Nantwich Waterlogged Deposits
Report No 2

The Character and Extent of Archaeological Preservation
Cheshire County Council & English Heritage 3839 Main

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Frontispiece
Excavation and lifting of medieval salt-ship from Second Wood Street, 2003

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NON-TECHNICAL SUMMARY

Background

Investigations in Nantwich over the past 30 years have revealed exceptional finds such as hollowed out oaks (salt-ships), stave-built barrels and lids, structural timbers and wooden water channels, leather shoes, accumulations of organic-rich stable floorings and domestic waste, and deep organic-rich silty deposits. These remains are of national importance and date from Iron Age, Roman and medieval times. Their distribution throughout the town, however, is not fully understood, their origins and the factors that have governed their preservation are unknown, and the threats to their continued survival through modern development and hydrological change are of great concern. With limited knowledge about the extent and character of these deposits effective planning control advice has been problematic, and Cheshire County Council Historic Environment Team proposed a programme of research to English Heritage, who agreed to fund the current scheme. SLR Consulting were commissioned to undertake this programme of investigation and to design a well-informed management strategy that can be implemented by the local planning authority.

Aims

The aims of the project were to provide a predictive model of the location of waterlogged deposits in Nantwich, to understand the parameters of their formation and their preservation, and to assess their vulnerability. From this model a strategy for promoting the preservation of waterlogged deposits in Nantwich was to be developed, and the resultant strategy was to be promoted so that regional and national best practice could be informed to assist with the preservation of urban waterlogged deposits at other locations (e.g. York, Droitwich, Boston).

Methods employed and phased approach

The aims of the project were addressed by a programme of investigation that included a desk study that has compiled and examined archaeological evidence in relation to geology and hydrogeology using GIS technology as well as more conventional analysis. The programme continued with two phases of borehole sampling and assessment of 30 sediment cores so that the physical and chemical character of the burial environment in which archaeological remains are preserved, can be understood. This was complemented by a scientific dating programme through use of dendrochronology and radiocarbon determination. An iterative approach was adopted so that each phase in the programme could be discussed with the steering group, and the results used to inform the next phase of work. On completion of the deposit characterization phase, assessment of palaeoenvironmental remains, diatoms and waterlogged wood was conducted. Interpretation of the results required application of a simplified terminology so that valid comparative analysis and synthesis could be undertaken. The present report has been prepared to provide a detailed account of all these phases and the results of the project, to disseminate the methodology followed, and to make recommendations for the future of the waterlogged deposits within Nantwich.

Success of recovery technique and sampling programme

Results from the boreholes have helped in defining limits to the waterlogged deposits, as well as characterising their nature. From the 30 locations investigated three boreholes recovered well preserved organic remains, two more revealed highly organic remains but poorer preservation and active decay. A further 12 boreholes and one sample from a test-pit had small amounts of organic debris including wood fragments, as well as carbonised remains. These 3 – 4m deep archaeological deposits appear to have accumulated and survive due to waterlogging, and although some did not contain large quantities of organic

remains, they nonetheless form part of stratigraphic sequences identified from adjacent archaeological investigations that have been shown to include organic survival. The small sample size of the cores relied on a certain amount of luck as to whether organic remains would be retrieved or not from any particular deposit.

Results and success of assessment programme

Waterlogging was not as uniform or widespread as expected, even in close proximity to deposits known from previous archaeological excavation. Over 93% (28 out of 30) of the boreholes have produced positive results, including ten boreholes that had been deliberately located to confirm that certain areas were outside of the zone of waterlogged deposits, and thus were never expected to have organic remains. The two remaining boreholes that had neither waterlogged deposits nor were located to test for the limits of the waterlogged zone, were drilled within the Castle area of Nantwich. Their negative results are surprising, as previous archaeological investigation has shown some very good preservation and deeply stratified deposits in the same general location. This demonstrates the variable nature of the deposits, in their formation process and preservation.

Chronology and results of scientific dating programme

Iron Age and Roman remains have been found by excavation at the periphery of the medieval town, and the majority of preserved timbers have been dated by dendorchronology to the 2nd century AD. Samples submitted for radiocarbon dating from the project's coring programme have demonstrated that extensive waterlogged conditions had already started accumulating before late Anglo-Saxon times. The majority of C14 dates are consistent with other evidence for a significant period of deposition during the 11th – 13th centuries, including parts of a roundwood trackway at the base of the deposit sequence. In addition small sherds of medieval pottery, of probable 12th -13th century date, were found below organic-rich deposits in two of the boreholes. Dendrochronological dates for preserved wooden structures have been gathered, mostly as part of previous investigations, which help to provide a framework for the chronological development of Nantwich's waterlogged deposits. Such evidence points to the 11th – 13th centuries as a period of particular importance in the growth of these deposits.

Predictive model for waterlogged deposits and zones of preservation

Two distinct zones of preservation dependent on urban hydrology have been identified from the geochemical assessment. A low-lying zone adjacent to the river in which well-preserved organic remains have been recovered, and a secondary zone along the higher slopes in which organic preservation has been detected but active decay appears to be in progress. Deep archaeological deposits still survive in this secondary zone, within which more isolated areas might still fall within the criteria for the well-preserved zone. The total area of waterlogged deposits covers approximately 10ha.

Formation process

Formation processes appear to derive from saturated terrace sands lying over impermeable glacial Till which provided a water- retentive matrix onto which organic and inorganic debris from human activity accumulated. As these deposits built up they in turn became saturated, recharged from surface and ground water which tried to follow hydrological pathways towards the Weaver. Geochemical analysis has demonstrated that reducing conditions predominate in the low-lying zone, with high sulphide to sulphate ratios and relatively high loss on ignition values, whilst levels of nitrate were low. In the secondary zone along the higher parts of the town, conditions varied from good to poor preservation, with low levels of sulphide tending towards an oxidising environment in the upper levels of core samples, and

methane “hotspots” were active decay was probably in progress. The pH values were generally neutral or slightly acidic. Conductivity values in water quality testing indicated recharge from both groundwater and rainwater, and that the groundwater was of a reduced nature favouring preservation of organic remains at this depth. Most recharge in the secondary zone appeared to derive from surface water flow. Diatoms have suggested a contrast between freshwater on the west of the Weaver, with some evidence for more brackish groundwater on the east.

The waterlogged area on the west bank is low-lying and was dominated by salt-working, thus the formation of deep archaeological deposits with organic preservation can be seen to have derived directly from its proximity to the river and the nature of the industrial and domestic use of the area. On the east bank the low-lying area at Snow Hill and the Castle can similarly be associated with the river and salt-working, and 16th century historical accounts describe the only known brine pit (located at Snow Hill) as already having c.2m of accumulated deposits above the original ground surface over 400 years ago.

Waterlogged deposits in the higher parts of the core of the historic town, the area of High Street, Churchyard Side and north of Hospital Street, can be explained because this area forms a natural drainage between two low watersheds, with axes along Hospital Street to the south and the Civic Centre - Manor Street on the north. The land on which the church was built, historically recorded as lying on saturated sands, formed a watertight base for the trapping of industrial, domestic, animal and stabling refuse from the medieval properties that were constructed in this area, and from burials placed in the graveyard. Recharge from surface and ground water created the conditions of waterlogging that have prevented the normal processes of microbiological decay, leading to the formation of up to 3 – 4m of accumulated archaeological deposits.

Vulnerability

Since insertion of town sewers, and paving over of the main thoroughfares, during the 1850s the natural recharge from rainwater has been severely impeded, leading to an incremental process of desiccation and decay to waterlogged deposits over 150 years. This scenario suggests that the continued preservation of organic remains within the higher parts of the town is under severe threat, and could be difficult to counter on a site by site basis. This will be of considerable concern not only to the archaeological community, but also to the wider public who wish to protect and understand their past, and appreciate a sense of place epitomised by the uniqueness of Nantwich.

The threat posed by this desiccation of waterlogged archaeological deposits may have wider repercussions than the destruction of a rich archaeological resource of national importance. The shrinkage associated with such desiccation of previously waterlogged deposits can lead to serious structural damage to existing properties and future developments. Such problems have been manifested by subsidence at the memorial cross (underpinned 2002) and the north range of the Lamb Hotel (demolished in 2004), as well as major works to the floor and foundations of the church in the 1980s. It is therefore in the interests of town planners and developers to address the conclusions from this project through a proactive strategic management plan.

Supplementary Planning Document and management pan

A *Management Strategy: Supplementary Planning Document for the Historic Environment and Archaeological Deposits* was issued as Report No 3 in December 2008. This document is designed to assist those involved in decision-making for spatial planning, urban drainage, highways engineering, infra-structure and utilities, property development and development control so that changes to groundwater level, flow and quality are managed in a manner that

will help to preserve the sub-surface archaeological deposits and by these means also protect the stability of the above ground built heritage. The zone of waterlogged deposits within Nantwich has been identified as an *Area of Special Archaeological Potential* and the management strategy seeks to provide guidance on construction techniques that will ensure the preservation of sensitive archaeological deposits, and avoid the need for large-scale time-consuming, and expensive archaeological excavation, in accordance with PPG16. The strategy also conforms with enhancing and preserving the cultural character of the Nantwich Conservation Area, the North West of England Regional Spatial Strategy 2008 Policy EM1 (C): *Historic Environment*, and with the Borough of Crewe and Nantwich Replacement Local Plan 2011 Policy BE.16: *Development and Archaeology*.

Conclusions

Previous studies into the mechanisms of in situ preservation of organic remains have tended to focus on rural wetlands, for example, Sutton Common, South Yorkshire (Cheetham, 2007) and Nydam Mose, Denmark (for example refer to Gregory et al, 2001) . However, attention is turning increasingly to urban "wetlands" where issues including climate change, flood alleviation schemes, drainage and re-development are all likely to impact upon continued preservation. The Nantwich study represents one of the first investigations undertaken in the UK that has adopted an holistic and systematic approach into identifying mechanisms of preservation and potential risks and threats to the archaeology.

The implications of the Nantwich research are of value far beyond the application of a supplementary planning document to manage change within the historic core of the town. Issues of ground stability, sustainable development and urban water management raised by this project are equally applicable to all urban centres with known or potential preservation of organic-rich deposits. Results from the World Heritage Site of Bryggen, Bergen in Norway have demonstrated the vulnerability of the built heritage as well as below ground archaeological deposits to the impact of the modern world. It has also identified the difficulties in producing a coherent understanding of all the complex issues involved that help to preserve and to threaten such cultural heritage, and the problems of influencing decisions at a sufficiently strategic level to provide effective long-term management.

The Nantwich study forms a rare piece of scientific research which will help to increase the sum of conservation knowledge and enable informed decision-making at the highest levels. It is therefore proposed that a second stage to this project will include not only a programme of long-term monitoring of the dipwells that have been installed in Nantwich, and dissemination of the results and interpretation from this programme, but will also include the distribution of this report to international bodies such as ICOMOS, UNESCO and the World Bank. The threat from climate change adds greater emphasis to the needs for this issue to be appreciated and acted upon at the highest levels.

RESOURCES

This project was commissioned by the Historic Environment Team, Cheshire County Council, carried out by SLR Consulting Ltd and funded by the Historic Environment Enabling Programme, English Heritage.

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1.0 INTRODUCTION

1.1 Project concept and funding

This report presents the results of an investigation into the remarkably well-preserved waterlogged deposits under the historic core and environs of Nantwich. A desk-based assessment was undertaken and reported on in July 2007 which examined the existing evidence for depth and extent of waterlogging based upon archaeological investigations, historic sources and map regression, and geological and geotechnical boreholes. In August and September of 2007 a programme of geo-archaeological coring and environmental assessment was undertaken which was designed to establish the limits to the waterlogged deposits, and to characterise the nature of the below ground preservation conditions. The project was funded by English Heritage in response to a project proposal by Cheshire County Council to assist in the strategic management of these well-preserved archaeological remains lying beneath the modern town. Roman and later deposits which include timber structures, organic remains and significant archaeological horizons, have accumulated to a depth of up to 4m, but these have become vulnerable to increasing development pressures as part of the town's economic regeneration over the past 15 years. Such complicated planning issues have often led to compromise over the continued preservation of the archaeological resource and thus have resulted in its piecemeal attrition.

1.2 Aims and objectives

The main aim of the project is to design a management action plan, based on detailed knowledge and a robust understanding of the principal elements that have led to the creation and preservation of this exceptional archaeological resource. The project objectives included interpretation and analysis of the sub-surface formation processes that had led to the build-up of deeply stratified archaeological remains, and for a detailed study of the existing burial environment, so that an understanding of the potential value and vulnerability of preserved organic remains could be determined. The project was designed and undertaken by SLR Consulting Ltd, together with specialist conservation science provided by York Archaeological Trust, and palaeoenvironmental analysis by Palaeoecological Research Services of Durham.

The aims in the project brief were defined as:

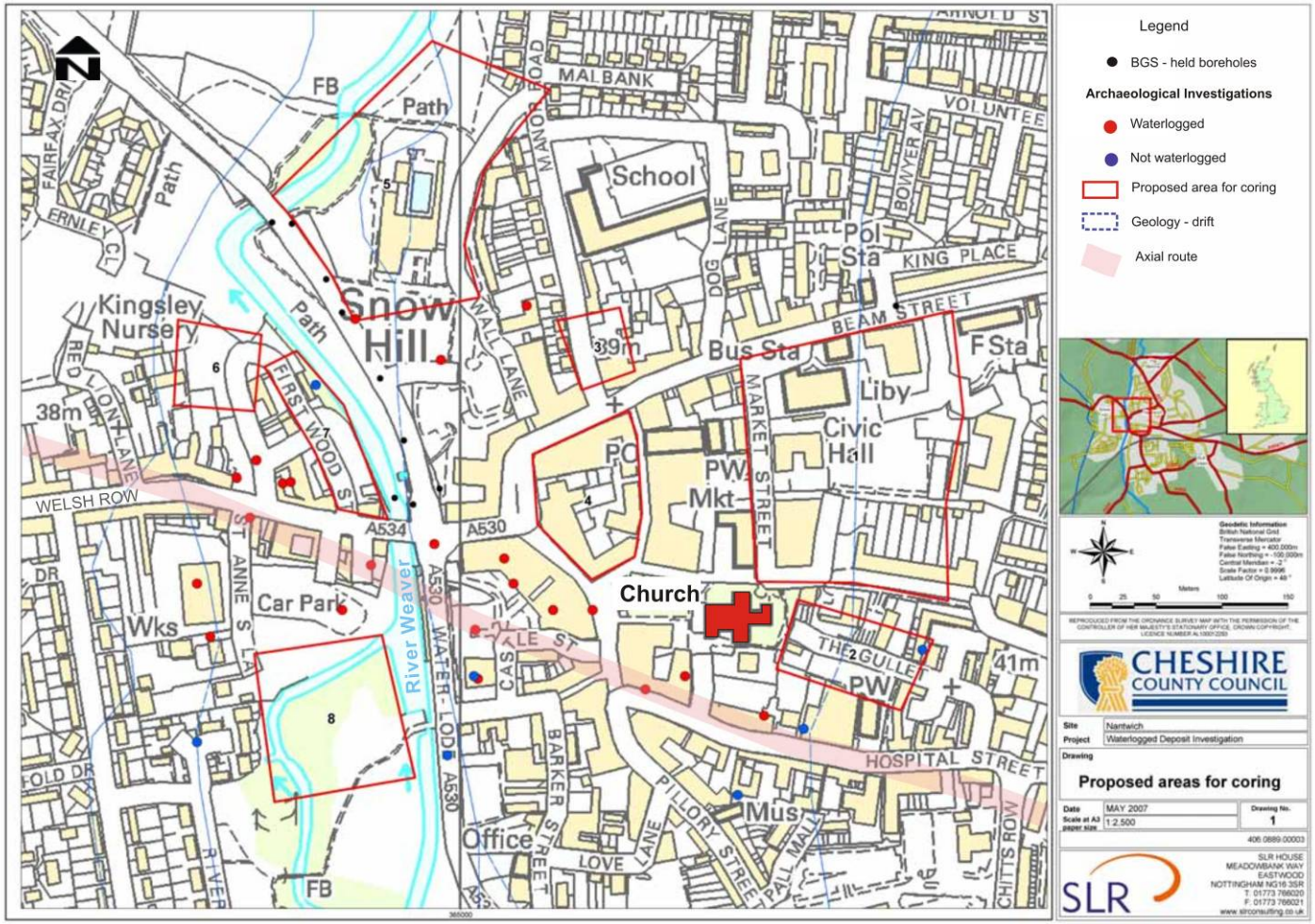
- To provide a predictive model of the location of waterlogged deposits in Nantwich and to understand the parameters of formation and preservation of these deposits and their vulnerability to destruction

- To develop a strategy to promote the preservation of waterlogged deposits in Nantwich

- To promote the resultant strategy, in association with similar policies that have been developed in other urban centres with extensive waterlogged deposits (York), both regionally and nationally. This "best practice" will inform the preservation of waterlogged urban deposits in locations where the issue has yet to be addressed at the strategic, or in many instances, the tactical level

Seven objectives were identified: to map the extent of deposits, to characterize their nature and formation processes, to date their inception and development, to assess state of preservation, to assess threats, to improve understanding of waterlogged deposits and the salt industry, and to ensure the survival of waterlogged organic deposits within the urban environment.

Figure 1
Nantwich town centre labelled up with principal streets mentioned in text



1.3 Location, topography, geology, hydrogeology and historic context

Nantwich is a large market town located in the southern part of central Cheshire. The River Weaver divides the historic town into two parts, a west side which lies north and south of the arterial route westwards called Welsh Row, and an east side which includes Snow Hill, the Castle area, Beam Street, High Street and the Church, with the arterial route eastwards along Hospital Street (Figure 1). The origins of Nantwich owe much to this major routeway and the crossing point of the Weaver (Plate 1). The river flows north to the Mersey and is crossed by a single bridge connecting Welsh Row with the High Street. To the south of this bridge the location of a medieval mill has created an island by cutting a millrace across the neck of a meander in the river. The historic core covers approximately 10ha on the east side and 4ha on the west, summarised in the Cheshire Historic Towns Survey 2003.

Plates 1 and 2 River Weaver looking north to the bridge; timber-frame buildings, High Street

The solid geology of the town is the Wilkesley Halite Formation (Upper Keuper Saliferous Beds) of the Triassic Mercian Mudstone Group. Lying over this is Glacial Till (including Lower and Upper Boulder Clay horizons separated by Middle Sands). The Till is overlain by superficial deposits of river terrace sands and gravels, which, where cut by the river, are capped by alluvium (Drawing 1). Elevation from the edge of the historic town ranges from 44m on the west side and 39m on the east side, down to 34 – 33m AOD for the valley floor (south – north) in the centre. The Castle area, parts of Snow Hill, and the eastern end of Welsh Row form the lowest areas of the town, and lie within the flood zone. The heterogeneous nature of the drift geology which includes permeable horizons has the potential for lenses of perched water-table, as well as lateral flow of groundwater within River Terrace Deposits with hydraulic continuity. A line of springs and sinks may be the product of dissolution features in the underlying halite formation, particularly at the interface of the Lower Boulder Clay with the overlying Middle Sands, resulting in sandy, waterlogged soils.

Many of Nantwich's historic timber-frame houses were rebuilt after the great fire of 1583 (Hall 1883 (1976)) and still survive today, especially around the market area centring on High Street, Beam Street and Pepper Street (Plate 2). The Hospital Street – Welsh Row orientation broadly follows an ancient routeway that crossed the Weaver at this point (Plates 2 – 4), and undoubtedly contributed to Roman settlement, military and industrial activity

being located there. Most Roman evidence has been found in the northern half of historic Nantwich, in Snow Hill and especially on the West side along St Anne's Lane, south of Welsh Row, and to the north at Kingsley Fields.

Plates 3 & 4 Lamb Hotel & Hospital Street looking east; Welsh Row looking east

Nantwich was known as "*Hellath Wen*", the "White Salt-Pit", by the Welsh (Calvert 1916, 32) and it is possible that salt-making at Nantwich could date back to the Iron Age or earlier times, with dendrochronological dates for one group of timbers at Snow Hill ranging between 118 – 20 BC (Reid 2004). Although there is evidence for salt-working during Roman times, it was during the medieval period that it formed one of the principal economic activities of the town when Nantwich was the leading producer of salt amongst the three Cheshire Wich towns, renowned for the quality of its fineness and whiteness. As early as the 16th century William Camden in *Britannia* (1586) refers to the build up of deposits "*In Nantwich the (brine) pit is full 7 yards (deep) from the footing about the pit, which is guessed to be the natural height of the ground, though the bank be six foot higher, accidentally raised by rubbish of long making salt or "Walling" as they call it*". In the early 16th century there were 400 salt-works recorded by John Leland, which had reduced to 216 during Elizabethan times. It was a highly regulated industry, and at Nantwich production was limited to just 12 days in the year, six at New Year and six at Barnes week. This was concentrated around First[t] and Second Wood Streets and Snow Hill, and the current Wall Lane refers to the name by which the salt-making district was called, Walling-land (Figure 2[1]). There was a single 6m deep brine pit at Nantwich, located next to the river at Snow Hill, from where brine was conveyed in wooden troughs and pipes to adjacent wich-houses and across the river to the Wood Streets (Calvert 1916, 41-2). A short-lived Norman castle, presumed to have been a motte and bailey, was constructed on the east bank of the Weaver to control the river crossing (McNeil 1978). The imposition of the defensive circuit appears to have determined the morphology of the medieval town.

[1] Figure 2 shows George Twigg's sketch plan superimposed over modern OS map. Red dots = waterlogged deposits; yellow dots = waterlogged deposits and location of dipwells; orange and yellow lines = transects through boreholes (see Figure 3)

Figure 2 Walling Lands (wych houses) Survey of Nantwich 1624 (after George Twigg)

Until the Industrial Revolution Nantwich was the second largest town after Chester, and it played a significant part in the Civil War, but by 1650 Nantwich had reduced to 55 wich-houses, by 1682 there were 27 lead-pans in operation (there were six pans to each wich-house), by 1778 there were just two remaining, and by 1856 salt-working had stopped altogether; the decline of the salt-industry during post-medieval times was partially due to frequent fires at the works, partially due to the failure to make the Weaver navigable, as well as Nantwich's distance from a coal supply, a fuel which replaced the abundant local wood resource as the main fuel from the 17th century, which put Nantwich at a disadvantage to its competitors (Calvert 1916, 52).

1.4 Desktop study

The first phase in the project was a desk-based survey (SLR July 2007), including analysis and compilation of data from previous archaeological investigations as well as borehole logs from the British Geological Survey and a few development schemes for which borehole logs were still available. This study plotted the occurrence of waterlogged deposits and their depths, as well as investigations that had provided negative evidence for waterlogging.

It is not intended to reproduce the deskstudy in full here, but a summary of the findings are essential in providing a comprehensive understanding of the nature and distribution of the waterlogged remains. Excavation records show that waterlogged deposits are widespread throughout much of historic Nantwich, but the terminology that has been used by different authors does not follow a standard nomenclature. The nature of the build-up of archaeological deposits includes many timber structures as well as leather and wooden artefacts, and other types of organic remains such as plant macrofossils and insects, contained within a matrix of silty-clays. Clay surfaces are interspersed amongst some of the accumulated deposits, as well as organic-rich lenses, but the 3 – 4m of post-Roman waterlogged deposits are not comprised entirely of organic remains.

Waterlogged deposits revealed through archaeological investigation are presented in Appendix 1 Table 1, and each site is cross-referenced by a reference number to Drawings 2 & 3, and Figure 3. Appendix 1 Table 2 presents archaeological investigations that showed the absence of waterlogged deposits, cross-referenced to Drawings 2 & 3, and Figure 3 in the same manner. Many of these deposits have been dated by association with wooden artefacts and therefore a list of dendrochronological dates is presented in Appendix 1 Table 3 (Radiocarbon dates from borehole samples submitted as part of the current study are also included in this table in order to collate all scientific dating for the town into a single table).

In Snow Hill, for example, very little excavation has occurred, but observations of deeply stratified deposits has allowed retrieval of timbers, dendrochronologically dated to 118 – 20 BC and 129 $\pm$ 18 AD (Reid 2004). Other Roman period timber structures have been found, mainly on the west side of the river, most notably at Kingsley Fields where two brine tanks (Plate 5) as well as a range of wooden tools and wicker-lined pits were excavated in 2002 – 3 (dendrochronologically dated to 130 AD), but a timber-lined tank (dated to 132 AD) and other structural remains have also been found west of St Anne's Lane, on the south side of Welsh Row (McNeil 1985 and Gifford 2006). Evidence for Roman waterlogged deposits suggests these are largely confined to features cut into the underlying clay, and there is little to suggest waterlogging led to an accumulation of material.

Plates 5 & 6 Roman brine tank Kingsley Fields 2003; medieval salt-ship preserved in situ at the Three Pigeons 2004

In the Welsh Row district four salt-ships, hollowed-out oak tree trunks for storing brine within salt-houses, have been found (in the 1980s and during the recent years (Frontispiece and Plate 6), on First and Second Wood Streets. Two medieval wich-houses were found, with wicker hurdles forming the inner walls and the salt-working arrangements still clearly laid out (Plate 7). Dendrochronological and pottery dating place these buildings in the period 1170 – 1250 (McNeil 1983). In addition stave-built barrels and parts of timber-frame buildings have been found in the same area during 2003-4 (Plate 8), a centre for medieval salt-making in Nantwich on the west side of the River Weaver, together with the area of Snow Hill on the opposite side of the River, industrial suburbs known as the walling lands (Figure 2).

Plates 7 & 8 First Wood Street excavation 1980 (note depth below surface, wattle walls and salt-ship); barrels and salt-ship at Second Wood Street excavation 2003

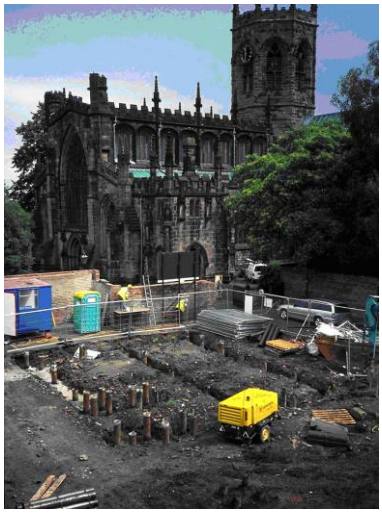
Corduroy trackways have been found during digging of service trenches along the High Street in the 1930s and 1980s, and along Welsh Row in 2007. The High Street timber roadways are associated with a coin of Henry III (1216 – 1272) found on the surface, and dendrochronological dating of the Welsh Row roadway has established a date in the second half of the 13th century as well (Tyers 2008), as well as an earlier roundwood track dated by radiocarbon to 1020 – 1150 AD. Along Churchyard Side on the north side of the church discoveries of saturated wooden coffins and skeletons wrapped in cerecloth and accompanied by hazel sticks have been reported over several centuries, in 1780, 1855, 1883, and 1925 (Simpson and Tasker 1925, 67-70). The coffins were dated to the 13th century, and in addition wooden drainpipes found along Churchyard Side in 1925 were suggested to be from 1584, inserted after the Great Fire of Nantwich. The report also mentions how the church was constructed "*on a bed of sand that is saturated with water*" (Plate 9 shows how steps down to the church are needed because of later build up), and that "*the graves are not eligible ones, for scarce are they got a foot below the surface but the coffins are immerst in water*", and that further coffins had been found in 1863 when the District Bank was built at the "extreme south end of Churchyard Side". Further records of waterlogged coffins and problems with sub-surface water at the church are recorded during floor replacement and service trenches (Williams 1985, 55 - 64). Archaeological monitoring of electric cables that were trenched through the churchyard in 2005 revealed "a collapsed timber coffin" at less than a metre below the surface as well as many skeletal remains, within a layer of dark brown clayey silt (Earthworks Archaeology 2005). Underpinning works because of subsidence of the Memorial Cross in 2002 revealed c.3m depth of deposit accumulation (Plate 10).

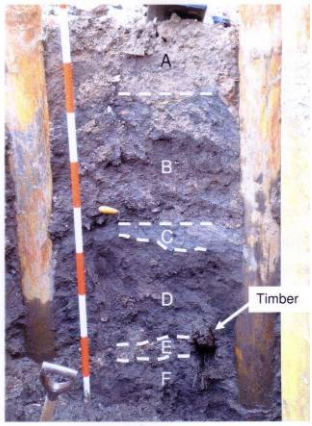
Plates 9 – 11 Steps down to church and back of Lamb Hotel; Memorial cross; "Lothburne" medieval drain excavated in 1995

Organic remains and a wooden drain (the "Lothburne" (Plate 11)) dated 1218 – 1263 were found in the Castle area, at a depth of 1.5m in the Bowers Row Car Park (Gifford 1995), but other investigations in this area have had variable results, with some organic-rich deeply-filled features being found, whilst adjoining areas seem to have had minimal accumulation above the natural geology (see Appendix 1 Tables 1 & 2). This could be explained by the nature of its use in the early medieval period as a castle, a fact that probably also governed many later activities on the site. The castle would have had some significant features, ditches and pits, which would have easily become waterlogged, whilst other areas would have had imported clay to form solid foundations for construction of the keep.

Along the north side of Hospital Street within the eastern part of the historic centre, waterlogged deposits over 3m in depth have been found in the 1970s and 2003 - 4. At the latter site, The Lamb Hotel (Plates 12 – 14), soil micromorphological studies confirmed

archaeological interpretation of probable stable refuse and related accumulations of debris interspersed with clay surfaces and horticultural activities. In addition a number of structural timbers, beams and plank floors, as well as wooden artefacts such as a stave built tub, were retrieved which have been dendrochronologically dated variously to post-1042, 1158 – 1183, and 1162 – 1322 (Gifford 2005).





Plates12 - 14 Lamb Hotel 2004 construction works in progress; plank floor & tub stave 2003; micromorphological study and stratigraphic sequence within new lift pit, 2004

From an analysis of this data, together with geological mapping and sub-surface hydro-geological modelling, it was possible to suggest an interpretation for the occurrence of deep waterlogged deposits in some areas, but not in others, and where the boundaries to the waterlogged zone might lie. The on-set of waterlogged deposits accumulating above the existing ground surface, rather than merely leading to preservation within cut features, appears to have been a post-Roman phenomenon, in which the mid 13th century seems to occur as a fairly consistent date obtained through dendrochronology, pottery and coin finds, for a period when the stratigraphic build-up was well-established, and after which accumulation continued for another century or two. A range of dates provide evidence for structures and artefacts that predate and post-date the mid 13th century, but it is this period that appears to be the heyday for the growth of waterlogged deposits in Nantwich. A predictive model was produced which was tested by the second phase of the project, the coring programme.

1.5 Coring programme

The coring programme consisted of 29 boreholes plus one further core location (Drawing 2) and was undertaken in two stages, allowing a period in-between for review of the first stage and revision for the second stage so that locations of boreholes, methods and resources could be utilised most effectively. The first stage concentrated on confirming the suspected outer limits of the waterlogged deposits, whilst the second stage targeted areas within the known zone of waterlogging to provide samples for palaeoenvironmental assessment and radiocarbon dating. In addition advantage was taken of a National Grid pipeline to make a rapid record of the deposits beneath the roadway in Welsh Row, and to utilise samples from this work for contributing to the general results from the structured coring programme (see section 4.8 below).

Prior to the present project “waterlogged deposit” was used as a label for much of the deep archaeological build-up that had been found during many investigations, including alluvial lenses interspersed with riverside archaeological remains. Additionally the term had also

been used at times to describe deposits that contained predominantly dry and inorganic archaeological remains. The depth of accumulation and the nature of the dark silts containing charred remains were suggestive of previously wet deposits, but during assessment of the sediment cores for palaeoenvironmental evidence, for assessment of the state of preservation, and for scientific dating of waterlogged deposits, it became evident that only a proportion of the previously identified waterlogged deposits could be technically labelled as such. There is therefore a distinction between the general understanding of what is meant by the waterlogged deposits in Nantwich and a more precise definition that would have excluded many of the deposits as characterized by the limited sampling from sediment cores.

In the context of the present project the phrase *waterlogged deposits* is understood to mean those sediments with archaeological remains that include both survival of organic material (described below in 3.1.1 as *Non-carbonised organic-rich deposits*) as well as survival of charcoal and other signs of human activity (*Archaeological deposits, silts clays and sands of black – light grey colour*). In the conclusions two zones of preservation are identified, Zone 1 close to the river with good preservation of organic material, and Zone 2 which includes deposits that were previously waterlogged but are now in a state of organic degradation and decay. The aim of the project was to examine both types of deposit and to characterize them and their state of preservation, and thus this report refers to both types as part of the waterlogged deposits of Nantwich.

1.6 Baseline monitoring

A variation was proposed and accepted for the second stage coring to take advantage of the programme so that a series of 11 dipwells could be installed (Figure 3). Baseline testing of these was undertaken in November so that the water-level and water-chemistry could be established in each dipwell. As part of the management plan a longer-term monitoring regime will be recommended to form a second phase to the overall project and therefore the first round of dipwell testing will establish baseline conditions against which comparative results can be plotted over successive years.

2.0 METHODOLOGY

2.1 Drilling Rig Selection

An important initial decision was the selection of the most suitable sampling method. A key objective of the project was to gain samples from numerous locations to significant depths (up to 6.0m below ground level) across a wide area of Nantwich, often in sensitive locations. Using an excavator would not have been a practical method of obtaining the samples (due to depth of deposits, area needed for excavation and public safety concerns), and the logical alternative was to use a drilling rig to obtain samples for recording and analysis.

As a wide range of drilling techniques were available it was necessary to select the most appropriate rig for the task. The key criteria for selection of the drilling method included retrieval of a valid uncontaminated sample size, penetration depth, cleanliness, operating area and size of the machinery, health and safety, speed and cost effectiveness. The main types of drilling techniques available were rotary coring, rotary auguring, shell and auger and window sampling.

Rotary coring was eliminated as a suitable option due to the prohibitive cost in obtaining the samples and the potentially poor rate of sample recovery. The soft deposits needed to be sampled would largely have been washed away by the water flush used to lubricate the drilling process. This technique is only suitable for harder geological formations.

Although rotary auguring could have advanced the boreholes very quickly, it would not provide the quality of sample required for this project. Not only would the sample have been highly disturbed by the grinding and screw design of the drilling process but it would also be extremely difficult to accurately gauge the depth that the sample came from. It would also have been more expensive to use than a percussive drilling technique.

Using a shell and auger rig (cable percussion) would provide relatively high quality samples, but the technique was considered to pose an unnecessary risk to the health and safety of the general public. The free falling cutting tool could potentially be very hazardous in busy public areas, with the resulting spillages of wet mud also creating a potential slipping hazard. There were also issues relating to the size (particularly the height and manoeuvrability of the rig which would prevent access to key locations and limit the amount of sampling locations that could be completed per day.

Plate 15 Windowless sampler in operation at BH E (Mill Island)

It was decided that the most suitable technique would be to use a compact windowless sampling rig to obtain percussive core samples, extracted in cylindrical Perspex sampling tubes which preserves the samples intact and protects them during transportation (Plates 15 -17). This technique uses a heavy weight attached to a sliding runner enclosed behind a metal cage to hammer in a metre long sampling barrel to obtain a one metre core of soil contained within the plastic tube. A tubular metal case is advanced outside the cutting barrel every time a sampling tube is advanced. This ensures that any overlying loose material does not collapse in on top of the material below, ensuring that a sequentially continuous sample is obtained. This is essential in correlating the depth of sampling with the chronological succession of deposition.

Plates 16 & 17 Windowless sampler, percussion rig and steel case; Perspex sampling tube

The rig is also very compact, and being mounted on tracks it is highly manoeuvrable, enabling the rig to access locations quickly and easily (Plates 18 - 20). In addition to providing high quality samples quickly and safely, windowless sampling was the most cost effective solution available. Although this method can struggle to penetrate harder materials at depth it was considered not to be a problem as it would only be necessary to sample soft superficial deposits at depths of less than 6 metres. A combination of factors including good quality sampling, high levels of safety and low cost, made windowless sampling the most suitable choice for this project.

2.2 Drilling Methodology

The coring of each borehole was completed using the same methodology at each location. The drilling works comprised:

- Checking for underground services at each location using a cable avoidance tool, checking all manhole covers in the vicinity and referring to the services drawings provided by the utilities companies.

- Setting safety barriers around the work area to prevent the general public being injured by the window sampling rig.

- Setting up the rig over the drilling location and ensuring that the machine was level before commencing the drilling.

- Cutting through any concrete or tarmacadam hard surfacing using a rotary coring device attached to the window sampling rig and removing the hard material as a solid cylinder approximately 200mm in diameter.

- Advancing a 100mm steel cutting tool containing a plastic core liner with a percussive hammer. The percussive hammer is repeatedly lifted and dropped by a revolving chain on the window sampler pushing the window sampler into the ground in an increment of a few centimetres until a depth of one metre has been reached. A tubular steel cylindrical casing is advanced simultaneously outside the cutting tool to prevent loose material collapsing back into the hole.

- The cutting tool is then extracted from the hole using a winch and the plastic core liner containing the sediment core sample is pulled out of the cutting tool (visible on Plate 3). A new plastic core liner is then inserted into the cutting tool ready for the next sample.

- The empty cutting tool is then placed back into the hole ready to progress the hole by another metre. A steel rod is screwed into the base of the cutting tool and an additional length of casing was connected to the length already in the ground. The next metre was then advanced using the percussive hammer and the next core sample was extracted using the winch on the rig.

- This process was repeated until the desired depth was reached.

- The casing was not extracted until the groundwater monitoring well was installed if it was required.

The sediment core samples were then taken to the field archaeologists for recording and sampling.

2.3 Location Selection

The first stage of drilling followed the project proposal of using public space, mostly car parks, in which to place boreholes (Figure 3 and Drawing 2). The strategy for this stage was to define and confirm the limits to the extent of waterlogged deposits as predicted through the desktop exercise. Of the 11 locations two (A and B) were beyond the built up area, north of Snow Hill, two were on the west side of the river within the area of the two Wood Streets (C and D); BH E was on Mill island, G north of the Market area in a back plot (private land) for a medieval property (19 High Street), H was in a garden area immediately south of the Civic Hall, I was next to the public conveniences in the Civic Hall car park, and J was in The Gullet car park. BH K was drilled in the Castle car park where archaeological investigations in recent years have produced conflicting evidence for waterlogged deposits. BH F was located in Church Lane car park as a control to the other boreholes, as this location was adjacent to known deep waterlogged archaeological remains at The Lamb Hotel and to the northwest of 31 Hospital Street.

Plate 18-20 Drilling in small spaces; an advantage of the windowless sampler (BH G, H, Z)

The second stage of drilling took a different approach, by choosing locations from a detailed ground reconnaissance in the area of suspected waterlogged deposits, and then negotiated access with private owners. This targeted key areas and provided a grid of locations to help with sub-surface modelling (Drawing 2). Two locations were chosen on the west side of the river (AA and AB), to confirm the western boundary for waterlogged deposits; an additional sample was provided by the National Grid pipeline in Welsh Row (AD). Two boreholes were sunk in the area of the castle to supplement K and investigate the variability of deposits within this zone (X and Y). BH Z was located in a yard fronting on Barker Street to test the prediction that this area was outside of the zone of waterlogged deposits. BH P was located behind 29 High Street, S was next to the memorial cross in the Market Place, three boreholes continued a line eastwards from BH S through the church yard (T, U and V), whilst R and Q were locate in the yard beside the covered market north of Churchyard Side. BH W was located in the Rectory gardens to help form a north-south transect with the previous boreholes, and also with BH O which was drilled on the western side of the Baptist Church off Market Street. BHs M, N and AC were located in Snow Hill car park to trace the spatial extent and depth of waterlogged deposits in this area. The final location was in a small car park off Manor Lane to confirm that this area lay outside of the zone of waterlogging.

2.4 Recording, Sampling and Testing of Deposits

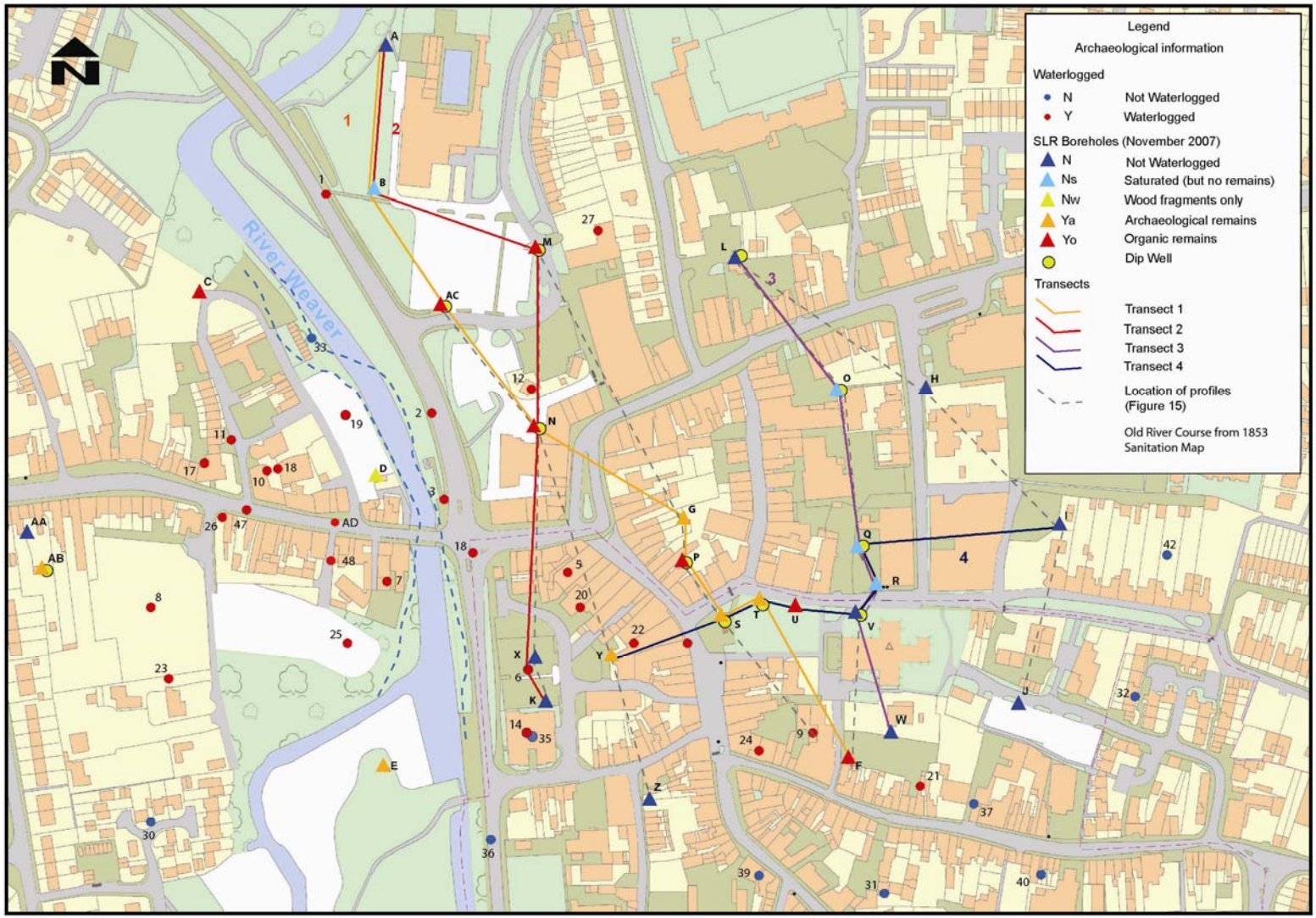
A total of twenty-nine boreholes (designated BHs BH A-Z and AA-AC) were sunk to depths of between 3 and 6 metres below the current ground surface. The cores were retrieved in 1 metre plastic sleeves which were split for examination of the deposit sequence and the deposits separated into subsamples with recorded depth ranges (marked on the subsamples) – where possible the subsamples were packaged so as to retain the stratigraphic sequence of the deposits.

2.5 Staged Approach and Iterative Process

As part of the original design it had been proposed that the coring programme should be split into two or three stages so that lessons could be learnt from the first stage, and a revised strategy could be adopted for subsequent stages. The coring programme was undertaken in two stages, in August and September 2007. The first stage included sinking 11 boreholes in locations that had been planned to test the expected boundaries of the waterlogged deposits. The second stage included 18 boreholes and a National Grid inspection hole (labelled AD) targeted at the areas with known waterlogged deposits so that samples could be retrieved for palaeoenvironmental and chemical assessment, and so that a grid of borehole logs could assist in mapping the sub-surface deposits (Figure 3 and Drawing 2).

Once the core samples had had detailed descriptions recorded standard software was used to produce a series of graphic borehole logs. The complexity of the deposit sequence resulted in a wide range of descriptions (see 4.1 below), and in order to progress interpretation and analysis these diverse descriptions were rationalised into a small number of simplified deposit categories (see discussion in 4.2.2 and 4.4.1). From these it was possible to undertake deposit mapping through selection of four transect lines to connect boreholes on north-south and west-east orientations (Figure 3; Figures 4 - 7).

Figure 3 Boreholes, dipwells, and borehole transects to aid deposit mapping



2.6 Monitoring Well Installation

A 50 mm diameter slotted PVC monitoring well was installed in eleven boreholes to provide a means of monitoring groundwater and soil gas, and obtaining groundwater and gas samples as required (Figure 3 and Table 2). Well screens were positioned to intercept water levels within the underlying soil strata, and the annulus between blank casing and the borehole was sealed with bentonite. A rubber bung with a gas tap was placed on top of each well to allow natural soil gases to build and be monitored using a gas analyser. Each hole was capped off with a stopcock cover set in concrete.

2.7 Groundwater Baseline Testing

All of the groundwater monitoring wells installed during the coring programme were monitored on the 19th and 20th November 2007, prior to sampling for the baseline testing.

The depth to groundwater and the base of the well were measured using a dip meter, and the total organic vapours were measured using a GMI gas surveyor calibrated to pentane. Groundwater samples were taken using a peristaltic pump discharging through a flow cell connected to a digital water quality meter made by Hannah© instruments ltd. All of the groundwater samples were filtered using a 45 micron filter. Properties including pH, eH (REDOX Potential), conductivity, temperature and dissolved oxygen were recorded using the water quality meter.

The analysis for sulphate, sulphide, sulphur, nitrate, phosphate, acid soluble carbonate, carbonate alkalinity, natural moisture content, total organic carbon and loss on ignition was completed at an accredited laboratory, Alcontrol of Chester. Separate samples were taken using preservatives according to the instructions from the laboratory. These included hydrochloric acid and zinc acetate.

2.8 Palaeoecological assessment methodology

Coring

Twenty-nine boreholes (designated BHs A-Z and AA-AC) were sunk to depths of between 3 and 6 metres below the current ground level using a sleeved windowless coring rig during two phases of sampling in August and September 2007 (Drawing 3). In addition, a single small bulk sediment sample (designated AD) recovered from a post-Roman layer overlying a Roman road during excavations by Earthworks Archaeology at Welsh Row, Nantwich was submitted for investigation.

Sediment descriptions and sampling

The boreholes were extracted in one metre plastic sleeves which had to be split in order to examine and describe the sediment sequences in the field (some were similarly examined at PRS as recording of the cores proved to be a longer process than their recovery).

The properties of the sediments were recorded and a preservation category (PC) assigned to the layers following the state of preservation scale (SOPS) established by the Bergen excavation office for the recording of borehole samples.

The cores were subdivided into subsamples according to their stratigraphic composition and placed into labelled polythene bags. Where the sediment was consolidated the sampling was undertaken so as to preserve the stratigraphy. Where unconsolidated, the depth range of the sequence was recorded but the internal stratigraphy of the subsample could not be retained.

During recording, subsamples were also extracted for chemical analysis, where possible retaining approximately half of the sediment sequence for the preservation study. The chemical analyses were co-ordinated by Ian Panter (York Archaeological Trust – YAT) and are presented elsewhere (see sections 2.10 and 3.5).

The positions of organic inclusions (typically of waterlogged wood) within the boreholes were recorded and they were removed as organic 'spot' samples (*sensu* Dobney *et al*. 1992) for identification, recording and subsequent submission as possible candidates for radiocarbon dating. The initial identifications and recording were undertaken by Steve Allen (YAT) and are reported elsewhere (see section 3.4; the species identifications are included in Appendix 3: Table 1).

Sample selection and processing

Samples were selected for processing based on their potential to address the project aims (i.e. to provide information on the waterlogged preservation of organic remains in the deposits under Nantwich). In addition, some apparently 'natural' lower sequence deposits from BHs F, N and P were investigated primarily to ensure the absence of artefactual remains of late date (post-medieval or later) which would preclude radiocarbon dating of remains from higher in the sequences.

