pebble sized angular cinders. Sharp boundary to:
	0.29	0.53	Structural remains	2.5YR5/8 *in situ* red brick and white mortar. Two courses with crushed brick and mortar. Sharp boundary to:
	0.53	0.55	Overburden	Horizontal layered fibrous material (felt or cardboard). Sharp boundary to:
	0.55	0.70	Overburden	10YR3/2 Very dark greyish brown fine diamict of clay containing granular to pebble-sized clasts, glass, and plastic. Includes a piece of a plastic screw fitting. Charcoal concentrated towards the base. Sharp boundary to:
	0.70	0.81	Overburden	A semi consolidated diamict of mortar, pebble-sized brick fragments. Single cobble-sized brick fragment and a cobble-sized machine made iron object. Sharp boundary to:
	0.81	1.00	Overburden	Consolidated clay with fine layer-sized charcoal bands and pockets. Moderate granular-sized fragments of mortar and brick. Occasional pebble-sized cinders and rounded quartzite clasts. Towards the base there is a layer of pebble-sized glass fragments.
	1.00	1.10	No Recover	Void
	1.10	1.40	Overburden	10YR2/2 Very dark brown unconsolidated diamict of pebble-sized, angular cinders, charcoal, brick and occasional pottery fragments. Two metal wires 80mm. Diffuse boundary to:
	1.40	2.00	Overburden	10YR2/2 Very dark brown unconsolidated diamict of pebble-sized, angular cinders, charcoal, brick and occasional pottery fragments. Sharp boundary to:
	2.00	2.15	No Recover	Void
	2.15	2.37	Cultural deposit	2.5YR3/1Dark reddish grey semi consolidated layer of metalworking waste comprising granular to pebble sized pieces of slag. Frequent, granular sized plant fragments. Iron oxide staining increases towards the base. Sharp boundary to:
	2.37	2.40	Peat	10 YR 2/1 Black 'peat' of pebble and granular-sized leaves, twigs, roots. Sharp boundary to:
	2.40	2.42	Cultural deposit	2.5YR3/1Dark reddish grey semi consolidated layer of metalworking waste comprising granular to pebble sized pieces of slag. Frequent, granular sized plant fragments. Sharp boundary to:
	2.42	2.44	Cultural deposit	10 YR 2/1 Black granular to pebble-sized, black carbonised plant fragments. Diffuse boundary to:

2.44	2.55	Organic mud	5Y2.5/2 Black silt/clay with frequent, granular sized, charcoal fragments and plant fibres, and fine sand. Rare sandstone granules. Diffuse boundary to:
2.55	2.90	Silt	5Y3/1 Very dark grey normally bedded silt/clay with frequent fine sand and occasional pebble sized, sub-rounded sandstone and quartzite fragments and charcoal fragments. Diffuse boundary to:
2.90	2.94	Organic mud	5Y2.5/1 Black organic silt/clay with frequent coarse sand and granular to pebble sized waterlogged plant remains.
2.94	3.00	No Recover	Void
3.00	3.43	No Recover	Void
3.43	3.89	Silt	5Y3/1 Very dark grey normally bedded silt/clay with frequent coarse sand and granular to pebble-sized plant fragments. Occasional sub rounded pebble-sized quartzite and fine grained sandstone clasts. Diffuse boundary to:
3.89	4.00	Silt	2.5Y5/1 Grey silt/clay with occasional to frequent fine sand. Rare pebble sized plant fragments. Moderately sorted
4.00	4.27	No Recover	Void
4.27	4.43	No Recover	Slump
4.43	4.60	Clay	10YR4/4 dark yellowish brown fine sandy clay mottled by 7.5YR4/3 brown granular-sized patches. Rare, rounded, pebble sized, fine grained sandstone/quartzite clasts at the base. Diffuse boundary to:
4.60	5.00	Clay	5YR4/4 Reddish brown silt/clay with occasional fine sand. Moderately sorted. The unit is broken up into hard, compact rhomboids.
5.00	5.04	No Recover	Void
5.04	5.08	Clay	7.5YR2.5/1Black sandy silt/clay with occasional pebble-sized, well rounded quartzite clasts. Sharp boundary to:
5.08	5.22	Clay	7.5YR4/2 Brown silt/clay with occasional to frequent fine sand and rare, rounded, pebble-sized quartzite clasts. Disruption to the unit between 5.06 and 5.12m. Sharp boundary to:
5.22	5.98	Clay	5YR3/4 Dark reddish brown silt clay with a lamina of Gley 1 5/5GY greenish grey at 5.58 to 5.59m. Below this, the unit is broken into rhomboidal, pebble sized fragments.
5.98	6.00	No Recover	Void

Appendix 2 Pollen processing methodology (Tim Mighall, Department of Geography & 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.

Appendix 3 Radiocarbon dating results

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: 11/15/2010

University of Worcester — Material Received: 10/25/2010

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 286991	3470 +/- 40 BP	-26.7 o/oo	3440 +/- 40 BP

SAMPLE : P3557/2.50-1
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION : Cal BC 1880 to 1650 (Cal BP 3830 to 3600)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 286992	1740 +/- 40 BP	-26.5 o/oo	1720 +/- 40 BP

SAMPLE : P3557/3.50-1
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 230 to 410 (Cal BP 1720 to 1540)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 286993	3820 +/- 40 BP	-28.2 o/oo	3770 +/- 40 BP

SAMPLE : P3557/3.80-1
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 2300 to 2120 (Cal BP 4250 to 4070) AND Cal BC 2090 to 2040 (Cal BP 4040 to 3990)

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.

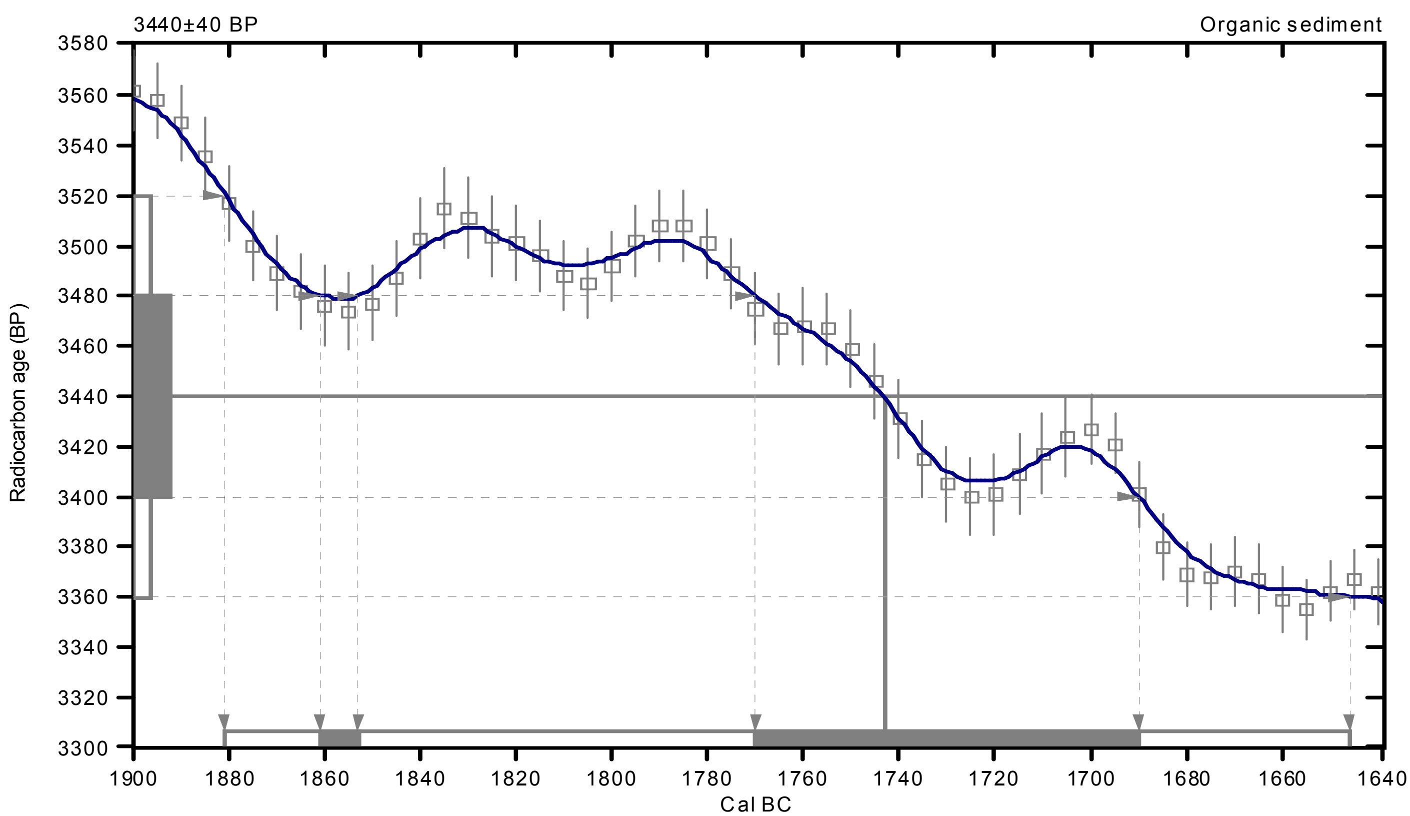
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.7:lab. mult=1)