A total of 78 subsamples were processed representing deposits within 17 of the boreholes and the additional small bulk sample AD. The most extensive organic sequences were identified within boreholes BH F, N and P and, consequently, these were the most heavily subsampled. Other boreholes from which smaller numbers of subsamples were processed were BH B, C, D, E, G, M, Q, R, S, T, U, V, Y and AC. The remaining sediment from sequence sections (either 'vouchers' of unprocessed sediment from the subsamples or 'whole' deposit samples of those not selected for investigation at this stage) were retained for cold storage. The exceptions to this were the upper deposits of modern overburden/'hardcore' present (usually in the first metre below the current surface).

Subsamples were processed for the recovery of plant and invertebrate macrofossils, broadly following the techniques of Kenward *et al*. (1980). The weights of the subsamples were recorded prior to processing.

For each of the processed macrofossil subsamples small quantities of sediment (a few tens of grammes) were extracted for a parallel investigation of microfossil preservation.

Macrofossil recording

Plant and invertebrate remains in the processed subsample fractions (washovers and residues) were recorded briefly by 'scanning' (using a low-power microscope where necessary), identifiable taxa and other components being listed on paper. When the fractions were primarily mineral in nature or of charred remains they were dried prior to recording and when predominantly of waterlogged organic material they were examined wet. A five-point scale was employed to record the proportion of organic material recovered in the washover fraction (see Appendix: Table 2).

Five-point scales were also employed to record the abundance, diversity and preservation of the plant and invertebrate remains recovered (Appendix 3: Table 2); the scales for diversity and preservation following those created by Smit *et al*. (2006) for the recording of botanical macrofossils, with some minor modifications to accommodate their extension to additional classes of remains. [Note that these three values, together with that for the overall proportion of organic content, provide a 4-point baseline record of the organic survival within the deposits for each class of remains present. The requirement of the Norwegian protocol for

the recording of excavation deposits is for a single value to be assigned for each class but this was felt to be insufficiently precise for the current exercise where records of both quality and quantity of preservation were required].

Specific identification of macrofossil remains was undertaken where this was necessary to determine values for abundance and diversity and/or would provide additional information regarding the origin of the material or the nature and depositional environment of the deposit.

During recording, consideration was given to the suitability of the remains for submission for radiocarbon dating by standard radiometric technique or accelerator mass spectrometry (AMS). Notes of the presence of such material are included in Tables 4-7.

Nomenclature for plant taxa follows Stace (1997) and insects follow Kloet and Hincks (1964-77).

Microfossil recording

Microfossil content and preservation was investigated using the 'squash' technique of Dainton (1992). This was originally developed specifically to assess the content of eggs of intestinal parasitic nematodes but routinely reveals other microfossils, such as pollen and diatoms. The assessment slides were scanned at 150x magnification with 600x used where necessary.

The same scale employed for the proportion of organic material within the washover was used to record the percentage of organic material within the raw sediment seen under the microscope (at 150x magnification). Similar five-point scales to those used to record the abundance, diversity and preservation of macrofossils were created for the assessment of the microfossils (Table 3).

Nomenclature and comparative size values for intestinal parasite eggs follow Ash and Orihel (1984) for human parasites and Kassai (1998) for those of domestic animals. Occasional identification of fungal spores (where particularly abundant) follows van Geel *et al*. (2003).

2.9 Method for assessing the condition of preserved wood

Spot samples of wood were collected from six of the boreholes (C, D, F, N, U and V) and submitted for laboratory testing at York Archaeological Trust to assess the level of preservation. Standard wood decay tests (Panter and Spriggs 1996) were carried out including maximum water content, density and "loss in wood substance".

Maximum Water Content: this is a measure of the amount of water present within the sample of wood expressed as a percentage of the dry weight. High water content (usually greater than 185%) indicates a high level of decay of the wood.

Density Assay: the density of wood is determined by the amount of "wood substance" present per unit volume (Dinwoodie 1989) and hence a reduction in "wood substance" (through decay) will result in a lower density. Density values were determined by weighing the sample in air and submerged under water and using standard formulae (Cook and Grattan, 1990).

Loss in Wood Substance: is defined as the difference between the sample density and the density of undecayed wood of the same species. For example, the standard density of English oak is 0.56g/cc.

2.10 Geochemical assessment methodology

In order to characterise the nature of the burial environment, a total of 45 soil samples were collected from 23 boreholes and submitted to Alcontrol for analysis. Samples were selected following on site assessment of each core in discussion with the project palaeoenvironmentalist. Samples were selected from those deposits that appeared to be "archaeological" and also from deposits that appeared to have an organic component. Further samples were also taken from predominantly mineral sediments and also from around fragments of wood. Overall, whilst not all boreholes were sampled, sufficient samples were taken from a range of deposit types to enable deposit characterisation.

Approximately 250g of sediment was extracted from the core and stored in an airtight plastic container which was then kept at a low temperature until despatch to the laboratory. The majority of samples were despatched within 96 hours of sampling. Parameters measured by Alcontrol (using standard techniques) included pH, loss on ignition, total organic carbon, natural moisture content ratio and assays for total sulphur, sulphide, sulphate, nitrate, carbonate and phosphate. Unfortunately the laboratory was unable to undertake iron II and III assays.

Rationale for tests

The suitability of a burial environment for preservation of organic material can be determined by looking for a number of chemical species which are termed redox sensitive parameters.

Redox sensitive parameters

Decay processes within soils and sediments are primarily an oxidative process mediated by microorganisms. In deposits where oxygen is abundant aerobic organisms will utilise this oxygen to oxidise organic material, and the oxidation reaction is always accompanied by the reduction of other compounds. When the oxygen supply is exhausted further oxidation/reduction (redox) reactions will occur again mediated by specific groups of microorganisms, and represented by the predominance of different chemical species/compounds within the burial environment. Therefore oxidation reactions will occur even if oxygen is absent. The major redox sensitive parameters that can be measured include:

Table 1 Redox sensitive parameters (from Corfield 2007)

System	Redox potential range (mV) corrected to pH 7	Microbiology
Oxygen disappearance	+500 to +350	Aerobes
Nitrate disappearance	+350 to +100	Facultative anaerobes
Manganese^{2+} formation	Below +400	Facultative anaerobes
Fe^{2+} formation	Below +400	Facultative anaerobes

Sulphide formation	0 to -150	Obligate anaerobes
Methane formation	below -150	Obligate anaerobes

The above redox sensitive compounds will be utilised by the microorganisms in order to oxidise organic material present in the burial environment, and once a compound has been exhausted, or is absent, then the microbes will utilise the next compound lower on the list. Aerobic bacteria require oxygen to be present, facultative anaerobic bacteria can grow in both oxygen rich and oxygen free environments and obligate bacteria can only grow in oxygen free environments.

Therefore it is possible to characterise the nature of a burial environment by either identifying which redox sensitive parameters are present or by measuring the redox potential (termed Eh, measured in mV) using a suitable redox probe. In order to better understand measured redox values, it is important to identify which redox sensitive parameters are present within the burial environment.

Additional tests carried out on each sediment sample included phosphates (to assess level of nutrients for microbiological activity, Loss on Ignition (LOI) to assess overall concentration of organic material in the sediments, and carbonate and pH to identify whether the deposits were acidic or alkaline in character. Further tests automatically undertaken by the laboratory included total organic carbon (TOC) and moisture content ratios.

2.11 Diatom assessment methodology

The key aim of this study was the identification and assessment of diatom presence, state of preservation and indications on environment or water quality data to include the degree of salinity present. The samples were recovered from cores taken during an assessment of waterlogged preservation. As such, the samples lack data relating to their specific archaeological context, and with the exception of the samples from BH P, these samples are effectively 'spot' samples.

The samples were prepared following standard techniques (Battarbee 1986). Organic matter was oxidised in a 30% hydrogen peroxide (H_2O_2) solution, by placing samples in beakers on a hotplate at a temperature of 90ºC for approximately 2 hours. A few drops of concentrated hydrochloric acid (HCl) were added to each sample following oxidation in order to remove carbonates. The samples were then transferred to test tubes and washed with distilled water in a Centaur 2 centrifuge at a speed of 1200rpm for five minutes, to allow the clay particles to form in suspension while the diatoms and other silt-sized particles formed a pellet at the base of the test tubes. The water was decanted after each wash, leaving the pellet intact, and individually numbered plastic pipettes were used to re-mix each sample and avoid cross contamination. This process was repeated until all clays had been removed (i.e., when the supernatant ceased to be cloudy). Samples were then topped up with distilled water to 10ml.

Sample residues of two different concentrations were dried overnight on 40mm round cover slips then mounted onto microscope slides using Naphrax®, which has a suitable refractive index. Slides were heated on a hotplate in the fume cupboard at a temperature of 90˚C for ten minutes, to evaporate the toluene from the Naphrax®, and then cooled before counting.

Taxonomic identification was made using a Leica DMLS under oil immersion at a magnification of x 1000 and identification was determined to species level using Germain (1981) and Krammer and Lange-Bertalot (1986, 1988, 1991a, b). Approximately 200-300 valves were counted per slide so as to provide a statistically reliable estimate of species composition; the number counted was dependant on the frequency of diatom frustules in

each sample. To indicate their relative abundance, the species counts for each sample were converted to a percentage of the whole sample count and species present at under 4% were disqualified.

The preservation of diatom frustules was noted and diversity was categorised based on the number of species present in each sample; 1 to 10 = low; 11 to 14 = low-medium; 15 to 19 = medium; 20 and over = medium-high. For BH P the diatom data were displayed using TILIA (Grimm, 1991) and TG View (Grimm, 2004) to highlight changes in species composition through the profile. For the discussion, the environmental affinities of individual species were taken from Germain (1981) and Juggins (2008).

3.0 RESULTS OF BOREHOLE INVESTIGATION AND BASELINE TESTING

3.1 Overview of Stratigraphic sequence and geological deposits

3.1.1 General

The ground conditions encountered during the coring programme were generally as anticipated from the desk study (SLR July 2007). The natural superficial strata encountered included Alluvium, River Terrace Deposits and Glacial Till; no solid geological strata were encountered. As anticipated within the developed area, the natural strata were overlain by made ground (Figures 4 - 7). In addition, archaeological (waterlogged) deposits were clearly identified within the shallow sequence (see detailed logs in Appendix 2).

The following criteria were used as guidance in simplifying the boreholes so that the detailed records could be fitted into general categories to aid comparison and deposit modelling, plotted as a series of transects shown on Figure 3 (see also Drawing 2 and Figures 4 -7; the same colour coding has been used in plans and sections):

- Made ground: records from the higher part of the borehole which included brick, mortar, modern materials, or identifiable inclusions datable to the 18th – 20th centuries

- Archaeological deposits: silts, clays and sands, black – light grey in colour, which contained evidence of human activity such as ash, charcoal, pottery, bone etc (first part of “waterlogged deposits”)

- Non-carbonised organic-rich deposits: plant-microfossils, wood, leather, plant debris and sulphide smell (second part of “waterlogged deposits”)

- Mineral-rich deposits: grey clays, silts and sands that contained no inclusions of archaeological origin but were also not part of the natural drift geological sequence; this category includes deposits adjacent to the river that are of probable alluvial origin

- Fluvio-glacial deposits: records from the lowest part of the borehole describing sands that form the top of the natural geological sequence

Figure 4
Deposit model from eastern borehole transect (north – south)

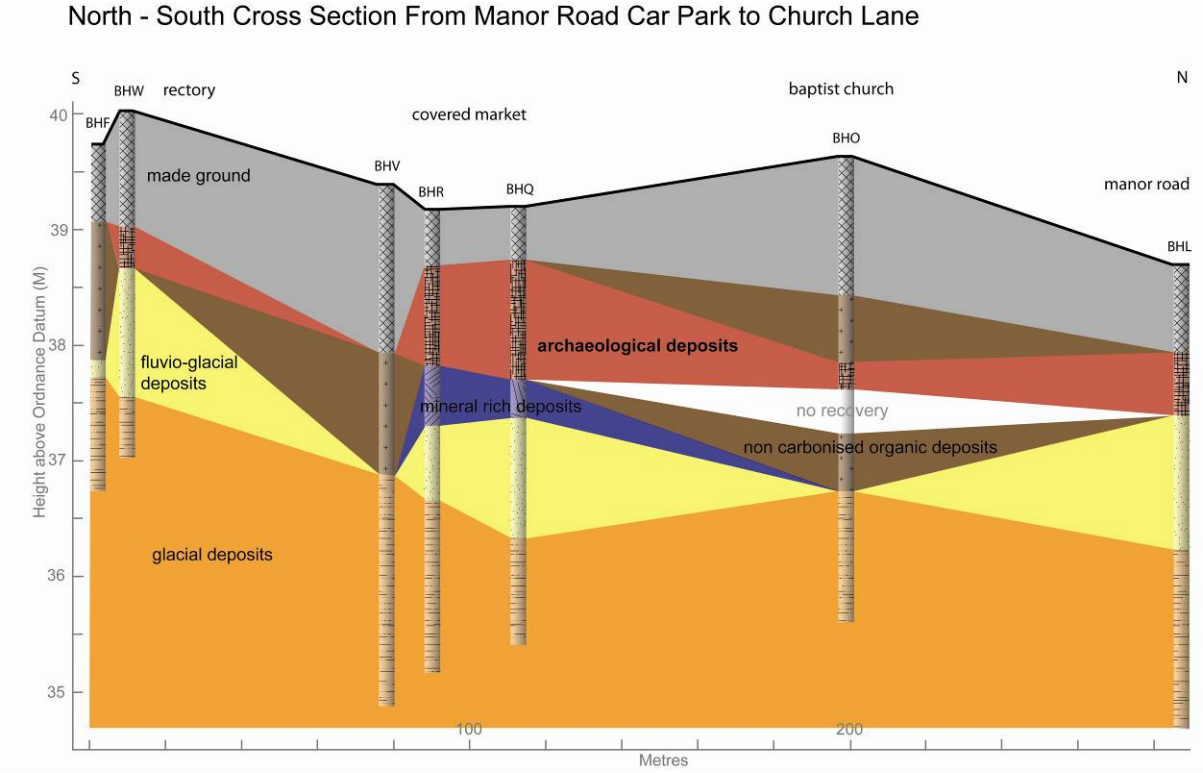
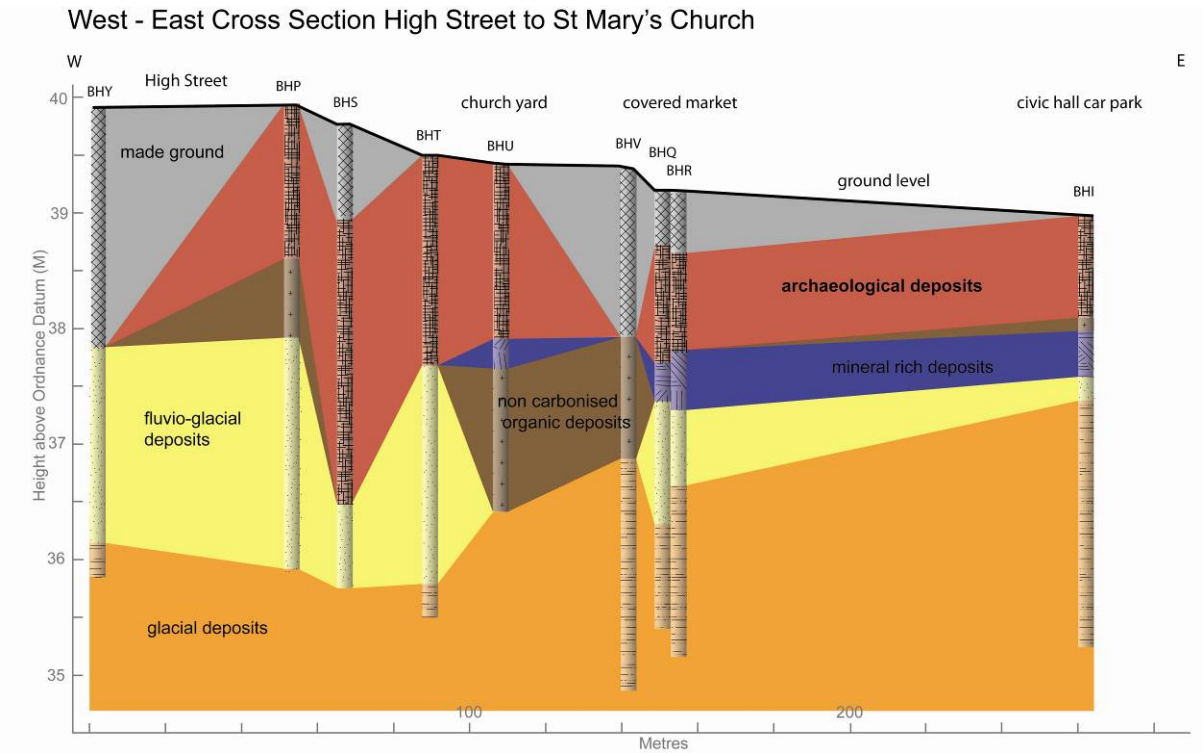


Figure 5
Deposit model from west-east borehole transect



The strata encountered are described in more detail below.

3.1.2 Made Ground

A variable thickness of made ground was encountered beneath the developed areas of the town, with typical thicknesses of between 0.2m and 2m recorded.

The made ground comprised a variety of naturally sourced soils and sediments (clays, silts, sands and gravels) containing fragments of man-made materials including brick, masonry, ceramics, glass, ash/clinker and wood fragments etc.

3.1.3 Waterlogged Deposits

The archaeological deposits encountered (Drawing 2) were typically described as moist/wet dark grey or dark brown organic silts. They were divided into two categories:

- Archaeological deposits consisting of silts, clays and sands, black – light grey in colour, which contained evidence of human activity such as ash, charcoal, pottery, bone, and:

- Non-carbonised organic-rich deposits which included plant-microfossils, wood, leather, plant debris and sulphide smell.

Figure 6
Deposit model from central borehole transect (NW – SE)

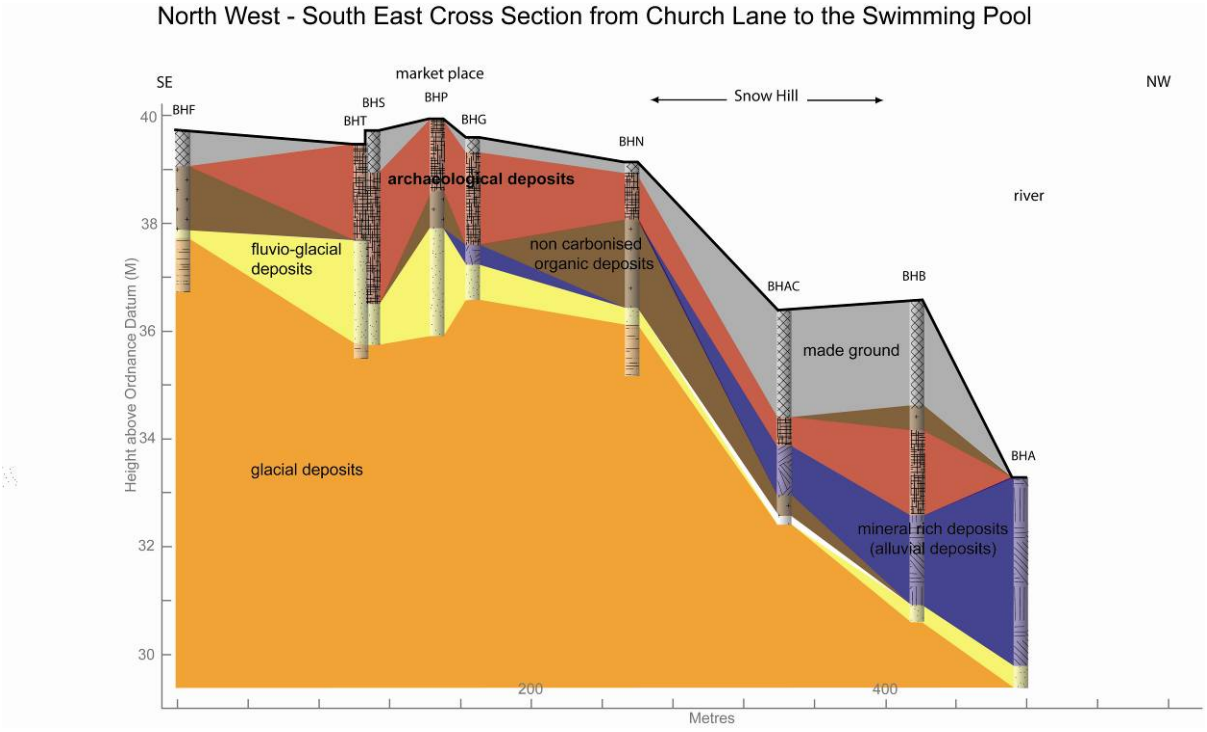
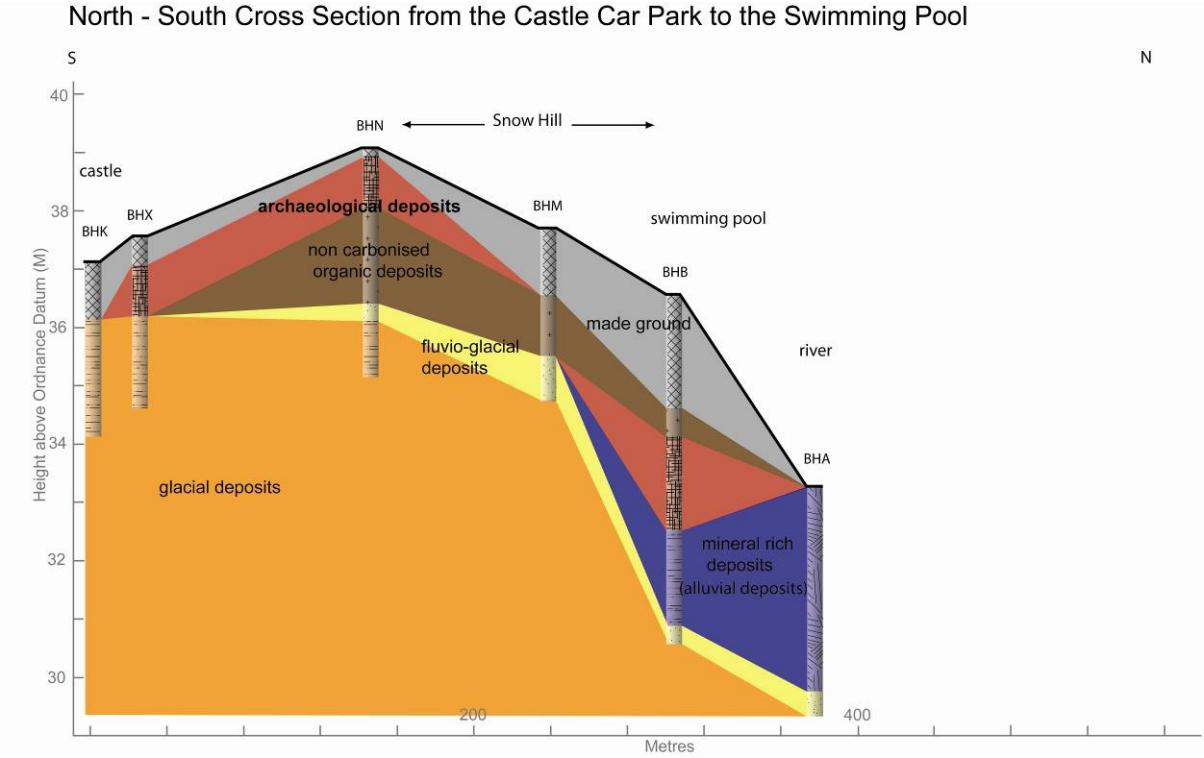


Figure 7
Deposit model western borehole transect (N – S)



3.1.4 Mineral-rich Deposits and alluvium

In some boreholes sediments were found which were not deposited by fluvio-glacial action, but also these sediments did not contain organic or archaeological material. It was assumed that these were re-worked, as sometimes they were encountered overlying archaeological deposits (e.g. BH U at the churchyard, perhaps due to grave-digging).

Alluvial deposits were included in this mineral-rich category, and were encountered in the boreholes drilled close to the river (e.g. BH A, BH B, BH C) at lower elevations below approximately 34m above Ordnance datum (aOD). The Alluvium encountered consisted of cohesive deposits typically comprising occasionally organic clayey silts and sandy silty clays.

3.1.5 Fluvio-glacial (River Terrace) Deposits

The River Terrace Deposits were generally encountered beneath the Alluvium in the vicinity of the river, at elevations below approximately 30m aOD, gradually rising to 38m to 39m aOD beneath the higher ground with distance away from the river.

The River Terrace Deposits encountered consisted of predominantly granular materials typically described as occasionally slightly clayey sands withy occasional gravels.

3.1.6 Fluvio-glacial (Till) Deposits

The Glacial Till was the deepest strata encountered beneath Nantwich.

The Glacial Till consists of a cohesive stratum typically described as very stiff brown clay, occasionally sandy and with occasional gravel.

3.2 Groundwater: levels, flow and quality

The results of the groundwater testing are tabulated below, and some general conclusions based on these results are summarised.

Table 2
Groundwater Monitoring Data

Dipwell No	Screened interval (m)	Surface elevation (m aTBM)	Depth to water (m)	Water elevation (m aTBM)	Well vapours (ppm TOV)
AB	1.0-3.0	37.93	2.13	35.8	40
AC	1.0-4.0	36.42	2.83	33.59	20 000
L	1.0-4.0	38.710	2.28	36.43	35
M	1.0-3.0	37.810	1.58	36.23	905
N	1.0-4.0	39.165	1.37	37.795	80
O	1.0-4.0	39.642	1.44	38.202	10
P	1.0-3.8	39.925	3.33	36.595	170
Q	1.0-4.0	39.215	1.71	37.505	170
S	1.0-4.0	39.770	3.34	36.43	130
T	1.0-3.0	39.495	3.16	36.335	140
V	1.0-3.0	39.390	1.95	37.44	60

[1] Depths are below grade measurements made relative to ordnance datum
[2] Separate Phase Hydrocarbons
[3] parts per million Total Organic Volatiles, measured using a GMI Gasurveyor calibrated to pentane

The average depth to groundwater was approximately 2.3m below ground level.

The direction of groundwater flow is inferred to be towards the river, however the results from the groundwater monitoring were too inconsistent to prove this definitively.

A limited programme of groundwater analysis has been conducted following the installation of 11 dipwells. The data from the water quality testing are contained in Appendices 4 and 5. Parameters recorded include water levels, redox potential, pH, conductivity, salinity, dissolved oxygen, as well as the major redox sensitive parameters and methane gas. Data was collected on 20th November 2007, and data plots can be viewed in Appendix 5. Conclusions drawn from these data sets can only be tentative – the data represents readings collected on one day only, and each dipwell has a broad response zone collecting water from between 1-3m below the ground surface. However, the results broadly complement the conclusions from the sediment geochemical analysis.

Measured redox values lie above the sulphur boundary and therefore groundwater conditions on 20th November 2007 in Nantwich can be described as being of a reduced nature (see Fig. 18 and Table).

The pH values recorded from groundwater in the dipwells is marginally more acidic than the pH values measured in the sediment samples. This may reflect the more oxidised nature of the water.

Conductivity values ranged from a minimum of 471 μS/cm (BH V) to a maximum of 3505 μS/cm (BH AC). Conductivity values have been used to determine the source of water in natural ecosystems, with values less than 100μS/cm being indicative of moisture derived solely from precipitation and values in excess of 100μS/cm indicative of moisture derived

from groundwater as well (Caple and Dungworth, 1998 p20). The below ground deposits in Nantwich are likely to be recharged by a combination of ground- and surface water flow.

There is a high degree of correlation between conductivity and salinity (see A5 figures 1 and 2) which suggests that most deposits within Zone 2, the medieval core of the town, are recharged principally through surface water flow and that there is no connectivity with the river. This is to be expected given the elevated topography of this area.

Analysis of methane levels (A5 Figure 9) reveals 3 “hot spots” within the medieval core of the town. One “hotspot” is centred around BH N where preservation of organic remains was good. Methane is an indicator of highly reducing/anoxic conditions conducive to preservation of organic remains. Comparison with other data sets for BH N is informative. For example, low levels of phosphate and nitrate (A5 Figures 10 and 7) were recorded from groundwater samples, and a negative redox reading (A5 Figure 4) is indicative of reducing conditions. Low levels of sulphate and ferric iron were also detected too (see A5 Figures 5 and 6).

3.3 Palaeoenvironmental Assessment

3.3.1 Results

A brief summary of the results of the investigations is presented below. Details of the recorded sediments are presented in Appendix 3, Table 1 (i-xxix). Details and summary data for the plants remains are given in Appendix 3, Tables 4-10 and 13 and Figures 1-3, invertebrate macrofossils (other than unidentified mollusc shell) in Table 11 and microfossil records are shown in Table 12.

Twelve of the boreholes (BH A, H, I, J, K, L, W, X, Z, AA and AB) were judged unlikely to provide information useful to the aims of the project (many containing voids within the sediment sequence when extracted so that the depths of the deposits could not be reliably determined). No investigation of these deposits was undertaken beyond the initial sediment descriptions.

Borehole B

Possible ‘ancient’ waterlogged organic material was noted during the recording of BH B and three subsamples were investigated – subsamples B1 (depth 3.00-4.00 metres; AOD 33.26-32.26), B2 (depth 2.44-2.64 metres; AOD 33.82-33.62) and B3 (depth 2.64-3.00 metres; AOD 33.62-33.26).

The macroscopic organic content of these deposits was predominantly charcoal, wood and rootlet, with an occasional twig (subsample B3) and a little bone. None of the remains could be identified.

The microfossil subsamples showed some organic content but identifiable remains were confined to a few diatoms and fungal spores from subsample B3.

Borehole C

Possible ‘ancient’ waterlogged organic material was noted during the recording of BH C and three subsamples were investigated – subsamples C1 (depth 3.00-4.00 metres; AOD 31.87-30.87), C2 (depth 2.09-2.19 metres; AOD 32.78-32.68) and C3 (depth 1.90-1.95 metres; AOD 32.97-32.92).

Although the proportion of organic content in these subsamples was high, the remains were predominantly charcoal, very fragile wood and rootlet, with an occasional twig (subsample

C3) and traces of fly puparia (also in subsample C3). None of the remains could be identified.

The microfossil subsamples also showed some organic content (high in subsample C3), with identifiable remains confined to diatoms (in subsamples C2 and C3 – more numerous and better preserved in C3) and a few rather poorly preserved fungal spores (subsample C2).

Sulphide staining from possible decayed rootlets was observed from between 2.19 and 3.00m below the ground surface. A full discussion on the interpretation of these results for conditions of preservation can be found in the Discussion chapter, section 4.11.

Borehole D

Possible 'ancient' waterlogged organic material and probable archaeological remains were noted during the recording of BH D and two subsamples were investigated – subsamples D1 (depth 2.37-3.00 metres; AOD 32.66-32.03) and D2 (depth 2.00-2.09 metres; AOD 33.03-32.94).

The macroscopic organic content of these deposits was predominantly charcoal, wood and rootlet, with a little bone (subsample D2). None of the remains could be identified.

The microfossil subsamples showed D1 to have no organic matrix component at this level. Subsample D2 had a significantly higher general organic content (25-50%) and contained at least five forms of pollen grains/spores and a few plant silica fragments ('phytoliths').

Borehole E

BH E did not appear to contain organic material other than probable modern rootlet but appeared to pass through archaeological layers and two subsamples were investigated – subsamples E1 (depth 2.41-3.00 metres; AOD 32.925-32.335) and E2 (depth 2.12 -2.24 metres; AOD 33.215-33.095).

The organic content of both subsamples was low (from both macrofossil and microfossil records) and consisted largely of either charred (charcoal) or modern (rootlet) material. A few unidentified fungal spores were recorded from subsample E1 and there was a little unidentified bone in subsample E2.

Borehole F

A sequence of organic deposits was encountered in BH F at depths between 0.76 and 2.00 metres (AOD 38.98-37.74 metres) and investigated via seven subsamples (F1-F7), the uppermost of which (F7) yielding few organic remains. Waterlogged plant remains were recovered from the other six subsamples and consisted largely of decayed wood fragments, twig fragments and modern rootlets, with a little charcoal and, in addition, some 'straw'-like material in subsamples F3 and F6. The lowest one metre core tube of the borehole had split and was not subsampled or investigated; other than to check for 'late date' artefacts which were not present (i.e. pottery or other chronological indicators that could help in as a check for the radiocarbon dating of the stratigraphic sequence).

The identifiable components of the plant assemblages were dominated by fairly large number of moderately well preserved waterlogged seeds and fruits. Overall, plant taxa indicative of waste/open ground were the most frequently represented and included chickweed, common nettle, corn marigold, hemlock, knotgrass, nipplewort, orache/goosefoot, prickly sow-thistle, small nettle and stinking chamomile. There were also plant remains of woody shrubs such as blackberry/raspberry, elder, and hazel which might

suggest hedgerow and/or woodland nearby but, equally, the fruit stones (and additionally remains of apple/pear) may have arrived with faeces (see below). Traces of charred cereal crops were noted in three of the subsamples – barley from subsamples F2 and F7, and oat from subsample F6.

The plant assemblage from subsample F3 (depth 1.50-1.86 m; AOD 38.24-37.88 m) also contained a component from wild plant taxa of wet places such as ponds, water-filled ditches and marshy fields (celery-leaved buttercup, lesser spearwort, sedge, spike-rush), and traces of bog-myrtles and marsh pennywort, which probably originated in imported peat.

Invertebrate macrofossils were recorded from five of the subsamples (F2-F6), but preservation was poor. Most of the remains were extremely fragmented and eroded and could not be identified. Better preserved remains were occasionally recorded, however; particularly from subsample F3. Here, cladoceran (water flea, probably *Daphnia*) ephippia (resting eggs) were present and a few sclerites of the woodworm beetle, *Anobium punctatum*, were also recorded. The former suggest standing water at the time of deposition (in support of the evidence from the plant remains). Cladocerans form ephippia as a response to environmental stress and often to survive periods of drying out of temporary bodies of water. However, here, it could be that the process was triggered by a decline in water quality caused by pollution from the dumping of waste. *Anobium punctatum* attacks untreated domestic timbers and, together with the quantity of wood fragments present, may indicate the disposal of decaying structural timber. Remains of woodworm were also noted from subsample F5. Small numbers of fragments of fly puparia were recorded from three of the subsamples (F2-F4).

All of the microfossil subsamples showed some organic content, although this was relatively small and preservation was recorded as poor in both of the lowermost (F1 and F2) and the uppermost (F7). Subsamples F5 and F6 showed a very high proportion of organic detritus and F3 and F4 were moderately organic. Records for individual microfossil remains were rather few from subsample F5 and particularly numerous in F6. Single whipworm (trichurid) eggs were recorded from three of the subsamples (F3, F5 and F6) indicating a minor faecal component. Spot measurements of the *Trichuris* eggs showed them to be within the size range for the human whipworm, *T. trichiura* (Linnaeus). However, as this is a wholly contained subset of the size range for the pig whipworm, *T. suis* (Schrank), multiple measurements and a statistical investigation of the data would be required before a more definite statement could (perhaps) be made.

Overall, the biological remains from the subsamples from BH F suggest several different origins, some clearly indicative of human activity and others reflecting 'natural' habitats. In combination they suggest the disposal of waste (including but not primarily faeces) in an area of damp (and possibly intermittently wet) waste ground.

Borehole G

BH G did not appear to contain organic material other than charcoal and a little very shell but did appear to pass through archaeological layers and three subsamples were investigated – subsamples G1 (depth 2.35-2.44 metres; AOD 37.25-37.16), G2 (depth 1.25 - 1.48 metres; AOD 38.35-38.12) and G3 (depth 0.56-1.00 metres; AOD 39.04-38.60).

Waterlogged organic remains were few and consisted largely of modern rootlets in subsample G1. Charcoal and unidentified bone were recorded from subsamples G2 and G3, and there was a little shell (as noted during the sediment descriptions) from subsample G3. The microfossil subsamples were also largely inorganic but subsample G3 showed a slightly higher proportion and included some diatoms and fungal spores (at least three and two forms were present, respectively).

Borehole M

Possible 'ancient' waterlogged organic material was noted during the recording of BH M and two subsamples were investigated – subsamples M1 (depth 2.00-2.23 metres; AOD 35.81-35.58) and M2 (depth 1.23-1.60 metres; AOD 36.58-36.21).

Subsample M2 was taken from slightly above the observed level of the ground water and yielded no identifiable macrofossils. The microfossil subsample did contain a few diatoms and moderate amounts of organic detritus, however.

Subsample M1 represented a small layer of waterlogged organic material dominated by degraded wood fragments. There was also a small assemblage of quite well preserved and identifiable waterlogged plant remains of species growing in hedges, including elder and hazel, and areas of waste ground (common nettle, hemlock and thistle). There was a smaller component of other plant species indicative of wet places which included celery-leaved buttercup and, perhaps, sedge. The microfossil 'squash' also revealed a moderate organic content to this deposit and some fairly well preserved diatoms (of at least five forms), together with smaller numbers of other organic remains (fungal spores, other spores/pollen grains and fragments of plant silica bodies).

There was no direct evidence for human activity from the organic remains recovered from the subsamples from this borehole.

Borehole N

A sequence of organic deposits was encountered in BH N at depths between 0.63 and 2.85 metres (AOD 38.535-36.315 metres) and investigated via twelve subsamples (N8-N19). A further seven subsamples (N1-N7) from the lower part of the sequence were also processed to ensure no 'late date' artefacts were present (e.g. any artefact that was later than medieval would have cast doubt on the validity of the core samples being from an uncontaminated stratigraphic sequence; but no late date artefacts were found) and as representatives of the underlying stiff clay deposits found in several of the boreholes. The lowest five subsamples yielded no ancient organic remains and were essentially mineral in nature. Subsamples N6 and N7 showed a greater percentage of organic content from both the microfossil and macrofossil subsamples but identifiable remains were few and preservation was poor.

The subsamples from the organic section were mostly composed of herbaceous and woody detritus, with some charcoal, mosses (Bryophyta) and modern rootlets. A component of 'straw'-like material was recorded in subsamples N8, N10 and N17. A wide range of mostly well preserved waterlogged seeds and fruits was recovered from the subsamples, representing plants growing in wet places (celery-leaved buttercup, gypsywort, lesser spearwort, spike-rush, water-dropwort and water-pepper), as weeds in arable fields and in areas of waste and open ground (black-bindweed, dock, fool's parsley, hemlock, knotgrass, knotweed, orache/goosefoot, stinking chamomile and wild radish). In addition, there were several fruit stones of plum, blackberry/raspberry, sloe and wild cherry and some fragments of hazelnut shell – either representing hedgerow in the vicinity or waste from food resources gathered from such places. There was little evidence of crop plants other than caryopses and a rachis segment of bread wheat in subsample N8 (depth 2.46-2.61 metres; AOD 36.705-36.555 metres) and a wheat caryopsis in subsample N19 (depth 0.63-1.00 metres; AOD 38.535-38.165). In the case of subsample N8, the cereal remains may well derive from faecal material as a *Trichuris* egg (from a whipworm of humans or pigs) was detected in the corresponding microfossil 'squash'.

Invertebrate macrofossil remains were recorded from just two of the subsamples from this sequence, N8 and N9. The remains were, in general, very poorly preserved and present as

'scraps' of heavily fragmented and eroded ('filmy') insect cuticle; although N9 contained an occasional better preserved beetle sclerite. These remains were of no interpretative value.

The microfossil 'squashes' showed a high or very high organic content within subsamples N8-N11 and N17, with lesser percentages noted from N9-N16 and N18-N19. The numbers and ranges of identifiable microfossils present were similarly distributed, with preservation being particularly good within N8 and N17. In addition to the parasite egg from N8 (see above), two further trichurid eggs (human or pig whipworm) were recorded from N11, indicating a minor faecal content in these sections of the deposit sequence.

Borehole O

A slight sulphide odour was detected from two layers within BH O during recording but subsamples were not investigated for organic macrofossil and microfossil remains. The uppermost of these layers (at AOD 38.442-37.872 metres) was not investigated as it lay directly below the modern overburden and its apparent organic content consisted of modern rootlet. The lower layer (nominally at AOD 37.252-36.752 metres), although waterlogged, was devoid of visible organic content and was recorded below a 0.37 metre void in the core tube so that its actual depth was uncertain.

Borehole P

BH P contained an organic sequence between 1.31 and 2.67 m (AOD 38.615 to 37.255 m). On initial inspection in the field was thought to represent a 'natural' highly humified peat. However, subsequent processing of subsamples and recording of the macrofossil and microfossil content of the deposits revealed their composition to be similar in nature to those seen in BH F and BH N. Twelve subsamples (P1-P12) were investigated and the organic material was, again, mostly wood, twig fragments and bark, with a few 'stems' with 'leaves' from mosses (Bryophyta), modern rootlets and some charcoal. Subsamples P1-P3 were taken from sand deposits below 2.67 metres depth, primarily to confirm that no 'late date' artefactual remains were present (none were recorded); these subsample were effectively barren of organic content.

The identifiable components of the plant assemblages were dominated by fairly well-preserved waterlogged seeds and fruits of plants from various habitats; mainly present between 1.73 and 2.00 metres (AOD 38.195 to 37.925 metres) in subsamples P6 and P7. Remains of wild species which would have favoured habitats such as waste ground (e.g. chickweed, corn marigold, nipplewort, orache/goosefoot, small nettle) and damp places (e.g. celery-leaved buttercup and possibly sedge) were recorded. Standing water was indicated by the presence of horned pondweed in subsample P4. In addition, there were numerous fragments of hazelnut shell and fruit stones of blackberry/raspberry; perhaps from nearby hedgerow but, in view of the records for parasite eggs (see below), more likely from food waste, with the fruit stones deriving from faeces. Remains of crop plants were rare with only traces of charred oat caryopses recorded from subsamples P7 and P10-P12.

The only invertebrate macrofossils recorded from this sequence were some quite well preserved *Daphnia* ephippia from subsample P4 providing further evidence of standing (though perhaps not permanent) water.

The microfossil subsamples revealed low levels of organic content within P4, P5 and P12 and high to very high percentages within P6-P11. Records for identifiable remains accorded well with the overall levels of organic content, with relatively large numbers of diatoms, fungal spores, other spores/pollen grains and plant silica fragments (sometimes there were very large numbers – fungal spores in subsample P8, for example). The presence of faeces was indicated by records of intestinal parasite eggs from five of the 'squashes'. Eggs of the

whipworm of either humans or pigs were noted in subsamples P6, P7, P9, P10 and P12 and there was also a single ascarid egg in P10. In two of the subsamples, P8 and P9, many of the fungal spores present were *Chaetomium* species ascospores – *Chaetomium* species are common, saprophytic cellulose-decomposers occurring on decaying herbaceous material and other decaying organic materials such as cloth and leather (van Geel *et al* 2003, pp. 881).

A few fragments of leather were noted from subsample P9.

Borehole Q

BH Q did not appear to contain organic remains but appeared to pass through archaeological layers and three subsamples were investigated – subsamples Q1 (depth 2.88-2.98 metres; AOD 36.335-36.235), Q2 (depth 1.63-1.83 metres; AOD 37.585-37.385) and Q3 (depth 1.00-1.47 metres; AOD 38.215-37.745).

Subsamples Q1 and Q2 gave no uncharred 'ancient' organic remains. Subsample Q3 contained charcoal, unidentified shell and bone fragments, and at least three forms of diatom were seen in the microfossil 'squash'. A moderate organic content was also recorded in the 'squash' but was predominantly charcoal.

Borehole R

BH R did not appear to contain organic remains but appeared to pass through archaeological layers and two subsamples from lower deposits were investigated to confirm the absence of remains – subsamples R1 (depth 1.87-2.00 metres; AOD 37.31-37.18) and R2 (depth 1.74-1.87 metres; AOD 37.44-37.31).

The subsamples were barren of biological remains other than traces of charcoal from subsample R2.

Borehole S

BH S did not appear to contain organic remains but appeared to pass through archaeological layers and four subsamples were investigated to confirm the absence of waterlogged remains – subsamples S1 (depth 3.28-4.00 metres; AOD 36.49-35.77), S2 (depth 2.62-3.28 metres; AOD 37.15-36.49), S3 (depth 2.55-2.62 metres; 37.22-37.15) and S4 (depth 1.28-2.00 metres; AOD 38.49-37.77).

The subsamples were effectively barren of identifiable organic microfossil and macrofossil remains other than a little hazelnut shell from subsample S2.

Borehole T

BH T did not appear to contain organic remains but appeared to pass through archaeological layers and three subsamples were investigated to confirm the absence of waterlogged remains – subsamples T1 (depth 3.70-4.00 metres; AOD 35.795-35.495), T2 (depth 1.80-3.70 metres; AOD 37.695-35.795) and T3 (depth 1.60-1.80 metres; AOD 37.895-37.695)

The organic content of all three subsamples was very low; the microfossil 'squash' from subsample T3 showed an apparent increase in organic detritus but this was most probably decayed modern rootlet. Subsample T3 contained a little unidentified bone and charcoal; the latter was also noted from subsample T2.

Borehole U

Possible 'ancient' waterlogged organic material was noted during the recording of BH U and two subsamples were investigated – subsamples U1 (depth 2.17-3.00 metres; AOD 37.075-36.245) and U2 (depth 1.77-1.96 metres; AOD 37.475-37.285).

Subsample U1 contained waterlogged organic material, including decayed wood fragments and numerous quite well preserved seeds and fruits. There were also some unidentifiable plant fibres, leaf fragments, a little unidentified bone and some invertebrate remains (the last rather less well preserved than the plant remains and unidentifiable). The identifiable component of the plant assemblage was dominated by taxa growing in wet places and included celery-leaved buttercup, crowfoot, rush and water-pepper. In addition, there were remains of two 'useful' plants, namely seeds and capsule fragments of flax (*Linum usitatissimum* L.) and achenes of hemp (*Cannabis sativa* L.). These species may be exploited for the production of fibres and oil. Identifiable microfossil remains were relatively scarce consisting of just a few pollen grains/spores and diatoms.

Remains recovered from subsample U2 were mostly charcoal and wood fragments, with a little unidentified bone. The 'squash' subsample appeared to have a greater organic component than that seen in subsample U1 but this was probably largely charcoal.

Borehole V

Possible 'ancient' waterlogged organic material was noted during the recording of BH V and four subsamples were investigated – subsamples V1 (depth 2.00-2.50 metres; AOD 37.39-36.89), V2 (depth 1.79-2.00 metres; AOD 37.60-37.39), V3 (depth 1.70-1.79; AOD 37.69-37.60) and V4 (depth 1.51-1.70; AOD 37.88-37.69).

The organic component of the washovers was relatively large but consisted largely of wood fragments, with a little charcoal (in subsamples V3 and V4) and an occasional unidentified fragment of bone (subsample V3). No identifiable plant or invertebrate macrofossils were recorded.

The organic content of the microfossil 'squashes' was low and only subsample V3 contained any identifiable remains (small numbers of diatoms and fungal spores – at least two forms of each) and traces of plant silica fragments.

Borehole Y

BH Y did not appear to contain organic remains but appeared to pass through archaeological layers and two subsamples were investigated to confirm the absence of waterlogged remains – subsamples Y1 (depth 3.74-4.00 metres; AOD 36.16-35.90) and Y2 (depth 2.12-2.75 metres; AOD 37.78-37.15).

The subsamples were effectively barren of organic microfossil and macrofossil remains other than a little charcoal from subsample Y2.

Borehole AC

Possible 'ancient' waterlogged organic material including a large wood fragment (at depth 3.30-3.44 metres) was noted during the recording of BH AC and two subsamples from other deposits were investigated for traces of preservation elsewhere in the sequence – subsamples AC1 (depth 2.87-3.00 metres; AOD 33.55-33.42) and AC2 (depth 1.58-2.00 metres; AOD 34.84-34.42).

Subsample AC1 was barren of organic remains. Subsample AC2 contained modern rootlet (as recorded in the description of the sediment) but also some wood fragments, together

with charcoal and a little unidentified bone. No identifiable microfossil remains were recorded but the matrix did contain a moderate amount of organic detritus, presumably deriving from both the wood and the modern rootlet.

Sample AD – small bulk sediment sample from Earthworks Archaeology excavations at Welsh Row

This sample was collected from a deposit overlying a Roman road and was primarily sand, with only a trace organic component (seen at a microscopic level in the 'squash') to the matrix. However, it did contain pieces of worked roundwood and twig fragments (to 120 mm in length and 30 mm in diameter), with associated small fragments of (soft and decayed) wood; perhaps from a wattle structure.

3.4 Condition of preserved wood

3.4.1 Baseline Condition of the Wood

The results are shown below:

Table 3 Loss in wood substance

Spot Sample	Bore hole	Depth AOD m	Wood Species	Maximum water content	Density	Loss in Wood Substance
1	D	32.58–32.53	*Quercus spp*	362%	0.233g/cc	58%
2	C	33.15	*Salix spp*	875%	0.106g/cc	69%
3	F	38.98–38.92	*Ulmus spp.*	386%	0.221g/cc	49%
4	N	37.88–37.85	*Salix spp.*	556%	0.161g/cc	53%
6a	N	37.17–37.12	*Salix spp.*	510%	0.173g/cc	49%
6b	N	37.17–37.12	*Corylus avellana L.*	606%	0.149g/cc	63%
7	N	37.07–36.99	*Alnus spp.*	334%	0.250g/cc	40%
8	N	36.94–36.79	*Alnus spp.*	559%	0.160g/cc	62%
9	N	36.82–36.78	*Fraxinus excelsior L.*	667%	0.136g/cc	74%
10	N	36.55–36.47	*Salix spp.*	487%	0.181g/cc	47%
14	U	37.26–37.20	*Quercus spp.*	81%	0.676g/cc	----

15	V	37.95–37.88	*Ulmus spp.*	439%	0.198g/cc	54%
16	V	37.64–37.60	*Quercus spp.*	90%	0.640g/cc	----
17	V	37.83–37.76	*Fraxinus excelsior L.*	620%	0.146g/cc	72%
18	AC	33.04–32.98	*Quercus spp.*	117%	0.545g/cc	3%

All wood species identifications follow Schweingruber (1982) and were carried out by Steve Allan, Timber Technologist at York Archaeological Trust.

Alnus spp. Alder, exact species not distinguishable.
Corylus avellana L. Hazel.
Fraxinus excelsior L. Ash.
Quercus spp. Oak, exact species not distinguishable.
Salix spp. Willows, exact species not distinguishable.
Ulmus spp. Elms, exact species not distinguishable.

Much of the wood was un-diagnostic although sample 6a (BH N) had well preserved tool marks from an axe. Samples of roundwood, possibly elements from wattle, were recovered from BH C (sample 2) and BH N (samples 6b, 9 and 10). Samples 6b and 10 had both been worked to produce a single facetted point.

Overall, the majority of the wood samples had undergone appreciable levels of decay, with the non-oak species suffering more decay than the oak samples. This is often the case due to the structure and chemical composition of oak wood. The calculated “loss in wood substance” values for the non-oak samples range from 40% – 74% and between 3% - 58% for oak. However, two oak samples recovered from BHs U (sample 15) and V (sample 16) recorded apparent density increases, and maximum water contents of less than 100%. These values suggest very well preserved wood and are not unusual from archaeological deposits. Chemical analyses of the samples from around these samples revealed high sulphate concentrations with sulphide levels below the detection limits of the test method. However a sulphide odour was detected from the sediment around sample 15 from BH U suggesting that near anoxic conditions had been established. Rapid oxidation of the sulphide to sulphate probably occurred during the interval between sampling and analysis thereby accounting for the low value of sulphide measured.

The condition of the oak sample from BH V is unusual as the non-oak samples were poorly preserved. The geochemical assay revealed high concentrations of sulphate , and sulphide levels below the limits of detection. No sulphide odour was detected during sampling of the core, so it is possible that this deposit should be considered as a “reducing” one, rather than ”highly reducing”. This example also highlights one of the major issues of taphonomy – identifying decay that has occurred before, during and post-burial, and is an area that would benefit from further research.

3.5 Geochemical Assessment

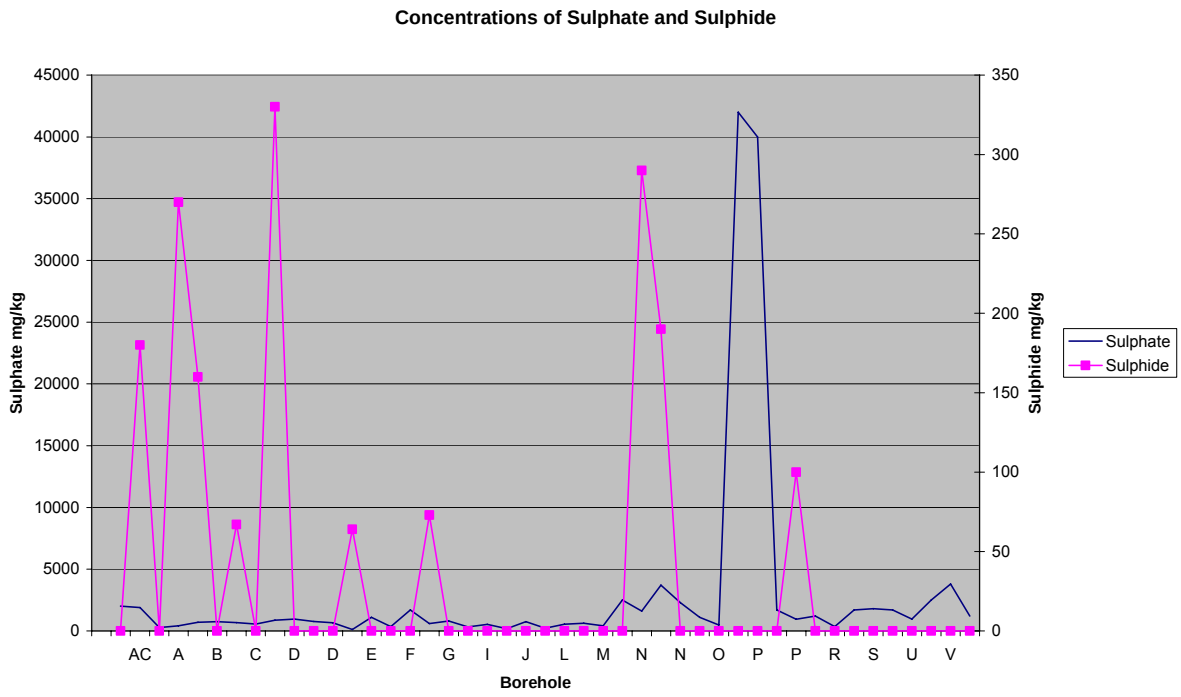
The detailed results of the geochemical assessment are shown in Appendix 4

3.5.1 Redox sensitive parameters

All samples from the Nantwich boreholes had appreciable levels of sulphate ranging from 110 mg/kg to 42000 mg/kg, whilst sulphide levels were low, ranging from 64 mg/kg to 330 mg/kg. Sulphide levels in 35 samples were below the limits of detection of the respective test method. Nitrate levels also tended to be on the low level, with 19 samples below the limits of detection and values ranging between 2mg/kg and 110mg/kg.

The concentrations of sulphide and sulphate from 23 boreholes are shown on the chart below (Figure 8):

Figure 8 Sulphide to Sulphate ratios



The highest sulphide levels were seen in samples from the deeper cores taken from locations A, B, AC, C and N. All but N were from samples taken from boreholes inserted into alluvial deposits located in the Weaver floodplain and suggest that these deposits remain in hydraulic connection with the river. BH N is located at the top of Snow Hill and the sample was from an organic rich archaeological deposit. Sulphate levels for all four samples from N were high too.

Calculating the ratio of sulphate to sulphide concentraions reveals a broad trend towards increasing sulphide levels with increasing depth, which correlates with the presence of a strong sulphide odour detected from several of the cores. For example, sulphide odour was detected immediately cores from BHs AB, B, C, D, F, M, N, O, P, T and U were examined.

Two samples extracted from below the water level from BH N produced 290mg/kg of sulphide and 1600mg/kg of sulphate and 190mg/kg of sulphide and 3700mg/kg of sulphate respectively and a strong sulphide odour was detected as soon as the core was opened. The iron phosphate, vivianite, was also observed within the sediments at this depth which is often taken as an indicator of oxygen ingress into waterlogged sediments (French pers comm.) Wood samples recovered from N also exhibited high levels of decay.

BH S also generated high sulphate levels but no sulphide odour was detected during processing.

The largest concentrations of sulphate were detected from BH P, with the highest value of 42,000mg/kg coming from a sample interpreted as “stable manure” (see environmental assessment report) between 38.62 and 37.93 AOD. Whilst sulphide levels were below detectable limits for three of the samples, the deepest sample (between 37.93 – 37.38 AOD) gave an assay of 100mg/kg and a slight sulphide odour was detected. The nitrate level here was also very low (1mg/kg).

Nitrate levels were low with 19 core samples recording levels below the sensitivity of the test method. The highest level 110mg/kg was recorded from BH Q (at a depth of 1.5-1.55m. Overall, high nitrate levels coincided with high sulphate and negligible sulphide concentrations, indicating oxidising conditions.

Where high sulphate concentrations predominate (with little or no sulphur), the conditions can be described as “reducing” or “oxidising” and not conducive to the long-term preservation of organic material.

3.5.2 pH

The pH of the burial environment provides an indication of the degree of acidity or alkalinity and gives a good indication of what types of material are likely to be preserved. Furthermore pH and Eh are interrelated and shouldn’t be considered in isolation (see section on water analysis from dipwells). In broad terms, ideal preservation conditions will be one where the pH is near neutral (pH 7), although most organic materials can tolerate slightly acidic conditions (pH 4-7), whilst calcareous materials prefer more alkaline environments.

Most of the samples from Nantwich gave near neutral pH values, although samples from BHs P and V were mildly acidic. Samples of the stable manure deposits gave values of 5.64 and 4.88, whilst samples below this layer gave near neutral pH values (7.33 and 7.36). Such low pH values are not unexpected given that the sulphate concentrations were very high – oxidation reactions of sulphur will result in the formation of sulphurous acid and therefore a low pH.

Slightly alkaline conditions were observed from 5 samples from BHs D, J, N and O, although carbonate levels of each sample was surprisingly low.

3.5.3 Loss on Ignition (LOI) and Total Organic Carbon (TOC)

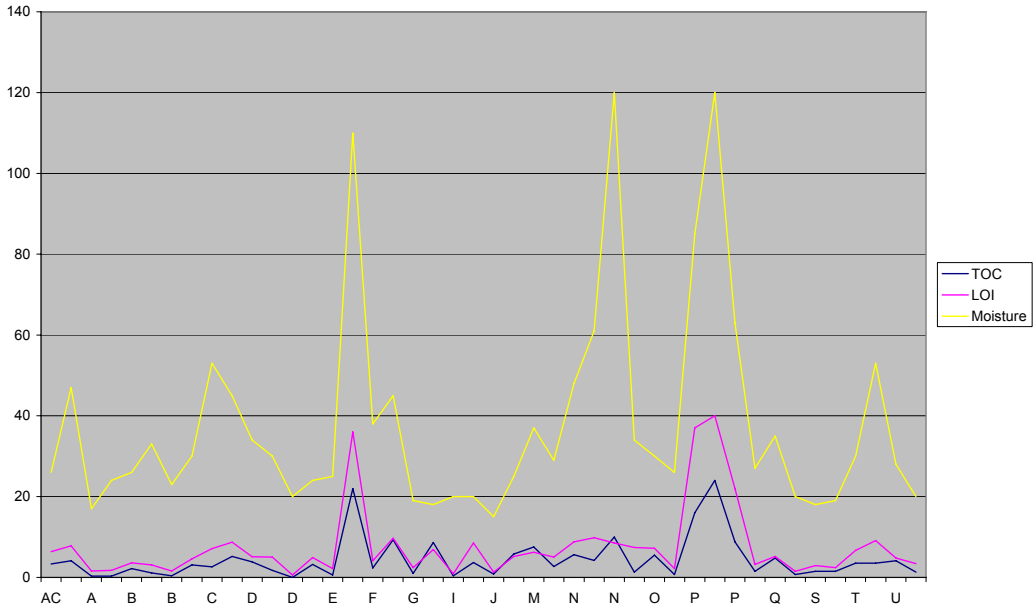
An indication of the organic component of the deposits can be gained by assessing loss on ignition and total organic carbon (TOC). In most cases both values are low suggesting that there is very little organic matter present in these deposits. There is broad correlation between the LOI values and the classification of deposits as either mineral based or organic based, with predominantly mineral deposits having LOI values of around 1%-2%, with values increasing where wood and other organic material is preserved within a mineral deposit. Data suggests that loss on ignition simply measures the amount of organic matter within deposits – on its own it doesn’t measure the state of preservation of that organic matter though.

The highest LOI and TOC values were observed in two samples collected from the peat layer found in BH P, with LOI values of 37% and 40%, and TOC values of 16% and 24%.

When LOI and TOC values are compared (see Figure 9) there is good correlation between the two values, which is to be expected. There is a moderate degree of correlation between

moisture content and levels of preservation of organic material. The organic rich samples from BH P produced the highest values for loss on ignition as well as moisture content, indicating the richness of organic preservation.

Figure 9 Loss on Ignition and Total Organic Carbon content



3.5.4 Nutrients - phosphates

Values range from 2mg/Kg (BH C, 31.97 – 31.87 AOD) to 58mg/Kg (BH J, 38.84 – 38.78 AOD). Overall, nutrient levels can be considered low, and therefore indicative of potentially good preservation conditions.

3.6 Diatom assessment

3.6.1 Summary

The key aim of this study was the identification and assessment of diatom presence, state of preservation and indications on environment or water quality data, in particular salinity levels to help locate brine deposits. The samples were recovered from cores taken during an assessment of waterlogged preservation. As such, the samples lack data relating to their specific archaeological context, and with the exception of the samples from BH P, these samples are effectively 'spot' samples.

Although only one sample was recovered from the western side of the floodplain, the data reported here indicates that considerable differences occur between the west and the east sides of the River Weaver floodplain. This is commensurate with the results obtained from previous geochemical and palaeoenvironmental studies. In the areas to the east of the River Weaver, both within and above the floodplain area, it appears that the specific hydrological context (Upper River Terrace deposits away from the floodplain), and anthropogenic impacts (this area is more heavily developed), are producing compromised burial environments in

relation diatom preservation. In the single location studied from the west of the floodplain, preservation appears to be good.

The strong freshwater component in these assemblages is likely to be associated with the river Weaver itself; many of the oligo-halophobous species are typical of river environments, and their presence suggests either normal environmental conditions associated with river function, or freshwater inputs from stream run-off and other sources such as precipitation etc. Whilst some of the species identified are tolerant of brackish conditions, the analysis undertaken in the current study cannot provide any indication of salinity and/or the spatial extent of brackish environments, as the samples studied were pre-selected, and not targeted from a sampling strategy designed to specifically identify these characteristics of the burial environment.

In addition, where a brackish environmental tolerance is suggested for the diatom species identified, this does not mean that brackish conditions prevailed, as these species are also influenced by substrate. *Pinnularia borealis* and *Cypatopleura solea*, for example, are diatoms associated with damp soil and it is possible that these species are derived from the surrounding substrate. Any attempts at inferring past salinity values for the samples analysed would be extremely limited due to the poor condition of the samples, the weak statistical representation of species in the dataset, and the lack of specific context in relation to brine springs and saltworkings. This latter observation reflects the fact that the precise location of brine springs and salt working areas were not targeted in the sampling strategy.

3.6.2 Results in borehole order

Fifteen samples recovered from boreholes excavated throughout Nantwich, were assessed (see Appendix 6 for detailed report and tabulated data). The assessment was aimed at the identification of diatom presence, state of preservation and indications on environment or water quality data. In addition, the data was compared to existing geochemical and palaeoenvironmental data from Nantwich in order to determine how the diatom assemblages investigated can inform studies of *in situ* preservation status.

BH C (C3/P (190-195cm) – south-west river bank)

Diatom preservation in sample C3/P was excellent, with a total of 25 taxa present at >4%. Appendix 6: Table 3.1 gives the results of diatom analysis and indicates that the diatom assemblage was composed of large benthic forms typical of shallow, freshwater environments and associated with epiphytic and epilithic habitats. The diversity and frequency of diatom frustules was medium to high and dominated by *N. cryptotenella* at 14.6% and a range of *Nitszchia* and *Achnanthese* spp. (16.2% and 11.4% respectively). *Surirella ovalis* (3.5%) and *Diatoma vulgare* (4.9%) were also present.

All samples from further up-slope from the river demonstrated a high degree of frustules breakage and a high mineral content that was difficult to remove using conventional diatom preparation techniques (Appendix 6: Table 3.1).

Sample 3 from BH C (C3/P), exhibited a low sedimentary mineral content which enabled clear assessment of species composition. Preservation of diatom frustules was of excellent quality, suggesting an undisturbed, post-depositional environment; even the more delicate species such as *Fragilaria capucina* and *Nitzschia palaea* were mostly intact. The diversity and frequency of diatoms was high with a dominance of *Navicula cryptotenella*, which is characteristic of British rivers and streams and was common in all of the samples from both Zones. There was a clear lack of planktonic taxa in this sample, and with the exception of *Cyclotella comta*, which was present at a low relative abundance of 0.8% and is more commonly found in shallow lakes or ponds with soils of high acidity, all taxa were benthic in

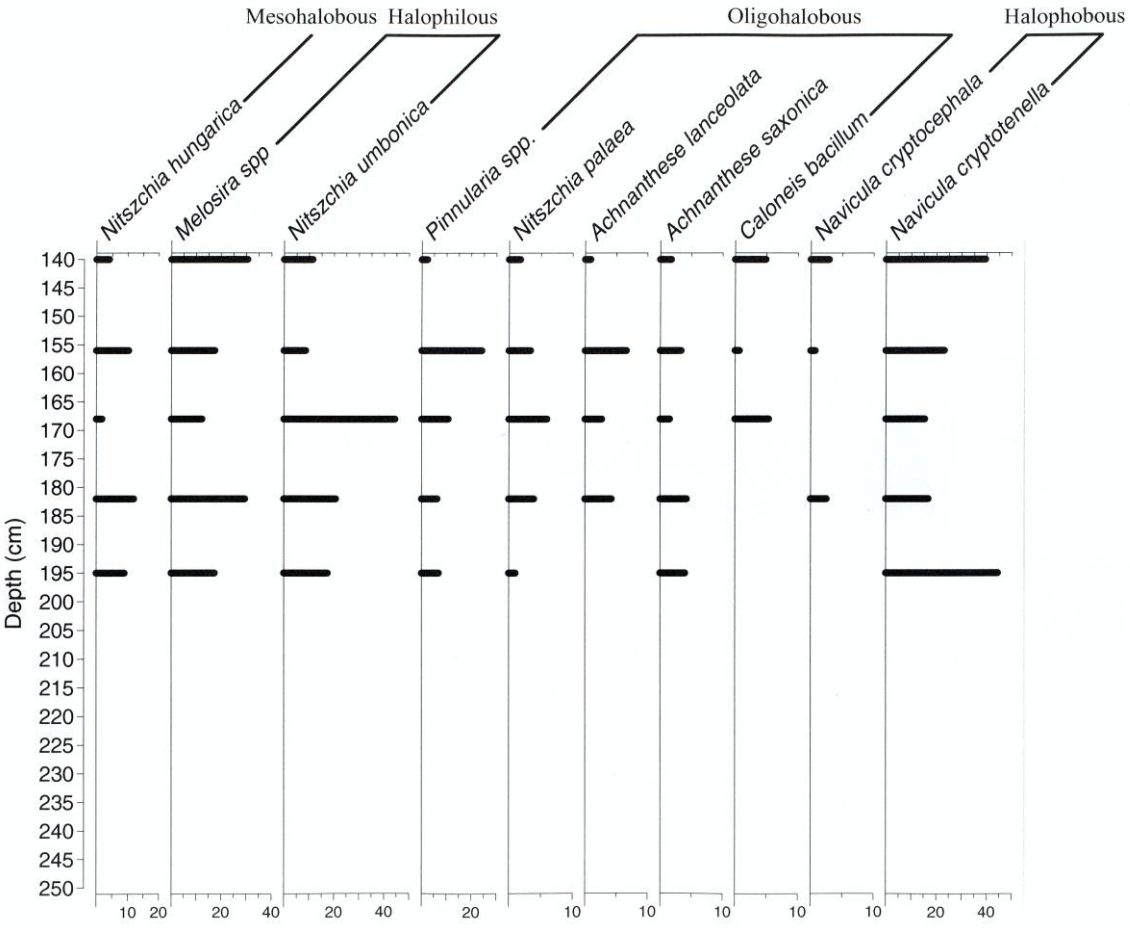
nature and typical of fairly shallow, river habitats.

The character of the diatom assemblage was essentially freshwater, though some of the species present can also indicate brackish conditions (e.g. *Diatoma vulgare, Diploneis ovalis, Navicula halophila, Navicula sclevensis, Surirella ovalis*) suggesting either permanent, or the occasional influence of salinity, on the diatom flora (Cooper, 1999). The high proportion of periphytic and epiphytic forms (e.g, *Fragilaria*, *Cocconeis, Achnanthese, Navicula* spp.) also indicate a strong macrophyte influence on the diatom flora, which could suggest the presence of wetland areas where alluvial deposits are often prone to reducing conditions due to the anoxic nature of the sediments.

BH P (P4/P - 250cm; P5/P - 217cm; P6/P - 191-200cm; P7/P - 173-191; P8/P - 168cm; P9/P -150-163cm; P10/P - 131-150cm)

Diatom preservation in these samples was poor, particularly in P4/P and P5/P, taken from the deepest part of the borehole. At these locations the breakage was so extreme that diatoms could not be counted. The results of diatom analysis for the remaining samples (P6/P to P10/P), expressed as percentage counts for taxa present at <4%, are given in Appendix 6: Table 3.1 and Figure 10. Sample P6/P displayed the lowest diversity with only 8 identifiable species, whilst all other samples exhibited low to medium diversity. All samples contained high frequencies of *N. cryptotenella*, *Nitszchia* spp., and *Melosira varians* with samples P6/P and P10/P dominated by *N. cryptotenella* (32.9 and 30.2% respectively), sample P8/P by *N. umbonata* (43.0%), sample P9/P by *Pinnularia* spp. (22.3%) and sample P7/P by *M. varians* (29.7%). A profile of the main taxa found in these samples is given in Figure 1 to highlight changes in species abundance and composition between 195cm and 140cm.

Figure 10 Analysis of diatom samples from BH P



BH F (F4/P (125-150cm)

Although sample F4/P exhibited a high degree of breakage again, there was an overall improvement in diatom preservation compared to BH P with 15 species present, thus exhibiting medium diversity (Table 1). *Melosira varians* dominated at 25.2% followed by *N. hungarica* at17.0%. The total relative abundance of *Nitszchi*a spp. was high at 21.4% and *Achnanthese* spp. were also high at 17.6%. *Cympatopleura solea* and *Navicula cohnii* were also present in this sample at 2.5% and 1.9% respectively.

BH G (G3/P - 56-100cm)

Diatom preservation in sample G3/P was poor. This low to medium diversity assemblage, with 13 identifiable species, was dominated by *N. cryptotenella* (21.9%), followed by *N. hungarica* (16.6%). *C. solea* was present at 4.0% accompanied by a significantly high relative abundance of *M. varians* (13.9%) and *N. cohnii* (11.3%).

BH M (M1/P - 211cm, M2/P -142cm)

Diatom preservation in samples M1/P and M2/P was poor. Sample M1/P demonstrated low to medium diversity with 13 species present, whilst sample M2/P exhibited a low diversity assemblage containing only 10 species. Both samples were dominated by *N. cryptotenella* followed by *Pinnularia* spp. (17.5%) and *A. lanceolata* (13.5%) in sample M1/P and *Navicula cincta* (17.4%) and *N. palaea* (17.4%) in sample M2/P.

BH N (N8/P - 246-261cm, N17/P – 122-129cm)

Diatom preservation in samples N8/P and N17/P was poor with low to medium diversity assemblages containing 12 and 13 identifiable species respectively. Sample N8/P was dominated by *N. cryptotenella* at 53.7% followed by *Pinnularia* spp. at 20.6% and sample N17/P was dominated by *M. varians* at 44.5% presence. N17/P was the only sample where *Fragilaria pinnata* was clearly visible.

BH Q (Q3/P - 100-147)

Diatom preservation in this sample was also poor with a low to medium diversity assemblage of 12 species. Of these species *N. hungarica* dominated at 33.9%, followed by *M. varians* at 27%.

3.6.3 Indicators of salinity

Finally, it should also be noted that, whilst there is a strong freshwater context in evidence in the samples, there are a broad range of non-planktonic species tolerant of slightly brackish conditions. For instance, the presence of mesohalobian and oligohalobian species indicate the influence of dissolved salts on the diatom flora. The lack of marine influence (Nantwich is approx. 45km from the coast) suggests that samples with a high relative abundance of these latter species are directly influenced by the dissolved rock salts occurring in brine springs throughout the region (Penney and Shotter 1996). For example, sample Q3/P is dominated by *Nitzschia hungarica* (34%), samples P7/P and F4/P by *Melosira varians* and P8/P by *Nitzschia umbonata*. Although at low relative abundance, the presence of *Cympatopleura solea* and *Navicula cohnii* in samples F4/P and G3/P and *Surirella ovalis* in sample C3/P also indicates a salinity influence.

3.7 Radiocarbon dating programme

3.7.1 Results of radiocarbon dating

The radiocarbon results for the samples submitted from three boreholes with the best preserved organic sequences are shown in the table below.

Table 4 Radiocarbon samples and age determinations

Laboratory number	Sample reference and depth in core	Material dated	$\delta^{13}C$ (‰)	Radiocarbon age (BP)	Calendar date (95% confidence)
Borehole F					
OxA-18722	Spot sample 3, 0.76–0.82m	*Ulmus* sp. sapwood	-24.6	150 ±23	cal AD 1660–1950
SUERC-18781	076100F06, 0.76–1.00m	hazel nutshell	-25.7	775 ±30	cal AD 1210–1290
OxA-18683	100125F05, 1.00–1.25m	hazel nutshell	-24.5	946 ±20	cal AD 1020–1160
SUERC-18780	125150F04, 1.25–1.50m	sloe stone	-27.1	970 ±30	cal AD 1010–1160
OxA-18721	150186F03, 1.50–1.86m	hazel nutshell	-24.3	966 ±23	cal AD 1010–1160
Borehole N					
OxA-18684	Spot sample 6A, 2.00–2.05m	*Salix* sp. wood	-24.8	1068 ±23	cal AD 890–1020
SUERC-18782	Spot sample 6B, 2.00–2.05m	*Corylus* sp. wood	-27.2	1130 ±30	cal AD 780–990
SUERC-18783	Spot sample 8, 2.23–2.33m	*Alnus* sp. wood	-27.1	1215 ±30	cal AD 690–890
OxA-18723	Spot sample 9, 2.35–2.40m	*Fraxinus* sp. roundwood	-28.5	1071 ±24	cal AD 890–1020
OxA-18724	Spot sample 10A, 2.62–2.70m	*Salix* sp. roundwood	-28.2	1192 ±24	cal AD 730–940

SUERC-18784	Spot sample 10B, 2.62–2.70m	*Salix* sp. roundwood	-27.1	1215 ±30	cal AD 690–890
Borehole P					
SUERC-18786	150163P09, 1.50–1.63m	hazel nutshell	-25.2	865 ±30	cal AD 1040–1260
OxA-18726	163173P08, 1.63–1.73m	hazel nutshell	-20.6	840 ±25	cal AD 1160–1260
SUERC-18785	173191P07, 1.73–1.91m	hazel nutshell	-27.7	910 ±30	cal AD 1030–1210
OxA-18725	191200P06, 1.91–2.00m	hazel nutshell	-23.3	841 ±24	cal AD 1160–1260
Borehole AD (Welsh Row brushwood trackway)					
GrN-31797	Timber 1	*Acer campestre*	-29.6	945 ±15	cal AD 1020–1150
GrN-31798	Timber 2	*Alnus* sp.	-27.8	970 ±15	cal AD 1025–1160

3.7.2 Discussion of radiocarbon dating results

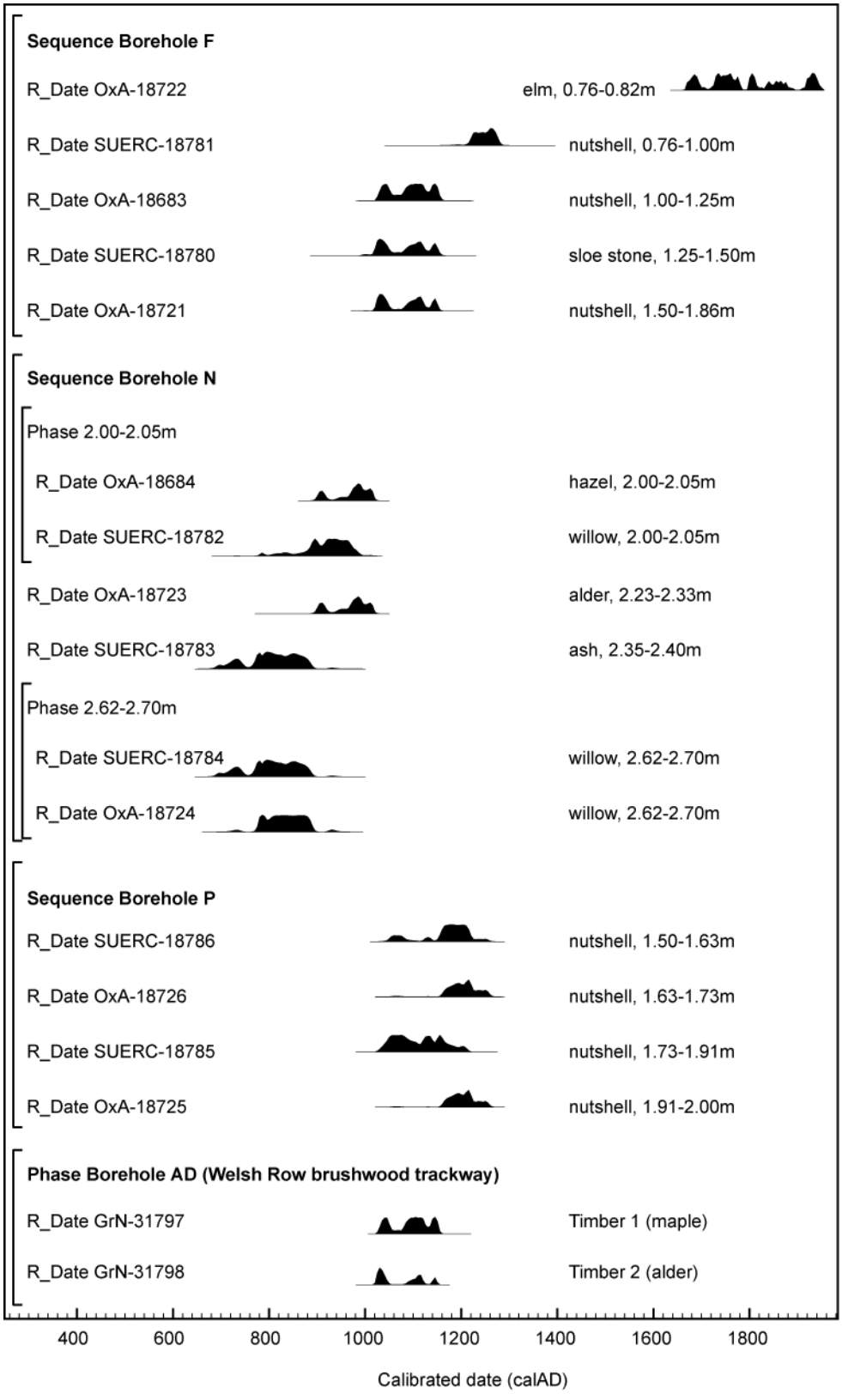
Each sample consisted of a single-entity short-lived plant macrofossil or timber (Ashmore 1999). The samples from Boreholes F, N, and P were dated by Accelerator Mass Spectrometry (AMS) radiocarbon dating at the Scottish Universities Environmental Research Centre in East Kilbride (SUERC; technical procedures are described by Vandenputte *et al* (1996), Slota *et al* (1987), and Xu *et al* (2004)), or at the Oxford Radiocarbon Accelerator Unit (OxA; laboratory methods are given by Bronk Ramsey *et al* (2002; 2004)). The Welsh Row timbers were dated by Gas Proportional Counting at the Centre for Isotope Research, Groningen University, The Netherlands, following Mook and Streurman (1983). Internal quality assurance procedures at all three laboratories and international inter-comparisons (Scott 2003) indicate no laboratory offsets, and validate the measurement precision quoted.
The results reported are conventional radiocarbon ages (Stuiver and Polach 1977). The calibrated date ranges have been calculated by the maximum intercept method (Stuiver and Reimer 1986), using the program OxCal v4.05(Bronk Ramsey 1995; 1998; 2001; 2008) and the IntCal04 data set (Reimer *et al* 2004), and are quoted in the form recommended by Mook (1986), with the ranges rounded outwards by 10 years, or by 5 years where the radiocarbon error is less than ±25. The probability distributions shown in the figure below have been calculated using the probability method (Stuiver and Reimer 1993), and the same data.

The four results from Borehole P are statistically consistent with a single radiocarbon age (T' = 4.1, T'(5%) = 7.8, v = 3; Ward and Wilson 1978), and could thus be of the same calendar date. This is what we would expect to find if the organic deposit between 1.50 and 2.00m depth in this core had accumulated very rapidly.

The six results from Borehole N are not statistically consistent (T' = 35.4, T'(5%) = 11.1, v = 5), and these samples therefore cannot all be of the same date. You can see from the figure that although SUERC-18783 (spot sample 8) appears to be slightly earlier than the underlying OxA-18723 (spot sample 9), there is a general trend for samples from stratigraphically-earlier levels to be older than those from later levels, which we would expect to find if the samples were not intrusive or residual, and if a period of time had elapsed between deposition at 2.70m and 2.00m. This suggests that the waterlogged deposit in this section of the borehole dates to the late Saxon period, an impression reinforced by the statistical consistency between results from the two samples at the top of this deposit, 6A and 6B (OxA-18684 and SUERC-18782; T' = 2.7, T'(5%) = 3.8, v = 1), and those at the base of it, 10A and 10B (OxA-18724 and SUERC-18784; T' = 0.4, T'(5%) = 3.8, v = 1). It is difficult to say precisely when sedimentation at these levels took place, or what time span is represented by the waterlogged deposit between 2.00 and 2.70m; it could be as little as a few decades in the ninth and/or tenth century AD.

The five results from Borehole F fail the test of consistency by a wide margin (T' = 872.1, T'(5%) = 9.5 v = 4), but this is due to the post-medieval elm spot sample 3 (OxA-18722) at 0.76–0.82m depth. The four medieval results are still not consistent, however (T' = 31.0, T'(5%) = 7.8, v = 3), and the nutshell at 0.76–1.00m is appreciably more recent than the three samples from lower in the core. Whether the thirteenth-century date of this sample provides more than just a *terminus post quem* for this deposit is worth thinking about, but at any rate the deposit appears to be significantly later than the waterlogged deposit between 1.86 and 1.00m in the core, which may have accumulated rapidly in the eleventh or twelfth century AD; the three results here are statistically indistinguishable (T' = 0.6, T'(5%) = 6.0, v = 2).

Figure 11
Probability distributions for radiocarbon calibrated date ranges



The two results from Borehole AD are statistically consistent with a single radiocarbon age (T' = 1.4, T'(5%) = 3.8, v = 1; Ward and Wilson 1978), and could thus be of the same calendar date – as expected, given that neither timber had a significant intrinsic age and that the two timbers formed part of the same structure. If we assume that this trackway was built of freshly-felled timber, it was built between the early-mid eleventh century and the middle of the twelfth century cal AD. This is somewhat later than the post-Roman date permitted by the sherds in the underlying deposit, and a century or two earlier than the dendro-dated corduroy trackway nearby.

4.0 DISCUSSION OF RESULTS

4.1 Summary of significant results

Significant horizons of organic-rich deposits were found in three BHs, F, N and P, whilst several more contained surviving evidence for decaying organic content. In addition further boreholes had evidence for thick build-up of archaeological deposits containing carbonised remains and inorganic artefacts. During previous archaeological excavations such deposits have been shown to contain pockets of organic preservation, and therefore the identification of the extent of these deposits is of similar importance to the organic-rich horizons in BHs F, N and P which have actually been sampled and analysed as part of the current project.

Palaeoenvironmental evidence include a range of plant fossils which have been identified as relating mostly to on-site activities and interpreted as domestic refuse and stabling debris. In common with the results from the Second Wood Street excavations, small quantities of cereal grains are found as well as parasite eggs. Evidence for the general environmental conditions of the area has been recovered in a number of boreholes. These species are chiefly water-loving plants and indicators of rough ground. Insect remains are poorly preserved, results that are similar to those from the excavations at second Wood Street (Druce & Huckerby 2007), indicating that decay has occurred in these deposits at some point in the past. This general phenomenon regarding the often poor survival of invertebrate remains in organic-rich deposits is discussed elsewhere (Kenward & Hall forthcoming).

Wood identification and density analysis show six species of which oak is best preserved. All samples showed considerable levels of decay, with loss in wood substance of 40 - 74% and 3 – 58% for non-oak and oak species respectively. Samples from BH U and V in contrast suggest very well preserved wood, with near anaerobic conditions established for the former and reducing conditions for the latter. The ability to recognize ancient decay as opposed to recent decay is not possible on present knowledge, and therefore the implications of this variability cannot be attributed to modern factors on single evidence.

Chemical testing of the sediment samples from the boreholes was undertaken to identify the main chemical species that act as redox sensitivity parameters and are present in the burial environment. This data can help to guide the use of redox probes for long-term monitoring.

Water-quality testing has identified a number of important attributes of the burial environment. Both nitrate and sulphate levels are generally low, and pH values were near neutral, which is another good indicator for preservation of organic remains. Loss on Ignition and Total Organic Carbon levels have indicated locations where organic-rich deposits survive (BH F, N and P), whilst phosphate assay has identified what nutrients are available for micro-organisms to feed on, and thus pose a threat to continued preservation: levels are fortunately low. In contrast high sulphate and nitrate levels were detected in some locations, indicating an oxidising environment, not conducive to preservation.

The extent of waterlogged deposits can be mapped and the zone identified with reasonable accuracy. The nature of deposits have been characterised and their current condition in terms of the burial environment identified. A baseline has been established against which future monitoring can assess their vulnerability or continued viability as a valuable archaeological resource.

The main limitations to the study lie in the sample size achieved; 30 locations within 10 hectares. Additional sampling and assessment in the future from more cores from boreholes or archaeological investigations, will add data to the model and perhaps change some of the findings. Indicators of decay are often difficult to ascribe to either the current burial environment, to long-term slow decay, or to ancient episodes of decay. Conditions of

preservation can change unpredictably due to local factors, even in close proximity to a borehole location, and the broad-brush modelling has been based on small boreholes as being representative of extensive areas. Borehole locations were largely dictated by accessibility, and some strategic locations were, and will probably always be, unattainable. Considerably more information could have been available, if borehole logs from development had been retained over the past two decades, rather than being discarded once planning consent had been granted and the development had been undertaken. Similarly no data on subsidence of buildings was available except as anecdotal evidence; these could indicate desiccation of underlying deposits and would thus be a useful addition to the information derived from boreholes and archaeological investigation.

4.2 GIS and Modelling

4.2.1 Data manipulation and sub-surface deposit models

Three main software packages have been used in data-manipulation and modelling of the results from the borehole investigation; ArcView GIS for interrogation and spatial analysis, Gint for borehole logs and transects, and Surfer for 3-D plotting of the sub-surface deposits (Figure 12). The grid of boreholes on the eastern side of the river has allowed a reasonable profile to be constructed, based principally on four transects, three of which run broadly north-south, and one east – west. At present there are insufficient borehole details on the west side of the river to run the same programmes, but this can be refined by additional boreholes in the future, and by integrating details from previous and future archaeological investigation. Unfortunately this has not been possible as yet because there is a lack of ordnance datum elevation data recorded in the reports from previous archaeological investigations.

4.2.2 Sediment recording and graphic presentation of borehole data

During the course of the desktop study it became clear that the term ‘waterlogged deposits’ had a variety of possible meanings to different archaeologists and other specialists. This broad term has been accepted for the project name, but as work proceeded it was realized that within this lay considerable scope for misunderstanding between the disparate specialists and disciplines involved. A simplified generalization was therefore introduced to facilitate the graphical representation of the complex subtleties of the deposits as logged. The relatively simple recording of the Norwegian protocol as applicable to borehole records presented no difficulties but was complicated considerably by the need to record possible archaeological variations, the importance of accurately locating organic inclusions for scientific dating and, for the assessment samples, the multiple parameter records required to provide an adequate baseline record of the biological macrofossil and microfossil remains where present. For the last, the single parameter values for each class of remains as stipulated under the Norwegian protocol for recording of deposits during excavation were insufficient; it should also be noted that some of the other parameters of the far more detailed version of the Norwegian protocol employed for excavations cannot be recorded from borehole samples as these are inherently lacking in archaeological context.

Three broad categories were initially identified and defined as:

- *Organic-rich deposits*: including significant non-carbonised organic inclusions (e.g. leather, wood, macro & micro plant, insect, bone) and/or a matrix composed primarily of humified organic matter

- *Archaeological deposits*: primarily an inorganic matrix but with visible archaeological remains (largely non-biological but including concentrations of carbonised biological remains (e.g. charcoal) likely to result from human activity

• *Mineral-rich deposits*: an inorganic matrix of natural or anthropogenic origin, with no recorded remains (biological or archaeological)

As a result of the detailed recording of the borehole cores extremely complicated and diverse ranges of horizons and lenses were identified. Migration of this detailed information to standard borehole logging designed for BS5930 (where all archaeological contexts would simply be described as 'made ground'), made the visual presentation and interpretation of the results, comparison and generalisation between boreholes, very complicated. It was therefore decided to assign individual lenses from the detailed logs into groups that conformed to one of the three categories listed above (organic-rich, mineral-rich, or archaeological), together with two additional sub-divisions for the top and base of the sequences (borrowing the term 'made ground' from the terminology of geotechnical survey for a sub-division of *archaeological deposits* but with the archaeological slant of also being of 18th century or later date, and 'fluvio-glacial' deposits as a sub-division of *mineral-rich deposit,* respectively). The borehole logs and transects presented in this report have been produced by this synthetic method, although the original detailed records for each borehole can be found in Appendices 2 and 3.

In summary then, where simplified categories of deposit were required – for graphical presentation of the transect modelling, for example (see section 3.1.1, above) – the following where employed:

• Made ground: records from the higher part of the borehole which included brick, mortar, modern materials, or identifiable inclusions datable to the 18th – 20th centuries

• Archaeological deposits: silts, clays and sands, black – light grey in colour, which contained evidence of human activity such as ash, charcoal, pottery, bone etc

• Mineral-rich deposits: grey clays, silts and sands that contained no organic or archaeological inclusions but were not part of the natural drift geological sequence

• Non-carbonised organic-rich deposits: plant-microfossils, wood, leather, plant debris and sulphide smell

• Fluvio-glacial deposits: records from the lowest part of the borehole describing sands that form the top of the natural geological sequence

Such generalization may have led to some slight discrepancies between the detailed reports of the various disciplines involved in this project, but it has served to make the data more intelligible and transferable between different specialists. Some of the mineral-rich deposits from BHs A and B for example, could be interpreted as alluvial because of their description and proximity to the river; these could therefore be grouped with the fluvio-glacial category as part of the interpretation process. BH V had a mineral-rich deposit that occurred out of sequence at the top of the borehole; this was interpreted as redeposited natural sands, probably from grave-digging activity. Various consecutive lenses had some trace or residual evidence for organic matter (detritus, wood fragments, sulphide smell) and therefore these were included as non-carbonised "organic-rich" deposits (such as BH B, M, O, U, and V) although the more quantitative palaeoenvironmental assessment could provide little information for boreholes with minimal surviving evidence and consequently focussed on those with sufficient material for worthwhile study in the stage 2 assessment.

4.2.3 Modelling preservation variables

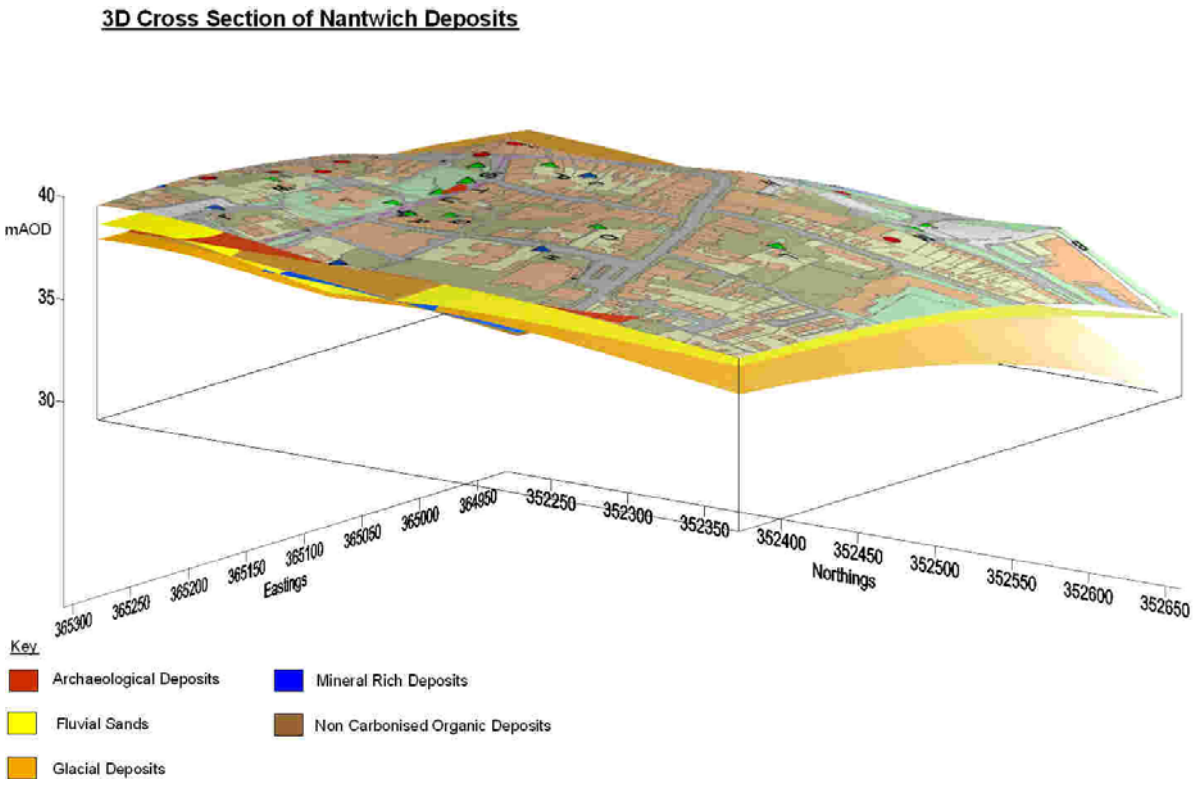
The aim of the project was to identify and map the extent and formation processes for waterlogged deposits, and thus the potential for the preservation of organic remains. Clearly

the detection of surviving organic remains was an important factor, but others, such as the conditions detected by the geochemical studies, provided equally (or perhaps even more) important information with regard to the potential for organic survival within deposits which yielded no direct evidence of such or where organic remains were once present but had decayed away. This wider interpretation of the deposits that included at least some marginal organic content was essential in regard to the last as some of these deposits appeared to represent formerly organic-rich layers in a state of active decay and therefore provided invaluable information on the threats facing the still well-preserved deposits elsewhere in the town.