Laboratory number:	**Beta-286991**
Conventional radiocarbon age:	**3440±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 1880 to 1650 (Cal BP 3830 to 3600)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 1740 (Cal BP 3690)
1 Sigma calibrated results: (68% probability)	Cal BC 1860 to 1850 (Cal BP 3810 to 3800) and Cal BC 1770 to 1690 (Cal BP 3720 to 3640)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.5:lab. mult=1)

Laboratory number: **Beta-286992**

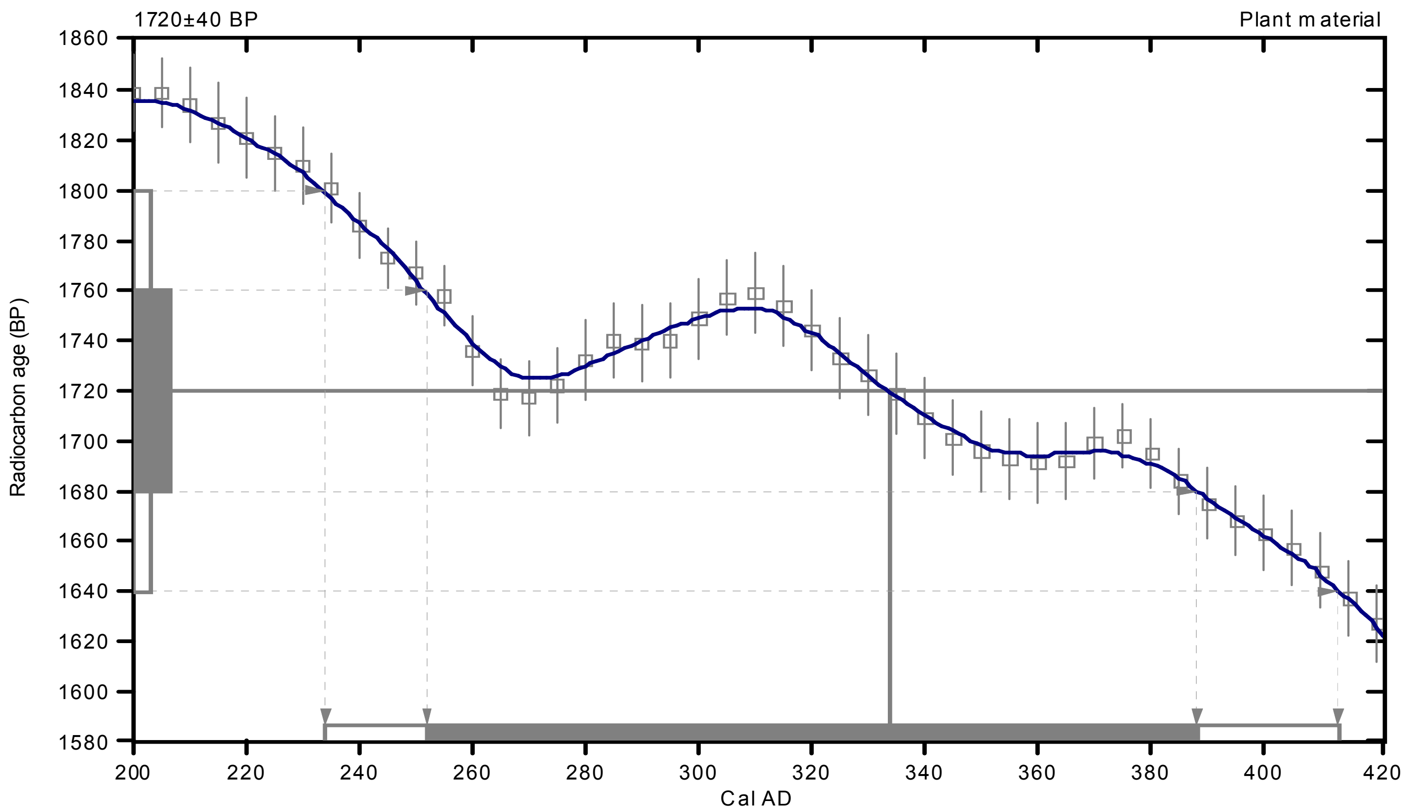
Conventional radiocarbon age: **1720±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 230 to 410 (Cal BP 1720 to 1540)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 330 (Cal BP 1620)

1 Sigma calibrated result: (68% probability) Cal AD 250 to 390 (Cal BP 1700 to 1560)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-28.2:lab. mult=1)