A simple summary of 'zones' of potential preservation based on the borehole locations could be established – though additional data points (cores) would undoubtedly help to refine this model – based on just three categories:

- *Known preservation* (i.e. where organic preservation is seen to exist)
- *Potential preservation* (i.e. where organic preservation is not necessarily seen but suitable conditions for preservation can be shown or inferred, for example by a consistently high groundwater level, suitable chemical conditions, analogy with other similar deposits)
- *No preservation* (i.e. where organic preservation is not seen and conditions for preservation are poor)

Figure 12
Example of 3D deposit model using Surfer software



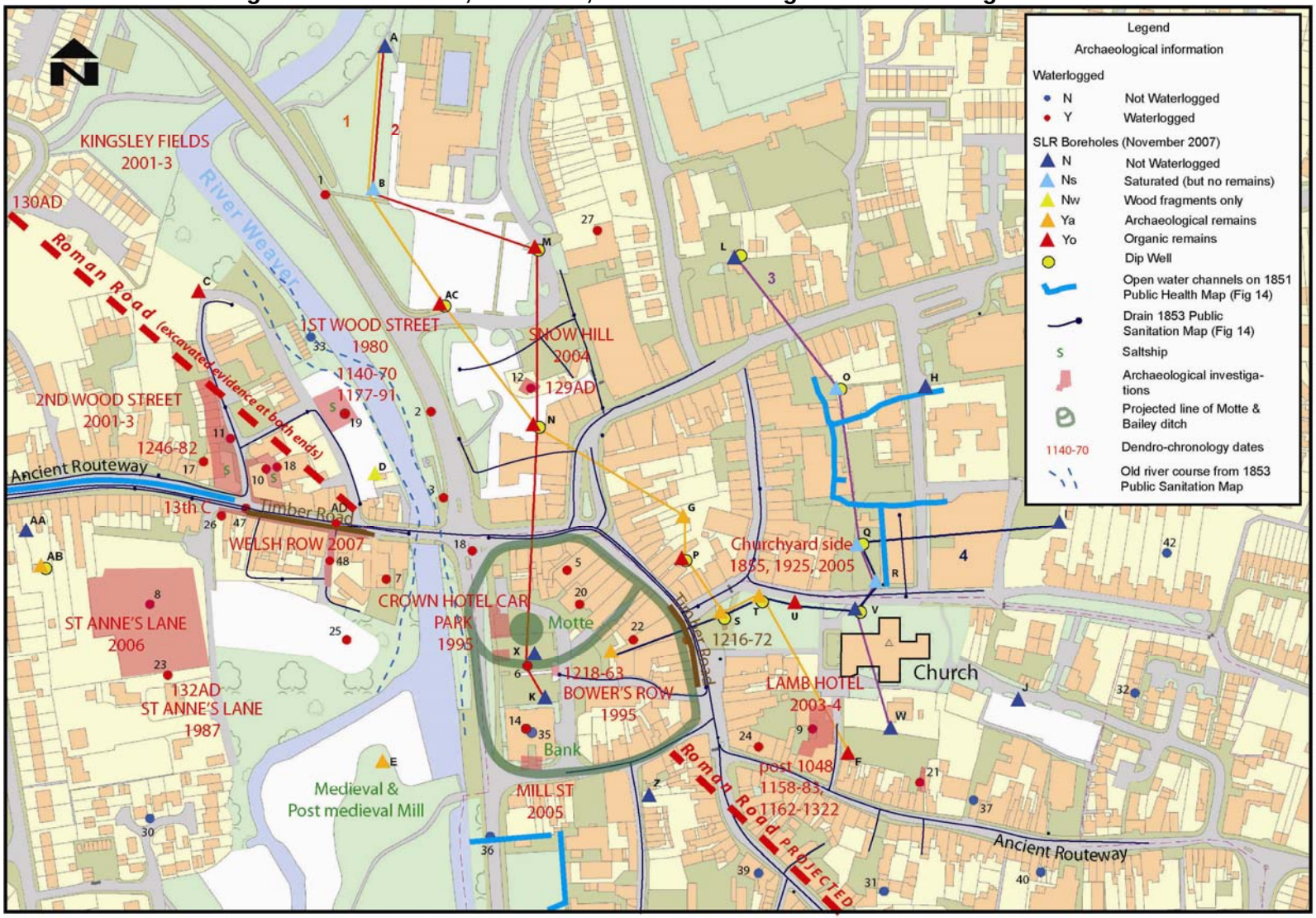
4.3 Extent of Deposits

4.3.1 Geographical distribution of waterlogged remains

The total area with evidence for waterlogged archaeological deposits amounts to approximately 12ha which lies within the historic core of Nantwich: c.320m west-east from BH C at the northern end of Wood Street to BH L at Manor Road, and c.420m west-east from St Anne's Lane to the church and BH F; c.320m north-south from Snow Hill to Mill Street and Hospital Street (see Figures 13 & 16). In addition waterlogged remains have been found within discrete features at Kingsley Fields, to the west of the central area of waterlogged deposit accumulation.

The general build up of waterlogged deposits can be divided into two parts: Zone 1 which is along the low-lying land bordering the River Weaver and is characterised as having good conditions of preservation for organic remains, and Zone 2 which is on higher land and is characterised by past and active decay of organic remains (see Figure 16).

Figure 13 Boreholes , transects, Victorian drainage and archaeological data



4.3.2 Identifying Areas for Further Investigation

The distribution of boreholes from the current project, in addition to previous data from archaeological investigations and boreholes, has provided a broad understanding of the nature and extent of the waterlogged deposits within Nantwich (Figure 13). With any model, however, refinement is always possible with additional data, and there are some key areas which can be identified at the present time for future investigation.

These include:

- the castle area, which has revealed both deeply stratified organic-rich deposits and also shallow non-organic deposits; one interpretation for this is that the waterlogged remains in this area lie within large archaeological features;

- the High Street and market area which contains well referenced archaeological preservation as well as organic-rich deposits in BH P, but non-organic archaeological accumulation spreading east through the church-yard and market hall area;

- Hospital Street and High Street; waterlogged deposits and deep archaeological accumulation is found on the north side of Hospital Street, in contrast to shallow and non-organic deposits on the south side, but within a large area from The Lamb Hotel to the High Street and to the Memorial Cross no data for sub-surface deposit modelling is available;

- On the west side of the river there are too few boreholes and too little elevation data to accurately plot the full extent of the deep waterlogged deposits, and there is only one dipwell for future monitoring.

4.4 Summary and discussion of palaeoenvironmental assessment results

4.4.1 Classification of deposits

Preservation classes were assigned according to the Norwegian protocol's 'state of preservation scale' (see Figure 17) as applicable to recording of borehole deposits and also in long hand visual records of the sediment type and any inclusions employed for recording samples from archaeological excavations prior to subsample processing. This provided a detailed characterization of the deposits which are presented in full in appendix 3. In order to facilitate the visual representation of these deposits in borehole logs and other graphical forms, however, the detailed descriptions were grouped into the following three general categories as 'organic-rich deposits', 'archaeological deposits' and 'mineral-rich deposits' (see definitions in section 4.2.2, above):

As part of the recording process a first stage of assessment identified presence or absence of biological remains within the sediments, and then from this initial study samples were selected for a second stage of more detailed assessment.

4.4.2 Preservation of biological remains

Twelve of the boreholes were excluded from this second stage of investigation because of the nature of the deposits encountered (with little to suggest archaeological content, organic or otherwise) and/or voids within the cores rendering depth information indeterminate. These were BHs A, H, I, J, K, L, O, W, X, Z, AA and AB and were not assigned to a project classification by direct study, but can be attributed to the category of 'mineral-rich deposits'. [BH BH O warrants continued geochemical monitoring, however – see above]

The subsamples from six of the boreholes (BH E, Q, R, S, T and Y), included in the investigation as they contained possible evidence for archaeological activity, showed little or no waterlogged organic content and provided no interpretatively valuable remains. In the terminology adopted for the project as a whole, these may also be classified as 'archaeological deposits'.

The deposits with valuable concentrations of waterlogged organic remains were concentrated in sequences from BHs F, N and P (which formed part of the central borehole transect from north-west to south-east). Overall, the plant, invertebrate and microfossil assemblages from the waterlogged deposits in the three boreholes (all found between 36.315 and 38.98 metres AOD) were very similar and represented several origins which included material derived from within buildings, presumably floor sweepings and possibly 'stable manure' (*sensu* Kenward and Hall 1997 – a mixture of dung and litter, here including hay, 'straw' and bracken, and itself derived from several sources), faeces (probably human though the possibility of pig cannot be excluded) and also a component associated with timbers. This waste matter seems to have been dumped into an area of damp, waste ground, as indicated by many of the wild plant taxa recorded, and there were two instances where standing (though perhaps not permanent) water was indicated (subsample P4 – BH P; depth 2.34-2.67 metres, AOD 37.585-37.255; subsample F3 (BH F, depth 1.50-1.86 metres, AOD 38.24-37.88). It is clear that these deposits represent waterlogged preservation of organic archaeological deposits rather than wholly 'natural' organic accumulations and can be classified as 'organic-rich deposits'.

The lower of the two subsamples processed from BH U (subsample U1, depth 2.17-3.00 metres, AOD 37.075-36.245) also, and more unexpectedly, yielded numerous remains of the 'useful' plant taxa, flax and hemp. These plants may be processed for fibres and oil and the remains perhaps hint that these crops were being processed in the surroundings. British archaeobotanical evidence suggests that flax and hemp retting (a rather noxious process) were largely countryside (rather than urban) activities (Greig 1991), however. The numbers of remains seen here were rather few for the assertion of processing to be more than a tentative suggestion, but for the purposes of this project it seems prudent to assume that they represent past human activity. Subsample M1 (BH M, depth 2.00-2.23 metres, AOD 35.81-35.58) also yielded a small assemblage of waterlogged plant remains from waste ground and hedgerow taxa; here there was no definite evidence of human activity but this was strongly suggested in some of the other layers within this borehole. Regardless of whether or not human activity has had an input to these deposits both can clearly also be categorised as 'organic-rich deposits'.

Deposits in the remaining boreholes (BH B, C, D, G, V and AC) may then be allocated to the third project category and described as 'archaeological deposits'. Most contained at least some material probably derived from past human activity (e.g. charcoal, bone fragments) and, although, identifiable microfossil and macrofossil remains were not always recorded, some waterlogged organic content (perhaps mostly wood). Four of these boreholes also gave spot finds of waterlogged wood (BH C, D, V and AC) as did AD (the single small bulk sample from Welsh Row) which contained worked roundwood and twig fragments; this deposit can also be classed as an 'archaeological deposit'.

4.4.3 Preservation of waterlogged organic remains

The preservation of the biological remains was somewhat variable. Clearly, the preservation of macrofossils in the subsamples from the boreholes listed above as containing 'archaeological deposits' must be described as poor as no identifiable remains were observed. However, some of these subsamples did contain identifiable microfossil remains (from BH B, C, D, G and V) and very decayed wood fragments, and there were also inclusions of more substantial wood fragments within BH C, D, V and AC, and also AD (the

bulk sample from Welsh Row). Variable preservation of the remains may not be taken as direct evidence for ongoing decay as other factors need to be considered, and further research is required in order to gain a better understanding of taphonomic processes.

Sequences with waterlogged preservation of identifiable plant macrofossils, microfossils and, less frequently, invertebrate macrofossils were identified within BH F, N and P and also within single deposits (of those investigated) from BH M and U. The best preservation of plant remains was observed in BH N (notably subsamples N7, N8, N9, N10, N13 and N17), although the greatest ranges of plant taxa (diversity) were largely recorded from the subsamples from BH F and the subsamples from BH P provided several of the most diverse assemblages of microfossils. Overall, the preservation of organic remains in these deposits may be described as fair to good, but it would appear that this varies considerably between classes of remains and that, in particular, invertebrate macrofossil remains have decayed strongly.

4.5 Summary and discussion of sediment geochemistry and conditions for preservation

One of the main strengths of this current project has been the collection of data pertaining to the chemical nature of the burial environment and the assessment of the degree of preservation of the surviving organic remains (timber, plant macrofossils etc.), and a "baseline" condition has been established.

Timber samples were recovered from six boreholes although only one BH, P, produced wood that exhibited evidence of working; in addition the National Grid excavation in Welsh Row, referred to as BH AD, also produced worked wood including parts of a timber roadway. Significant concentrations of bio-archaeological materials were recovered from BHs F, N and P.

BH F – characterised by increasing sulphide to sulphate ratio with depth (indicating greater concentration of sulphide), loss on ignition around 5% towards base of organic deposit, although intriguingly the loss on ignition value is much higher in the shallower sample than the deeper one. One sample of waterlogged elm wood was recovered (38.98-38.92 AOD) which recorded almost 50% decay. The higher loss in ignition value for the sediment sample adjacent to this sample can be explained by the presence of wood decay products within the sediment matrix. A high sulphate concentration was recorded from the upper level of deposit, and as pH value is 7.78, this high value may represent rapid oxidation of sulphide compounds during sampling. No groundwater was recorded.

BH N – characterised by relatively high sulphide to sulphate ratios from two samples taken from top and middle of the organic rich deposit, corresponding with overpowering sulphide odour encountered during process of the sample. High sulphate and negligible sulphide concentrations recorded within shallow subsurface deposits and from the lowermost level of the organic deposit. Recovered wood samples exhibit decay ranging from 40% to 74%. Groundwater monitoring in November 2007 showed that almost 75% of the organic deposit was saturated. The relatively high sulphate values are probably caused by a combination of oxidation of reduced sulphur species during recovery, as well as intermittent saturation conditions.

BH P – characterised by extremely high sulphate concentrations from the organic layer described as "stable manure". Sulphate concentrations decline with depth though, with sulphides detected within sand deposit underlying the organic layer, which corresponded to a sulphide odour detected during on site processing. Recorded pH values within the stable

manure deposit are acidic whilst the sand layer was neutral. The very high sulphate levels, the acidic pH values and water table at some depth below the upper level of the organic deposits indicates a deposit that is intermittently saturated and therefore in active decay through the activity of sulphate reducing bacteria. Fragile remains including invertebrates will be at risk.

4.6 Summary and discussion of diatom assessment

Diatom analysis has revealed two distinct categories of frustule preservation and sedimentary mineral content. In terms of human impact and its effect on the sediment record, the results of this study have important implications for the *in situ* preservation of archaeological material. A detailed account is contained within Appendix 6.

The presence of brackish water tolerant species in the samples from Nantwich is perhaps unsurprising given the fact that the Cheshire salt industry is based on the occurrence of thick Triassic rock salt beds which underlie a large part of the country.

In contrast to BH C and the area adjacent to the river, the diversity and frequency of diatom frustules in all of the other samples was low with a high degree of frustules breakage. This situation can cause bias in the sub-fossil assemblage, and demonstrates a significant tendency towards the preservation of the more robust species (e.g. *Pinnularia* spp., *Melosira varians*). The differences in species composition between the samples could not be used to analyse differences in the immediate environment as there is a strong possibility that between-sample differences in breakage is occurring. Analysis of the full diatom assemblage was also inhibited by the extremely high mineral content, which is difficult to remove using standard techniques without further diluting the assemblage in the cleaning process, and probably introducing further bias.

Interestingly, and apparently in contrast to the geochemical data, the diatom samples from BH N (N8/P & N17/P), in the Weaver floodplain area, exhibit poor preservation and reduced species diversity in line with the general situation for all diatom samples from further uphill. In addition, the palaeoenvironmental assessment of BH N reports that preservation of waterlogged plant macrofossils was higher at this location than elsewhere in the study area, and that saturation occurred from *c*. 0.7m depth in the profile. This suggests that the poor preservation occurring in samples N8 and N17 is not a reflection of the current *in situ* status of these samples, and may well reflect the conditions prevailing at the time of deposition of the diatom assemblage. However, the reported high sulphate/sulphide levels (depending on depth through the profile) may complicate this suggestion, as the diatoms may be more susceptible than the waterlogged plant macrofossil remains in relation to the specific geochemical composition of this depositional context.

Furthermore, the high mineral content of the samples in this higher zone is likely to be implicated as a cause of frustules breakage.; Flower (1993) states that dry, carbonate rich sediments, common in areas of human impact, are a major cause of diatom frustule fragmentation and that this can seriously bias the diatom record. When compared to the site map of borehole locations, it is clear that the high degree of breakage in samples from the east side of the River Weaver could be a direct reflection of human impact and the reworking of dry, mineral rich sediments.

The identifiable taxa in the samples from this zone were all common components of freshwater assemblages, with species typical of river environments and particularly characteristic of epilithic (e.g. *Gomphonema* spp., *Nitszchia* spp.) and epipelic (e.g. *Pinnularia borealis, Cymatopleura solea, Surirella ovalis*) substrates. The species *Navicula cryptotenella,* is in evidence, and whilst these species have little value in the assessment of specific environmental conditions, they do, unfortunately, dominate in the majority of the

samples studied (e.g. M1, M2, C3, G3 and N8). Of the five remaining samples two (F4 and N17) are dominated by *Melosira varians*. This species is often found in slow moving waters, and has been found to increase during periods of flooding (Biggs, 2006). Its presence in diatom flora is also common under brackish conditions often reflecting estuarine conditions or, as noted for Nantwich, saltworkings (Juggins, 1992).

On the whole the sample from BH C (sample 3), reflects excellent potential for the *in situ* preservation of organic remains, and further analysis of samples from the boreholes on the western side of the river floodplain is recommended in order to reconstruct any through-the-profile changes in the diatom assemblage character, and examine the causes of the changes identified.

A consideration of the reasons for the marked variability between the west and east sides of the River Weaver floodplain, in terms of diatom preservation status, suggests that hydrological conditions to the east of the river (wherein water levels occur up to *c*. 3m+ below the modern ground level alongside increased urban developmental impacts, are resulting in compromised conditions in the burial environments studied. In addition, the geochemical data indicates that reducing conditions occur in the alluvial floodplain sequences associated with BH C, and that LOI values reflect relatively high organic content in this area.

The strong freshwater component in these assemblages is likely to be associated with the river Weaver; many of the oligo-halophobous species are typical of river environments and their presence suggests either normal environmental conditions associated with river function, or freshwater inputs from stream run-off and other sources such as precipitation etc. As noted above, some of the species are tolerant of brackish conditions, however, these species are also influenced by substrate. *Pinnularia borealis* and *Cypatopleura solea*, for example, are diatoms associated with damp soil and it is possible that these species are derived from the surrounding substrate. Any attempts at inferring past salinity values for the samples would be tentative due to the poor condition of the samples, the weak statistical representation of species in the dataset, and the lack of specific context in relation to brine springs and saltworkings.

Finally, it should be noted that the rationale for the selection of samples for the analysis undertaken in this report is influenced by pre-determined conditions in the burial environment. This has resulted in a biased dataset, against the riverside zone, where more favourable *in situ* conditions are suggested by the analyses undertaken to date. In addition, and compounding this bias, it should also be noted that the analysis of random ‘spot’ samples does not enable a full assessment of either the diatom assemblage or the environmental conditions relating to deposition over time (i.e. through-the-profile), and as such the analysis of these samples only provides a ‘snap shot’ in time, as opposed to the more informative aspects of environmental change over time, which can influence the diatom record.

Similarly, no insights into the main depositional processes responsible for the composition of the diatom assemblages are forthcoming from this approach. Essentially, this problem is only partly solved by the assessment of BH P, and as is demonstrated by the stratigraphy and state of preservation in evidence from this borehole, there may be changes in species abundance throughout a sequence, as a result of differential depositional environments and specific *in situ* conditions such as geochemical status, that are missed by spot sampling. Identifying these changes using through-the-profile studies may help to better explain changes in the immediate environment.

4.7 Summary and discussion of dating and C14 Results

Spot samples of material suitable for submission for radiocarbon dating were collected from several of the cores during examination: BH C roundwood fragments at 1.76-1.79 and 1.95m depth below surface; BH N twig fragment at 1.67, 2.17, 2.40 and 2.74m depth; BH AC twig fragment at 3.54m depth. Other organic remains suitable for dating have been recovered from sub-sample processing of material from several of the other boreholes (e.g. BH F, BH M); also, there are some dateable artefactual remains. These include medieval pottery sherds of 12th – 13th century date from BH F and P.

Plates 21 - 23 Pot sherds of c.13th century date from BH F

Dates obtained from particular remains may not necessarily reflect the date of formation of the deposits – it will be difficult to assess the 'integrity' of the deposits from core samples for which an archaeological context is inherently difficult (or impossible) to determine. It would, therefore, be prudent not to rely on single items of evidence to provide dating for the deposits (where possible). The main emphasis on choice of samples for C14 determination has therefore concentrated on the sequence from BH F, N and P, those with organic-rich deposits. Further samples have been selected from those boreholes with archaeological deposits which have carbonised remains, but which do not have organic-rich deposits. It is hoped by these means to establish a broad chronology for the inception and chronological development of waterlogged deposits in Nantwich, both organic-rich remains and archaeological build-up.

The samples submitted for radiocarbon assay have resulted in a group of dates for the late Anglo-Saxon period, and a second group within the 11th – 13th century (see Appendix 1: Table 3). At BH N deposits accumulated between 2.0 and 2.7m depth below the surface are dated by four samples to the ninth-tenth centuries AD with two more samples of the 10th - 11th centuries. At BH F the sequence at 1 – 1.86m depth shows three samples of Saxo-Norman dates (11th – 12th centuries), and one sample from 0.76 – 1m depth dates to the 13th century. At BH P four samples from between 1.5 – 2m in depth give a range for deposition within the 11th – 13th centuries (heights AOD are contained within in Appendix 1: Table 3).

4.8 National Grid Pipeline and dendrochronology

During the period of the coring programme a National Grid pipeline was laid in a narrow trench cut through the road surfaces, from High Street across the bridge and along Welsh Row to St Anne's Lane (EAS 2008). A side-line turned off Welsh Row along Wychbank House Lane. It was monitored and recorded by Earthworks Archaeological Services, but the opportunity was also taken to observe the deposits by members of the SLR team.

Plates 24 - 25 Barrel-lids recovered from Wychbank House Lane and brushwood trackway at base of National Grid junction pit in Welsh Row (location labelled BH AD)

Dark silts with decaying organic remains and timbers were visible as disturbed layers within the High Street, particularly as the pipeline trench travelled down towards the bridge. On the west side of the river the deposits were deep and rich in organic remains, including a series of stave-built barrels and lids in Wychbank House Lane, and a corduroy timber roadway and a brushwood trackway in two locations along Welsh Row.

One of these in the trench next to 33 Welsh Row and opposite the entrance to Second Wood Street, has been sampled and a dendrochronological assessment has dated the timber roadway to the second half of the 13th century (felling date range AD1259-95; Tyers 2008). The timber lay 0.75m below the road surface, with the water level recorded at 0.82m below the road surface, and total depth approximately 1.5m to base of deposits from surface.

The second wooden structure, found during excavation of an inspection pit in front of 14 Welsh Row, appears to be aligned on a Roman road discovered in 2003 at Kingsley Fields to the north-west, and the structure lies on top of a gravel roadway. This brushwood trackway is at 32.6m AOD, 2.3m below the current surface, and is overlain by a series of sandy and organic-rich deposits, typical of the kind of accumulation expected from the Wood Street and Welsh Row area. The inspection pit was given the project label of BH AD and samples from these deposits have been processed and examined by the project. Unfortunately these appear to contain little of interest, being composed mostly of decayed wood fragments and larger pieces of round-wood. The round-wood from the brushwood trackway, however, was more robust and has been identified as Field Maple, Alder and Oak. Samples from the two former species have been dated to the early-mid 11th century and the middle of the 12th century cal AD (see section 3.7 above).

4.9 Discussion on effectiveness of approach and methods

4.9.1 Effectiveness of general approach

Reliance on public space such as car parks was unsatisfactory as this limited the range of locations available for investigation. Personal contact with owners and occupiers opened up access to a much wider range of potential locations, but this involved an increased amount

of time spent on discovering who to contact, negotiating and confirming access arrangements, whilst also timetabling and co-ordinating a drilling rig and crew.

The choice of a small, highly manoeuvrable, windowless-sampler percussion-driven coring rig proved effective. It was relatively rapid, could move into small spaces, and made little mess.

The samples lifted in Perspex sheaths and packaged on site was efficient. On-site recording and sub-sampling of these cores through the use of a mobile office (a transit van) was also successful, but during the second stage of coring this was not possible for the full duration. Samples that were kept and transported back to the laboratory did not fare well, with some losing material from too much movement, whilst others suffered from oxidation.

The Norwegian protocols adopted for the recording of the samples provided a far more detailed log than the British Standard 5930, but it was over-complex for plotting and manipulation purposes, or comparative analysis.

The dipwells seem appropriate for the level of baseline testing and type of monitoring envisaged for the future. After an initial round of manual testing it is recommended that an automated system of data-logging is installed. In addition multi-level sampling and gas analyser 2000 can be employed to enhance the monitoring of the burial environment (see recommendation 5.3.3 below).

4.9.2 Effectiveness of drilling methodology

The drilling methodology was generally very successful in delivering the objectives for this project. Good quality samples were obtained from 29 boreholes up to depths of 6m below ground level. The technique proved to be very cost effective, advancing up to 5 boreholes per day in sensitive locations, often separated by a considerable distance. The only exception to the success of the sampling was in BH Y where a large piece of brick got stuck in the cutting tool, which resulted in no sample being recovered for the top one metre.

However, the logging and sampling of the core samples in the field could be improved. The drilling technique produced cores of sample so quickly that it was impossible to log them in sufficient detail to the standards of archaeological recording adopted by the project, in the field. This resulted in the cores from the last two days of drilling during the second phase of the coring programme being unrecorded until they had been transported to the laboratory, with some consequential decay through the onset of oxidation, and disaggregation of less compact deposits through the unnecessary movement to which they were subjected during transportation (see recommendations 5.3.1 and 5.3.3 below).

As a large proportion of the material produced was of no real archaeological value it is recommended that in future the material of potential interest for detailed analysis under laboratory conditions should be separated from bulk deposits of made ground or natural geology. The remaining material with no archaeological remains could then have been logged and recorded in the field and disposed of in an appropriate manner. Obviously a cautious approach would need to be taken to ensure that no material of potential significance was discarded. Even if samples of marginal interest were retained a significant amount of overburden and underlying natural deposit could still be effectively disposed of in the field. This would speed up the logging and recording process and enable the samples of significant interest to be processed in more detail, and allow transport of higher quality samples to the laboratory more quickly (see recommendations 5.3.1 and 5.3.3 below).

Such an approach would enable the field archaeologist to keep pace with the drilling process and allow the geologist to log the samples at the same time to BS5930. The delays caused

by the need for detailed archaeological logging in the field meant that the geologist was not able to log the deposits simultaneously and this was detrimental to the interpretation of the geology. By working together the archaeologist and the geologist could decide when to terminate the drilling at each location more accurately. This would prevent excessive drilling in some locations where the basal clay deposits are penetrated at shallow depths, and enable some locations to be extended to establish the thickness of the fluvial sands and the depth to the basal clay.

The groundwater sampling methodology was also very successful with high quality data and samples being obtained from all of the installed wells. The process could be improved in future by using a GA2000 gas analyser to analyse the gasses present in the wells (see recommendation 5.3.3 below). Detection of hydrogen sulphide, methane and carbon dioxide concentrations would provide useful information on the biodegradation processes occurring. It could also be possible to install sampling points at two different levels within the wells to assess any vertical variations in geochemistry within the water column. These differences could highlight specific geochemical differences related to the variation in the surrounding deposits.

It is also recommended that future projects should include the installation of dipwells as a default option for all boreholes, so that monitoring regimes can be established rapidly and at minimal extra cost (see recommendation 5.3.3 below). Field results and density of core locations can determine whether every location is chosen for a dipwell, or whether certain ones are merely backfilled and reinstated.

A particularly successful outcome of the project was that it was completed without damaging any services or reportable health and safety incidents. The importance of this can not be underestimated bearing in mind the very public locations in which the boreholes were drilled.

4.9.3 Comparison with other Urban Remains

Waterlogged urban deposits are known from a wide range of towns and cities, both in the UK and internationally. These include well known examples such as York, London, Dublin, Bergen, Paris, Novgorod, Cairo but there are many more that have as yet received minimal study. One of these lesser known examples is that at Great Yarmouth, Norfolk, where a programme of coring in 2005 was embarked upon in order to create a 3D model of sub-surface deposits. This project was funded jointly by European Union Objective 2, English Heritage and Norfolk County Council grants, which enabled 140 boreholes to be drilled[2]. Such a number ensured that the project had sufficient data on which to build their model, and analysis of the deposits which included waterlogged wood, was undertaken by a multi-disciplinary research team from various universities. Although the Nantwich project followed this approach of investigation and developed the suite of geo-chemical characteristics that were analysed, the number of boreholes drilled were considerably less, and therefore the modelling has been coarser than for Great Yarmouth.

The Nantwich study has been one of the first attempts to systematically characterise burial environments in an urban context, following earlier investigations looking into soil pH and level of preservation of metallic artefacts at the Coppergate excavations in York in the 1980s. More recent developer funded investigations in Droitwich have also adopted a similar approach, although attention has focussed towards groundwater monitoring and limited soil assessment (Cheetham 2006). Previous studies in urban environments in the UK have

[2] www.museums.norfolk.gov.uk/default.asp?Document=600.37.10

concentrated on assessing the characteristics of the burial environment either through redox measurements on groundwater sampled from dipwells (for example Moffett and Panter, 2006) or via in-situ redox probes inserted into the archaeological deposits (for example, Lillie and Cheetham, 2002) rather than a geochemical assay of the sediments themselves. The emphasis of more recent studies has been rural wetland locations including the Somerset Levels (Jones et al, 2007) and the Iron Age enclosures at Sutton Common in South Yorkshire (Cheetham 2007). See Holden et al. 2006 for a comprehensive summary.

The Nantwich project has broadly followed the pioneering work conducted in a number of towns in Norway where substantial waterlogged remains survive, including recent work at the world heritage site of Bryggen (Bergen) and Tønsberg (Hartnik and Matthiesen, 2007). The Norway studies have attempted to characterise waterlogged burial environments using a combination of in- and ex- situ methods including redox measurements and chemical analysis of the soils and sediments.

4.10 Formation processes and contributory factors to continued preservation

Although wooden tanks and artefacts of Roman date have been found in Kingsley Fields, St Anne's Lane and Snow Hill, as well as a group of Iron Age timbers, the evidence gathered from previous investigations and from the coring programme described above, suggests that the on-set of waterlogged conditions and associated accumulation of deposits occurred in post-Roman times. The gravel Roman road seen in Kingsley Fields in 2003 and found at the base of the National Grid excavation in Welsh Row in 2007 demonstrates that this lies on sand with waterlogged deposits above.

The concentration of dendrochronological dates, as well as relative dating methods (coins, coffin typology (Churchyard Side), and pottery) show a key period was during the 11th – 13th centuries, when corduroy roadways were built along Welsh Row and High Street, salt-ships and wich houses were in operation at the Wood Streets, timber buildings were erected at the Lamb Hotel, and a timber conduit was laid in the castle area. Earlier dates have been established from some sites, such as The Lamb Hotel with its possible late-Saxon dendrochronological date for a stave from a tub, and the results of the radiocarbon dating programme (see Appendix 1). Timber structures of 14th – 15th century date replaced the earlier wich house at Second Wood Street, and wooden drains on the east side of the river (Bowers Row) may also be from a late medieval or early modern date.

This growth of waterlogged deposit is not confined to salt-working areas, nor is it located merely within the flood zone adjacent to the river, but it is also found on higher ground towards the church. Some of these deposits seem to have derived from domestic refuse and stable cleaning, such as suggested at The Lamb Hotel, Second Wood Street, and BH P. Charred remains occur in most deposits, whilst organic-rich lenses occur erratically. The contribution of town fires during the medieval period must have been significant, but this would have been similar to many other towns that, however, do not contain a build-up of deposit. Perched water-tables have been suggested as a possible hydrological phenomenon that might have provided conditions suitable for waterlogging to occur at Nantwich, and a number of sub-surface aquifers have been postulated within the old town, which could also have contributed to wet conditions.

The geo-chemical data from the baseline testing has shown that the burial environment has a largely neutral pH (and slightly acidic for BH P and N), which is good for preservation, but that below ground water conditions range from a predominantly reduced state in permanently saturated areas (Zone 1 areas adjacent to the river) to conditions that are currently oxidising where intermittent saturation occurs (Zone 2, higher areas of the historic town (see Figure 16)). High sulphide suggests good preservation conditions, as seen at BH F, N and P which are particularly highly reduced with high sulphide to sulphate levels, as

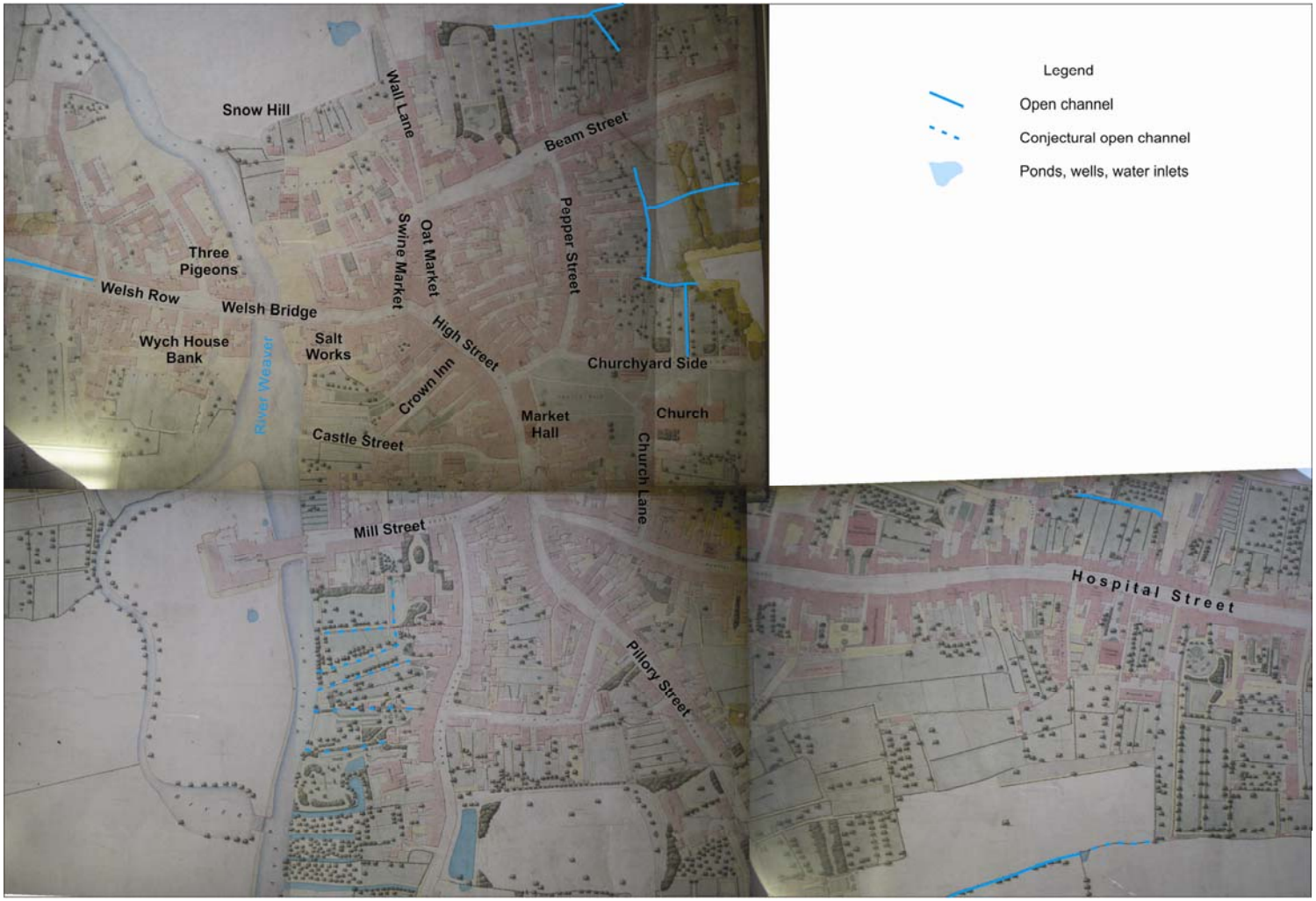
well as a low nitrate level, indicating a low level of decay. Low nutrient levels also suggest relatively good preservation conditions. In contrast BH V, O, and T for example display low sulphide to sulphate ratios indicating active decay. The water quality indicators suggest that the burial environment is recharged by both surface and ground water.

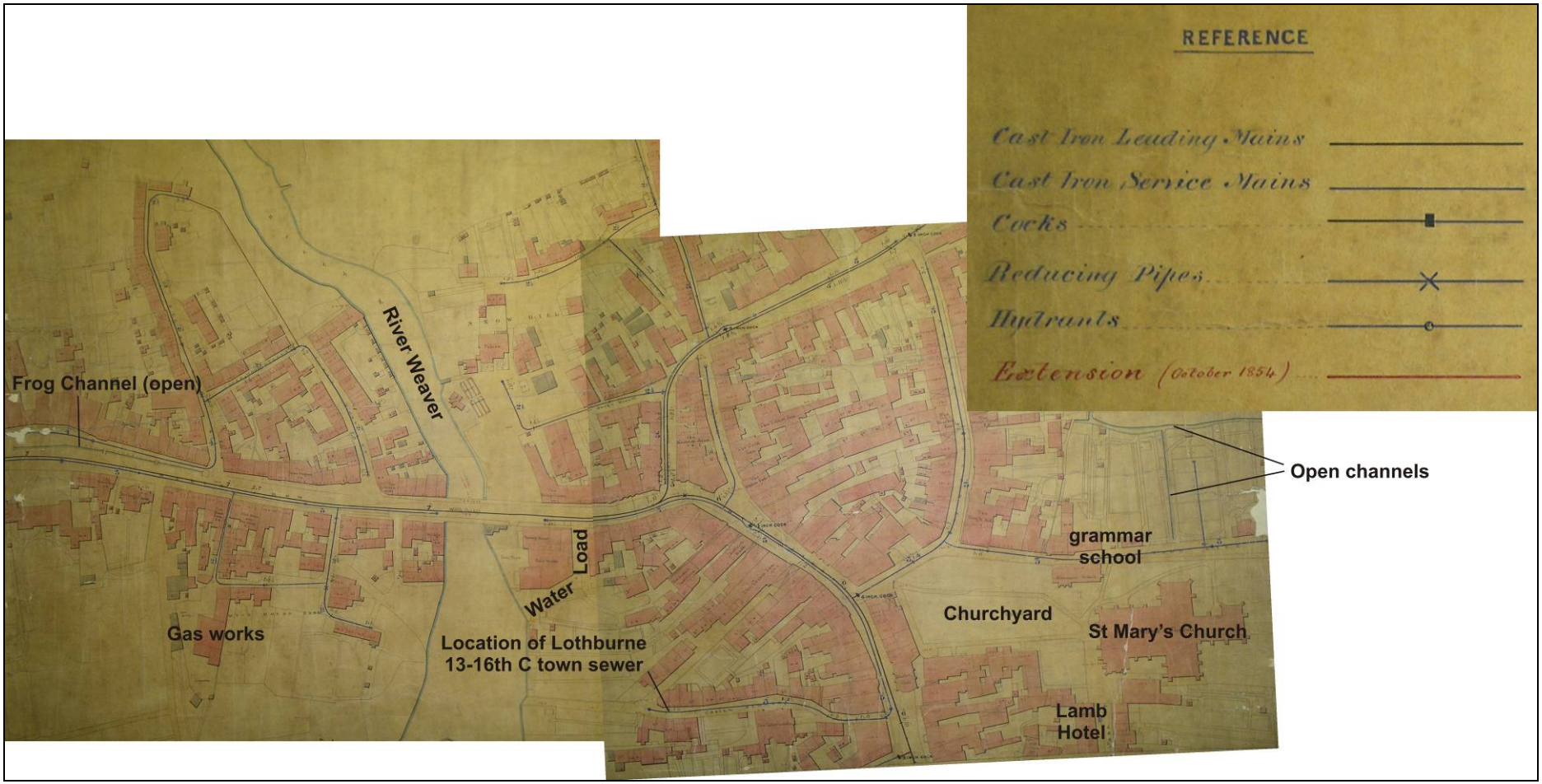
Saturated sands appear to underlie all the waterlogged deposits, and the reference in Simpson and Tasker's report (1925) to the church being built on such deposits demonstrates that this was a phenomenon observed in the past. The hydrogeological assessment in the desk study (SLR Consulting 2007) identified the potential for perched watertables and that seepages were generally within sand units comprising the drift geology; "perched water tables will either exist as isolate pockets or, where permeable deposits are extensive, and hydraulic continuity exists within the River Terrace Deposits, some lateral flow of groundwater may occur". If the sandy terrace deposits were saturated in antiquity, frequently recharged by both rain and ground water which could not drain through the deposits because of the impermeable basal layer of glacial till, then this would suggest a firm reason for the formation processes that allowed anaerobic conditions to develop preventing decay of organic matter, and thus the accumulation of deep archaeological deposits.

The period from which most dendrochronological dating comes in Nantwich, the 11th – 13th centuries (Appendix 1), corresponds with a period that is characterised as the climatic optimum (the Medieval Warm Period 900 – 1300), that had seen vineyards much further north than would be possible for almost a thousand years thereafter. Within this period the 10th – 12th centuries were particularly warm, whilst radial growth depression has been detected in tree rings for the period late 12th – mid 13th century, suggesting a time of stress for tree growth due to adverse climatic conditions (Sidorova et al 2006). In 1104 the Icelandic volcano Hecla erupted and its dust cloud arguably affected a wide part of northern Europe over many years. By the late 12th century temperatures were lowering across the North Atlantic, and by the early part of the 13th century there had been significant glacier advance in Iceland, to be followed across northern Europe (Aber 2007). During the early 14th century cooler and wetter summers caused problems with harvests, especially 1315 – 17. By the 17th century Europe was in a period known as the Little Ice Age, but to begin with the climate became colder and much wetter during the 13th – 15th centuries. This climatic deterioration must be one of the contributory factors to the growth of waterlogged deposits in Nantwich.

Figure 14 1851 Public Health Act and 1853 Sanitation Maps of Nantwich:

n.b. natural water channels and open drains visible on earlier map, whilst insertion of drains along main streets can be seen on later map (often replicating the ancient drainage pattern; see also Figure 13 & Drawing 3)



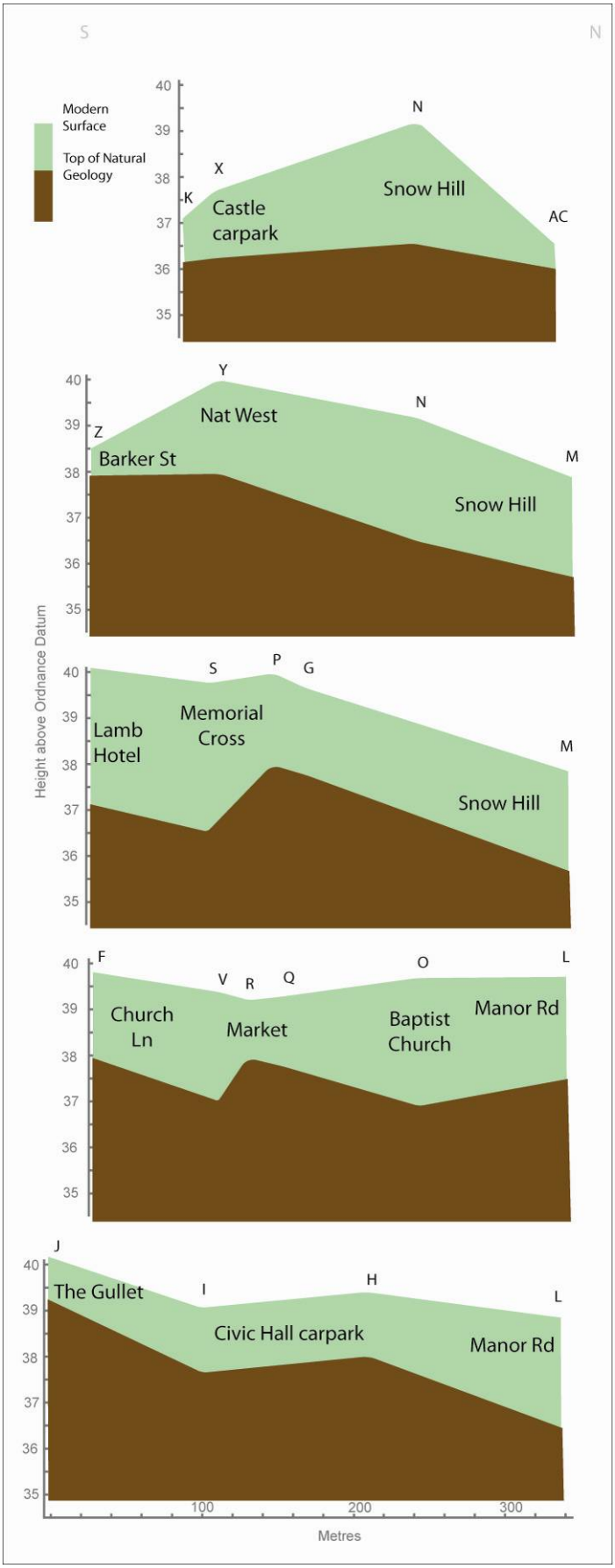

REFERENCE
Cast Iron Leading Mains
Cast Iron Service Mains
Cocks
Reducing Pipes
Hydrants
Extension (October 1854)
Frog Channel (open)
River Weaver
Water Load
Gas works
Location of Lothburne
13-16th C town sewer
Open channels
grammar
school
Churchyard
St Mary's Church
Lamb
Hotel

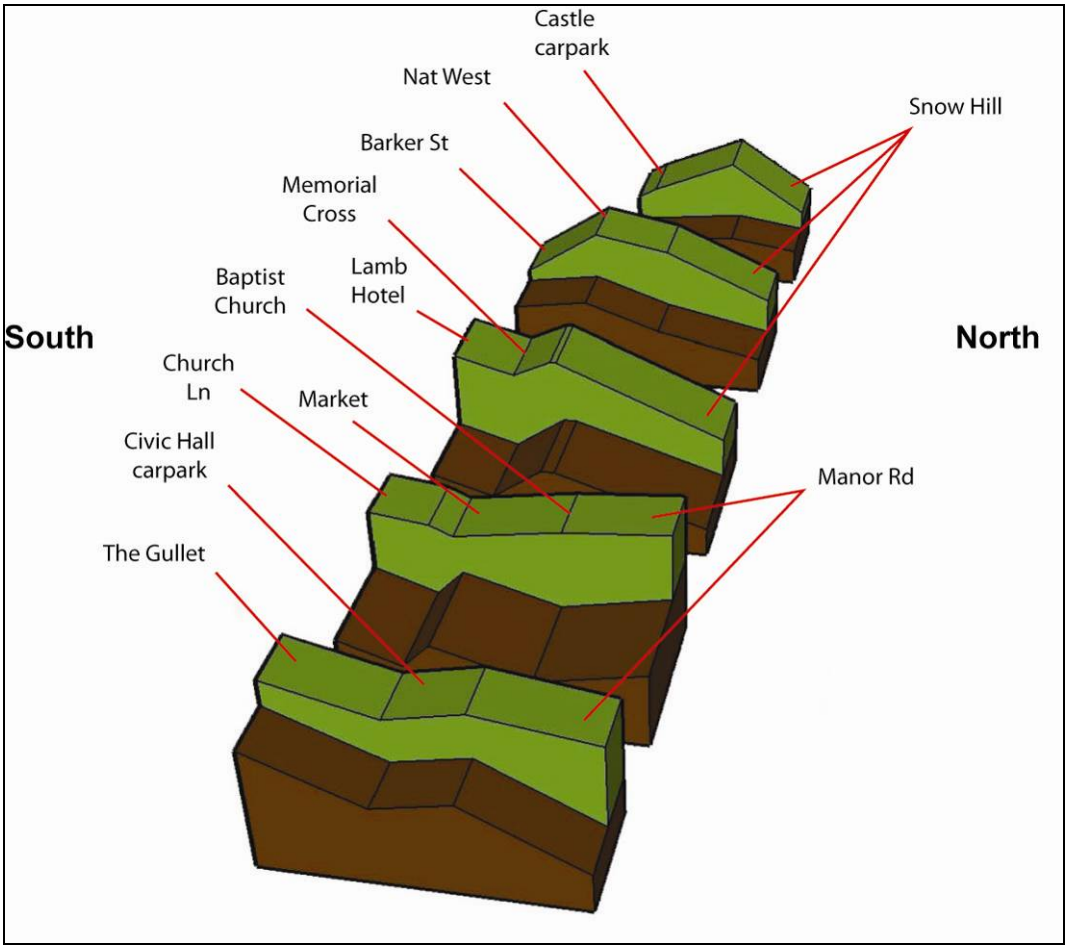
Perhaps of greater significance is the change to the natural pattern of hydrological drainage since 1850. The 1851 Public Health Act map of Nantwich, and the 1853 for the Public Sanitation Map show the locations of previous open water channels, and where mains water pipes were inserted (on the later map), (Figure 14). These mains tend to follow the prevailing sub-surface pattern of natural drainage, adapted to the street pattern of the 19th century town. It is interesting to note, for example, that one pipeline runs from High Street to the castle area, terminating at the same location as the medieval wooden conduit and drain ("Lothburne") identified during archaeological monitoring of waterworks at Bowers Row car park (Gifford 1995). During archaeological monitoring of an electric main being laid through the Churchyard in 2005, a ceramic drain was found at a depth of 1.8m; it was noted that deposits were dry to this depth, in spite of wet deposits being recorded at 0.7m depth elsewhere along the cable route (EAS 2005, 4).

In Drawing 3 an attempt has been made to reconstruct the underlying topographical location for probable aquifers (Natural Surface Flow Accumulation Paths) and this suggests the importance of Churchyard Side and the High Street for the sub-surface drainage to the river (incorporating BHs R, V, U, T, S, and P (n.b. BHs N and AC lie on smaller aquifers within the same drainage area)). To the south of this a local watershed runs along the gravel ridge on which Hospital Street is constructed, with another local watershed running southeast – northwest (through BHs I, H, L, M, and B (n.b. BH O is an exception as it lies on an original water channel shown on the 1851 map)). This model supports the evidence derived from archaeological investigation and the recent coring programme, in that deeply stratified and waterlogged deposits largely lie and have infilled this natural "valley" (Figure 15), and this is probably a key factor in how and why such deposits (domestic refuse, stabling refuse, surfaces and episodic fires and levelling events) have accumulated and survived.

Drawing 3 shows the natural drainage reconstructed from elevation and dtm data, together with boreholes and archaeological evidence for waterlogging superimposed; note watershed along Hospital Street and Manor Road.

Figure 15 Infilled valley as shown by borehole transects and 3D representation





The prevalence of hard surfaces in the modern town will have had a major impact on the ability for surface recharge of these waterlogged deposits (especially in Zone 2, the higher slopes of the town), and it may have been that in the past, large areas such as the churchyard and unpaved streets provided an absorbent surface for rainwater to percolate down and be soaked up by underlying deposits, with drainage stopped by the glacial Till at the base of the terrace sands. The modernisation of the townscape for all-weather usage has probably led to gradual drying out of the waterlogged deposits and the previously saturated terrace sands, thus forming a major contributory factor to the onset of decay.

Physical evidence for this drying out can be demonstrated for example, through the need for underpinning at the memorial cross in 2002 and demolition of the north range to the Lamb Hotel in 2004, both of which displayed considerable subsidence. Flooding and disturbance to the fabric of St Mary's Church by underground springs and streams (Williams 1985, 55) has led to a number of campaigns of repair and maintenance in 1614, 1854-61, and in 1983.

4.11 Preservation potential in Nantwich – integrating the results of the palaeoenvironmental assessment, geochemical analysis and groundwater sampling

4.11.1 Zones of preservation

Taken together the geochemical data and the palaeoenvironmental assessment can be used to identify and provide supporting evidence for two distinct preservation zones within Nantwich, one zone where preservation can be expected to be good; and one where preservation will, by the nature of the topography be varied (Figure 16).

The principal redox sensitive parameter that can be used to define the characteristics of the burial environment is sulphur. Where sulphates are present the potential for the oxidation of organic matter through the activity of sulphate reducing bacteria exists. Where sulphides predominate then the burial environment can be considered to be tending towards a reducing nature and hence conducive to the continued preservation of organic material. Loss on ignition (LOI) data can be used as a broad indicator of the organic component of the deposit. However, LOI data does not indicate the state of preservation of the organic matter – which might be in active aerobic decay or undergoing very slow anaerobic decay – the detailed preservation records shown in Appendix 3, tabulated environmental data, were therefore made to provide a baseline record of the quality of the observed organic preservation within the deposits.

Zone 1 – River Weaver Floodplain, Preservation Potential Good (Riverine deposits)

Zone 1 lies within the floodplain of the River Weaver.

Boreholes AB, AC, A, B, C, D.

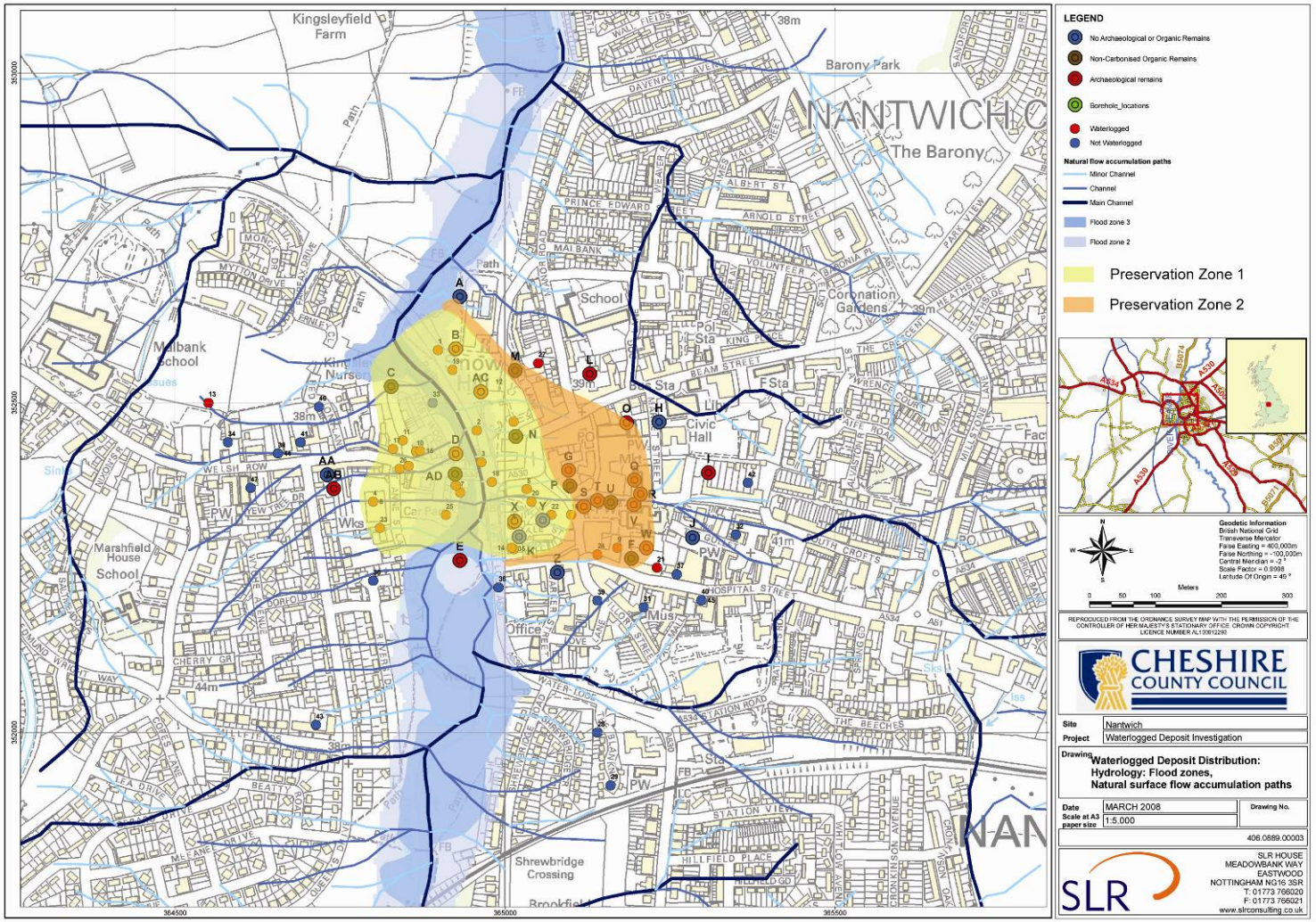
The geochemical data suggests that reducing conditions exist within the alluvial deposits. The deeper deposits can be characterised as having relatively high sulphide to sulphate ratios, with low levels of nitrate. The predominance of the reduced sulphur compound, sulphide, suggests that the deposits are tending towards a reducing environment. Loss on ignition values from two locations (BHs AC and C) were relatively high too, at around 8%.

Two small fragments of archaeologically undiagnostic wood were recovered, one from BH C, the other from AC. A small sample of oak wood was recovered from between 33.04 to 32.98 AOD (BH AC) which exhibited minimal decay (3% loss in wood substance). BH AB may delineate the western most extent of the zone – high levels of sulphate and negligible sulphide suggests that preservation potential would be minimal at this point.

BHs A and AB were not investigated for organic remains (both core sequences showing negligible uncharred organic content and containing voids) and the deposits recorded from the others were subsequently classified as ‘archaeological deposits’ containing little organic content within their matrix. Overall, the limited information from the assessment of the biological macrofossil and microfossil content of deposits within these boreholes could not provide evidence to substantiate or refute the implications of the geochemical data.

However, diatom preservation from BH C (sample 3) was excellent and provides further evidence that the riverine deposits are conducive to continued in situ preservation of organic remains.

Figure 16 Preservation Zones



Zone 2 – Archaeological Deposits above floodplain, Preservation Potential Variable.

This zone encompasses the rest of the assessment area, broadly east of the River Weaver, including archaeological deposits located above the floodplain and specifically within the core of the medieval town. The geochemical data are perhaps best summarised in terms of borehole transects through this zone.

Borehole transect Manor Road Car park to Church Lane – BHs F, W, V, R, Q, O, L.

This transect delineates the eastern limit. In broad terms, the deposits can be characterised by low or negligible levels of sulphide, moderate to high levels of sulphate, predominantly minimal levels of nitrate (apart from BH Q which recorded a high level of nitrates). All pH values near neutral although the sample from BH V was acidic (4.79) with a correspondingly high concentration of sulphate. The predominance of sulphate species suggests that some deposits are tending towards an oxidising environment and that preservation potential for organic remains is low in this area.

Borehole transect High Street to St Mary's Church – BHs Y, P, S, T, U, V, Q, R, I.
Sediments from this transect can be classified as having low sulphide concentrations and high sulphate levels. The pH values are near neutral apart from upper sediments from BH P which were markedly more acidic (corresponding to high sulphate values, and relatively high nitrate concentrations). BH P sediments were also characterised by a tendency towards reduced levels of sulphate with increasing depth (and saturation) which indicates that sediments that are likely to be intermittently waterlogged are oxidising whilst permanently waterlogged sediments can be described as reducing. Therefore preservation potential for this transect can be described as poor to moderate, and dependent upon dynamics of the water table.

Borehole transect Church Lane to the Swimming Pool – BHs F, T, S, P, G, N, AC, B, A.

Best preservation conditions to be found within the Weaver floodplain where geochemical analysis points to a more reducing burial environment. Reducing conditions (characterised by increasing sulphide levels, diminishing sulphate levels) to be found in the deeper core samples from F, N and G (although nitrate was present in both samples from G).

Borehole transect Castle Car Park to the Swimming Pool – BHs K, X, N, M, B, A.

From the results referred to above, preservation potential for this transect can be described as moderate to good. As discussed above, good preservation potential can be anticipated within the river Weaver floodplain, and moderate preservation elsewhere caused by water table dynamics. Reducing conditions will only exist where deposits are permanently waterlogged.

For Zone 2, assessment of the organic remains recovered from subsamples from some of the boreholes was able to provide rather more direct evidence in support of the geochemical data than was the case for Zone 1 (though in most cases the organic content of the deposits was still negligible). The preservation was observed to vary considerably from good to poor and this variability has also been reflected in deposits encountered during recent archaeological interventions located within this zone.

BHs F, N and P contained sequences of deposits with organic preservation lying between 36.315 and 38.98 metres AOD. Preservation of plant macrofossils and microfossil remains was often good within these deposits, but invertebrate macrofossil remains were mostly very strongly decayed (occasional better preserved remains were recorded from a small number

of samples some, but certainly not all, of which may represent post-depositional invaders). For BHs F and P, the geochemical assessment showed decreasing sulphate levels and increasing sulphide levels with depth (and for BH P significant drops in nitrate levels). This implies better conditions for the survival of waterlogged organic remains will also occur at greater depth in the vicinity of these boreholes (although, as noted above, the specific conditions prevailing at particular levels at any given time will be largely dependent on the dynamics of the water table). For BH F good preservation (other than of invertebrate macrofossils) was recorded throughout the principal organic deposits (subsamples F3-F6; 38.98-37.78 metres AOD) but in BH P the best preservation was recorded from subsamples P8 and P9 (38.425-38.195 metres AOD) approximately the middle third of the organic sequence. The very high sulphate and nitrate values recorded from the two uppermost (of three) geochemical samples from BH P indicate that the waterlogged organic remains present are in active decay and represent formerly saturated deposits which are now only intermittently wet (at best); the baseline groundwater level recorded in November 2007 was at well over 3 metres below the current surface at 36.595 metres AOD. The implication of the massively reduced sulphate and nitrate levels recorded from the lowest geochemical subsample in BH P (at 37.925-37.375 metres AOD) is that deeper archaeological deposits in the vicinity may exhibit exceptional waterlogged organic preservation. Deposits with waterlogged remains at the level of those recorded in BH P and above are clearly at risk, however. For BH F, it may be argued that the presence of invertebrate macrofossil remains (albeit mostly heavily decayed) in most of the subsamples examined implies even better organic preservation that that seen from BH P. Unlike BH P, no groundwater level was available for BH F, but recording in the field suggested that (at this time) this would be at more than 3 metres below the current surface (below 36.74 metres AOD) and hence that a similar potential and risk exists for nearby deposits with waterlogged organic preservation.

BH N showed the best preservation of waterlogged plant macrofossils seen during the assessment – from subsamples N7-N10 (37.255-36.445 metres AOD), N13 (37.415-37.365 metres AOD) and N17 (37.945-37.875 metres AOD) – within the organic sequence encountered between 38.095 to 36.165 metres AOD. In the field, the deposits were observed to become wet from as little at 0.7 metres depth (38.465 metres AOD) and subsequent baseline recording (in November 2007) reported the groundwater level as 37.795 metres AOD. Here then, it appears that, despite the relatively high sulphate levels recorded (suspected to reflect oxidation of sulphides within the geochemical sample prior to analysis), the organic remains are being preserved by reducing conditions within permanently waterlogged sediments – the preservation of the organic remains recorded from the subsamples above the baseline groundwater level (subsamples N18-N19; 38.535-37.945 metres AOD) was markedly poorer, presumably as a result of the oxidising environment created in intermittently wet deposits. Conditions for the preservation of waterlogged organic remains are therefore very good within these deposits, and any others nearby where the groundwater level remains constantly high, provided that these conditions continue to prevail.

Assessment of sediment samples collected from six boreholes in Zone 2 (F, G, M, N, P and Q) revealed that the quality of preservation of diatoms is poor. Intriguingly, the series of samples examined from BH P shows that the worst preservation was observed in material collected from the deeper section of the borehole (at a depth of between 2.17 and 2.50m), whilst marginally better preservation and diversity was observed in samples collected higher up the sequence. The extreme fragmentation of the diatoms is likely to be a function of reworking through human influence as well as the fact that the samples were collected from deposits exposed to a fluctuating water table.

Poor diatom preservation observed in samples from BH N presents a conflicting picture to that observed from the geochemical and palaeoenvironmental assessment which suggests that conditions conducive to continued preservation of organic remains exist at depth. As

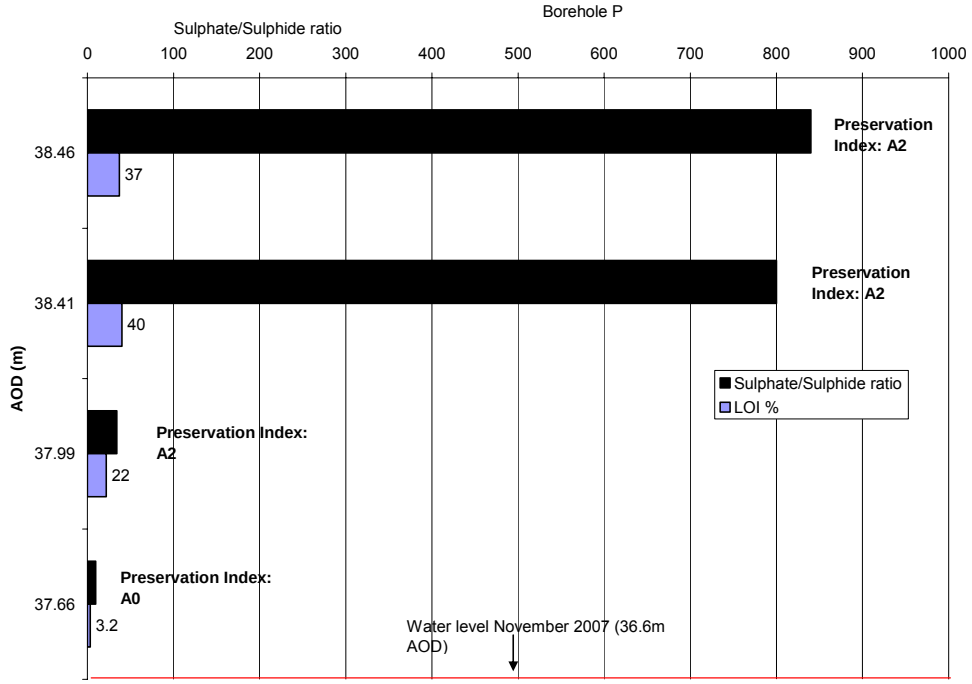
diatoms are principally siliceous in nature, the observed fragmentation in samples from BH N represents the nature of the burial environment at the time of deposition, rather than being indicative of current conditions.

4.11.2 State of Preservation scales and geochemical data

Two plots are included below showing the sulphate/sulphide ratio (the x-axis) the loss on ignition values (LOI, expressed as a percentage) and the overall preservation index (using the "State of Preservation Scale" from The Monitoring Manual, Riksantikvaren/Niku– also shown below – the more detailed preservation records for these deposits may be found in the tabulated environmental data in Appendix 3) for the deposits for two boreholes, BH P and BH N. Ground water levels for November 2007 have also been included.

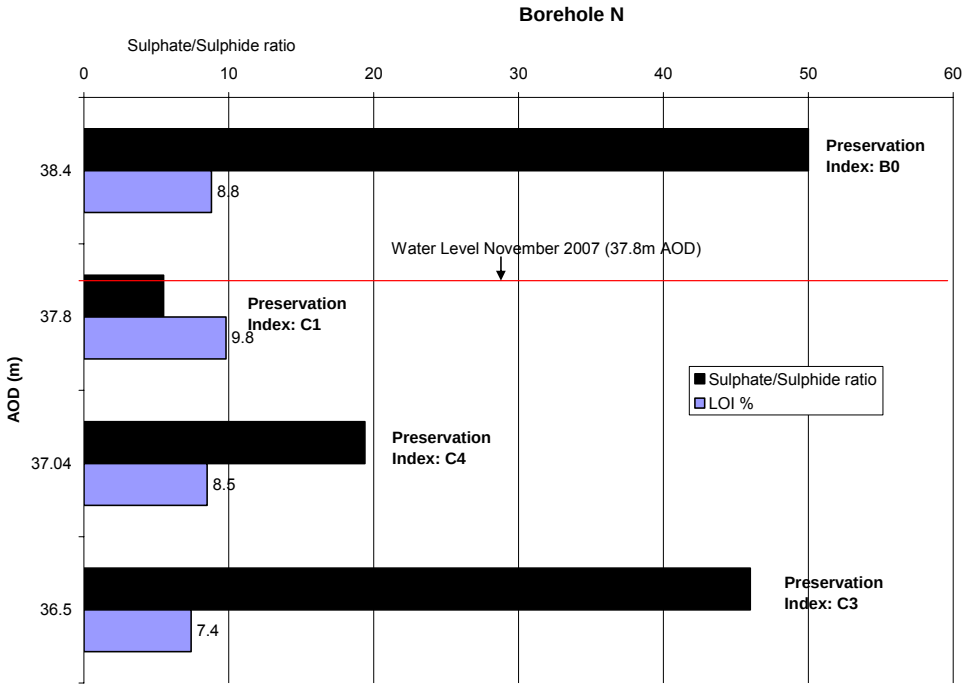
Figure 17 State of preservation scale (SOPS) and plots for BHs P and N

PRESERVATION SCALE		DEGREE OF PRESERVATION						
		NULL-VALUE	LOUSY	POOR	MED-IUM	GOOD	EXCEL-LENT	
POSITION IN RELATION TO GROUNDWATER	OVER	A0	A1	A2	A3	A4	A5	A
	OVER/IN	B0	B1	B2	B3	B4	B5	B
	IN	C0	C1	C2	C3	C4	C5	C
		0	1	2	3	4	5	
"Extreme situations/cases"		D0	D1	D2	D3	D4	D5	D
Fill etc later than ca. 1900		E0	E1	E2	E3	E4	E5	E



This plot for BH P shows that the sulphate levels are decreasing, and sulphide levels are increasing, with increasing depth and that the upper deposits have an overall poor level of

preservation (A2). All of the assessed samples are from deposits which were above the water table as recorded in November 2007 and which are likely to be in active decay. No organic material was recorded from the lower most sample, at 37.66mAOD (evidenced by the very low LOI value) hence a preservation index of A0 was assigned. However, conditions at this depth can be considered as being conducive to in-situ preservation of organic remains (where, and if, present). If the ground water maintains this observed level then decay will continue.



The plot for BH N illustrates how preservation potential improves where deposits sit within the water table and are potentially fully saturated for much of the time. Preservation ranges from “lousy” (just within the water table) to medium-good where saturated (Preservation indices C3 and C4). The moderate LOI value for the uppermost sample reflects the presence of rootlets (almost certainly modern) and charcoal. Note the increasing sulphate/sulphide ratio with increasing depth which is probably a result of oxidation of the sediment sample prior to analysis. Laboratory analysis of these samples detected high levels of sulphide, supported by the strong sulphide odour detected during opening of the core (recorded as “overpowering” in Appendix 3).

Preservation of waterlogged organic remains was also recorded from the lower subsamples in BHs M and U (M1 at 35.81-35.58 and U1 at 37.075-36.245 metres AOD, respectively). BH U was located approximately equidistant between BH F and BH P near the centre of the historic town and the subsample with preservation was from a somewhat deeper lying deposit. The organic content of the subsample was recorded as very high but the preservation of remains was poor. Groundwater levels are not being monitored for BH U but records from the adjacent BH T (to the west) and BH V (to the east) reported this as 36.335 metres AOD and 37.44 AOD, respectively. It therefore seems plausible (and consistent with the recorded condition of the biological remains) that the groundwater level at BH U is such that the deposit subsampled as U1 is intermittently wet and that consequently its organic content will be subject to oxidation and relatively rapid decay (sulphate levels were moderate from the lower of the two geochemical subsamples at 37.195-37.125 metres AOD but significantly lower – only about two-fifths the value – than recorded from higher in the sequence at 37.555-37.455 metres AOD). For subsample M1 groundwater levels are being

monitored and the November 2007 baseline record was at 36.23 metres AOD, well above the level of the deposit. However, the preservation in subsample M1 was recorded as similar in nature to that from U1, i.e. very highly organic but with rather poor preservation of individual remains. It may be that this deposit too is subject to repeated wetting and drying and that the resultant oxidising environment is causing fairly rapid decay of its waterlogged organic content.

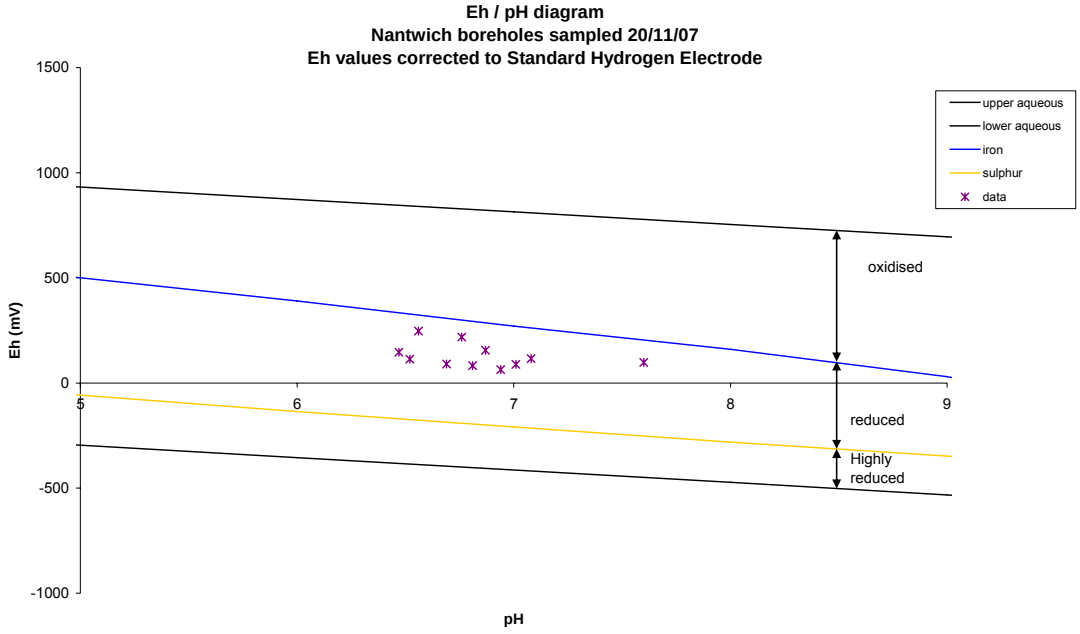
The subsamples from six of the boreholes (BH E, Q, R, S, T and Y), included in the investigation as they contained possible evidence for archaeological activity, showed little or no waterlogged organic content and provided no interpretatively valuable remains for comparison. Similarly, BHs G and V provided too few organic remains for useful comparison with the geochemical assessment results.

4.11.3 Groundwater analysis

A limited programme of groundwater analysis has been conducted following the installation of 11 dipwells. Parameters recorded include water levels, redox potential, pH, conductivity, salinity, dissolved oxygen, as well as the major redox sensitive parameters and methane gas. Data was collected on 20th November 2007, and data plots can be viewed in Appendix 5. Conclusions drawn from these data sets can only be tentative – the data represents readings collected on one day only, and each dipwell has a broad response zone collecting water from between 1-3m below the ground surface. However, the results broadly complement the conclusions from the sediment geochemical analysis.

Redox readings taken with the ORP probe have been calibrated to the Standard Hydrogen Electrode and are shown in figure 12 below, plotted onto a stability field diagram.

Figure 18 Redox Potential of deposits in Nantwich



The plot shows a number of boundary conditions that have been used to define the characteristics of the burial environment – whether iron (II) or iron (III) predominates, or whether sulphur is present in its reduced form (sulphide) or oxidised form (sulphate).

Standard categories to define the redox potential of burial environments are based on previous studies into rice production (Patrick and Mahapatra, 1968) and have been adopted by in situ preservation scientists. These categories are:

Table 5 Ranges in redox states

Redox State	Redox potential range
Oxidised	> +400mV
Moderately-reduced	+100 to +400mV
Reduced	-100 to + 100mV
Highly reduced	-300 to – 100mV

However, following recent investigations at Sutton Common (Cheetham 2007), a revised system has been designed for the interpretation of Eh/pH diagrams. Hence conditions between the iron II/III boundary and the upper limit of the aqueous system represent oxidised soil conditions, those between the sulphate/sulphide and the iron II/III boundaries represent reduced soil conditions and those between the sulphate/sulphide and the lower limit of the aqueous system represent highly reduced, anoxic conditions.

Measured redox values lie above the sulphur boundary and therefore groundwater conditions on 20th November 2007 in Nantwich can be described as being of a reduced nature. This suggests that the burial environment is one where the oxidised form of sulphur, sulphate, can be reduced through the action of Sulphate Reducing Bacteria using organic material as a substrate. The sulphate reducing bacteria would be capable of oxidising organic material as well as initiating corrosion of iron artefacts.

The pH values recorded from groundwater in the dipwells is marginally more acidic than the pH values measured in the sediment samples. This may reflect the more oxidised nature of the water.

Conductivity values ranged from a minimum of 471 μS/cm (BH V) to a maximum of 3505 μS/cm (BH AC). Conductivity values have been used to determine the source of water in natural ecosystems, with values less than 100μS/cm being indicative of moisture derived solely from precipitation and values in excess of 100μS/cm indicative of moisture derived from groundwater as well (Caple and Dungworth, 1998 p20). The below ground deposits in Nantwich are likely to be recharged by a combination of ground- and surface water flow.

There is a high degree of correlation between conductivity and salinity (see A5 figures 1 and 2) which suggests that most deposits within Zone 2, the medieval core of the town, are recharged principally through surface water flow and that there is no connectivity with the river. This is to be expected given the elevated topography of this area.

Analysis of methane levels (A5 Figure 9) reveals 3 “hot spots” within the medieval core of the town. One “hotspot” is centred around BH N where preservation of organic remains was good. Methane is an indicator of highly reducing/anoxic conditions conducive to preservation of organic remains. Comparison with other data sets for BH N is informative. For example, low levels of phosphate and nitrate (A5 Figures 10 and 7) were recorded from groundwater

samples, and a negative redox reading (A5 Figure 4) is indicative of reducing conditions. Low levels of sulphate and ferric iron were also detected too (see A5 Figures 5 and 6).

4.11.4 Overview of preservation potential

In broad terms, the preservation potential within Zone 2 is variable, with areas where some of the preserved organic remains are already in active decay and others are most likely at risk. Three of the boreholes investigated contained organic sequences of deposits and there is certainly evidence of substantial organic remains, preserved by waterlogging rather than charring, of Roman and medieval date from recent archaeological interventions within this zone. These include structural timbers and wooden coffins (e.g. in 2007 at High Street, Welsh Row and Wych House Bank – Earthworks Archaeological Services Ltd, Project No. E962; in 2005 from a watching brief at St Mary's Church – also undertaken by Earthworks and including human skeletal remains – and an evaluation at Bowers Row by Gifford and Partners; in 2003 from an assessment at Second Wood Street by Earthworks – biological remains investigated by Oxford Archaeology North in 2007 (Druce & Huckerby)); medieval oak coffins were also reported from Churchyard Side in 1925 (Simpson & Tasker). In these cases, the majority of the organic remains appear to be of substantial wooden items or compressed layers of smaller woody fragments (e.g. bark and wood chippings – Context 37 in Area 2b at Welsh Row) preserved within or sandwiched between essentially inorganic deposits of sands, silts and clays. Various routes to waterlogged organic preservation in urban archaeological deposits, and the loss of 'easily-decayed' organic remains therein, have been discussed by Kenward and Hall (2006). In Nantwich Zone 2, we are perhaps seeing evidence (in BHs F and P) of what Kenward and Hall (*op*. *cit*.) would classify as waterlogged 'sponge' deposits, i.e. "Local concentrations of highly organic material which retain water like a sponge" and located above the true water-table. These deposits may be highly localised (e.g. the fills of a single pit) or very extensive, with the smaller organic 'sponges' being highly susceptible to rapid decay of organic content in the event of dewatering – a process strongly suspected to be occurring within deposits seen at 44-5 Parliament Street, York (Davis *et al*. 2002), for example. Within BH N we see excellent waterlogged organic preservation within deposits which currently lie within the water-table and which are therefore much less vulnerable to decay – provided, of course, that the groundwater level is not drastically reduced. The geochemical assessment suggests that, at depth, conditions exist for the continued preservation of this vulnerable resource. Nutrient levels are low, pH values tend towards neutral (therefore having limited impact upon non-organic remains) and that the predominant redox sensitive parameters fall within the sulphur and iron boundaries. The key issue is therefore water levels – where deposits are kept fully saturated decay will be that mediated by anaerobic bacteria operating at extremely low levels of activity. Those deposits residing above or within the fluctuating groundwater levels will be prone to decay, initiated by sulphate reducing bacteria. The next stage of the Nantwich project should aim to investigate the dynamics of the urban hydrology in more detail.

5.0 CONCLUSIONS

5.1 Review of Objectives

The project has achieved the initial set of objectives and laid the foundation for design of a robust management strategy. This strategy will be essential in continuing preservation for Nantwich's rich waterlogged archaeological deposits, archaeological remains which, although of national importance, are not given statutory protection. It will also be essential to develop a second stage to the project so that the efficacy of the management strategy can be analysed and refined as necessary over the short - medium term.

The first stage has put in place the infrastructure for future monitoring of the burial environment so that change can be detected at an early stage, and once agreement has been reached to implement a second stage this monitoring programme can be implemented as part of an iterative process. The network of dipwells is, however, incomplete, especially on the west side of the river. Formation processes for the onset and growth of waterlogged remains is as yet incompletely understood, and although various hypotheses have been deduced, they remain to be tested (see 4.11 above). There are therefore actions that need to be taken in the immediate future as part of an on-going management strategy.

5.2 Defining a Management Strategy

The foundation laid by the project to date has been sufficient to write a management strategy and formulate an action plan. The management strategy has included the following:

1. Production of guidance on development including mitigation techniques for design solutions and for long-term monitoring of any impact from development

2. Production of constraint map showing waterlogged deposits

3. Explanation and significance in support of constraints map

All of the above have been contained within a Supplementary Planning Document for Crewe and Nantwich Borough Council and their successor authority[3]. The following points are raised in more detail within the recommendations section, and their implementation would need to form a second stage as a continuation to the existing project.

4. Identification of key research issues and locations

5. Insertion of supplementary dipwells, logging and sampling of cores on drilling

6. Long-term monitoring of groundwater levels and chemistry

7. Dissemination of the results of the project for various audiences

8. Sharing of knowledge and benefits from pioneering project

[3] Nantwich Waterlogged Deposits Report No. 3 *Management Strategy: Supplementary Planning Document for the Historic Environment and Archaeological Deposits* SLR December 2008

5.3 Recommendations for further work

5.3.1 Palaeoenvironmental investigation

The purpose of the current investigations, to determine the extent and quality of preservation of waterlogged organic remains in the deposits under Nantwich as encountered by the borehole survey (and, to a lesser degree, establish the character of the assemblages recovered) has been achieved. Although no further study of the waterlogged plant remains collected during the survey and reported here is warranted, it is recommended that a second stage to the project be undertaken to enable review of the effectiveness of the management strategy and help to ensure the future stability of the deposits. As part of this second stage, supplementary data on the palaeoecological remains will be gathered and assessed to provide more extensive evidence for the nature of the organic remains, and their variable susceptibility to development and desiccation within diverse parts of the town.

5.3.2 Diatoms

Further investigation of BH C from Zone 1 (or other boreholes from within the western areas of the River Weaver floodplain (see section 4.6)) and the incorporation of a salinity transfer function would be of great value in helping to identify changes in the diatom assemblage and external influences on the diatom flora. The through-the-profile analysis of BH P (Figure 10) demonstrates the usefulness of this technique.

Comparison of the diatom and plant fossil records from the river floodplain in Zone 1 would help to identify the presence of varying wetland contexts, thereby providing an indication of the potential for reducing conditions and the preservation of organic material. Similarly, the identification of the specific contexts of deposition associated with the samples studied from the eastern side of the Weaver floodplain would assist in the identification of the specific factors responsible for the compromised preservation status in evidence in the samples from Zone 2.

If the analysis of samples from Zone 2 is considered important, the application of other methods of preparation (e.g. flotation) could be applied in order to isolate the mineral faction. However, it should be noted that the high degree of breakage indicates that the removal of the mineral component (which utilises harsh chemicals) may not assist in the diagnosis of the character of the diatom assemblage to any significant degree.

5.3.3 Deposit monitoring and geochemical assessment

Baseline conditions characterising the burial environment and degree of preservation of organic remains have been established. The evidence points to active decay of organic remains in those deposits that are intermittently saturated, whereas those deposits permanently saturated remain conducive to in situ preservation. There appears to be little ingress of nutrients including phosphates into the deposits.

The project has succeeded in producing an outline model of where deep, organic-rich waterlogged deposits are likely to be encountered in Nantwich, and provides the immediate basis for designing a management strategy (see section 4.9.1):

- A second stage is required to monitor the effectiveness of this strategy, and to refine it in the event that the waterlogged deposits experience increased levels of decay.

- In addition the second stage will need to establish more detail about the spatial locations and depth of these deposits in particular areas of the town including the castle area and the west bank (see section 4.3.2).

- The second stage will develop methodologies so that improved methods for recording cores on site are designed, and so that decisions can be objectively reached as to discard policy on material with no archaeological value (see section 4.9.2)

A second stage is strongly recommended in order to establish whether these deposits remain in a stable condition once the management strategy has been implemented, their susceptibility to decompose and shrink, and to investigate their vulnerability to modern interventions such as construction of new buildings or insertion of services. The focus of a Stage 2 for the project should be towards a robust monitoring of the management strategy to ensure continued preservation of the waterlogged deposits through a more thorough understanding of the urban hydrology of both preservation zones:

Zone 1: Two monitoring transects should be established within Zone 1 – one running west-east towards the river, along Welsh Row and a second running north-south parallel to the river between BHs C-D. Multi-level sampling may be required depending upon the nature of the below ground sediments.

Zone 2: An additional monitoring point should be installed at BH F, BH P (to specifically record 'stable manure' deposit between 38.62 to 37.93 AOD), BH V (organic – decayed wood fragments – deposit at 37.95 to 36.89 AOD).

- Frequency of groundwater monitoring should be fortnightly for a minimum of 12 months, when data will be reviewed.

- Rainfall data from the nearest meteorological station should be collected and factored into the groundwater modelling using a bespoke installation at Nantwich.

Soil chemistry – using groundwater redox values as proxy indicators for soil redox conditions can be unreliable. Interpretation of redox data has been improved through the initial geochemical assessment.

- It is recommended that automated arrangements for measuring redox at varying levels are implemented (see section 4.9.1).

- Ideally redox and other chemical parameters should be monitored at the same frequency as water level monitoring.

The potential of using methane as a proxy indicator warrants further study (see section 4.9.2). Whilst the source of the gas might be contamination (i.e. as a result of a fractured gas main, and easily tested by C14 dating a sample) and the nature of the gas itself may cause problems (methane will percolate some distance underground from its source):

- it is recommended that a further campaign of gas monitoring is carried out to test its efficacy as a proxy indicator of the nature of the burial environment and hence preservation potential for organic remains.

- This should be complemented by monitoring carbon dioxide levels, which would indicate aerobic conditions (see section 4.9.1).

- This can be achieved through acquisition of a GA 200 gas analyser and with multi-level sampling from each well (see section 4.9.2)

As a general policy for development within Nantwich it is recommended that:

- All future projects should include installation of dipwells as a default option for boreholes, so that monitoring regimes can be established quickly and at minimal extra cost (see section 4.9.2)

- All geotechnical borehole logs and locations from future development should be retained for inclusion within any future modelling of the deposits. These records should be integrated as a standard part of all archaeological desk-based assessment reports

- All archaeological investigations must contain data that have been corrected to ordnance datum in their drawn and published output so that stratigraphic sequences from diverse investigations can be correlated

5.4 Conclusion

The Nantwich project has advanced not only our understanding of the waterlogged deposits beneath the historic town, but also it has developed methods for effective analysis of the burial environment and the factors that influence conditions suitable for preservation of organic remains. The approach and lessons learnt from the Nantwich project have an applicability for many other locations in the UK and internationally. This area of scientific study is still very much in its infancy, and adequate response to the severe threats faced by archaeologically-rich waterlogged deposits is both complex and pioneering. The vulnerability to cultural heritage posed by a modern world susceptible to climate change, exacerbated within urban areas where development pressures are intense and the management or water is a major area of concern, is an issue that seems almost too massive to counter. It is through a multitude of small-scale studies and incremental development of methodologies, such as the example provided by the Nantwich project, however, that solutions might be found. There is therefore an imperative to share knowledge between conservation professionals, regionally, nationally and internationally, so that proactive measures can be designed to enable the continued preservation and investigation of such waterlogged archaeological deposits. They are a common heritage to many communities, and an awareness of their fragility, together with management strategies for their protection, needs to be raised at the highest levels in order that co-ordinated policies can be agreed as part of the multi-disciplinary spatial planning, and urban water management agendas.

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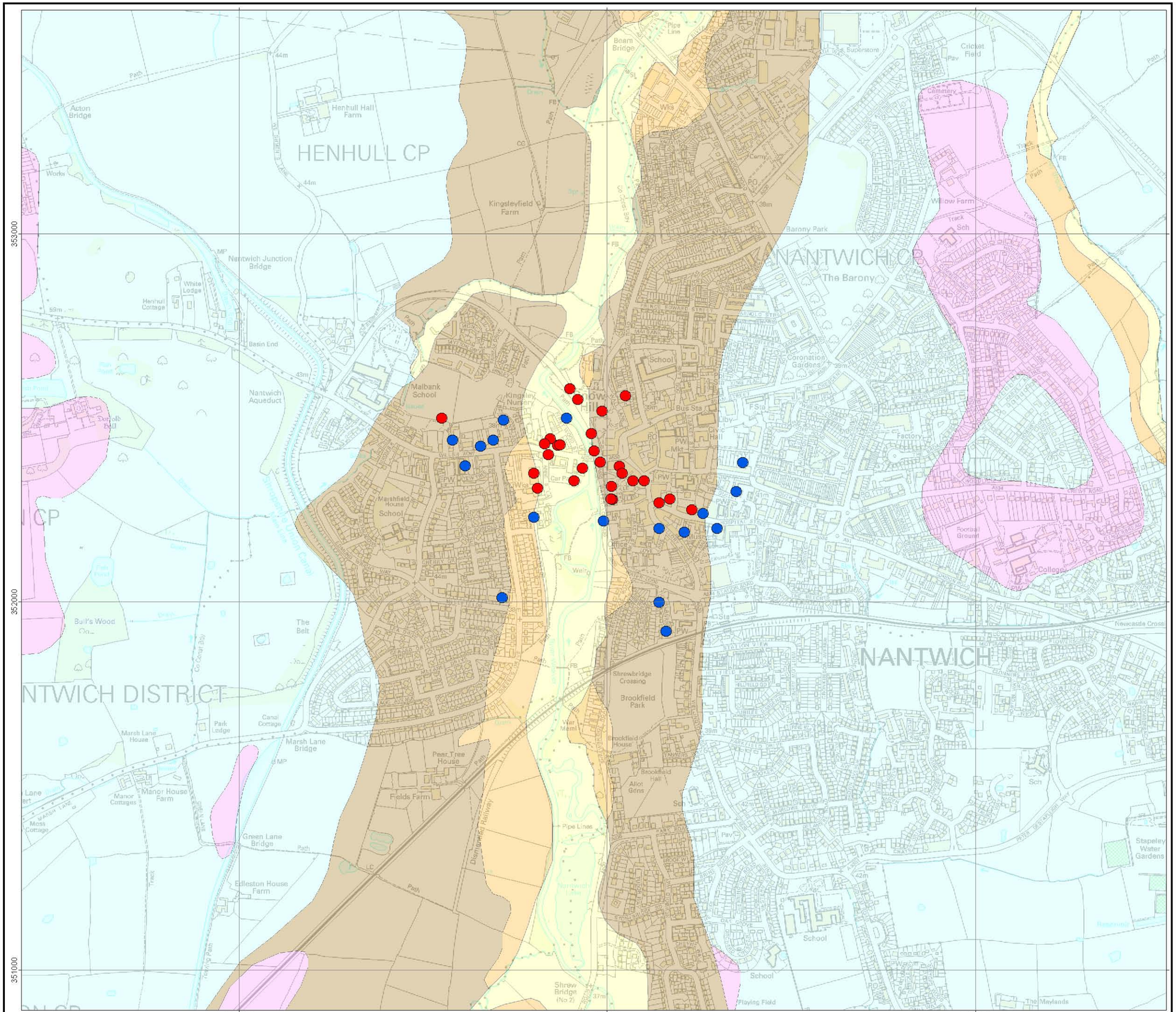
DRAWINGS



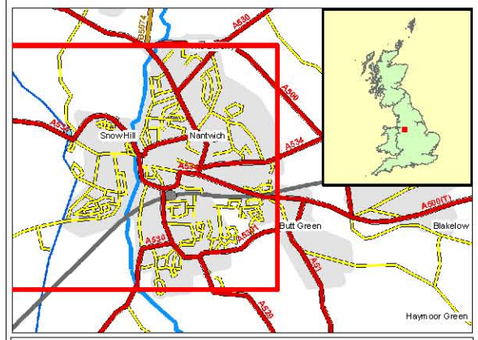
LEGEND

Archaeological data

- Waterlogged
- Not Waterlogged

Geology - drift

- Alluvium
- River terrace deposits, 1
- River terrace deposits, 2
- Glaciofluvial deposits (undifferentiated)
- Till



N W E S

Geodetic Information
British National Grid
Transverse Mercator
False Easting = 400,000m
False Northing = -100,000m
Central Meridian = -2°
Scale Factor = 0.9996
Latitude Of Origin = 49°

Meters
0 100 200 400 600

REPRODUCED FROM THE ORDNANCE SURVEY MAP WITH THE PERMISSION OF THE CONTROLLER OF HER MAJESTY'S STATIONARY OFFICE, CROWN COPYRIGHT, LICENCE NUMBER AL100012293

ENGLISH HERITAGE

CHESHIRE COUNTY COUNCIL

Site	Nantwich
Project	Waterlogged Deposit Investigation

Drawing

Waterlogged Deposit Distribution: Local Geology - drift

Date	NOVEMBER 2007	**Drawing No.** 1
Scale at A3 paper size	1:10,000	

406.0889.00003

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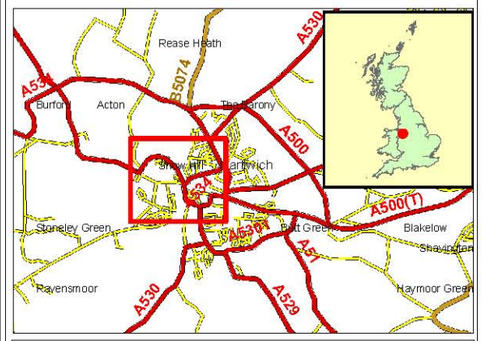
LEGEND

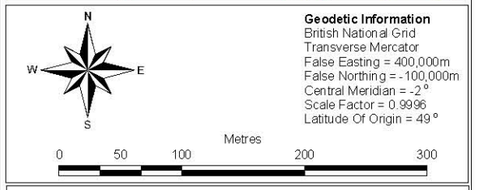
Borehole Data

- No Archaeological or Organic Remains
- Non-Carbonised Organic Remains
- Archaeological remains (previously waterlogged)

Archaeological Data

- Waterlogged
- Not Waterlogged





Geodetic Information
British National Grid
Transverse Mercator
False Easting = 400,000m
False Northing = -100,000m
Central Meridian = -2°
Scale Factor = 0.9996
Latitude Of Origin = 49°

REPRODUCED FROM THE ORDNANCE SURVEY MAP WITH THE PERMISSION OF THE CONTROLLER OF HER MAJESTY'S STATIONARY OFFICE, CROWN COPYRIGHT, LICENCE NUMBER AL100012293

ENGLISH HERITAGE

CHESHIRE COUNTY COUNCIL

Site	Nantwich
Project	Waterlogged Deposit Investigation
Figure:	Borehole locations
Date	NOVEMBER 2008
Scale	1:5,000 @ A3 paper size
Drawing No.	2
	406.0889.00003

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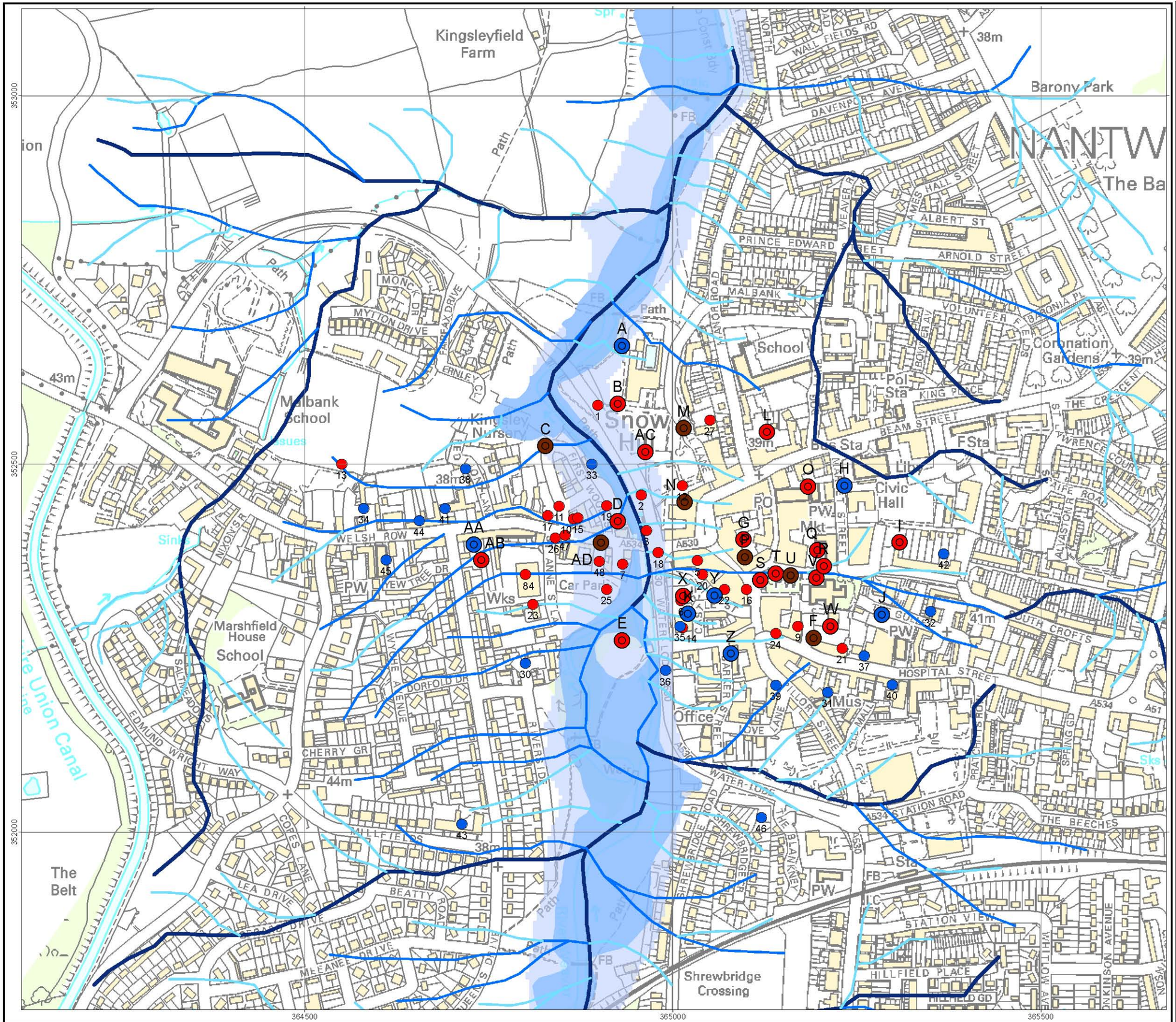