Laboratory number: **Beta-286993**

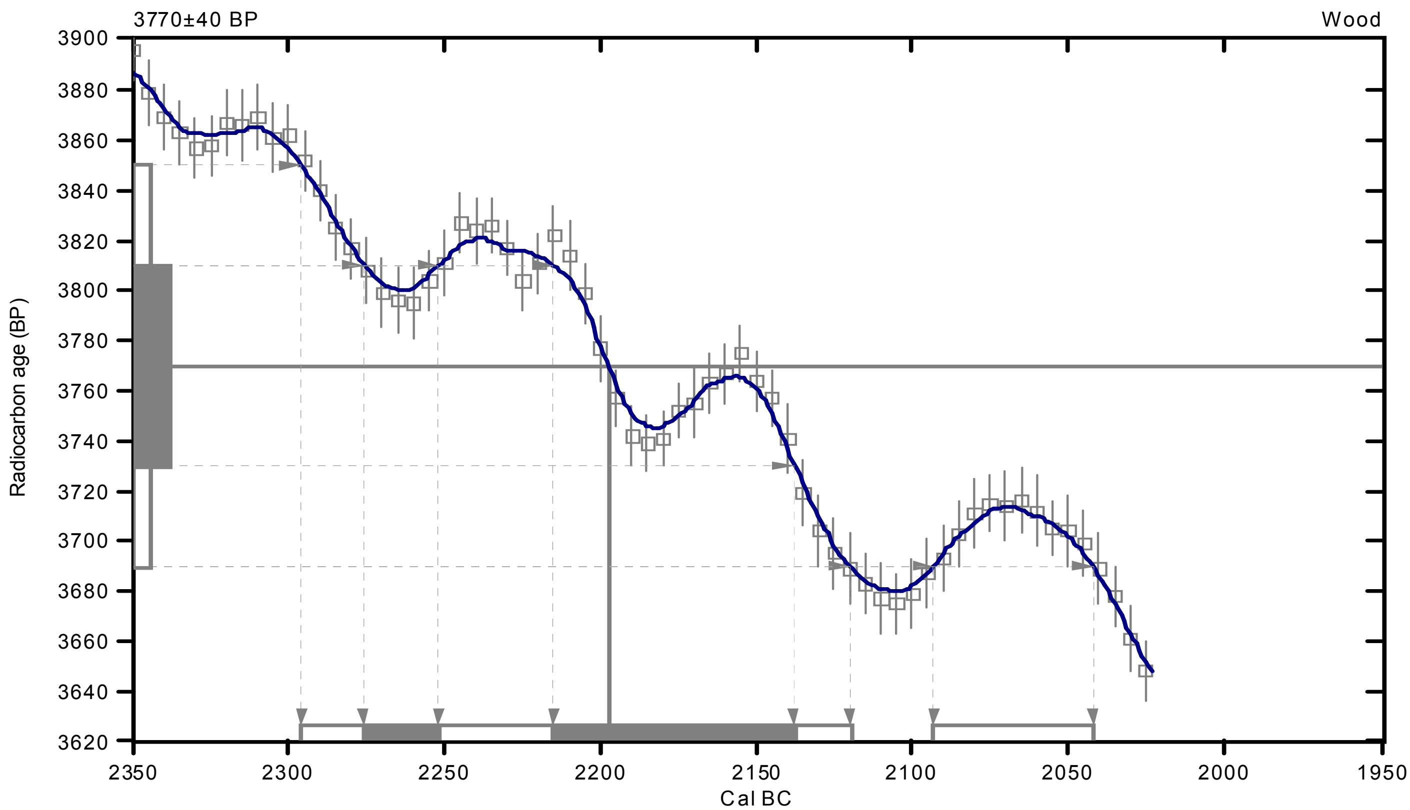
Conventional radiocarbon age: **3770±40 BP**

2 Sigma calibrated results: **Cal BC 2300 to 2120 (Cal BP 4250 to 4070) and**
(95% probability) **Cal BC 2090 to 2040 (Cal BP 4040 to 3990)**

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 2200 (Cal BP 4150)

1 Sigma calibrated results: Cal BC 2280 to 2250 (Cal BP 4230 to 4200) and
(68% probability) Cal BC 2220 to 2140 (Cal BP 4160 to 4090)



References:

Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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Appendix 4 Technical information

The archive

The archive consists of:

1	Fieldwork progress records AS2
9	Digital Photos
6	Pollen preparations (in vials)
6	Pollen slides

The project archive is intended to be placed at:

Worcestershire County Museum
Hartlebury Castle
Hartlebury
Near Kidderminster
Worcestershire DY11 7XZ
Tel Hartlebury (01299) 250416