LEGEND

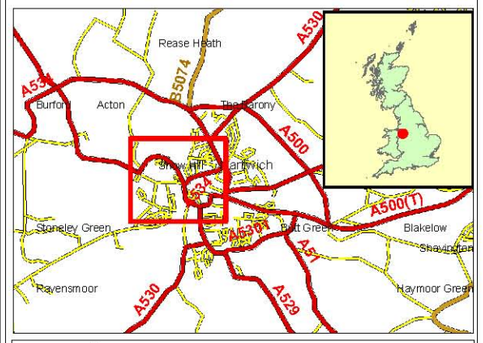
Borehole Data

- No Archaeological or Organic Remains
- Non-Carbonised Organic Remains
- Archaeological remains (previously waterlogged)

Archaeological Data

- Waterlogged
- Not Waterlogged

- Minor Channel
- Channel
- Main Channel
- Flood zone 3
- Flood zone 2



N
W
E
S

Geodetic Information
British National Grid
Transverse Mercator
False Easting = 400,000m
False Northing = -100,000m
Central Meridian = -2°
Scale Factor = 0.9996
Latitude Of Origin = 49°

Metres
0 50 100 200 300

REPRODUCED FROM THE ORDNANCE SURVEY MAP WITH THE PERMISSION OF THE CONTROLLER OF HER MAJESTY'S STATIONARY OFFICE, CROWN COPYRIGHT, LICENCE NUMBER AL100012293

ENGLISH HERITAGE

CHESHIRE COUNTY COUNCIL

Site	Nantwich
Project	Waterlogged Deposit Investigation

Figure:
Waterlogged Deposit Distribution: Hydrology: Flood Zones, Natural surface flow accumulation paths

Date	NOVEMBER 2008	Drawing No.
Scale	1:5,000 @ A3 paper size	3

406.0889.00003

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APPENDIX 1

Tabulated syntheses
archaeological investigations & scientific dating

Table 1: Nantwich Waterlogged Deposits: Archaeological Report data

Reference number (Fig 1) & Location	NGR	OD asl surface	OD asl top of organic remains	OD base of organic remains (& deposit thickness)	OD natural geology	Depth of deposits from surface	Nature of deposits	Dating	Historic context	Report reference	HER reference	Year of investigation	Organization involved
Ref 1 Snow Hill new road BH12	SJ 6496 5241	36.3	33.6	29.8 (3.8)	29.8	3.8	Loose grey sandy silt, organic matter, wood fragments			CCC BH log		2001	
Ref 2 Snow Hill new road BH11	SJ 6495 5245	36	33.1	29.9 (3.2)	29.9	3.2	Loose black fine/med organic sandy silt; wood fragments			CCC BH log		2001	
Ref 3 Snow Hill New road BH10	SJ 6489 5258	35.4	32	>28.9 (>3.1)	unknown	>3.3	Soft brown sandy clay; pockets of organic matter, organic laminated clay & wood frags overlain by alluvium			CCC BH log		2001	
Ref 4 & 8 St Anne's Lane	SJ 6480 5235	36.2	35.6	(>3.0)		4	Organic remains, timbers, ditches	Roman		2531, 2603	4085, 4145	2004 - 5	Gifford
Ref 5 10 - 16 High St	SJ 65033 52369	(c.37.5)				2	Organic remains,pits, cobbled surface	12th - 17th c	Town centre	2129	3629, 179/0/50	1996	EAS
Ref 6 Bowers Row car park	SJ 65011 52315	100'.5 – 98'.9 (c.36)		(>1.6)		>2.5	Organic remains, wooden culvert,wattle fencing, castle platform	1218 - 1263, 14th - 16th c	Castle, Lothburne town sewer	2064	3577, 179/0/47	1995	Gifford
Ref 7 1 - 5 Welsh Row	SJ 64932 52364	(c.35)		(>0.57)		>0.72	Organic remains, timbers, salt working	12th - 14th c	Salt working	2538	4091	2004	EAS
Ref 9 The Lamb Hotel	SJ 6517 5228	40	38.8	37 (1.8)	37	3	Organic remains, timbers, surfaces, wooden artefacts	1162 - 1322, 11th - 20th c	Town centre	2484, 2545	3991, 4098	2003 - 4	Gifford
Ref 10 Cheshire Cat Welsh Row	SJ 64865 52426	(c.36.5)		(>3.0)		>3.25	Organic remains, wooden artefacts, leather		Salt working	2410	3894	2002	EAS
Ref 11 Cheshire Cat car park	SJ 6483 5243	(c.36.5)		(>3.25)		4.5	Timber structure	12th c	Salt working		180/0/2	1980s	R Turner

Reference number (Fig 1) & Location	NGR	OD asl surface	OD asl top of organic remains	OD base of organic remains (& deposit thickness)	OD natural geology	Depth of deposits from surface	Nature of deposits	Dating	Historic context	Report reference	HER reference	Year of investigation	Organization involved
Ref 12 Snow Hill car park	SJ 64985 52519	(c.36.5)		(>2.8)		3.5	Organic remains, timbers, wattle hurdles	Roman		2552	4218, 4055	2004	Malcolm Reid
Ref 13 Kingsley Fields	SJ 6455 5250	(c.38-40.5)		(c.1.2)		2.8	Timbers, wicker, wooden artefacts, ditches	Roman		2540	4094	2001-3	UMAU
Ref 14 Mill St	SJ 65013 52278	(c.35)		(c.0.4)		1 - 2.35	Timbers	Roman	Castle	2557	4213	2005	EAS
Ref 15 Three Pigeons, Welsh Row	SJ 64871 52427	34.82 - 35.06	34.12 - 34.36	(>0.4)		>1.1	Organic remains, timbers, salt ship, wattling	medieval	Salt working	2569	4201	2005	EAS
Ref 16 Nat West Bank, High St	SJ 6510 5233	(c.40)				1.32	Organic remains, timber roadway, leather	1216 - 72 Henry III coin	Town centre	CAB10	179/0/39	1984	P Hutchings
Ref 17 Second Wood St	SJ 64845 52443	34 - 37	32.9 - 35.9	(>1.25)		>1.65	Organic remains, timbers, peat	13th - 14th c	Salt working	2377	3861, 180/4	2001	EAS
Ref 18 High St	SJ 6498 5238	(c.40)		(>3.6)		>3.6	Timber drains, straw, leather, wooden artefacts		Town centre & salt working		180/0/8	1978	A Blacklay
Ref 19 First Wood St	SJ 6492 5255	35			32 - 32.5	2.75	Waterlogging, timbers, wooden artefacts, leather	12th c	Salt working	Med Arch 27	180/2	1979-80	R McNeil
Ref 20 Crown car park	SJ 6504 5235	(c.37.5)				3	Organic remains, timbers, peat, wood, leather		Castle		179/2	1978	R McNeil
Ref 21 31 Hospital St	SJ 6523 5225	(c.40.5)		(1.08)		2	Organic remains, timbers, wood, twigs	13th - 15th c	Town centre	CAB4	179/0/19	1976	J Ray
Ref 22 Nat West, High St	SJ 6507 5233	(c.40)					Organic remains, timber conduits, wattling, leather	Saxo-Norman	Town centre, salt working, tannery, pottery		179/3, 180/3	1974-6	D Hill
Ref 23 St Anne's Lane	SJ 6481 5231	(c.36.5)		(0.3)			Organic remains, timber tank, cess pit	Roman 132AD	Salt working		178/0/2	1985	R McNeil

Reference number (Fig 1) & Location	NGR	OD asl surface	OD asl top of organic remains	OD base of organic remains (& deposit thickness)	OD natural geology	Depth of deposits from surface	Nature of deposits	Dating	Historic context	Report reference	HER reference	Year of investigation	Organization involved
Ref 24 47 High Street	SJ 6514 5227	(c.40)				2.85	Wooden fences, deep deposit	13th - 15th c	Town centre	CAB3	179/0/18	1975	J Dent
Ref 25 St Anne's Lane	SJ 6491 5233	(c.35.5)				2.5 - 3	Timbers, wattle hurdles		Salt working	Gas works remediation	180/0/1	1986	R Turner
Ref 26 37 Welsh Row	SJ 6484 5240	(c.35.5)				>2	Waterlogged wood, timber beams				180/0/3		R Turner
Ref 27 Snow Hill car park	SJ 6505 5256	(c.38)					Wood, posts, grey-black soil		Salt working	CAB10 Dendrochronological Consultancy Report 103; EAS report E962 May 2008	180/0/7	1982	P Hutchings
Ref 47 33 Welsh Row	SJ 64848 52406	(c.36)	c. 35.25	c.34.5	c.34.5	1.5	Timber corduroy roadway	mid-late 13th C	Main thoroughfare			2007	SLR; EAS; Tyers 2008
Ref 48 Wych House Bank	SJ 64901 522387	(c.36)					Barrels and barrel lids		Salt working	EAS report E962 May 2008		2007	EAS
BH AD 14 Welsh Row	SJ 64900 52394	(c.36.5)		(2.87)		c. 3	Timber brushwood trackway over Roman road; worked wood	medieval	Main thoroughfare	EAS report E962 May 2008		2007	SLR; EAS
Church-yard Side	SJ 65206 52326	(c. 39)	c.38.3			0.6 – 0.75	Oak coffins, hazel rods, cerecloth	13th – 14th C	Burials	Chester Arch Soc 1925 Electric main 2584: EAS 2005	4186	1780, 1855, 1883, 1925, 2005	Simpson and Tasker EAS

Table 2: Nantwich Investigations: no waterlogged remains

Location	NGR	OD asl surface	OD natural geology	Depth of sequence	Nature of deposits	Dating	Historic context	Report reference	HER reference	Year of investigation	Organization involved
Ref 30 Riverside	SJ 6480 5223	34 - 37	33 - 36	1	Ditch, posthole, pottery	Roman	Settlement?	2217	3715, 177/0/12	1997	EAS
Ref 31 Cocoa Yard	SJ 6521 5219	(c.40.2)		1 - 1.5	Ditch, pits, no finds	13th - 14th c	Town centre	2237	3722, 179/0/53	1997	EAS
Ref 32 Bowling Green	SJ 6535 5230	(c.40.8)			Ditches	medieval		CAB8	179/0/55	1982	Liverpool University
Ref 33 West bank	SJ 6489 5250	(c.37)		2	Ash, charcoal, briquetage, clays	medieval	Salt working	CAB10	180/0/6	1985	P Hutchings
Ref 34 Townsend House	SJ 6458 5244	(c.41)			Brick walls	post-medieval	western suburbs	2175	3673, 179/7	1997	Gifford
Ref 35 Mill Street	SJ 6501 5228	(c.36)	49	>1.5	Ditch	13th - 14th c	Castle Bailey	2454	3952	2003	EAS
Ref 36 Mill Street	SJ 6499 5222	(c.36)		>1	Water turbine, drains, pottery, black fibrous material	18th - 19th c	Castle		179/0/48	1975	Keele University
Ref 37 *35 Hospital Street*	*SJ 6526 5224*	*(c.40.5)*	*No data on sequence but could be wet (leather)*	*>0.18*	*Pit, medieval leather shoes, oyster mussel shells, pipe, pottery*	*Medieval and 16th - 17th c*	*Town centre*		*179/0/20*	*1976 & 1991*	*J Ray*

Location	NGR	OD asl surface	OD natural geology	Depth of sequence	Nature of deposits	Dating	Historic context	Report reference	HER reference	Year of investigation	Organization involved
Ref 38 Red Lion Lane	SJ 6471 5249	(c.38.5)		1	No waterlogging, natural sand				4099	2004	CCC
Ref 39 Pillory Street	SJ 6514 5220	(c.40)		1.2	Natural sand, no archaeology				3501	2001	CCC
Ref 40 62 Hospital St	SJ 6529 5220	(c.41.5)		>2	Made ground	20th c			4052	2004	CCC
Ref 41 68 Welsh Row	SJ 6469 5246	(c.41)		0.6	Natural sand, no organics				4109	2005	CCC
Ref 42 7 Dysart Buildings	SJ 6536 5237	(c.41)		1.2	Natural clay, no waterlogging				4124	2005	CCC
Ref 43 Mill House	SJ 6471 5201	(c.40)			Natural sand, no archaeology				4248	2007	CCC
Ref 44 88 Welsh Row	SJ 6466 5242	(c.42)			Topsoil to natural clay, no waterlogging				4054	2004	CCC
Ref 45 99/101 Welsh Row	SJ 6461 5237	(c.41)			No details				4126	2006	CCC
Ref 46 The Blankney	SJ 6512 5202	(c.39)			Topsoil only, shallow foundations				4249	2007	CCC

Table 3: Dendrochronological & radiocarbon dates

Reference No and Location	NGR	Dendrochronological & C14 dates	Material	Notes
Ref 13 Kingsley Fields	SJ 6455 5250	Cistern AD 130 – 137 Cistern post-AD94 Additional chamber post-AD99 Failed wall AD114 – 142 Trough post-AD96	359 structural timbers from which 24 gave viable dates, these were divided into 5 structure groups. No samples dated included bark.	Analysis by Ian Tyers (2004) from 2003 excavations by UMAU
Ref 23 St Anne's Lane	SJ 6481 5231	AD 132 (felling date)	Samples from timber planks of Roman tank. 3 samples had sapwood and were from same tree	Howard et al (Nottingham University) reported in McNeil and Roberts 1987
Ref 12 Snow Hill	SJ 6501 5247	AD 129±18 (felling date for SH05B)	Twelve oak timbers recovered: 5 posts, 4 planks, 2. post/planks, and a wedge-shaped timber. All squared except wedge, and most had joints. 9 timbers had more than 50 rings, 2 with sapwood and felling date could be estimated.	Timbers fell into two groups from cross-matching analysis: 88 BC – AD 111 (for group SH_1BA) 118 BC – 20 BC (for group SH_2)
		AD 125±18 (felling date for SH08M)		Analysis by Jonathan Lageard reported in Reid et al 2004
Ref 9 The Lamb Hotel	SJ 6517 5228		Five samples from individual wooden items recovered, all or which were found to cross-match with each other or with reference sequences.	Analysis by Ian Tyers from investigations 2003 – 4 by Gifford
		Post- AD 1048 (felling date)	Path retaining plank from watching brief	
		AD 1158 – 1183 (felling date range)	Beam-sill and upright from watching brief	
		Post – AD 1139 (felling date)	Beam-sill from watching brief	
		Post- AD 1162 (felling date)	Barrel stave from evaluation	
		AD 1286 – 1322 (felling date range)	Beam-sill from evaluation	

Reference No and Location	NGR	Dendrochronological & C14 dates	Material	Notes
Ref 6 Bower St Car Park	SJ 65011 52315	AD 1218 – 1263 AD (felling date range)	Four samples from the timber planks of a drain/sewer were submitted for assessment. All the samples were potentially suitable for tree ring dating, having at least 100 rings each.	Analysis by Jennifer Hillam, Sheffield, Appendix E in Gifford 1995
Ref 17 Second Wood Street	SJ 64845 52443	AD1246 – 1282 (felling date range)	Sample from salt-ship timber	Analysis by Ian Tyers from 2003 excavations by EAS
Ref 19 First Wood Street	SJ 6492 5255	AD 1183 felling date 1153 last measured ring AD 1172 felling date 1142 last measured ring AD1189 felling date 1159 last measured ring AD1177 felling date 1153 last measured ring AD1191 felling date 1166 last measured ring	Eight oak timbers from the excavation were sampled as transverse slices, five of which could be dated.	Analysis by M. Hughes & P. Leggett, reported in McNeil 1983
		AD 1140 – 1170 (last ring date range)	The last measured ring in each of the five timbers fell within this period.	
		AD 1177 – 1191 (felling date range)	Estimated felling dates were within this period.	
Ref 47 Welsh Row timber corduroy roadway	SJ 6490 5239	AD 1259 – 1295 (felling date range)	Oak timber roadway plank: felling date range calculated from 4 sapwood rings; final ring 1253	Analysis by Ian Tyers (Dendrochronological Consultancy Ltd report No. 103, Nov. 2008)
BH F	SJ 6519 5226	Calibrated radiocarbon dates @ 95% confidence		John Meadows English Heritage 2008
		Cal AD 1660 - 1950	Elm sapwood from 38.92–38.98m AOD	
		Cal AD 1210 - 1290	Hazel nutshell from 38.74-38.98m AOD	
		Cal AD 1020 - 1160	Hazel nutshell from 38.49-38.74m AOD	
		Cal AD 1010 -1160	Sloe stone from 38.24-38.49m AOD	
		Cal AD 1010 - 1160	Hazel nutshell from 37.88-38.24m AOD	

Reference No and Location	NGR	Dendrochronological & C14 dates	Material	Notes
BH N	SJ 6502 4245	Calibrated radiocarbon dates @ 95% confidence		John Meadows English Heritage 2008
		Cal AD 890 - 1020	Willow wood from 37.12-37.17m AOD	
		Cal AD 780 -990	Hazel wood from 37.12-37.17m AOD	
		Cal AD 690 -890	Alder wood from 36.84-36.94m AOD	
		Cal AD 890 -1020	Beech roundwood from 36.77-36.82m AOD	
		Cal AD 730 - 940	Willow roundwood from 36.47-36.55m AOD	
		Cal AD 690 - 890	Willow roundwood from 36.47-36.55m AOD	
BH P	SJ 6510 5237	Calibrated radiocarbon dates @ 95% confidence		John Meadows English Heritage 2008
		Cal AD 1040 -1260	Hazel nutshell from 38.30-38.43m AOD	
		Cal AD 1160 -1260	Hazel nutshell from 38.20-38.30m AOD	
		Cal AD 1030 -1210	Hazel nutshell from 38.02-38.20m AOD	
		Cal AD 1160 - 1260	Hazel nutshell from 37.93-38.02m AOD	
BH AD	SJ 6490 5239	Calibrated radiocarbon dates @ 95% confidence		John Meadows English Heritage 2009
Welsh Row brushwood track		Cal AD 1020 - 1150	Field Maple roundwood from trackway from 32.6m AOD	
		Cal AD 1025 - 1160	Alder roundwood from trackway from 32.6m AOD	

APPENDIX 2

Borehole logs from 2007 coring programme: detailed descriptions

BOREHOLE LOG

BOREHOLE No.
BH AA

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	12/09/07	37.97mAOD	E364730 N352391

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	Instrument/ Backfill
					37.33		(0.64) 0.64	MADE GROUND/OVERBURDEN 0.35 - 0.54 Crushed brick and tile fragments present (<20mm).	
					35.37		(1.96) 2.60	SAND 0.64 - 0.74 Becomes dark greyish brown.	
					34.97		(0.40) 3.00	CLAY	
								Borehole complete at 3.00m	

1
2
3
4
5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

Form SLR AGS3 UK BH File 406.0889.00003.005 NANTWICH INTERPRETATION LOGS.GPJ 16-01-08

BOREHOLE LOG

BOREHOLE No.
BH AB

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	12/09/07	37.93mAOD	E364740 N352370

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
							(0.61)	MADE GROUND/OVERBURDEN 0.34 - 0.43 Brick becoming abundant.	
					37.32		0.61		
							(1.12)	ARCHAEOLOGICAL DEPOSIT 0.61 - 1.00 Brick, tile, coal and charcoal fragments (<20mm). 1.10 - 1.73 Ocasional black gravels of ash/cinder (<10mm).	
					36.20		1.73		
								NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT	
					35.93		2.00	1.73 - 2.00 Slight sulphide odour.	
				1	35.87		2.06	No Recovery.	
							(0.31)	MINERAL RICH DEPOSIT	
					35.56		2.37		
							(0.42)	SAND 2.70 - 2.79 Rounded pebbles (<20 mm) common.	
					35.14		2.79		
					34.93		3.00	CLAY	
								Borehole complete at 3.00m	

Boring Progress and Water Observations				Casing		Chiselling			Water Added	
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To

General Remarks
Groundwater present at 2.13m bgl. Well headspace concentration 40ppm.

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

Form SLR AGS3 UK BH File 406.0889.00003.005 NANTWICH INTERPRETATION LOGS.GPJ 16-01-08

BOREHOLE LOG

BOREHOLE No.
BH AC

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	12/09/07	36.42mAOD	E364963 N352517

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					34.42		(2.00) 2.00	MADE GROUND/OVERBURDEN 0.77 - 0.80 Brick and tile fragments (<40 mm) present. 0.99 - 1.00 Modern glass fragments (<40 mm) present.	
					33.90		(0.52) 2.52	ARCHAEOLOGICAL DEPOSIT 2.38 - 2.44 Rotted mortar (<12 mm) present.	
				1	32.98		(0.92) 3.44	MINERAL RICH DEPOSIT	
					32.56		(0.42) 3.86	NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT 3.55 - 3.59 Large stone inclusions (<60mm). 3.63 - 3.68 Large stone inclusions (<60mm).	
					32.42	?	4.00	No Recovery.	
								Borehole complete at 4.00m	

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	Groundwater present at 2.83m bgl. Well headspace concentration 20 000ppm.

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No.
BHA

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	30/07/07	33.29mAOD	E364931 N352661

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
								MINERAL RICH DEPOSIT	
							(3.48)	1.61 - 1.63 Discontinuity of moist to wet, soft to unconsolidated, light grey, sand.	
								2.35 - 2.65 Very granular appearance caused by presence of indurated clay lumps (<3 mm) within the matrix.	
								3.20 - 3.48 Becoming slightly wetter and more sticky.	
					29.81		3.48		
							(0.42)	SAND	
					29.39		3.90		
								Borehole complete at 3.90m	

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant: Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No. **BHB**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	30/07/07	36.62mAOD	E364925 N352582

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
							(2.00)	MADE GROUND/OVERBURDEN 0.06 - 0.08 Becoming mid to dark grey-brown.	
					34.62		2.00		
							(0.44)	NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT. Contains small organic inclusions, brick, stone, tile and glass.	
					34.18		2.44		
							(1.56)	ARCHAEOLOGICAL DEPOSIT. Contains cinder and burnt material. 3.00 - 4.00 Slight sulphide odour.	
					32.62		4.00	3.92 Rounded edge pot fragment (<11mm)	
							(1.69)	CLAY	
					30.93		5.69		
							(0.31)	SAND	
					30.62		6.00		

Boring Progress and Water Observations

Date	Time	Depth	Water Dpt

Casing

Depth	Dia. mm

Chiselling — Borehole complete at 6.00m

From	To	Hours

Water Added

From	To

General Remarks

All dimensions in metres
Scale 1:37.5

Contractor : Sherwood Drilling
Plant: Geotool

Method: Windowless Sampler
Hole Size:

Logged By:

Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No. **BHC**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	31/07/07	34.87mAOD	E364827 N352525

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
								ARCHAEOLOGICAL DEPOSIT	
								0.35 - 1.00 Fine ash/cinder.	
1							(1.90)		
								1.47 - 1.52 Pocket of orange sand. 1.60 - 1.62 Pocket of light grey-brown sand. 1.72 - 1.78 Waterlogged wood fragments.	
					32.97		1.90		
2								NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT 1.90 - 1.95 Slight sulphide odour. 1.95 Waterlogged wood fragments. 2.19 - 3.00 Moderate sulphide odour.	
3							(2.10)		
					30.87		4.00		
4								Borehole complete at 4.00m	
5									

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant: Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

Form SLR AGS3 UK BH File 406.0889.00003.005 NANTWICH INTERPRETATION LOGS.GPJ 16-01-08

BOREHOLE LOG

BOREHOLE No. **BHD**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	31/07/07	35.03mAOD	E364925 N352423

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
							(0.70)	MADE GROUND/OVERBURDEN	
					34.33		0.70		
							(1.39)	ARCHAEOLOGICAL DEPOSIT. Contains fine ash/cinder and mortar.	
					32.94		2.09	2.00 - 2.09 Slight sulphide odour.	
					32.66		2.37	SAND	
							(0.63)	NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT 2.47 - 2.50 Rotted wood.	
					32.03		3.00		
							(1.00)	SAND	
					31.03		4.00		
								Borehole complete at 3.00m	

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant: Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No. **BHE**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	31/07/07	35.34mAOD	E364931 N352261

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					34.34		(1.00) 1.00	MADE GROUND/OVERBURDEN	
					33.84		(0.50) 1.50	ARCHAEOLOGICAL DEPOSIT. Contains brick, stones and slate.	
					32.93		(0.91) 2.41	MINERAL RICH DEPOSIT	
					31.34		(1.59) 4.00	ARCHAEOLOGICAL DEPOSIT. Contains fragments of brick and ash.	
								Borehole complete at 4.00m	

1 2 3 4 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant: Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No.
BHF

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	01/08/07	39.74mAOD	E365191 N352264

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	Instrument/ Backfill
					39.07		(0.67) 0.67	MADE GROUND/OVERBURDEN	
					37.88		(1.19) 1.86	NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT 0.76 - 0.81 Waterlogged wood fragments 0.76 - 0.96 Moderate sulphide odour. 1.00 - 1.86 Slight sulphide odour. 1.48 - 1.52 Light grey sand intrusions (at ~45 degrees to horizontal). 1.50 - 1.86 Becomes wet. 1.56 - 1.60 Light grey sand intrusions (at ~45 degrees to horizontal). 1.64 - 1.72 Light grey sand intrusions (at ~45 degrees to horizontal). 1.76 - 1.80 Fibrous organic content.	
					37.74		2.00	SAND 1.96 - 2.00 Slight sulphide odour.	
					36.74		(1.00) 3.00	CLAY	
								Borehole complete at 3.00m	

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No.
BHG

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	01/08/07	39.60mAOD	E365096 N352398

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					39.33		0.27	MADE GROUND/OVERBURDEN	
					37.61		(1.72) 1.99	ARCHAEOLOGICAL DEPOSIT. Contains ash/cinder, brick, tile fragments and rotted charcoal. 0.87 Very rotted shell.	
					37.45		2.15	SAND	
					37.25		2.35	MINERAL RICH DEPOSIT	
					36.60		(0.65) 3.00	SAND	
								Borehole complete at 3.00m	

1
2
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4
5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No. **BHH**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	01/08/07	39.35mAOD	E365233 N352471

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					38.99		(0.36) 0.36	MADE GROUND/OVERBURDEN	
					38.35		(0.64) 1.00	ARCHAEOLOGICAL DEPOSIT. Contains ash/cinder, brick, mortar and glass.	
					37.93	?	(0.42) 1.42	No Recovery.	
					37.83		1.52	SAND	
							(2.48)	CLAY	
					35.35		4.00		
								Borehole complete at 4.00m	

1 2 3 4 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

Form SLR AGS3 UK BH File 406.0889.00003.005 NANTWICH INTERPRETATION LOGS.GPJ 16-01-08

BOREHOLE LOG

BOREHOLE No. **BHI**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	31/07/07	38.96mAOD	E365308 N352394

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
							(0.86)	ARCHAELOGICAL DEPOSIT 0.00 - 0.86 Very slight sulphide odour.	
					38.10		0.86		
					38.00		0.96	NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT. Contains ash/cinder and woody root fragments.	
							(0.41)	MINERAL RICH DEPOSIT	
					37.59		1.37		
					37.38		1.58	SAND	
							(2.12)	CLAY	
					35.26		3.70		
								Borehole complete at 3.70m	

1 2 3 4 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

Form SLR AGS3 UK BH File 406.0889.00003.005 NANTWICH INTERPRETATION LOGS.GPJ 16-01-08

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BOREHOLE LOG

BOREHOLE No. **BHJ**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	31/07/07	40.04mAOD	E365284 N352296

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					39.04		(1.00) 1.00	MADE GROUND/OVERBURDEN	
					38.29		(0.75) 1.75	SAND	
					36.04		(2.25) 4.00	CLAY	
								Borehole complete at 4.00m	

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant: Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

Form SLR AGS3 UK BH File 406.0889.00003.005 NANTWICH INTERPRETATION LOGS.GPJ 16-01-08

BOREHOLE LOG

BOREHOLE No. **BHK**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	31/07/07	37.14mAOD	E365021 N352297

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					36.14		(1.00) 1.00	MADE GROUND/OVERBURDEN	
					34.14		(2.00) 3.00	CLAY	
								Borehole complete at 3.00m	

1 2 3 4 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

Form SLR AGS3 UK BH File 406.0889.00003.005 NANTWICH INTERPRETATION LOGS.GPJ 16-01-08

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No. **BHL**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	11/09/07	38.71mAOD	E365128 N352544

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					37.96		(0.75) 0.75	MADE GROUND/OVERBURDEN	
					37.41		(0.55) 1.30	ARCHAELOGICAL DEPOSIT 0.97 Post medieval/modern pottery fragment (<35mm).	
				1	36.26		(1.15) 2.45	SAND	
					34.71		(1.55) 4.00	CLAY	
								Borehole complete at 4.00m	

1 – 2 – 3 – 4 – 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	Groundwater present at 2.28m bgl. Well headspace concentration 35ppm.

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No.
BHM

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	11/09/07	37.81mAOD	E365015 N352549

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					36.58		(1.23) 1.23	MADE GROUND/OVERBURDEN	
				1	35.58		(1.00) 2.23	NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT. Contains waterlogged organic material. 1.23 - 1.44 Slight sulphide odour. 1.44 - 1.60 Slight sulphide odour. 1.60 - 2.00 Slight sulphide odour. 2.00 - 2.23 Very slight sulphide odour.	
					34.81		(0.77) 3.00	SAND	
								Borehole complete at 3.00m	

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	Groundwater present at 1.58m bgl. Well headspace concentration 905ppm.

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No. **BHN**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	12/09/07	39.17mAOD	E365016 N352449

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					38.97		0.20	MADE GROUND/OVERBURDEN	
					38.10		(0.87) 1.07	ARCHAELOGICAL DEPOSIT. Contains ash/cinder, brick, tile fragments, mortar and rotted charcoal.	
1				1				NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT. Contains waterlogged wood and herbaceous detritus.	
2					36.45		(1.65) 2.72	1.74 Bone fragment (<11mm) 1.88 - 1.91 Slight sulphide odour. 1.91 Blue vivianite? (<12mm) 1.91 - 2.00 Overpowering sulphide odour. 1.93 Hazelnut fragment. 2.00 - 2.46 Overpowering sulphide odour. 2.61 - 2.72 Very slight sulphide odour. 2.62 - 2.70 Large round wood (wattle?) inclusions.	
3					36.17		3.00	SAND	
							(1.00)	CLAY	
4					35.17		4.00		
								Borehole complete at 4.00m	
5									

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	Groundwater present at 1.37m bgl. Well headspace concentration 80ppm.

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant: Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No. **BHO**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	11/09/07	39.64mAOD	E365184 N352470

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					38.44		(1.20) 1.20	MADE GROUND/OVERBURDEN 0.50 - 0.54 Brick/tile which becomes the dominant component.	
				1	37.87		(0.57) 1.77	NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT. Contains brick, tile, coal fragments and waterlogged plant remains. 1.20 - 1.77 Slight sulphide odour.	
					37.64		2.00	ARCHAELOGICAL DEPOSIT	
					37.25	?	(0.39) 2.39	No Recovery.	
					36.75		(0.50) 2.89	NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT 2.39 - 2.89 Slight sulphide odour.	
					35.64		(1.00) 4.00	CLAY	
								Borehole complete at 4.00m	

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	Groundwater present at 1.44m bgl. Well headspace concentration 10ppm.

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No.
BHP

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	10/09/07	39.93mAOD	E365098 N352374

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	Instrument/ Backfill
					38.62		(1.31) 1.31	ARCHAELOGICAL DEPOSIT. Contains brick, tile, coal fragments and charcoal.	
								1.30 Animal bone fragment (<20mm).	
					37.93		(0.69) 2.00	NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT. Very humified amorphous organic peat.	
								SAND	
				1				2.67 - 3.00 Slight sulphide odour.	
							(2.00)		
					35.93		4.00		
								Borehole complete at 4.00m	

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	Groundwater present at 3.33m bgl. Well headspace concentration 170ppm.

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No.
BHQ

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	10/09/07	39.22mAOD	E365196 N352383

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					38.74		(0.48) 0.48	MADE GROUND/OVERBURDEN	
					37.72		(1.02) 1.50	ARCHAELOGICAL DEPOSIT. Contains brick, tile, cinder/coal and glass fragments.	
				1	37.39		(0.33) 1.83	MINERAL RICH DEPOSIT	
					36.34		(1.05) 2.88	SAND	
					35.42		(0.92) 3.80	CLAY	
								Borehole complete at 3.80m	

1 2 3 4 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	Groundwater present at 1.71m bgl. Well headspace concentration 170ppm.

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No.
BHR

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	10/09/07	39.18mAOD	E365205 N352362

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					38.68		(0.50) 0.50	MADE GROUND/OVERBURDEN	
					37.82		(0.86) 1.36	ARCHAELOGICAL DEPOSIT. Contains brick, tile, cinder/coal and mortar fragments.	
					37.31		(0.51) 1.87	MINERAL RICH DEPOSIT	
					36.68		(0.63) 2.50	SAND	
					35.18		(1.50) 4.00	CLAY	
								Borehole complete at 4.00m	

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Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

Form SLR AGS3 UK BH File 406.0889.00003.005 NANTWICH INTERPRETATION LOGS.GPJ 16-01-08

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BOREHOLE LOG

BOREHOLE No.
BHS

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	11/09/07	39.77mAOD	E365119 N352343

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					38.96		(0.81) 0.81	MADE GROUND/OVERBURDEN	
							(2.47)	ARCHAELOGICAL DEPOSIT. Contains fragments of brick and tile.	
								2.44 Brick surface (Large fragments <130mm)	
				1	36.49		3.28		
					35.77		(0.72) 4.00	SAND	
								Borehole complete at 4.00m	

1 2 3 4 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	Groundwater present at 3.34m bgl. Well headspace concentration 130ppm.

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No.
BHT

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	14/09/07	39.50mAOD	E365140 N352352

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	Instrument/ Backfill
								ARCHAELOGICAL DEPOSIT	
							(1.80)	0.70 Human skull fragment.	
					37.70		1.80	1.59 Charred bone fragment (<20mm) 1.60 - 1.80 Very slight sulphide odour.	
								SAND	
				1			(1.90)		
					35.80		3.70		
							(0.30)	CLAY	
					35.50		4.00		
								Borehole complete at 4.00m	

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	Groundwater present at 3.16m bgl. Well headspace concentration 140ppm.

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No. **BHU**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	14/09/07	39.43mAOD	E365160 N352349

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					37.93		(1.50) 1.50	ARCHAELOGICAL DEPOSIT. Contains brick, tile and coal fragments. 0.35 Animal bone fragment (<55mm) 0.60 - 0.65 Human skull fragments (<40mm) 1.00 - 1.08 Large human skull fragment (<80mm)	
					37.66		1.77	MINERAL RICH DEPOSIT	
					36.43		(1.23) 3.00	NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT 1.77 - 1.96 Slight sulphide odour. 2.00 - 2.17 Slight sulphide odour.	
								Borehole complete at 3.00m	

1 2 3 4 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No.
BHV

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	14/09/07	39.39mAOD	E365195 N352346

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					37.95		(1.44) 1.44	MINERAL RICH DEPOSIT	
				1	36.89		(1.06) 2.50	NON-CARBONISED DEPOSIT WITH ORGANIC CONTENT. Contains waterlogged wood fragments.	
					34.89		(2.00) 4.50	CLAY	
								Borehole complete at 4.50m	

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Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	Groundwater present at 1.95m bgl. Well headspace concentration 60ppm.

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No. **BHW**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	13/09/07	40.03mAOD	E365214 N352280

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					39.03		(1.00) 1.00	MADE GROUND/OVERBURDEN	
					38.67		(0.36) 1.36	ARCHAELOGICAL DEPOSIT. Contains brick and tile fragments. 1.20 SIngle pot sherd	
					37.55		(1.12) 2.48	SAND	
					37.03		(0.52) 3.00	CLAY	
								Borehole complete at 3.00m	

1 2 3 4 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

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BOREHOLE LOG

BOREHOLE No. **BHX**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	13/09/07	37.62mAOD	E365014 N352321

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					37.02		(0.60) 0.60	MADE GROUND/OVERBURDEN	
					36.20		(0.82) 1.42	ARCHAELOGICAL DEPOSIT. Possible castle mound construction material.	
					34.62		(1.58) 3.00	CLAY	
								Borehole complete at 3.00m	

1 2 3 4 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No.
BHY

Client:
CHESHIRE COUNTY COUNCIL

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	13/09/07	39.90mAOD	E365057 N352322

Project:
NANTWICH WATERLOGGED DEPOSITS

Sheet:
1 of 1

SAMPLES & TESTS				Water	STRATA				
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	Instrument/ Backfill
								MADE GROUND/OVERBURDEN	
							(2.06)		
					37.84		2.06		
								SAND	
							(1.68)		
					36.16		3.74		
								CLAY	
					35.90		4.00		
								Borehole complete at 4.00m	

1 2 3 4 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant:Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

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SLR Consulting Ltd, , , Tel: , Fax:

BOREHOLE LOG

BOREHOLE No. **BHZ**

Client: **CHESHIRE COUNTY COUNCIL**

Project No:	Date:	Ground Level:	Co-ordinates:
406.0889.00003.005	13/09/07	38.46mAOD	E365079 N352243

Project: **NANTWICH WATERLOGGED DEPOSITS**

Sheet: 1 of 1

SAMPLES & TESTS				Water	STRATA				Instrument/ Backfill
Depth	Type No	Test Type	Test Result		Reduced Level	Legend (Thick-ness)	Depth	DESCRIPTION	
					37.76		(0.70) 0.70	MADE GROUND/OVERBURDEN	
					36.42		(1.34) 2.04	SAND	
					35.46		(0.96) 3.00	CLAY	
								Borehole complete at 3.00m	

1 2 3 4 5

Boring Progress and Water Observations				Casing		Chiselling			Water Added		General Remarks
Date	Time	Depth	Water Dpt	Depth	Dia. mm	From	To	Hours	From	To	

All dimensions in metres Scale 1:37.5	Contractor : Sherwood Drilling Plant: Geotool	Method: Windowless Sampler Hole Size:	Logged By:	Approved By:

SLR Consulting Ltd, , , Tel: , Fax:

APPENDIX 3

Tabulated data: sediment & palaeoenvironmental assessment

Table 1. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Description of deposit sequences encountered by borehole. Key: Key: 'PC' = Preservational condition (following the Bergen excavation office state of preservation scale); 'Spot sample' = material removed as an organic spot find (usually wood fragments – species identifications by Steve Allen, YAT); 'C14' = any additional material noted of possible value for radiocarbon dating.

i) Borehole A

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.040	33.290	33.250	E5	Void	Fresh grass at 0.04	none	level	-	-	-
0.040	0.400	33.250	32.890	E2	Moist, mid to dark grey-brown, crumbly (working soft), slightly clay silt	modern rootlet penetration to 0.14	none	level	-	-	-
0.400	1.000	32.890	32.290	E0	Moist, light to mid brown, soft (working more or less plastic), clay silt (more clay in places)	trace of ?iron pan at 0.95-1.00	none	level	Sample 4 = all of core from 0.95-1.00	-	-
1.000	1.060	32.290	32.230	D0	Void	-	-	level	-	-	-
1.060	2.000	32.230	31.290	A0	Moist, light yellow-brown to light grey (colours mixed/inter-mingled), stiff (working plastic), very slightly silty clay. Discontinuity of moist to wet, soft to unconsolidated, light grey, sand at 1.61-1.63	none	none	level	-	-	-
2.000	2.350	31.290	30.940	D0	Void	-	-	level	-	-	-
2.350	2.800	30.940	30.490	A0	Moist, light to mid brown (with some areas of light to mid orange-brown - ?iron pan/oxide staining), stiff and sticky (working plastic), clay (perhaps with a slight silt content in places)	Very granular appearance from 2.35 - 2.65 caused by presence of indurated clay lumps (to 3 mm) within the matrix	none	level	-	-	-
2.800	2.920	30.490	30.370	D0	Void	-	-	level	-	-	-
2.920	3.480	30.370	29.810	A0	Moist, light to mid brown to grey-brown to grey, soft (working slightly sticky and then more or less plastic), slightly silty clay. Slightly wetter and more sticky from 3.20-3.48	none	none	level	-	-	-

3.440	3.900	29.810	29.390	A0	Moist to wet, light grey and light to mid grey, unconsolidated, fine and coarse sand	none	none	-	Sample 5 = all of core from 3.80-3.90	-	-

ii) Borehole B

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.080	36.260	36.180	E5	Moist, mid brown to mid grey-brown, stiff (working plastic), slightly silty clay. Slightly darker - mid to dark grey-brown in lowest 0.02 metres	Fresh grass and associated rootlet penetration at current ground surface. Small stones and occasional cinder (both to 3 mm) and mortar/sand flecks at 0.05. Second very recent ground surface with fresh (still green) grass and clover. Live earthworm	none	level	-	-	-
0.080	0.120	36.180	36.140	E5	Moist, mid brown to mid grey-brown, stiff (working plastic), sandy clay - becomes more sandy in lowest few millimetres (this area working soft)	Fresh grass, clover and associated rootlet penetration from third recent surface at interface with next lowest section. Live earthworm and rounded pebble (to 45 mm) also at lower interface	none	level	-	-	-
0.120	0.220	36.140	36.040	E4	Moist, mid to dark grey-brown, stiff to crumbly (working soft), slightly silty clay sand	Rootlet penetration from third recent land surface and flecked with light grey-brown sand grains throughout. Moist and rather rotted wood fragment declined at approximately 30 degrees at interface with next lowest section (~100 x 15-25 x 20 mm). Rounded pebble (to 12 mm) at 0.21-0.22. Live earthworm	none	declined 30 degrees - interface depth range from 0.19-0.22	-	-	-
0.220	1.000	36.040	35.260	E0	Just moist, mid to dark grey to grey-brown, crumbly (working more or less soft), slightly ?silty, clay sand - some areas slightly more clay but still mostly sand	Occasional inclusions of rounded pebbles (at 0.22), brick/tile (at 0.23-0.25, 0.42, 0.70-0.71, 0.87, 0.89). Also 'hard core' throughout but particularly at 0.35, 0.73, 0.87	none	level	-	-	-
1.000	1.140	35.260	35.120	E0	as layer above	Occasional inclusions of soft, very	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
						rotted charcoal					
1.140	1.460	35.120	34.800	E0	Just moist, mid to dark grey to grey-brown, stiff (working more or less plastic), slightly sandy clay - some areas slightly more clay but still mostly sand	Make-up/levelling inclusions, e.g. brick, glass, coal, throughout. ?Asbestos fragment at 1.44	none	level	-	-	-
1.460	1.620	34.800	34.640	E0	Just moist, light to mid brown, stiff (working plastic), clay	Boundary to next lowest section with cinder, ?brick and ?mortar inclusions	none	level	-	-	-
1.620	2.000	34.640	34.260	E0	Just moist, mid brown to grey-brown, stiff and slightly sticky (working more or less plastic), slightly sandy clay (more sandy in places). Becomes slightly wetter in lowest 0.20 m	Occasional 'build up' inclusions - e.g. brick (at 1.71), metal (?tin at 1.92 - 1.94), glass (at 1.93)	none	level	Sample 1 = all of core section from 1.80 - 1.85	-	-
2.000	2.440	34.260	33.820	E1	As layer above	Small organic inclusions at upper interface (looks to be 'ancient' rootlet). Brick (at 2.05 - 2.18), stone (at 2.19), white (modern) tile (at 2.26-2.28), large (to 30 mm) bottle glass fragments (at 2.42)	none	level	-	-	-
2.440	2.640	33.820	33.620	A0	Clay as from 1.46-1.62	cinder at 2.54	none	level	-	-	-
2.640	3.000	33.620	33.260	A0	Moist, mid to dark grey- brown, slightly silty slightly clay sand	cinder (to 12 mm) and ?other burnt material throughout but particlulary at 2.68 and 2.85	none	level	-	-	-
3.000	4.000	33.260	32.260	A0	Just moist, mid to dark (slightly blueish) grey, stiff and slightly sticky (working soft), slightly clay slightly sandy silt. Becomes slightly wetter with depth	Small stones from 3.70 downwards becoming more frequent and larger with depth (to 20 mm; common). Rounded edged ?pot fragment (~11 mm square) at 3.92	slight	level	Sample 2 = half of core section from 3.90 - 4.00	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
4.000	4.350	32.260	31.910	A0	Moist, mid brown to grey-brown, soft, clay silt (to silty clay). Grades into moist, light to mid yellow-brown, stiff (working plastic), very slightly silty clay from 4.10 - 4.35	Occasional very small stones (to 2 mm)	none	grades	-	-	-
4.350	5.000	31.910	31.260	A0	Moist, light to mid yellow-brown, stiff (working plastic), very slightly silty clay	none	none	level	-	-	-
5.000	5.180	31.260	31.080	D0	Void	-	-	level	-	-	-
5.180	5.350	31.080	30.910	B0	Moist to wet, light to mid brown, firm to soft and sticky (working more or less plastic), slightly silty clay	none	none	level	-	-	-
5.350	5.440	30.910	30.820	B0	As 4.35 - 5.00	none	none	level	-	-	-
5.440	5.690	30.820	30.570	B0	Moist to wet, light to mid brown, soft, sandy clay	none	none	level	-	-	-
5.690	5.790	30.570	30.470	C0	Wet, light to mid brown, unconsolidated, slightly clay sand	none	none	level	-	-	-
5.790	5.950	30.470	30.310	C0	Moist to wet, light to mid grey-brown, soft and sticky, sandy clay silt	none	none	level	-	-	-
5.950	6.000	30.310	30.260	C0	Moist to wet, light to mid grey, soft to unconsolidated, clay sand	none	none	-	Sample 3 = material spilling from base of core tube ~all of 5.95 - 6.00	-	-

iii) Borehole C

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.300	34.870	34.570	D5	Void	grass of current ground surface at 0.30	-	level	-	-	-
0.300	0.350	34.570	34.520	E3	Just moist, mid to dark grey, unconsolidated, slightly silty sand	modern rootlet penetration throughout	none	level	-	-	-
0.350	1.000	34.520	33.870	A1	Matrix continues as for 0.30-0.35 (above) but with mixed colours from light to mid brown to mid to dark grey-brown	Probable fine ash/cinder throughout (concentration, to 9 mm, at 0.81), occasional stones (to 12 mm) throughout. ?Ancient rootlet at 0.70-0.81 and from 0.94 downwards	none	level	-	-	-
1.000	1.900	33.870	32.970	A2	Matrix continues as above with some minor variations and inclusions of mid orange sand at 1.47-1.52 and light grey-brown sand at 1.60-1.62	Rootlet continues to 1.06 and also seen at 1.40, 1.50 and 1.68, ?charcoal flecks (to 3 mm) at around 1.58. Waterlogged and very fragile roundwood fragments at 1.72 and 1.78	none	level	Sample 12 = sediment around round wood at ~1.72-1.74	Spot Sample 2: willow roundwood	second roundwood fragment (~15 mm diameter, 42 mm long) at 1.76-1.79
1.900	1.950	32.970	32.920	A2	Moist, dark grey, slightly sticky (works soft), slightly sandy silt	Rootlet at upper interface (~1.90), waterlogged and soft roundwood at 1.95 (~7 mm diameter)	?slight	level	-	-	possible roundwood fragments (~7 mm diameter) at 1.95
1.950	2.000	32.920	32.870	A1	Moist, light to mid brown to mid to dark grey-brown, slightly sticky (working soft), silty sand	Rootlet at 1.98-1.99			-	-	-
2.000	2.090	32.870	32.780	A0	Moist to wet, light to mid grey-brown, unconsolidated and somewhat thixotropic, slightly clay	none	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
					silt						
2.090	2.190	32.780	32.680	A2	Moist, mid grey-brown, soft, sandy silt	thin sliver of very decayed wood (to 40 mm, declined at ~15 degrees to horizontal)	none	level	-	-	-
2.190	3.000	32.680	31.870	B2	Moist, mid grey to grey-brown, firm (working soft), clay silt (slightly more clay in places)	Sulphide staining throughout but markedly at 2.37-2.43, 2.58-2.60, 2.68-2.75, 2.79-2.93. Perhaps all resulting from decayed rootlet	moderate	level	Sample 13 = ~half of core section 2.90-3.00	-	-
3.000	4.000	31.870	30.870	B1	Moist, mid grey-brown, fairly stiff and sticky (working soft and sticky), clay silt	Small 'thread-like' filaments throughout - ?fungal hyphae. Occasional black patches - perhaps sulphide staining but no associated odour - notable at 3.21-3.24 and 3.80-3.84	none	-	-	-	-

iv) Borehole D

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.200	35.030	34.830	D0	Void	-	-	level	-	-	-
0.200	0.430	34.830	34.600	E0	Small amount of matrix (~20%) of moist, mid to dark grey-brown, unconsolidated slightly clay, sandy silt/silty sand	Mostly brick (to 75 mm) and stone (to 30 mm) rubble, with a piece of modern glass (to 45 mm) at 0.23	none	level	-	-	-
0.430	0.470	34.600	34.560	A0	continues as 0.20-0.43 but black in parts - ?ash/cinder content	continues as 0.20-0.43 but black in parts - ?ash/cinder content	none	level	-	-	-
0.470	0.700	34.560	34.330	A0	More or less dry, white, unconsolidated mortar grades into next lowest layer from 0.63-0.70	-	none	grades	-	-	-
0.700	1.000	34.330	34.030	A0	Moist, mid brown to mid to dark grey-brown, firm to crumbly (working soft), slightly clay silt, with occasional patches of light brown sand	black ?cinder/ash and white mortar throughout	none	level	-	-	-
1.000	1.220	34.030	33.810	D0	Void	-	-	level	-	-	-
1.220	1.270	33.810	33.760	A0	Moist, light brown to mid to dark grey-brown (and shades between - colours jumbled), soft to crumbly (working soft), slightly clay sandy silt	a little ?ash/cinder thoroughout	none	level	-	-	-
1.270	1.510	33.760	33.520	A0	Just moist, dark grey to black, unconsolidated sandy silt, with a high fine cinder/ash content. Occasional mid to dark brown patches where the cinder/ash content is less	Very light grey/grey-brown mortar inter-mixed with matrix	none	level	-	-	-
1.510	1.600	33.520	33.430	A0	Mortar as at 0.47-0.63 above	-	none	level	-	-	-
1.600	1.770	33.430	33.260	A0	A little mid brown sand	Mostly composed of dry brick rubble (to 40 mm), with some black ash/cinder	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
						(at 1.66-1.71) and mortar (as above) common (at 1.72-1.77)					
1.770	1.920	33.260	33.110	A0	Moist, mid brown and dark grey, sticky (working soft), slightly clay silt	black ash/cinder common throughout and mortar (as above) present at 1.88-1.92	none	level	-	-	-
1.920	2.000	33.110	33.030	A0	Moist, mid brown, soft (working soft to more or less plastic), silty clay, darker (dark grey/ black) and more silty in lowest 0.02 m	darker lowest 0.02 m could be stained by fine ash/cinder or perhaps sulphides (no odour though)	none	level	Sample 8 = all of core from 1.98-2.00	-	-
2.000	2.090	33.030	32.940	A0	Moist, mid brown to dark grey-brown, crumbly to unconsolidated, slightly silty sand (more silty in parts), with some black patches as noted in lowest part of overlying section	?very rotted charcoal in small patches	?slight	level	Sample 9 = ~half of this core section	-	-
2.090	2.370	32.940	32.660	A0	Moist, varicoloured (from light to mid brown to mid to dark grey-brown inshades of brown and grey-brown), unconsolidated to crumbly, slightly silty sand	none	none	level	-	-	-
2.370	3.000	32.660	32.030	B2	Moist, mid brown, firm to crumbly (working soft), slightly silty clay sand. Becomes slightly wetter with increasing depth	rotted wood at 2.47-2.50	none	level	Sample 10 = sediment from around wood	Spot sample 1: oak	-
3.000	4.000	32.030	31.030	C0	Saturated, light to mid brown, unconsolidated (works sticky and soft), slightly sitly clay sand. Appears to be within ground water at least from 3.10 downwards	none	none	-	Sample 11 = all of core from 3.90-4.00	-	-

v) Borehole E

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.110	35.335	35.225	D5	Void	Fresh grass at 0.11	none	level	-	-	-
0.110	0.170	35.225	35.165	E4	Moist, dark brown to grey-brown, slightly humic, crumbly (working soft), slightly clay sandy silt	modern rootlet throughout	none	level	-	-	-
0.170	0.920	35.165	34.415	E3	continues as 0.11 - 0.17	modern rootlet penetration to 0.36. Frequent modern brick (to 60 mm; notably at 0.21-0.32, 0.37-0.44, 0.57-0.58) with associated white flecks of mortar	none	level	-	-	-
0.920	1.000	34.415	34.335	E0	More or less dry, mid to dark grey-brown, unconsolidated silty sand - constitutes perhap 5-10% of core at this point	Mostly modern brick (to 78 mm) and mortar (to 58 mm) rubble, with a fragment of modern clear glass (to 28 mm)	none	level	-	-	-
1.000	1.500	34.335	33.835	E1	Core section mostly collapsed. Matrix continues as layer above 0.17 - 0.92	Brick fragments small and sparse from 1.00-1.25 becoming common and larger (to 42 mm) from 1.25-1.50. Large stones including cobble fragments (to 50 mm) and slate (to 62 mm) at 1.00-1.06 and very large cobble (to 90 mm) at 1.15-1.24. Trace of ?old rootlet at 1.44-1.50	none	-	-	-	-
1.500	1.740	33.835	33.595	A0	Core section mostly collapsed. More or less dry, mid to dark grey-brown, crumbly to unconsolidated, silty sand	none	none	.-	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
1.740	1.860	33.595	33.475	A0	Part (~half) of section continues as layer above (1.50-1.74). Other half of section was a just moist, light to mid brown to grey-brown, stiff (working plastic), clay	none	none	level/divided	-	-	-
1.860	1.940	33.475	33.395	A0	Just moist, light brown to light to mid grey-brown, unconsolidated, ?slightly silty sand	Abundant rounded pebbles (to 36 mm) forming approximately half of this section	none	level	-	-	-
1.940	2.000	33.395	33.335	A0	clay as at 1.74-1.86	none	none	level	-	-	-
2.000	2.120	33.335	33.215	A0	Core section largely collapsed. Mix of unconsolidated coarse sand and lumps (to 70 mm) of stiff (working plastic) clay, both just moist and light to mid brown in colour	none	none	-	-	-	-
2.120	2.240	33.215	33.095	A1	clay as that component in 2.00-2.12 above	rootlets at 2.24	none	level	-	-	-
2.240	2.410	33.095	32.925	A1	Just moist, dark grey-brown, brittle, ?slightly clay silt	rootlet noted throughout, with occasional fragments of brick (to 10 mm at 2.35) and black ?ash lumps (to 6 mm at 2.41)	none	level	Sample 6 = all of core from 2.33-2.38	-	-
2.410	3.000	32.925	32.335	A0	Just moist, mid grey-brown, stiff (working plastic), clay	Large brick inclusion at 2.59-2.70 (fragments to 110 mm - probably shattered by corer)	none	level	-	-	-
3.000	3.180	32.335	32.155	D0	Void	-	-	level	-	-	-
3.180	3.980	32.155	31.355	A0	Moist, mid grey-brown, stiff (working plastic), clay. Becomes wetter in lower 0.20 metres	Occasional black flecks of ?ash/charcoal (to 1 mm) throughout	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
3.980	4.000	31.355	31.335	A0	Moist, light grey-brown, unconsolidated, sand (possible slight silt content)	none	none	-	Sample 7 = all of core from 3.90-3.98	-	-

vi) Borehole F

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.600	39.740	39.140	E0	Moist (dry in top 0.10 m), loose gravel (to 70 mm) - no sediment matrix = car park surface	?Terram membrane at base (0.60)	none	level	-	-	-
0.600	0.670	39.140	39.070	A0	Moist, light brown to mid grey (in shades of brown and grey-brown), stiff (working soft and more or less plastic), slightly silty clay	Abundant stones and brick fragments (both to 30 mm) throughout	none	level	-	-	-
0.670	0.760	39.070	38.980	A0	Moist, light to mid grey-brown, stiff (working soft and more or less plastic), slightly silty clay	Occasional brick fragments (to 20 mm) throughout and sliver of bone (to 55 mm) at 0.75	none	level	-	-	-
0.760	0.960	38.980	38.780	A3	Moist, very dark grey-brown to black, crumbly to unconsolidated (working soft), humic, very slightly sandy slightly clay silt	Abundant waterlogged wood fragments (to 60 mm) concentrated in 0.76-0.81	moderate	level	Sample 20 = ~half of core from 0.76-0.82	Spot sample 3: elm	-
0.960	1.000	38.780	38.740	A1	As the lower part of layer above (0.81-0.96) but more or less dry, compacted and brittle to crumbly	none	slight	level	-	-	-
1.000	1.860	38.740	37.880	A3	As 0.76-0.96 but with no further concentrations of wood. Light grey sand intrusions (at ~45 degrees to horizontal) at 1.48-1.52 and 1.56-1.60, and more inter-mixed at 1.64-1.72. Dusted with sand grains from 1.00-1.40. Fibrous organic content at 1.76 and 1.80. Becomes wet from 1.50-1.86	Occasional wood ?chips and twig/root fragments (e.g. at 1.05-1.10) and rounded pebbles (to 15 mm) throughout	slight	level	Sample 21 = ~half of core from 1.80-1.85		-
1.860	1.960	37.880	37.780	A0	Moist, light to mid grey, soft to unconsolidated (working more or less plastic), sandy clay	Large pebble (to 100 mm) present	none	level	-	-	-
1.960	2.000	37.780	37.740	A0	Moist, light to mid brown to grey-brown, unconsolidated, sand, with some black patches	black patches perhaps ?sulphide staining from rotted organics or perhaps very rotted charcoal	slight	level	-	-	-

2.000	3.000	37.740	36.740	A0	Core tube split and sequence largely unrecordable. Terminated in 0.08 m of moist, light to mid brown, very stiff (working plastic), clay	none	none	-	-	-	-

vii) Borehole G

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.270	39.600	39.330	E5	Core section collapsed and occupies only ~one-third of the core tube. More or less dry, mid grey-brown, unconsolidated, humic, silty sand/sandy silt	Fresh grass at 0.00 = current ground surface. Modern rootlet and other herbaceous detritus throughout. Stones, brick, mortar (all to 45 mm) present throughout	none	level	-	-	-
0.270	0.400	39.330	39.200	E5	Just moist, mid grey-brown, unconsolidated, slightly silty sand, with some small areas (to 10 mm) of moist, light brown, stiff (working plastic), clay and patches (to 8 mm) of mid brown, unconsolidated, sand	Rotted brick fragments (to 10 mm) at 0.36-0.40	none	level	-	-	-
0.400	0.480	39.200	39.120	A0	Moist, mid to dark grey, firm (working soft), clay silt	Frequent (~30%) inclusions of black ash/cinder and traces of rotted brick throughout	none	level	-	-	-
0.480	0.530	39.120	39.070	A0	Moist, very pale (off-white), rather slimy, very fine grained ?lime or lime-rich clay	none	none	level	-	-	-
0.530	0.540	39.070	39.060	A0	Collapsed band of moist, unconsolidated, fine sand and gravel	none	none	level	-	-	-
0.540	0.560	39.060	39.040	A0	?Lime as 0.48 - 0.53 (above)	none	none	level	-	-	-
0.560	1.000	39.040	38.600	A0	Moist, dark grey-brown to very dark grey, crumbly to firm (working soft and somewhat plastic), clay silt (some areas perhaps silty clay)	Black ash and/or very rotted charcoal/cinder quite common (~10%) throughout, with some rotted charcoal pieces (to 12 mm) also present. Very rotted shell (soft and	none	level	Sample 18 = all of core from 0.65 - 0.70	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
						disintegrates) at 0.87-0.88, ?tile fragments at 0.62-0.66 (to 55 mm) and 0.91-0.93 (to 20 mm)					
1.000	1.250	38.600	38.350	D0	Void	-	-	level	-	-	-
1.250	1.480	38.350	38.120	A1	Just moist, dark grey, crumbly to unconsolidated (working soft and somewhat plastic), sandy clay silt	Black inclusions of very rotted charcoal throughout. Rootlets at 1.27-1.29 and 1.39-1.48	none	level	-	-	-
1.480	1.600	38.120	38.000	A0	Moist, light brown, unconsolidated, sand	none	none	level	-	-	-
1.600	1.990	38.000	37.610	A0	Moist, mid to dark grey, crumbly to unconsolidated (working soft), ?slightly clay, silty sand	Rounded quartz pebble (to 15 mm) at 1.71-1.72 and black flecks of ?rotted charcoal at 1.81-1.82	none	level	Sample 19 = all of core from 1.75-1.80	-	-
1.990	2.000	37.610	37.600	A0	Sand as at 1.48-1.60	none	none	level		-	-
2.000	2.150	37.600	37.450	A0	Moist, light grey to grey-brown, unconsolidated, sand	none	none	level		-	-
2.150	2.350	37.450	37.250	A0	Moist, light to mid grey, firm (working soft then more or less plastic), slightly silty clay	none	none	declined at ~30 degrees to horizontal - interface depth range at 2.31-2.35	-	-	-
2.350	2.440	37.250	37.160	A0	Moist, mid grey, compacted (crumbles when worked), slightly silty sand	none	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
2.440	3.000	37.160	36.600	B0	Core section collapsed. Moist to wet, light brown to grey-brown, unconsolidated, coarse sand	Stones (to 30 mm) common (~30%), becoming abundant (>50%) in last 0.05 m	none	-	-	-	-

viii) Borehole H

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.060	39.352	39.292	D5	Void	Fresh grass of current ground surface at 0.06	-	level	-	-	-
0.060	0.200	39.292	39.152	E4	Topsoil of moist, mid to dark brown, crumbly (working soft), sandy clay silt	modern rootlet penetration throughout	none	level	-	-	-
0.200	0.360	39.152	38.992	E3	Similar to 0.06-0.20 (above) but mid brown and slightly more clay content in general, with an inclusion of light to mid brown, stiff clay at 0.21-0.24	occasional modern rootlet fragments throughout	none	level	-	-	-
0.360	0.380	38.992	38.972	A0	Moist, light to mid pinkish-orange ('salmon' pink), unconsolidated, sand	none	none	level	-	-	-
0.380	0.460	38.972	38.892	A0	More or less dry, mid to dark brown, unconsolidated, slightly silty sand	Abundant cinder (to 18 mm) and a little fine ?charcoal throughout	none	level	-	-	-
0.460	0.490	38.892	38.862	A0	More or less dry, very pale yellow-white, cushed mortar layer	none	none	level	-	-	-
0.490	1.000	38.862	38.352	A0	Just moist, mid grey (occasional small areas of mid brown), crumbly (working soft), slightly clay (more so in places) silty sand	Crushed brick (at 0.52-0.54), mortar flecks (at 0.60-0.63), glass (at 0.69-0.71) and occasional small rounded stones (to 10 mm) throughout	none	level	-	-	-
1.000	1.420	38.352	37.932	D0	Void	-	-	level	-	-	-
1.420	1.520	37.932	37.832	A0	Moist, light to mid grey, unconsolidated, slightly silty clay sand	none	none	level	-	-	-
1.520	1.900	37.832	37.452	A0	Just moist, mid brown, very stiff (working plastic), clay	none	none	level	-	-	-
1.900	2.000	37.452	37.352	D0	Void	-	-	level	-	-	-
2.000	3.000	37.352	36.352	A0	as clay at 1.52-1.90 (above)	none	none	level	-	-	-

3.000	4.000	36.352	35.352	A0	as clay at 1.52-1.90 (above) but only 0.35 metres of sediment in core tube, rest void - sediment mobile within tube so any depth record spurious	none	none	-	-	-	-

ix) Borehole I

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.860	38.955	38.095	A1	Moist, mid to dark grey, unconsolidated, slightly silty sand. Slightly clay at 0.77-0.86	Stones (to 65 mm) present throughout - mostly rounded but occasional more angular ones too. Decayed rootlet at 0.30-0.34, 0.37-0.46 and 0.62-0.72. Traces of cinder and coal (both to 7 mm) at 0.74 and 0.77-0.86 and of brick/tile (to 3 mm) at 0.82	very slight	level	Sample 16 = ~half of core at 0.80-0.86	-	-
0.860	0.960	38.095	37.995	A3	Moist, light to mid brown to grey-brown, unconsolidated, sand, with some discrete mid grey clay lumps (to 40 mm)	Large woody root fragments at 0.69-0.72, small stones at 0.86-0.88, ?cinder/ash at 0.88-0.92	none	level	-	-	-
0.960	1.000	37.995	37.955	A0	Moist, light to mid brown, stiff (working plastic), clay	none	none	level	-	-	-
1.000	1.370	37.955	37.585	A0	Moist to wet, mid grey, unconsolidated, slightly silty sand	Occasional rounded quartz pebble (to 6 mm) - e.g. at 1.09 and 1.14. Horizontal band of small rounded stones (to 10 mm) at 1.30-1.31	none	level	Sample 17 = all of core at 1.28-1.32	-	-
1.370	1.580	37.585	37.375	A0	Core section collapsed. Moist, light to mid brown, unconsolidated, fine and coarse sand	none	none	level	-	-	-
1.580	2.000	37.375	36.955	A0	Moist, mid brown to grey-brown, very stiff (working plastic), clay	none	none	level	-	-	-
2.000	3.000	36.955	35.955	A0	Just moist, light to mid brown, very stiff (working plastic), clay	rotted ?sandstone lumps (to 12 mm) at 2.72-2.75	none	level	-	-	-
3.000	3.700	35.955	35.255	A0	clay as at 2.00 - 3.00 (above)	none	none	-	-	-	-

x) Borehole J

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.360	40.040	39.680	E4	Just moist, dark brown, unconsolidated, silty sand	modern woody root and rootlet throughout	none	level	-	-	-
0.360	0.440	39.680	39.600	A0	No real matrix	Lumps of ?furnace slag/'hard core' (to 115 mm)	none	level	-	-	-
0.440	0.860	39.600	39.180	A0	Modern sand and gravel dry mix hard core	Two layers of terram membrane at 0.86	none	level	-	-	-
0.860	1.000	39.180	39.040	A2	Moist, dark brown to grey-brown, crumbly (working soft)	Small fragments of ?cinder (to 3 mm) in 0.86-0.89 and a few modern rootlet fragments throughout	none	level	Sample 14 = half of core 0.90-1.00	-	-
1.000	1.260	39.040	38.780	A0	Moist, mid to dark grey-brown, unconsolidated to crumbly, slightly clay slightly silty sand	Occasional rounded pebbles (to 24 mm) throughout	none	level	Sample 15 = all of core 1.20-1.26	-	-
1.260	1.750	38.780	38.290	A2	Moist, light brown, unconsolidated, sand (last 0.02 m slightly wetter and slightly clay)	Occasional rounded pebbles (to 15 mm) at 1.26-1.46	none	slightly diffuse	-	-	-
1.750	2.000	38.290	38.040	A0	Moist, mid to mid to dark brown, stiff, clay (slightly sandy in upper 0.02 m)	none	none	slightly diffuse	-	-	-
2.000	3.000	38.040	37.040	A0	Just moist, mid brown, very stiff and slightly sticky (working plastic), clay	none	none	level	-	-	-
3.000	4.000	37.040	36.040	A0	clay as 2.00-3.00 (above) with slightly silty patches at 3.00-3.20 and 3.34-3.40	none	none	-	-	-	-

xi) Borehole K

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.840	37.135	36.295	E0	Largely void - no real matrix	Largely void, with loose stones (to 55 mm) from 0.00-0.35 (very approximately) followed by a mix of brick (to 30 mm), coal (to 50 mm) and cinder (to 22 mm)	none	level	-	-	-
0.840	1.000	36.295	36.135	E0	Moist, light to mid grey-brown, crumbly (working soft and somewhat plastic), sandy, silty clay/clay silt	Crushed brick/tile, black ash/cinder and stones (to 12 mm) throughout. Smells of diesel oil contamination	none	level	-	-	-
1.000	2.000	36.135	35.135	A0	Just moist, mid brown, very stiff (working plastic), clay - stained dark grey/black by diesel oil contamination from 1.00-1.04	Diesel oil contamination in uppermost 0.04 m	none	level	-	-	-
2.000	2.500	35.135	34.635	A0	Large voids in tube - also contained further clay as seen at 1.00-2.00 (above) but any depth record spurious owing to voids	none	none	level (between clay sections and voids)	-	-	-
2.500	3.000	34.635	34.135	A0	Large voids in tube - also contained further clay as seen at 1.00-2.00 (above) but any depth record spurious owing to voids	none	none	level (between clay sections and voids)	-	-	-

xii) Borehole L

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.500	38.710	38.210	E0	Collapsed and loose in core tube - no matrix	Tarmac and stone (to 60 mm) modern 'hard core'	none	n/a	-	-	-
0.500	0.660	38.210	38.050	E0	A little matrix of more or less dry, light to mid grey, stiff (working plastic), clay	Stone (to 80 mm) 'hard core'	none	n/a	-	-	-
0.660	0.750	38.050	37.960	E0	No matrix	Loose 'hard core' stones (to 80 mm)	none	level	-	-	-
0.750	1.300	37.960	37.410	A0	Moist, dark brown to dark grey-brown, compacted to crumbly, ?ashy, slightly clay silt	?post-medieval/modern pottery fragment (to 35 mm) at 0.97-1.00	none	level	Sample 45 = ~half of core from 0.85-0.92	-	-
1.300	2.000	37.410	36.710	A0	Just moist, light brown, unconsolidated, sand - stained darker from layer above at 1.30-1.38	none	none	level	-	-	-
2.000	2.450	36.710	36.260	A0	Moist sand continues as at 1.30-2.00 (above)	Abundant stones (to 80 mm) at 2.00-2.35 - forming ~90% of tube contents at 2.00-2.20	none	level	-	-	-
2.450	3.980	36.260	34.730	A0	Moist, mid brown, very stiff (working plastic), clay	none	none	level	-	-	-
3.980	4.000	34.730	34.710	D0	Void	-	-	-	-	-	-

xiii) Borehole M

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.350	37.810	37.460	E5	More or less dry, mid grey-brown (flecked with light brown sand), uncosolidated (collapsed and loose in upper 0.18 m of tube), sandy silt	Stones (to 12 mm) and rootlets present throughout; the latter abundant from 0.00-0.09	none	level	-	-	-
0.350	0.450	37.460	37.360	E4	Dry, mid to dark grey-brown, unconsolidated, sandy silt (approx. 50% of core section volume)	Abundant brick/tile rubble (to 38 mm) - approx. 50% of core section volume. Cinder (to 12 mm) and fine (but woody) rootlet common throughout	none	level	-	-	-
0.450	0.490	37.360	37.320	A0	No matrix	All of section was of angular, pale grey/grey-brown, stone (to 24 mm)	none	level	-	-	-
0.490	0.520	37.320	37.290	A0	Dry, mid to dark grey layer of ?ashy silt	Abundant ?burnt stones (to 12 mm)	none	level	-	-	-
0.520	0.550	37.290	37.260	A0	As 0.49-0.52 (above) but colour mixed between mid to dark grey and mid to dark red-brown; latter probably leaching from layer below	none	none	level	-	-	-
0.550	0.580	37.260	37.230	A0	Dry, mid to dark grey-brown, unconsolidated (loose), ?ashy sandy silt matrix; very much a minor component (~10%) of this section	Mostly of dry, angular, brick/tile (to 35 mm), with a little ?mortar (to 37 mm)	none	level	-	-	-
0.580	0.800	37.230	37.010	A0	Just moist, mid brown, stiff (working plastic), clay	Cinder and ?ash lumps (both to 12 mm) present throughout	none	level	-	-	-
0.800	1.000	37.010	36.810	A0	Just moist, mid to dark grey-brown to mid to dark grey, crumbly (working more or less plastic), silty clay (grading to clay silt from top	Abundant fine ash throughout. Large brick/tile fragment (to 108 mm) at 0.80-0.88, with a little	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
					to bottom)	associated mortar (to 10 mm)					
1.000	1.230	36.810	36.580	A0	Just moist, very dark grey to black, crumbly to unconsolidated, very ashy sandy silt	Large lumps (to 110 mm) of conglomerate ?floor surface at 1.13-1.20 overlying a thin band with abundant angular and rounded stones (to 50 mm) at 1.20-1.23	none	level	-	-	-
1.230	1.440	36.580	36.370	A1	Moist, very dark grey to black, soft to unconsolidated, slightly clay silt	Fine ?ash, ?rootlet, stones (to 12 mm) and possible other waterlogged organic material throughout	slight	grades	-	-	-
1.440	1.600	36.370	36.210	A1	Moist, very dark grey to black, soft to unconsolidated, slightly sandy silt	Fine ?ash, ?rootlet, stones (to 12 mm) and possible other waterlogged organic material throughout. ?Standing ground water from ~1.50 downwards. Very rotted charcoal (to 3 mm) and some ?coal (to 4 mm) at 1.60	slight	grades	-	-	-
1.600	2.000	36.210	35.810	A1	Moist, very dark grey to black, soft to unconsolidated, slightly silt slightly clay sand	Fine ?ash, ?rootlet, stones (to 12 mm) and possible other waterlogged organic material throughout	slight	level	Sample 22 = ~half of core section from 1.60-1.65	-	-
2.000	2.230	35.810	35.580	A1	Continues as 1.60-2.00 above, with small clast of mid brown sand (to 10 mm)	Fine ?ash, ?rootlet, stones (to 12 mm) and possible other waterlogged organic material throughout	very slight	level	Sample 23 = ~half of core section from 2.10-2.20	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
2.230	2.840	35.580	34.970	B0	Wet, light to mid brown, unconsolidated, coarse sand	Rounded stones (to 14 mm) present at 2.64-2.84	none	level	-	-	-
2.840	3.000	34.970	34.810	C0	Largely void as core section collapsed. Remaining matrix of loose, saturated, coarse sand	Abundant rounded pebbles (to 45 mm)	-	-	-	-	-

xiv) Borehole N

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.200			E0	Core section collapsed in tube. No matrix.	More or less dry, light and dark grey, mostly cinder (to 30 mm) and ?ash, with some pieces of ?aggregate (to 40 mm)	none	level	-	-	-
0.200	0.500	39.165	38.665	A0	Just moist, mid brown to mid to dark grey-brown, unconsolidated, ashy and slightly silty, sand	Crushed cinder and coal (to 4 mm), brick/tile (to 28 mm) and ?mortar (to 8 mm, very rotted) were all common	none	level	-	-	-
0.500	0.630	38.665	38.535	A0	Just moist, mid brown, stiff (working plastic), clay - surface discoloured to dark grey from 0.55-0.63 (?transfer in sampling tube)	none	none	level	-	-	-
0.630	1.000	38.535	38.165	B0	Moist (becoming wet from 0.70 downwards - ?standing ground water), mid to dark grey-brown to dark grey to black, soft and slightly sticky (works very sticky), sandy clay, with some small clasts (to 20 mm) of light to mid brown clay (at 0.65-0.68, 0.79-0.81, 0.89-0.92, 0.96-1.00)	Abundant very rotted charcoal (to 8 mm) and very rotted ?mortar throughout (with a mortar concentration at 0.95-1.00)	none	level	Sample 29 = ~half of core from 0.75-0.80	-	-
1.000	1.070	38.165	38.095	B0	Core section collapsed in tube. Moist to wet, dark grey, unconsolidated and slightly sticky (working soft), slightly sandy clay silt	none	none	level	-	-	-
1.070	1.220	38.095	37.945	B1	Moist to wet, dark grey, soft (working soft and slightly sticky), slightly sandy clay silt	Very rotted wood (little more than an orange discolouration) at 1.08-1.10 and coal (to 3 mm) fragments (at 1.13-1.14) were present	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
1.220	1.290	37.945	37.875	B2	Moist, black, unconsolidated to crumbly (working more or less soft), very humic sediment. Appears to be mostly amorphous organic material with, perhaps, a little silt	Bark fragment (to 50 mm) at 1.25-1.26	none	level	-	-	-
1.290	1.320	37.875	37.845	C2	No matrix.	Consist entirely of a piece of poorly preserved saturated wood	none	level	-	Spot Sample 4: willow	-
1.320	1.580	37.845	37.585	C1	Wet, light to mid grey-brown to dark grey-brown, soft and somewhat thixotropic, silty sandy clay, perhaps with a little amorphous organic content at 1.32-1.35	none	none	level	Sample 30 = ~half of core from 1.35-1.40	-	-
1.580	1.600	37.585	37.565	C0	Wet to waterlogged, light grey-brown, unconsolidated and rather granular, slightly sandy clay - granules moslty seem to be small (to 2 mm) lumps of indurated clay	none	none	level	-	-	-
1.600	1.750	37.565	37.415	C3	As at 1.32-1.58 (above)	Twig fragments (to 3 mm diameter) at 1.67	none	level	-	-	Twig fragment taken as spot sample 5 for AMS dating
1.750	1.800	37.415	37.365	C2	Wet, mid grey to dark grey-brown (and shades between), soft (working sticky), silty clay (to clay silt)	Coal/cinder (to 4 mm) present throughout, bone fragment (to 11 mm) at 1.74 and wood fragment (saturated and rotted) at 1.80	none	level	-	-	-
1.800	1.880	37.365	37.285	C0	Discrete components of wet, pale blueish-grey, sticky, clay and wet, mid to dark brown to grey-brown, sticky (working soft), clay silt	Small coal fragments (to 5 mm) present throughout	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
1.880	1.910	37.285	37.255	C0	Band of wet, dark brown, slightly sticky (working soft), ?humic, slightly sandy clay silt	Blue ?vivianite (to 12 mm) at 1.91	slight	level	-	-	-
1.910	2.000	37.255	37.165	C4	Wet, dark brown, soft, very organic silt	Abundant waterlogged herbaceous detritus. Hazelnut fragment at 1.93-1.94	overpowering	level	-	-	-
2.000	2.460	37.165	36.705	C4	Continues as 1.91-2.00 (above), with a pale blueish-grey clay inclusion (as see in 1.80-1.88, above)	Abundant waterlogged herbaceous detritus, large wood fragments and also twigs throughout	overpowering	level	Sample 31 = core section at 2.10-2.15	Spot samples of roundwood (?wattle) taken from 2.00-2.05 (Spot sample 6: willow and hazel), 2.10-2.18 (Spot Sample 7: alder), 2.23-2.33 (Spot Sample 8: alder), 2.35-2.39 (Spot Sample 9: ash)	Spot samples 11 at 2.17 and 12 at 2.40 of twig fragments for AMS dating
2.460	2.610	36.705	36.555	C0	Moist to wet, very dark grey-brown, soft, silty clay sand	none	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
2.610	2.720	36.555	36.445	C3	Moist to wet, very dark grey-brown, crumbly (works soft), ?slightly silty, clay sand	Large roundwood (?wattle) inclusions at 2.62-2.64 and 2.67-2.70	very slight	level	Sample 32 = core section at 2.65-2.70	Two roundwood pieces at 2.62-2.64 and 2.67-2.70 taken as Spot Sample 10: willow	-
2.720	2.850	36.445	36.315	C2	Moist, light grey-brown to mid to dark grey (in shades of grey and grey-brown), unconsolidated, sand	Large rounded stones (to 40 mm) at 2.73-2.75	none	level	-	-	Spot sample 13 = twig fragment at 2.74 taken for AMS dating
2.850	3.000	36.315	36.165	C1	continues as 2.72-2.85 (above) but section collapsed in tube	Small sliver of decayed wood at 2.85	none	level	-	-	-
3.000	3.800	36.165	35.365	C0	Just moist, mid brown, very stiff (working plastic), clay	none	none	level	-	-	-
3.800	3.980	35.365	35.185	C0	Just moist, light to mid grey, stiff (working plastic), clay	none	none	grades	-	-	-
3.980	4.000	35.185	35.165	C0	Moist, light to mid grey, sticky (working soft), sandy clay	none	none	-	-	-	-

xv) Borehole O

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.400	39.642	39.242	A5	Section collapsed in tube. Small amount of matrix of just moist, mid to dark grey, slightly clay sandy silt	Some fine ?ash content within the matrix. Fresh grass and moss from current ground surface at 0.00-0.02 and associated rootlet penetration to 0.14 m. Brick/tile (to 30 mm), mortar (to 15 mm), cinder (to 12 mm) and large lumps of slag (to 70 mm) formed the bulk of this section of the core	none	level	-	-	-
0.400	0.540	39.242	39.102	A3	As 0.40-0.54 but with an increasing percentage of brick tile and small patched of mid brown sand (at 0.50-0.52)	As above but with an increasing percentage of brick/tile which becomes the dominant component at 0.50-0.54	none	level	-	-	-
0.540	0.680	39.102	38.962	A0	Moist, dark grey (occasionally mid to dark grey-brown), unconsolidated, ashy, slightly clay silty sand	Rotted mortar at 0.62-0.68	none	level	-	-	-
0.680	0.790	38.962	38.852	A0	Matrix as at 0.54-0.68 but only a minor component of this section	Mostly composed of cinder, slag, mortar and coal (all to 20 mm)	none	level	-	-	-
0.790	0.900	38.852	38.742	A0	Just moist, light grey, stiff (working more or less plastic), slightly silty clay	none	none	level	-	-	-
0.900	1.000	38.742	38.642	A0	No matrix	Almost entirely composed of dry, shattered brick (to 60 mm), with a little associated mortar and traces of ?ash/cinder (the last perhaps contamination from the layer above, however)	none	level	-	-	-
1.000	1.200	38.642	38.442	A0	Section collapsed in tube. Relatively small amount of matrix (~40% of volume) of moist, mid to dark grey-brown, soft (working more or less plastic), silty clay	Mostly of shattered brick (to 70 mm), also one piece of ?Victorian pottery noted	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
1.200	1.770	38.442	37.872	A2	Matrix continues as 1.00-1.20 (above)	Infrequent brick/tile and stones (both to 10 mm), large lumps of coal (to 60 mm) at 1.41-1.47 and fine waterlogged plant remains present throughout (most appears to be fine rootlet)	slight	level	Sample 24 = ~half of core from 1.30-1.35	-	-
1.770	2.000	37.872	37.642	B0	Wet (possibly within standing ground water from 1.77 downwards), mid to dark grey-brown, sticky (working plastic), clay, with a little sand content in 1.97-2.00	Brick/tile fragment (to 25 mm) at 1.77	none	level	-	-	-
2.000	2.390	37.642	37.252	D0	Void	-	none	level	-	-	-
2.390	2.890	37.252	36.752	C0	Waterlogged, mid to dark grey-brown, unconsolidated and slightly sticky, slightly clay silty sand (to sandy silt in places)	Occasional rounded stones (to 15 mm) throughout	slight	level	Sample 25 = core section from 2.70-2.75	-	-
2.890	3.000	36.752	36.642	C0	Just moist, mid brown to mid to dark grey-brown, stiff (working plastic), clay	none	none	level	-	-	-
3.000	4.000	36.642	35.642	C0	clay as at 2.89-3.00 (above) continues, with a void at 3.36-3.44	none	none	-	-	-	-

xvi) Borehole P

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.070	39.925	39.855	A0	More or less dry, light to mid slightly pinkish-brown, stiff (working plastic), clay, with a little sand	Small stones (to 6 mm) present throughout	none	n/a	-	-	-
0.070	0.270	39.855	39.655	A0	No real matrix - perhaps a little sand though this may be from the rotted mortar	More or less dry, loose and collapsed in core tube, mix of cinder/coal (to 4 mm - common becoming abundant at 0.19-0.27), brick/tile (to 8 mm) and mortar (to 8 mm)	none	n/a	-	-	-
0.270	0.320	39.655	39.605	A0	More or less dry, mid brown (slightly reddish in places), crumbly (working soft), clay sand	Coal (to 10 mm) present throughout	none	level	-	-	-
0.320	0.360	39.605	39.565	A0	More or less dry, approximately equal mix of buff, unconsolidated, sand and small lumps (to 8 mm) of mid to dark grey-brown clay sand	None	none	level	-	-	-
0.360	0.600	39.565	39.325	A0	More or less dry, light brown to light to mid grey-brown, firm (working more or less soft), clay sand (to sandy clay)	Occasional flecks of coal (to 3 mm) throughout	none	n/a	-	-	-
0.600	1.000	39.325	38.925	A2	Collapsed and loose in core tube - just moist, mid grey to mid grey-brown, unconsolidated (working soft and somewhat plastic), silty clay	Occasional fragments of brick/tile (to 70 mm) present and modern roots noted at 0.65-0.70	none	n/a	-	-	-
1.000	1.130	38.925	38.795	A2	Collapsed and loose in core tube - matrix description as for 1.13-1.31 below	Some charcoal and root fragments present	none	n/a	-	-	-
1.130	1.310	38.795	38.615	A3	Just moist, mid grey, crumbly (working soft), slightly sandy clay silt, with some inclusions of light grey-brown crumbly sand at 1.13-1.24	Roots (at 1.13-1.19) and charcoal (at 1.17-1.21) were common with charcoal becoming abundant from 1.21-1.31. Animal bone fragment (to 20 mm) at 1.30-1.31	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
1.310	1.500	38.615	38.425	A2	Just moist, dark brown to dark grey-brown, crumbly (working more or less soft), ?silt or very humified amorphous organic sediment - ?peat, flecked with buff sand/rotted mortar	None	none	level	Sample 33 = ~half of core from 1.45-1.50	-	-
1.500	1.630	38.425	38.295	A2	Just moist, mid to dark, slightly purplish-brown, amorphous organic sediment - ?humified peat	Fragments of moss 'stems and leaves', sedge (*Carex*) nulets and rootlets	none	level	Sample 34 = ~half of core from 1.50-1.55	-	-
1.630	1.730	38.295	38.195	A2	As 1.31-1.50 - ?peat but without the buff flecks	None	none	level	-	-	-
1.730	1.910	38.195	38.015	A0	Moist, dark brown to dark grey-brown, crumbly (working soft), slightly clay silt	A little fine ?charcoal (to 6 mm) at upper interface (i.e. at 1.73)	none	n/a	-	-	-
1.910	2.000	38.015	37.925	A2	Further ?very humified peat as 1.63-1.73 but collapsed and loose in core tube	None	none	n/a	Sample 35 = ~half of core from 1.91-1.96	-	-
2.000	2.670	37.925	37.255	A0	Moist, dark grey, crumbly (working soft), clay sand, becomes more clay at 2.48-2.67 and works soft and somewhat plastic	None	none	n/a	Sample 36 = ~half of core from 2.00-2.05	-	-
2.670	3.000	37.255	36.925	A0	Moist, light brown, unconsoildated, very 'clean' sand	None	slight	level	-	-	-
3.000	3.500	36.925	36.425	A0	Sand as at 2.67-3.00 continues but perhaps more light grey-brown than light brown	Rounded pebbles (to 30 mm) common to abundant throughout	none	level	-	-	-
3.500	4.000	36.425	35.925	B0	Sand as at 3.00-3.50 continues but mid brown in colour and becoming more wet than moist	Rounded pebbles (to 40 mm) common to abundant throughout	none	-	-	-	-

xvii) Borehole Q

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.480	39.215	38.735	E0	Collapsed and loose in core tube - just moist (to dry in places), light grey-brown to mid brown, unconsolidated, silty sand	Abundant stones (to 30 mm) throughout and modern glass fragment (to 25 mm) at 0.43-0.45	none	level	-	-	-
0.480	0.540	38.735	38.675	E0	Just moist, very dark grey to black, compressed (working more or less soft), very ashy, slightly clay silt, with some light to mid brown sand on outer surface in places	?Cinder/part burnt coal (to 20 mm) present throughout and occasional pieces of ?rotted mortar (to 8 mm)	none	level	-	-	-
0.540	1.000	38.675	38.215	E0	Just moist, dark grey-brown, firm (working soft), slightly clay sandy silt (more sandy in places) grading into stiff (working more or less plastic) slightly sandy slightly silty clay	Small rounded pebbles (to 12 mm) and occasional pieces of ?cinder/coal (to 8 mm) present throughout. Small modern glass fragment (to 7 mm) at 0.70	none	level	-	-	-
1.000	1.470	38.215	37.745	A0	Matrix as 0.54-1.00 (above) but varies between the predominantly silt and predominantly clay components	none	none	level	-	-	-
1.470	1.500	37.745	37.715	A0	Relatively small amount of matrix as at 1.00-1.47 (above) accounts for approximately half of this section	Mortar and crushed brick/tile (both to 15 mm) common to abundant	none	level	-	-	-
1.500	1.630	37.715	37.585	B0	Wet, mid to dark brown to grey-brown, stiff (working soft then more or less plastic), slightly sandy silty clay, becomes more sandy with depth and grades into next lowest section	Stones (to 30 mm) common at 1.53-1.55 and present throughout the rest of this section	none	grades	Sample 44 = ~half of core from 1.50-1.55	-	-
1.630	1.830	37.585	37.385	C0	Wet, mid to dark brown to grey-brown, compacted/firm, slightly clay slightly	Occasional rounded pebbles (to 20 mm)	none	n/a	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
					silty sand	throughout					
1.830	2.000	37.385	37.215	C0	Collapsed and loose in core tube - wet, mid brown, unconsolidated, coarse sand	none	none	n/a	-	-	-
2.000	2.100	37.215	37.115	D0	Void	-	-	level	-	-	-
2.100	2.480	37.115	36.735	C0	Moist to wet, light to mid brown to mid grey-brown, compacted (firm but crumbles), slightly silty sand	Stones (to 15 mm) present throughout	none	level	-	-	-
2.480	2.880	36.735	36.335	C0	Moist to wet, light to mid grey-brown, unconsolidated, coarse sand	Occasional stones (to 25 mm) present throughout but larger (to 70 mm) and more frequent (common) at 2.83-2.88	none	level	-	-	-
2.880	2.980	36.335	36.235	C0	Moist to wet, mid brown, stiff (working soft then plastic), clay	none	none	level	-	-	-
2.980	3.000	36.235	36.215	C0	Sand as at 2.48-2.88 (above)	Stones (to 50 mm) present throughout	none	level	-	-	-
3.000	3.800	36.215	35.415	C0	Core tube broken and only 0.8 metres long - just moist, mid brown, very stiff (working plastic), clay, with a slight 'dusting' of light to mid brown sand at 3.00-3.03 and a small intrusion of moist, mid brown, unconsolidated, sand at 3.21-3.24	A very occasional stone - e.g. small rounded pebble (to 12 mm) at 3.50-3.51	none	-	-	-	-

xviii) Borehole R

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.500	39.180	38.680	E0	Largely collapsed in core tube - no real matrix	Largely collapsed in core tube - slightly moist mix of mortar, brick, stones, cinder and sand, with a particular concentration of brick at 0.44-0.50	none	level	-	-	-
0.500	1.000	38.680	38.180	A0	Just moist, very dark grey, soft (working soft and slightly plastic), ?ashy, slightly sandy clay silt, flecked with occasional light coloured sand grains	Traces of brick/tile (to 8 mm) and occasional stones (to 9 mm) throughout, ?mortar (to 30 mm) at 0.84, Flecks of granular black ?cinder/part burnt coal (to 5 mm) at 0.95-1.00	none	level	-	-	-
1.000	1.090	38.180	38.090	D0	Void	-	-	level	-	-	-
1.090	1.360	38.090	37.820	A0	As 0.50-1.00 above, with occasional clasts (to 10 mm) of light to mid brown sticky clay	as 0.50-1.00 above but with coal (to 14 mm) throughout	none	level	-	-	-
1.360	1.560	37.820	37.620	A0	Moist to wet, light brown to light to mid grey-brown, soft, coarse sand	rounded pebbles (to 25 mm) at 1.53-1.56	none	level	Sample 27 = ~half of core from 1.40-1.45	-	-
1.560	1.600	37.620	37.580	A0	Grades from sediment above (1.36 to 1.56) info sediment below	none	none	level	-	-	-
1.600	1.740	37.580	37.440	A0	Moist,light to mid grey, firm (working soft and somewhat plastic	none	none	level	-	-	-
1.740	1.870	37.440	37.310	A0	Moist, light to mid brown to grey-brown, soft (working more or less plastic clay, with indurated 'granules' of mid brown clay (to 2 mm)	none	none	level	-	-	-
1.870	2.000	37.310	37.180	B0	Moist to wet, light brown to light to mid grey-brown, soft, coarse sand	abundant rounded pebbles (to 35 mm)	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
2.000	2.500	37.180	36.680	D0	Void	-	-	-	-	-	-
2.500	3.000	36.680	36.180	C0	Moist (to wet from 2.35 downwards, mid brown to mid grey-brown, stiff (working plastic), clay	none	none	declined at approximately 45 degrees - interface depth range 2.85-3.00	-	-	-
3.000	3.080	36.180	36.100	D0	Void	-	-	-	-	-	-
3.080	4.000	36.100	35.180	C0	clay as 2.50-3.00	none	none	-	-	-	-

xix) Borehole S

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.160	39.770	39.610	A0	Just moist, light brown, unconsolidated to soft, very 'clean' sand	None	none	level	-	-	-
0.160	0.810	39.610	38.960	A0	No matrix	More or less dry, unconsolidated (collapsed and loose in tube), angular stone (to 80 mm)	none	level	-	-	-
0.810	1.000	38.960	38.770	A0	Just moist, dark grey-brown, crumbly, slightly silty sand	possibly slightly ashy	none	level	-	-	-
1.000	1.280	38.770	38.490	D0	Void , with a little collapsed sand (as layer below)	None	none	level	-	-	-
1.280	2.000	38.490	37.770	A0	Moist, mostly mid to dark grey-brown, unconsolidated, slightly silty sand, with occasional light brown patches of sand at 1.40, 1.60, 1.70 and dark grey sand at 153 and 174 - section from 1.90-2.00 collapsed and loose in tube	Small stones (to 8 mm) present throughout. Traces of brick/tile (to 7 mm) from 1.90-2.00	none	level	Sample 27 = ~half of core from 1.50-1.55	-	-
2.000	2.360	37.770	37.410	A0	sand as at 1.28-2.00 continues	Small stones (to 8 mm) present throughout	none	level	Sample 28 = ~half of core from 2.30-2.35	-	-
2.360	2.440	37.410	37.330	A0	No matrix	Brick surface - large fragments to 130 mm	none	level	-	-	-
2.440	2.550	37.330	37.220	A0	No matrix	Angular stone and conglomerate (to 50 mm) - looks to be hardcore for overlying brick surface (2.36-2.44)	none	level	-	-	-
2.550	2.620	37.220	37.150	A0	Moist, mid to dark to dark grey, unconsolidated, sand	Flecks of rotted charcoal (to 6 mm) and small stones (to 8 mm) present throughout	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
2.620	3.280	37.150	36.490	A0	Moist, light brown to light grey-brown, unconsolidated, fairly coarse 'clean' sand	None - ?deliberately laid 'bedding'	none	level	-	-	-
3.280	4.000	36.490	35.770	A0	Moist, light brown to light grey-brown, unconsolidated, fairly coarse 'clean' sand	Abundant rounded pebbles (to 20 mm) throughout	none	-	-	-	-

xx) Borehole T

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	1.600	39.495	37.895	A2	Collapsed and loose in core tube - moist, light to mid brown to mid grey-brown, unconsolidated, slightly clay slightly silty sand. Occasional lumps of just moist, pale yellow, slightly stiff (working more or less plastic) clay at 0.10-0.22	Rootlets at 0.00-0.24 and 1.24-1.27, stones (to 25 mm) present throughout 0.00-1.00 and becoming larger (to 60 mm) and common from 1.00-1.60, ?human skull fragment at 0.70 and a ?charred bone fragment (to 20 mm) at 1.59 - depths nominal as core collapsed	none	n/a	-	-	-
1.600	1.800	37.895	37.695	A0	Moist, dark brown to very dark grey-brown to black, crumbly to unconsolidated (working soft), slightly sandy clay silt - dark colour perhaps caused by fine ash	Large ?sandstone inclusion (to 80 mm) at 1.66-1.73 and brick/tile (to 50 mm) at 1.68-1.73	very slight	n/a	Sample 40 = ~half of core from 1.65-1.70	-	-
1.800	3.700	37.695	35.795	A2	Collapsed and loose in core tube - moist, light brown to light to mid grey-brown, unconsolidated, fine and coarse sand (becoming more coarse with increasing depth)	Large rounded pebbles (to 80 mm) abundant at 3.44-3.54	none	level	-	-	-
3.700	4.000	35.795	35.495	A2	Moist mid brown, very stiff (working plastic), clay	none	none	-	-	-	-

xxi) Borehole U

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	1.000	39.245	38.245	A0	Collapsed and loose in core tube - moist, mid brown to mid grey-brown to mid to dark grey, unconsolidated, slightly silty clay sand	Stones (to 60 mm) and fragments of brick/tile (to 90 mm) present throughout. Depths rather meaningless given core collapse but animal bone fragment (to 55 mm) at 0.35 and several fragments of ?human skull (to 40 mm) at 0.60-0.65	none	n/a	-	-	-
1.000	1.500	38.245	37.745	A0	Moist (becomes wet at around 1.50), mid to dark grey-brown, slightly sticky (working soft then crumbly), slightly clay sandy silt/silty sand	Occasional stones (to 35 mm) and pieces of coal (to 8 mm) throughout. Large ?human skull fragment (to 80 mm) at 1.00-1.08	none	level	-	-	-
1.500	1.570	37.745	37.675	A0	A very little matrix as above (1.00-1.50) but wet and unconsolidated	Single large rounded pebble/?cobble (to 70 mm)	none	level	-	-	-
1.570	1.770	37.675	37.475	B0	Moist to wet, mid to dark grey-brown, slightly sticky (working soft then crumbly), slightly clay silty sand, with a small patch of light brown coarse sand at 1.77	Stones (to 15 mm) present throughout	none	level	Sample 38 = ~half of core from 1.65-1.70	-	-
1.770	1.960	37.475	37.285	B1	Moist to wet, dark grey-brown, brittle (working soft and slightly plastic), clay silt	Trace of ?waterlogged organic detritus and an occasional rounded pebble (to 18 mm) present	slight		-	-	-
1.960	2.000	37.285	37.245	D0	Void - sediment collapsed from tube	-	-	-	-	-	-
2.000	2.170	37.245	37.075	B2	As 1.77-1.96 above	Root at 2.03	slight	n/a	Sample 37 = ~half of core from 1.65-1.70	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
2.170	3.000	37.075	36.245	C2	Collapsed and loose in core tube - moist to wet, mid brown, unconsolidated (occasionally slightly sticky), slightly clay coarse sand	Rotted wood fragment (to 60 mm) at 2.17-2.23, rounded pebbles (to 60 mm) abundant throughout	none	-	-	Rotted wood inclusion (to 60 mm) Spot Sample 14: oak	-

xxii) Borehole V

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	1.000	39.390	38.390	A3	Collapsed and loose in core tube - more or less dry, mid to dark brown, unconsolidated, sand	Rounded stones (to 20 mm) present throughout and root penetration to 0.40 (with traces at 0.90 too); depths rather meaningless owing to collapse of core, however	none	n/a	-	-	-
1.000	1.440	38.390	37.950	A0	Collapsed and loose in core tube - matrix as above (0.00-1.00) but becoming moist from around 1.40 downwards	Rounded stones (to 20 mm) present throughout	none	n/a	-	-	-
1.440	1.510	37.950	37.880	A3	No matrix	Large wood fragment at 45 degrees to horizontal	none	n/a	-	Spot Sample 15: elm	-
1.510	1.700	37.880	37.690	A3	Matrix as at 1.00-1.44 but only partially collapsed and moist, with a slight clay content in places	Rounded stones (to 20 mm) present throughout and two areas with waterlogged wood fragments - several small pieces (to 15 mm) at 1.51-1.54 and slightly larger fragments (to 35 mm) at 1.56-1.63 (rather decayed and orange-coloured); also root fragment through a larger wood fragment	none	level	Sample 39 = ~half of core from 1.51-1.56	Several wood fragments from 1.56-1.63 Spot Sample 17: ash	-
1.700	1.790	37.690	37.600	A3	Moist, mid grey, crumbly to unconsolidated (working soft), clay sand, with some patches of mid orange unconsolidated sand	Large stone (to 60 mm) at 1.71-1.77 and large (to 60 mm) horizontal wood fragment at 1.75-1.79	none	level	-	Large wood fragment Spot Sample 16: oak	-
1.790	2.000	37.600	37.390	A0	Moist, mid grey-brown, stiff (working soft and somewhat plastic), sandy clay	Occasional rounded pebbles (to 15 mm) present	none	n/a	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
2.000	2.500	37.390	36.890	A2	Whole tube marked as 2.00-2.50 but half void - moist, mid brown, mid grey and mid grey-brown, unconsolidated, sand, with a little grey clay (more clay at 2.00-2.15, i.e. clay sand which works soft and slightly plastic)	Rounded pebbles (to 70 mm) common and an occasional rotted wood fragment (to 60 mm), e.g. at 2.15-2.20	none	level	-	-	-
2.500	3.500	36.890	35.890	A0	Whole tube marked as 2.50-3.50 but core discontinuous in 2 parts and total deposit length present 0.86 m - both sections of core the same just moist, mid brown, very stiff (working plastic), clay	upper surface (?2.50-2.60) sandy, very compacted and with inclusions of stones (to 30 mm)	none	level	-	-	-
3.500	4.500	35.890	34.890	A0	Clay as at 2.50-3.50 continues	pieces of contaminant fresh grass on outer surface of core	none	-	-	-	-

xxiii) Borehole W

Depth		AOD								
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	1.000	40.030	39.030	E4	Collapsed and loose in core tube - moist, mid to dark brown to grey-brown, unconsolidated, sand	Depthe records effectively meaningless owing to core collapse but roots and ?ornamental bark at 0.00-0.15, modern pot fragment (to 30 mm) at 0.50, stones (to 15 mm) present throughout becoming common from 0.80-1.00	none	n/a	-	-	-
1.000	1.360	39.030	38.670	A3	Just moist, dark grey-brown, crumbly to unconsolidated (working more or less soft), sandy clay silt	Occasional stones and brick/tile fragments (both to 15 mm) present throughout, root at 1.05-1.10 and 1.35 (continuing down to 1.48), single pot sherd (to 30 mm) at ~1.20	none	level	-	-	-
1.360	1.770	38.670	38.260	A3	Moist, mid brown, grey and grey-brown, crumbly to unconsolidated, sand	Root as noted above continues to 1.48 and stones (to 15 mm) were present at around 1.55	none	level	-	-	-
1.770	2.000	38.260	38.030	A0	Moist, light to light to mid brown/orange-brown, crumbly to unconsolidated, sand - orange colouration from ?iron pan/oxide	Stone (to 55 mm) present at 1.97-2.00	none	n/a	-	-	-
2.000	2.480	38.030	37.550	A0	As 1.77-2.00 but collapsed and loose in core tube	None	none	n/a	-	-	-
2.480	2.640	37.550	37.390	A0	Small amount of matrix of moist, light to mid slightly blue grey, sticky (working more or less plastic), slighly sandy clay - more sandy at 2.58-2.64 and this area more mid grey-brown in colour	Most of core section composed of abundant large stones (to 65 mm)	none	declined at 30 degrees	-	-	-
2.640	3.000	37.390	37.030	A0	Just moist, mid brown, very stiff (working plastic), clay	None	none	-	-	-	-

xxiv) Borehole X

Depth		AOD								
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.340	37.615	37.275	E0	Collapsed and loose in core tube - a little matrix of dry, light to mid grey, unconsolidated, clay	Mostly loose angular 'hard core' stones (to 45 mm)	none	level	-	-	-
0.340	0.600	37.275	37.015	E3	Just moist, mid to dark brown to dark brown, unconsolidated, silty sand (topsoil)	Brick/tile (to 20 mm), mortar (to 15 mm), modern rootlets and stones (to 35 mm) present throughout	none	level	-	-	-
0.600	1.120	37.015	36.495	A2	Moist, mid brown, very stiff (working plastic), clay, with sandy intrusion at 0.83-0.90	Stones at 0.83-0.90, and rootlets at 0.80-0.85 and 0.94	none	level	-	-	-
1.120	1.420	36.495	36.195	A0	Just moist, light brown to mid grey-brown to mid to dark grey, unconsolidated, sand	Stones (to 15 mm) present throughout	none	level	-	-	-
1.420	2.000	36.195	35.615	A0	Moist, mid brown, very stiff (working plastic), clay	Occasional stones (to 10 mm) present - particularly at 1.75-1.85, also a large angular rock (to 80 mm) inclined at ~45 degrees to horizontal at 1.53-1.59	none	level	-	-	-
2.000	2.210	35.615	35.405	D0	Void	-	-	-	-	-	-
2.210	2.840	35.405	34.775	A0	Clay as at 1.42-2.00 (above)	Occasional fairly large stones present, e.g. rounded pebble (to 65 mm) at 2.48-2.55	none	n/a	-	-	-
2.840	2.880	34.775	34.735	D0	Void	Single large angular stone (to 85 mm) penetrates into underlying clay to 2.92 - vertically aligned relative to greatest dimension	-	n/a	-	-	-
2.880	3.000	34.735	34.615	A0	Clay as at 2.21-2.84 (above)	none	none	-	-	-	-

xxv) Borehole Y

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.500	39.900	39.400	E0	Collapsed and loose in core tube - conglomerate 'hard core' in lumps to 80 mm; 'cemented' stones and loose light brown dry sand	none	none	n/a	-	-	-
0.500	0.830	39.400	39.070	E0	Collapsed and loose in core tube - as 0.00-0.50 above but also with large stones (to 80 mm), sand component moist and mid brown in colour	Collapsed and loose in core tube - as 0.00-0.50 above but also with large stones (to 80 mm), sand component moist and mid brown	none	n/a	-	-	-
0.830	1.000	39.070	38.900	A0	Collapsed and loose in core tube - a little matrix of moist, mid to dark brown, unconsolidated sand	Brick and stone rubble (both to 60 mm), with ?black ash/fine cinder common at 0.83-0.92	none	n/a	-	-	-
1.000	1.800	38.900	38.100	D0	Void	-	-	n/a	-	-	-
1.800	2.000	38.100	37.900	A0	No matrix	Dry shattered brick (to 90 mm)	none	n/a	-	-	-
2.000	2.060	37.900	37.840	A0	No matrix	'Plug' of dry brick (to 100 mm)	none	level	-	-	-
2.060	2.120	37.840	37.780	A0	'Plug' of moist mid to dark grey-brown to dark grey, compressed (working crumbly), silty sand	Crushed brick (to 50 mm) and black ash/cinder abundant at upper surface (2.06)	none	level	-	-	-
2.120	2.750	37.780	37.150	A0	Moist, light brown to light to mid grey-brown (rather orange from 2.12-2.30 probably from surface contamination from brick above), unconsolidated, sand	none	none	n/a	-	-	-
2.750	3.000	37.150	36.900	A0	Collapsed and loose in core tube - a little matrix of sand as at 2.12-2.75 continues	Abundant rounded pebbles (to 50 mm) form approximately 90% of the volume of this section	none	n/a	-	-	-
3.000	3.740	36.900	36.160	A0	Sand as at 2.12-2.75, with a slightly reddish area (?iron pan/oxide) at 3.38-3.44	Occasional rounded pebbles (to 40 mm) present throughout, small 'lens' of pebbles (to 25 mm) at 3.44-3.50, rounded pebbles (to 25 mm) common at interface with layer below (3.71-3.74)	none	n/a	-	-	-

3.740	4.000	36.160	35.900	A0	Just moist, mid brown, very stiff (working plastic), clay	none	none	-	-	-	-

xxvi) Borehole Z

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.250	38.460	38.210	E3	Collapsed and loose in core tube - a little sand may constitute matrix?	Fill consists largely of rounded pebbles (to 40 mm), with occasional fragments of brick/tile (to 15 mm) and a little sand - ?ornamental pebble surface? More or less dry grass at 0.25	none	level	-	-	-
0.250	0.700	38.210	37.760	A0	Just moist, light brown to mid grey (in shades of brown, grey and grey-brown), unconsolidated, sand	Brick/tile fragments (to 8 mm) at 0.43-0.45	none	level	-	-	-
0.700	1.000	37.760	37.460	A0	Just moist, light grey-brown, unconsolidated, sand	Abundant rounded pebbles (to 45 mm) throughout	none	n/a	-	-	-
1.000	1.680	37.460	36.780	D0	Void	-	-	level	-	-	-
1.680	2.040	36.780	36.420	A0	Sand as at 0.70-1.00, with some mid orange areas of ?iron pan/oxide	Abundant rounded pebbles (to 45 mm) throughout	none	level	-	-	-
2.040	2.980	36.420	35.480	A0	Moist, mid brown, very stiff (working plastic), clay	None	none	level	-	-	-
2.980	3.000	35.480	35.460	A0	Sand as at 0.70-1.00, but compacted	Rounded pebbles (to 20 mm) common	none	-	-	-	-

xxvii) Borehole AA

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.350	39.970	39.620	E0	Collapsed and loose in core tube - just moist, mid brown to mid to dark grey-brown, unconsolidated, silty sand	Abundant brick/tile (to 55 mm) throughout	none	level	-	-	-
0.350	0.640	39.620	39.330	A0	Moist, mid to dark grey to grey-brown, firm/stiff (working soft), slightly sandy clay silt	Crushed brick/tile fragments (to 20 mm) present at 0.35-0.54	none	level	-	-	-
0.640	1.000	39.330	38.970	A0	Moist, light brown (discoloured to mid to dark grey-brown from layer above at 0.64-0.74), unconsolidated, sand	none	none	level	-	-	-
1.000	2.600	38.970	37.370	A0	Moist, light to mid grey, unconsolidated, fine sand	none	none	level	-	-	-
2.600	3.000	37.370	36.970	A0	Just moist, mid brown to grey-brown, very stiff (working plastic), clay	none	none	-	-	-	-

xxviii) Borehole AB

Depth		AOD								
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.430	39.730	39.300	E0	Collapsed and loose in core tube - a little matrix of dry, light grey, unconsolidated, sand	Mostly modern 'hard core' of brick/tile fragments (to 70 mm) and stones (to 18 mm), with an upper surface 'plug' of tarmac at 0.00.0.05; brick becoming abundant at 0.33-0.43	none	level	-	-	-
0.430	0.480	39.300	39.250	A0	'Plug' of just moist, very dark grey, compacted, very ashy silt	Abundant ash content	none	level	-	-	-
0.480	0.610	39.250	39.120	A0	Collapsed and loose in core tube - matrix of dry, ashy silt as at 0.43-0.48 form approximately half of the volume of this section	Approximately half of the volume of this section composed of lumps of conglomerate 'hard core' (to 100 mm). Significant ash content	none	n/a	-	-	-
0.610	1.000	39.120	38.730	A0	Collapsed and loose in tube - more or less dry ashy silt as at 0.43-0.48 but not compacted	Traces of brick/tile (to 4 mm), coal (to 20 mm) and ?charcoal (to 6 mm) present throughout. Significant ash content	none	n/a	-	-	-
1.000	1.100	38.730	38.630	D0	Void	-	-	-	-	-	-
1.100	1.730	38.630	38.000	B0	Moist (becoming wet from 1.40 down), dark grey-brown, firm/stiff and compacted (collapses when removed from core tube), silty fine sand (to fine sandy silt)	Occasional black flecks/patches (to 10 mm) of ?black ash/cinder	none	level	-	-	-
1.730	2.000	38.000	37.730	B1	Moist, mid to dark grey to grey-brown, somewhat stiff to crumbly (working soft), ?humic, slightly sandy slightly clay silt	None	slight	level	Sample 43 = ~half of core from 1.80-1.85	-	-
2.000	2.060	37.730	37.670	D0	Void	-	-	level	-	-	-
2.060	2.370	37.670	37.360	B0	Moist, fine sandy silt/silty fine sand as at 1.10-1.73; compacted from 2.06 to 2.30 (but collapses when removed from tube) and collapsed in core tube at 2.30-2.37	Occasional rounded pebbles (to 50 mm) present throughout	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
2.370	2.790	37.360	36.940	C0	Moist to wet, light to mid yellow-brown, unconsolidated, coarse sand	Rounded pebbles (to 20 mm) common at 2.70-2.79	none	level	-	-	-
2.790	3.000	36.940	36.730	C0	Moist, mid brown, compacted to firm/stiff (working soft), clay sand - collapses when removed from tube	Rounded pebbles (to 60 mm) common throughout	none	-	-	-	-

xxix) Borehole AC

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
0.000	0.460	36.420	35.960	E0	Collapsed and loose in core tube - a little matrix of more or less dry, light grey-brown, sand (becomes very dark grey at 0.28-0.36 from abundant fine ash/cinder)	Most of core volume composed of angular 'hard core' stone (to 65 mm), with occasional fragments of brick/tile (to 45 mm). Abundant fine ash/cinder	none	level	-	-	-
0.460	0.590	35.960	35.830	E0	More or less dry, mid brown to dark grey-brown, compacted and firm (working soft), clay sand - some areas with much more clay content and working more or less plastic	Occasional stones (to 15 mm) and brick/tile (to 50 mm) fragments present	none	level	-	-	-
0.590	0.730	35.830	35.690	E0	No matrix	Large brick rubble inclusion (to 120 mm)	none	level	-	-	-
0.730	0.770	35.690	35.650	E0	Collapsed and loose in core tube - clay sand as at 0.46-0.59 (above)	none	none	level	-	-	-
0.770	1.000	35.650	35.420	E0	Collapsed and loose in core tube - clay sand as at 0.46-0.59 (above)	Brick/tile fragments (to 40 mm) at 0.77-0.80 and modern glass fragment (to 40 mm) at 0.99-1.00	none	level	-	-	-
1.000	1.510	35.420	34.910	E0	Collapsed and loose in core tube - moist, very dark grey, firm to unconsolidated, very ?ashy, slightly sandy silt	Occasional modern pot sherds (to 18 mm) and patches of ?rotted mortar	none	level	-	-	-
1.510	1.580	34.910	34.840	A0	No matrix	Large brick/tile inclusion (to 100 mm)	none	level	-	-	-
1.580	2.000	34.840	34.420	A1	Matrix as at 1.00-1.51	Occasional fragments of brick/tile (to 10 mm) and traces of ?fine root throughout	very slight	level	Sample 41 = ~half of core from 1.80-1.85	-	-
2.000	2.270	34.420	34.150	A0	Matrix continues as at 1.58-2.00 becoming slightly clay and working soft from 2.15 to 2.27	none	none	level	-	-	-

Depth		AOD									
From	**To**	**From**	**To**	**PC**	**Sediment description**	**Inclusions**	**Sulphide odour**	**Interface**	**Chemical sample**	**Spot sample**	**C14**
2.270	2.520	34.150	33.900	B0	Moist to wet, dark grey to grey-brown, firm (working soft and somewhat plastic), clay silt	?Rotted mortar (to 12 mm) at 2.38-2.44	none	level	-	-	-
2.520	2.620	33.900	33.800	B0	Moist to wet, mid grey, crumbly (working soft and sticky), clay silt	Stones (to 20 mm) present throughout	none	level	-	-	-
2.620	2.730	33.800	33.690	B0	Moist, light to mid grey to mid grey, firm and slightly sticky (working soft and somewhat plastic), silty clay, with a slight surface 'dusting' of sand	none	none	level	-	-	-
2.730	2.870	33.690	33.550	B0	Moist to wet, light grey to mid grey-brown, unconsolidated, coarse sand, with occasional patches somewhat clayey	none	none	level	-	-	-
2.870	3.000	33.550	33.420	B1	Moist, light to mid grey to mid grey-brown, stiff and slightly sticky (working plastic), very slightly sandy clay, with some black patches from ?sulphide staining left by rotted organics	none	slight	level	-	-	-
3.000	3.230	33.420	33.190	B0	Moist, mid to dark brown, crumbly to unconsolidated, very slightly clay sand	none	none	level	-	-	-
3.230	3.300	33.190	33.120	B0	Moist, light to mid grey, soft (working more or less plastic), slightly silty clay	none	none	level	-	-	-
3.300	3.440	33.120	32.980	B2	Sand as at 3.00-3.23	Large wood fragment (to 60 mm) inclined at approximately 45 degrees to horizontal	none	level	Sample 42 = ~half of core from 3.30-3.40	Wood taken as Spot Sample 18: oak	-
3.440	3.860	32.980	32.560	B2	Moist, mid to dark brown to grey-brown, compacted and firm (working soft), clay sand	Inclusions of large stones (to 60 mm) at 3.55-3.59 and 3.63-3.68, and occasional fragments of organic detritus (?rotted root) throughout	none	level	-	-	?Twig fragment at 3.54 for possible AMS dating
3.860	4.000	32.560	32.420	D0	Void	-	-	-	-	-	-

Table 2. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Scales employed for the recording of the general composition of the washover fractions from the processed subsamples and the plant and invertebrate (other than unidentified mollusc shell) macrofossil remains recovered.

1) Description of composition of the washover fractions: proportion of organic component

1 – 0%
2 – <25%
3 – <50%
4 – <75%
5 – >75%

2) Abundance: number of recorded items (identifiable waterlogged plant or invertebrate remains – seeds or fruits/minimum number of individuals represented)

1 – sample contained no identifiable items
2 – sample contained 1-20 items
3 – sample contained 21-100 items
4 – sample contained 101-500 items
5 – sample contained more than 500 items

3) Diversity: range of recorded items (minimum numbers of identifiable waterlogged plant or invertebrate taxa present)

1 – sample contained no non-carbonised, determinable botanical macro-remains, or only largely sub-recent intrusive/contaminant remains, carbonised macro-remains may be present
2 – sample contained non-carbonised remains of 1-5 taxa, typically largely corrosion-resistant species (e.g. goosefoot, chickweed, stinking nettle, knotweed)
3 – sample contained non-carbonised macro-remains of 6-10 taxa
4 – sample contained non-carbonised macro-remains of 11-40 taxa
5 – sample contained non-carbonised macro-remains of more than 40 taxa

4) Preservation: condition of recorded items (waterlogged plant or invertebrate remains)

1 – no taxon/species determination was possible to the level that should theoretically be possible for the taxon concerned, the material was too severely fragmented and/or corroded
2 – some species determination was possible, though the remains were highly fragmented and/or the seed coat was highly corroded
3 – most remains could be determined to the maximum taxonomic level feasible, though there was some damage or corrosion to the seed coat (other than splitting, which can be caused by germination prior to deposition)
4 – remains complete and undamaged, though no fine elements such as hairs or fragile husk remains were present
5 – remains complete and undamaged, and fine, fragile elements such as hairs and some husk remains were present. NB: A large number of species do not include these elements, and the husk of most types of grain is in fact more resistant than the seed coat, so this cannot be used for classification in category 5

The categories for Diversity and Preservation follow Smit *et al*. (2006) with minor modifications.

Table 3. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Scales employed for the recording of the general composition of the 'squash' subsamples and the microfossils present.

1) Description of composition of the 'squash': proportion of organic component

1 – 0%
2 – <25%
3 – <50%
4 – <75%
5 – >75%

2) Abundance: number of recorded items (identifiable microfossil remains)

1 – sample contained no identifiable items
2 – sample contained 1-20 items
3 – sample contained 21-100 items
4 – sample contained 101-500 items
5 – sample contained more than 500 items

3) Diversity: range of recorded items (minimum numbers of microfossil taxa present)

1 – sample contained no non-carbonised, determinable microfossil remains, or only largely sub-recent intrusive/contaminant remains, carbonised remains may be present
2 – sample contained non-carbonised remains of 1-5 taxa
3 – sample contained non-carbonised macro-remains of 6-10 taxa
4 – sample contained non-carbonised macro-remains of 11-40 taxa
5 – sample contained non-carbonised macro-remains of more than 40 taxa

4) Preservation: condition of recorded items (microfossils)

1 – no taxon/species determination was possible to the level that should theoretically be possible for the taxon concerned, the material was too severely fragmented and/or corroded
2 – some species determination was possible, though the remains were highly fragmented and/or corroded
3 – most remains could be determined to the maximum taxonomic level feasible, though there was some damage or corrosion

4 – remains more or less complete and undamaged, there may be some very slight chemical erosion (e.g. parasite eggs may be intact but rather pale)
5 – remains complete and undamaged

Table 4. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Records for plant remains from the washovers from subsamples from Boreholes B-E, G, M, O, Q-T, Y and AC, and also for the small bulk sample from excavations by Earthworks Archaeology (designated AD). Key: 'S' = subsample; 'Dep (cm)' = depth in borehole in centimetres; 'wt (kg)' = weight of processed subsample in kilos; 'w/o' = volume or weight of washover in ml or g; 'res' = weight of residue in kilos; 'C14' = possible material for radiocarbon dating; 'Desc' = description; 'Ab' = abundance; 'Div' = diversity; 'Pres' = preservation; 'char' = charcoal; 'eec' = earthworm egg capsules; 'fly' = fly puparia; 'sh' = shell; 'bo' = bone; '?fi' = possible fish bone; 'co' = coal; 'b/t' = brick/tile; 'm/p' = mortar/plaster; 'g' = glass; 's/s' = sand and stones; 's/c' = slag/cinder; 'pot/fc' = pottery/fired clay; 'me' = metal; 'lth' = leather; 'x' = present.

							Botanical macro-remains			**Other botanical remains**					**Animal remains**					**Artefactual and inorganic**							
S	**Dep (cm)**	**wt (kg)**	**w/o (ml/g)**	**res (kg)**	**C14**	**Desc**	**Ab**	**Div**	**Pres**	**char**	**mod. root**	**moss**	**wood**	**twig**	**eec**	**fly**	**sh**	**bo**	**?fi**	**co**	**b/t**	**m/p**	**g**	**s/s**	**s/c**	**pot/ fc**	**me**	**lth**
B1	300 to 400	7.200	150	none	none	2	1	1	1	x	x	-	-	-	-	-	-	x	-	-	-	-	-	x	-	x	-	-
B2	244 to 264	1.000	75	0.240	seeds & fruits	3	2	2	2	x	x	-	x	-	x	-	-	x	-	x	x	-	-	x	x	-	x	x
B3	264 to 300	2.100	350	0.430	seeds & fruits	3	2	2	2	x	x	-	x	x	-	-	-	x	-	x	-	-	-	x	x	-	-	-
C1	300 to 400	6.200	30	0.074	none	5	1	1	1	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C2	209 to 219	0.400	40	none	seeds & fruits	4	2	2	2	x	x	x	x	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-
C3	190 to 195	0.380	40	none	seeds & fruits	5	4	2	2	x	x	-	x	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-
D1	237 to 300	1.400	10	0.015	seeds & fruits	3	2	2	3	x	x	-	x	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-
D2	200 to 209	0.775	100	0.087	none	2	1	1	1	x	-	-	x	-	x	-	-	x	x	-	-	-	-	x	-	-	-	-
E1	241 to 300	5.000	66	0.286	cereal grain	2	2	2	3	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	x	-	-
E2	212 to	0.750	12	0.061	none	2	1	1	1	-	x	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-

							Botanical macro-remains			Other botanical remains					Animal remains					Artefactual and inorganic							
S	**Dep (cm)**	**wt (kg)**	**w/o (ml/g)**	**res (kg)**	**C14**	**Desc**	**Ab**	**Div**	**Pres**	**char**	**mod. root**	**moss**	**wood**	**twig**	**eec**	**fly**	**sh**	**bo**	**?fi**	**co**	**b/t**	**m/p**	**g**	**s/s**	**s/c**	**pot/ fc**	**me**	**lth**
	224																											
G1	235 to 244	0.750	6	0.181	none	2	1	1	1	-	x	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
G2	125 to 148	1.500	69	0.174	seeds & fruits	2	3	2	3	x	-	-	-	-	-	-	-	x	-	-	x	-	-	x	-	x	-	-
G3	56 to 100	2.200	108	0.398	seeds & fruits	2	2	2	3	x	-	-	-	-	x	-	x	x	-	x	x	-	x	x	-	-	-	-
M1	200 to 223	1.250	150	0.464	seeds & fruits	5	3	3	2	x	x	-	x	-	x	-	-	x	-	-	x	-	-	x	-	-	-	-
M2	123 to 160	1.200	123	0.182	none	1	1	1	1	x	-	-	-	-	x	-	-	x	-	x	x	-	-	x	x	-	-	-
Q1	288 to 298	1.000	20	0.149	none	5	1	1	1	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Q2	163 to 183	1.330	28	0.472	none	1	1	1	1	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Q3	100 to 147	3.200	268	0.614	seeds & fruits	2	2	2	2	x	-	-	-	-	-	-	x	x	x	x	x	x	x	x	x	x	-	-
R1	187 to 200	3.000	12	2.150	none	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
R2	174 to 187	0.700	16	0.270	none	1	1	1	1	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
S1	328 to 400	5.100	38	3.1	none	1	1	1	1	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
S2	262 to 328	5.000	41	2.65	hazel nut shell	2	2	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S3	255 to 262	0.580	17	0.201	none	1	1	1	1	x	x	-	-	-	-	-	-	x	-	-	x	-	-	-	-	x	-	-

							Botanical macro-remains			Other botanical remains					Animal remains					Artefactual and inorganic								
S	**Dep (cm)**	**wt (kg)**	**w/o (ml/g)**	**res (kg)**	**C14**	**Desc**	**Ab**	**Div**	**Pres**	**char**	**mod. root**	**moss**	**wood**	**twig**	**eec**	**fly**	**sh**	**bo**	**?fi**	**co**	**b/t**	**m/p**	**g**	**s/s**	**s/c**	**pot/ fc**	**me**	**lth**
S4	128 to 200	5.300	105	1.5	hazel nut shell	1	1	1	1	x	-	-	-	-	-	-	-	x	-	x	x	-	x	x	x	x	-	-
T1	370 to 400	2.650	7	0.039	none	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
T2	180 to 370	8.000	96	4.2	none	1	1	1	1	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
T3	160 to 180	1.300	39	0.488	none	1	1	1	1	x	x	-	-	-	x	-	-	x	-	-	-	-	-	x	-	x	-	-
U1	217 to 300	1.360	75	0.838	seeds & fruits	5	3	4	2	-	-	-	x	-	-	-	-	x	-	-	-	-	-	x	-	-	-	-
U2	177 to 196	1.300	100	0.110	seeds & fruits	5	3	2	2	x	-	-	x	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
V1	200 to 250	3.000	10	1.7	none	3	1	1	2	-	-	-	x	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
V2	179 to 200	1.900	10	0.519	none	5	2	2	2	-	-	-	x	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
V3	170 to 179	0.480	50	0.104	seeds & fruits	5	2	2	2	x	-	-	x	-	-	-	-	x	-	-	-	-	-	x	-	-	-	-
V4	151 to 170	1.100	250	0.396	none	5	1	1	2	x	x	-	x	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-
Y1	374 to 400	5.500	3	0.161	none	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Y2	212 to 275	1.800	11	2.230	none	1	1	1	1	x	-	-	-	-	-	-	-	-	-	x	-	-	-	x	-	-	-	-
AC1	287 to 300	0.800	10	0.071	none	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AC2	158	3.000	350	0.440	none	4	1	1	1	x	x	-	x	-	x	-	-	x	-	x	x	-	x	-	x	x	x	-

							Botanical macro-remains			Other botanical remains					Animal remains					Artefactual and inorganic							
S	**Dep (cm)**	**wt (kg)**	**w/o (ml/g)**	**res (kg)**	**C14**	**Desc**	**Ab**	**Div**	**Pres**	**char**	**mod. root**	**moss**	**wood**	**twig**	**eec**	**fly**	**sh**	**bo**	**?fi**	**co**	**b/t**	**m/p**	**g**	**s/s**	**s/c**	**pot/ fc**	**me**	**lth**
	to 200																											
AD		3.000	750	0.816	seeds & fruits	5	2	2	2	x	x	-	x	x	-	-	-	x	-	-	-	-	-	x	-	-	-	-

Table 5. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Records for plant macrofossil remains from the washovers from subsamples from Borehole F. Key: 'S' = subsample; 'Dep (cm)' = depth in borehole in centimetres; 'wt (kg)' = weight of processed subsample in kilos; 'w/o' = volume or weight of washover in ml or g; 'res' = weight of residue in kilos; 'C14' = possible material for radiocarbon dating; 'Desc' = description; 'Ab' = abundance; 'Div' = diversity; 'Pres' = preservation; 'char' = charcoal; 'straw' = straw-like material; 'arth' = 'arthropod'; 'eec' = earthworm egg capsules; 'fly' = fly puparia; 'bo' = bone; '?fi' = possible fish bone; 'co' = coal; 's/s' = sand and stones; 's/c' = slag/cinder; 'pot/fc' = pottery/fired clay; 'x' = present.

							Botanical macro-remains			**Other botanical remains**							**Animal remains**					**Artefactual and inorganic**			
S	**Dep (cm)**	**wt (kg)**	**w/o (ml/g)**	**res (kg)**	**C14**	**Desc**	**Ab**	**Div**	**Pres**	**char**	**mod. root**	**moss**	**wood**	**twig**	**bark**	**straw**	**arth**	**eec**	**fly**	**bo**	**?fi**	**co**	**s/s**	**s/c**	**pot/fc**
F1	196 to 200	0.150	10	0.037	seeds & fruits	4	3	4	2	x	-	-	x	x	-	-	-	x	-	-	-	-	x	-	-
F2	186 to 196	0.600	20	0.373	seeds & fruits	4	3	4	2	x	x	x	x	x	x	-	x	x	x	-	-	-	-	-	-
F3	150 to 186	2.280	125	0.749	hazel nut shell	5	4	4	3	x	x	-	x	x	-	x	x	x	x	-	-	-	-	-	-
F4	125 to 150	1.700	125	0.373	hazel nut shell	5	3	4	2	x	x	-	x	x	x	-	-	x	x	-	-	-	x	-	-
F5	100 to 125	1.180	250	0.059	hazel nut shell	5	3	4	3	x	x	x	x	x	x	-	x	x	-	-	-	-	x	-	-
F6	76 to 100	1.350	500	0.059	seeds & fruits	5	4	4	3	x	-	-	x	x	-	x	-	x	-	x	-	-	x	-	-
F7	67 to 76	0.450	15	0.083	cereal grain	2	1	1	1	x	-	-	-	-	-	-	-	x	-	x	x	x	-	x	x

Table 6. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Records for plant macrofossil remains from the washovers from subsamples from Borehole N. Key: 'S' = subsample; 'Dep (cm)' = depth in borehole in centimetres; 'wt (kg)' = weight of processed subsample in kilos; 'w/o' = volume or weight of washover in ml or g; 'res' = weight of residue in kilos; 'C14' = possible material for radiocarbon dating; 'Desc' = description; 'Ab' = abundance; 'Div' = diversity; 'Pres' = preservation; 'char' = charcoal; 'straw' = straw-like material; 'eec' = earthworm egg capsules; 'fly' = fly puparia; 'bo' = bone; '?fi' = possible fish bone; 's/s' = sand and stone; 'wo/res' = fractions not separated; 'x' = present.

							Botanical macro-remains			**Other botanical remains**							**Animal remains**				**Inorganic**
S	**Dep (cm)**	**wt (kg)**	**w/o (ml/g)**	**res (kg)**	**C14**	**Desc**	**Ab**	**Div**	**Pres**	**char**	**mod. root**	**moss**	**wood**	**twig**	**bark**	**straw**	**eec**	**fly**	**bo**	**?fi**	**s/s**
N1	398 to 400	0.153	10	wo/res	none	4	1	1	1	-	x	-	-	-	-	-	-	-	-	-	x
N2	380 to 398	1.450	20	0.065	none	4	1	1	1	-	x	-	-	-	-	-	-	-	-	-	x
N3	350 to 380	1.700	<10	0.061	none	3	1	1	1	-	x	-	-	-	-	-	-	-	-	-	x
N4	325 to 350	1.950	none	0.057	none	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
N5	300 to 325	1.800	none	0.067	none	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
N6	272 to 285	1.500	50	0.525	hazel nut shell	4	2	3	3	x	x	x	x	-	x	-	-	-	-	-	x
N7	261 to 272	0.500	150	0.045	fruits & twigs	3	2	2	4	-	x	x	x	x	x	-	-	-	-	-	x
N8	246 to 261	1.000	350	0.050	hazel nut shell & seeds fruits	5	3	4	4	x	x	x	x	x	x	x	-	-	-	-	x
N9	200	1.300	500	wo/res	hazel nut	4	3	4	4	x	x	x	x	x	x	-	x	x	-	-	x

							Botanical macro-remains			Other botanical remains							Animal remains				Inorganic
S	**Dep (cm)**	**wt (kg)**	**w/o (ml/g)**	**res (kg)**	**C14**	**Desc**	**Ab**	**Div**	**Pres**	**char**	**mod. root**	**moss**	**wood**	**twig**	**bark**	**straw**	**eec**	**fly**	**bo**	**?fi**	**s/s**
	to 241				shell																
N10	191 to 200	0.400	350	wo/res	hazel nut shell & fruits	5	2	4	4	x	x	x	x	x	x	x	-	x	-	-	-
N11	188 to 191	0.200	60	wo/res	fruits & seeds	4	2	3	3	x	x	x	x	x	x	-	-	-	-	-	x
N12	180 to 188	0.025	60	0.016	fruits & seeds	4	2	3	3	x	x	x	x	x	x	-	-	-	-	-	x
N13	175 to 180	0.475	250	wo/res	hazel nut shell & fruits	3	2	2	4	x	-	-	x	x	x	-	-	-	-	-	x
N14	160 to 175	0.400	50	0.063	fruit stones	4	3	4	3	x	x	x	x	x	x	-	x	-	-	-	x
N15	158 to 160	0.132	60	0.011	seeds & fruits	3	2	2	3	x	x	x	x	x	x	-	-	-	-	-	-
N16	132 to 158	0.640	150	0.054	hazel nut shell & fruits	3	2	3	3	x	x	-	x	-	-	-	x	-	-	-	x
N17	122 to 129	0.285	275	wo/res	seeds & fruits	5	3	4	4	x	x	-	x	-	-	x	x	x	-	-	-
N18	107 to 122	0.730	250	wo/res	seeds & fruits	3	2	3	3	x	-	-	x	-	-	-	x	-	x	-	x
N19	63 to 100	1.330	150	0. 160	fruit stones & charred	4	2	2	3	x	-	-	x	-	x	-	x	-	-	x	x

							Botanical macro-remains			Other botanical remains							Animal remains				Inorganic
S	**Dep (cm)**	**wt (kg)**	**w/o (ml/g)**	**res (kg)**	**C14**	**Desc**	**Ab**	**Div**	**Pres**	**char**	**mod. root**	**moss**	**wood**	**twig**	**bark**	**straw**	**eec**	**fly**	**bo**	**?fi**	**s/s**
					grain																

Table 7. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Records for plant macrofossil remains from the washovers from subsamples from Borehole P. 'S' = subsample; 'Dep (cm)' = depth in borehole in centimetres; 'wt (kg)' = weight of processed subsample in kilos; 'w/o' = volume or weight of washover in ml or g; 'res' = weight of residue in kilos; 'C14' = possible material for radiocarbon dating; 'Desc' = description; 'Ab' = abundance; 'Div' = diversity; 'Pres' = preservation; 'char' = charcoal; ''straw' = straw-like material; 'arth' = 'arthropod'; 'eec' = earthworm egg capsules; 'fly' = fly puparia; 'Dap' = Daphnia *ephippia; 'bo' = bone; '?fi' = possible fish bone; 'co' = coal; 'lth' = leather; 's/s' = sand and stones; 'wo/res' = fractions not separated; 'x' = present.*

							Botanical macro-remains			**Other botanical remains**							**Animal remains**					**Artefactual and inorganic**		
S	**Dep (cm)**	**wt (kg)**	**w/o (ml/g)**	**res (kg)**	**C14**	**Desc**	**Ab**	**Div**	**Pres**	**char**	**mod. root**	**moss**	**wood**	**twig**	**bark**	**straw**	**eec**	**fly**	**Dap**	**bo**	**?fi**	**co**	**lth**	**s/s**
P1	350 to 400	2.200	32	1.425	none	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
P2	300 to 350	3.100	2	1.225	none	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	x	-	x
P3	267 to 300	2.000	2	0.675	none	1	1	1	1	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x
P4	234 to 267	2.000	150	0.650	seeds & fruits	3	3	3	3	x	-	-	x	-	-	-	x	-	x	x	-	-	-	-
P5	200 to 234	1.470	2	0.425	seeds & fruits	2	2	2	3	x	-	-	-	-	-	-	-	-	-	-	-	x	-	-
P6	191 to 200	1.300	75	none	hazel nut shell	3	3	4	3	x	-	x	x	-	-	-	x	x	-	x	x	-	-	-
P7	173 to 191	0.840	250	wo/res	hazel nut shell	3	3	4	3	x	-	x	x	x	-	x	x	x	-	x	-	-	-	-
P8	163 to 173	0.420	250	wo/res	hazel nut shell	5	2	2	3	x	-	-	x	x	x	x	-	x	-	-	-	-	-	x

							Botanical macro-remains			Other botanical remains							Animal remains					Artefactual and inorganic		
S	**Dep (cm)**	**wt (kg)**	**w/o (ml/g)**	**res (kg)**	**C14**	**Desc**	**Ab**	**Div**	**Pres**	**char**	**mod. root**	**moss**	**wood**	**twig**	**bark**	**straw**	**eec**	**fly**	**Dap**	**bo**	**?fi**	**co**	**lth**	**s/s**
P9	150 to 163	0.355	250	wo/res	hazel nut shell	5	2	2	4	x	x	-	x	x	x	-	x	x	-	x	-	-	x	-
P10	131 to 150	0.750	250	0.052	charred grain	2	2	2	4	x	x	-	x	-	-	-	x	-	-	x	x	-	-	x
P11	113 to 131	0.680	110	wo/res	charred grain	2	2	2	4	x	-	-	-	-	-	-	-	-	-	x	x	-	-	x
P12	100 to 113	0.240	42	wo/res	charred grain	1	1	1	1	x	-	-	-	-	-	-	-	-	-	x	x	x	-	-

Table 8. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: List of identified plant remains from subsamples from Borehole F, with notes on the presence of other components. Key: 'c' = charred; 'w' = waterlogged.

Sample				**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
Crop plants										
Avena	oat	caryopsis	c						x	
Hordeum distichon L./*H. vulgare* L.	barley	caryopsis	c		x					x
Gathered plants										
Corylus avellana L.	hazel	nut shell	w			x	x	x	x	
Corylus avellana L.	hazel	nut shell	c						x	
Malus/Pyrus	apple/pear	seed	w				x			
Prunus avium (L.) L./*P. cerasus* L./ *P. spinosa* L.	wild/dwarf cherry/sloe	fruit stone	w			x	x			
Rubus fruticosus L. agg./ *R. idaeus* L.	blackberry/ raspberry	fruit stone	w	x		x	x		x	
Sambucus nigra L.	elder	seed	w	x		x	x	x		
Disturbed/cultivated ground										
Agrostemma githago L.	corncockle	seed	w	x	x	x		x	x	
Anagallis arvensis L.	pimpernel	seed	w		x					
Anthemis cotula L.	stinking chamomile	achene	w		x	x			x	
Atriplex/Chenopodium	orache/goosefoot	seed	w	x	x	x	x	x	x	
Brassica/Sinapis	cabbage/mustard	seed	w			x			x	
Centaurea cyanus L.	cornflower	achene	w					x	x	
Chrysanthemum segetum L.	corn marigold	achene	w	x	x	x		x	x	
Conium maculatum L.	hemlock	mericarp	w	x	x	x	x	x		
Galeopsis speciosa Mill./*G. tetrahit* L.	large-flowered/common hemp-nettle	nutlet	w		x	x		x	x	
Lamium album L./*L. purpureum* L	white/red dead-nettle	nutlet	w			x	x			
Lapsana communis L.	nipplewort	achene	w			x			x	
Polygonum aviculare L.	knotgrass	achene	w	x		x	x	x	x	
Raphanus raphanistrum L.	wild radish	mericarp	w			x	x			
Rumex obtusifolius L.	broad-leaved dock	achene with perianth	w	x		x		x		
Solanum nigrum L.	black nightshade	seed	w						x	
Sonchus asper (L.) Hill	prickly sow-thistle	achene	w	x		x	x			

Sample				**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
Stellaria media (L.) Vill.	chickweed	seeds	w	x	x	x		x		
Urtica dioica L.	common nettle	achene	w	x	x	x	x	x		
Urtica urens L.	small nettle	achene	w	x	x	x		x	x	
Ranunculus arvensis L./ *R. sarduos* Crantz	corn/hairy buttercup	achene	w			x	x		x	
Vicia hirsuta (L.) Gray/*V. tetrasperma* (L.) Schreb.	tare	seed	c				x			
Viola	violet	seed	w	x		x			x	
Grassland										
Carduus/Cirsium	thistle	achene	w			x		x		
Poa pratensis L./*P. trivialis* L.	smooth/rough meadow-grass	caryopsis	w				x			
Potentilla erecta (L.) Raeusch.	tormentil	achene	w			x				
Prunella vulgaris L.	selfheal	nutlet	w			x			x	
Ranunculus acris L./*R. repens* L.	meadow/creeping buttercup	achene	w	x	x			x	x	
Rumex acetosella L.	sheep's sorrel	achene	w	x	x	x		x	x	
Heath/moor										
Myrica	bog-myrtles	nut	w			x				
Wetland (e.g. bog, fen, marsh)										
Carex	sedge	caryopsis	w			x	x	x	x	
Eleocharis	spike-rush	nut	w		x	x	x		x	
Hydrocotyle vulgaris L.	marsh pennywort	mericarp	w			x				
Lycopus europaeus L.	gypsywort	nutlet	w			x				
Mentha	mint	nutlet	w	x		x				
Polygonum hydropiper (L.) Spach	water-pepper	achene with perianth	w	x		x	x	x		
Ranunculus subg. *Batrachium*	crowfoot	achene	w		x					
Ranunculus flammula L.	lesser spearwort	achene	w	x		x	x	x	x	
Ranunculus sceleratus L.	celery-leaved buttercup	achene	w	x		x		x	x	
Other wild plant taxa										
Apium	marshwort	mericarp	w				x	x		

Sample				**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
Persicaria	knotweed	achene	w	x		x		x	x	
Poaceae	grass family	caryopsis	c		x					
Potentilla	cinquefoil	achene	w						x	
Rumex	dock	achene	w	x	x	x	x	x	x	
Scrophulariaceae	figwort family	seed	w			x				
Other botanical remains										
bark fragments					x					
charcoal				x	x	x	x	x	x	
culm fragments						x		x		
modern rootlets					x	x	x	x		
mosses (Bryophyta)					x			x		
‘straw’						x		x		
twig fragments				x	x	x	x	x	x	
wood fragments				x	x	x	x	x	x	
Animal remains										
arthropod remains (elytra, capsules)					x	x		x		
bone fragments									x	x
earthworm egg capsules				x	x	x	x	x	x	x
?fish bone										x
fly puparia						x	x	x		
Artefactual and inorganic material										
coal										x
pottery/fired clay										x
sand/stones				x			x	x	x	
cinder/slag										x

Table 9. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: List of identified plant remains from subsamples from Borehole N, with notes on the presence of other components. Key: 'c' = charred; 'w' = waterlogged.

Sample				**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**N7**	**N8**	**N9**	**N10**	**N11**	**N12**	**N13**	**N14**	**N15**	**N16**	**N17**	**N18**	**N19**
Crop plants																						
Cerealia	cereals	caryopsis	w								x											
Triticum	wheat	caryopsis	c																			x
Triticum aestivum L.	bread wheat	rachis segment	w								x											
Gathered plants																						
Corylus avellana L.	hazel	nut shell	w						x			x	x			x	x		x			
Corylus avellana L.	hazel	nut shell	c								x									x		x
Prunus spinosa L.	sloe	fruit stone	w														x					
Rubus fruticosus L. agg./*R. idaeus* L.	blackberry/ raspberry	fruit stone	w						x		x			x					x			x
Sambucus nigra L.	elder	seed	w																		x	
Disturbed/cultivated ground																						
Aethusa cynapium L.	fool's parsley	mericarp	w										x		x							
Agrostemma githago L.	corncockle	seed	w								x	x										
Anthemis cotula L.	stinking chamomile	achene	w							x				x	x		x					
Atriplex/*Chenopodium*	orache/goosefoot	seed	w						x		x	x		x	x		x		x	x	x	
Conium maculatum L.	hemlock	mericarp	w													x						
Fallopia convolvulus (L.) Á. Löve	black-bindweed	achene	w								x		x						x	x		
Lapsana communis L.	nipplewort	achene	w								x									x		
Polygonum aviculare L.	knotgrass	achene	w						x											x	x	
Raphanus raphanistrum L.	wild radish	mericarp	w										x		x	x	x					
Sonchus asper (L.) Hill	prickly sow-thistle	achene	w									x			x					x		
Thlaspi arvense L.	field penny-cress	seed	w										x	x								
Urtica dioica L.	common nettle	achene	w																	x		

Sample				**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**N7**	**N8**	**N9**	**N10**	**N11**	**N12**	**N13**	**N14**	**N15**	**N16**	**N17**	**N18**	**N19**
Grassland																						
Filipendula ulmaria (L.) Maxim.	meadowsweet	achene	w								x											
Galeopsis speciosa Mill./*G. tetrahit* L.	large-flowered/common hemp-nettle	nutlet	w						x		x	x	x		x				x	x	x	
Lamium album L./*L. purpureum* L	white/red dead-nettle	nutlet	w															x				
Prunella vulgaris L.	selfheal	nutlet	w														x					
Ranunculus acris L./*R. repens* L.	meadow/creeping buttercup	achene	w									x			x		x	x				
Rumex acetosella L.	sheep's sorrel	achene	w						x						x		x					
Heath/moor																						
Danthonia decumbens (L.) DC.	heath-grass	caryopsis	w								x		x									
Pteridium aquilinum (L.) Kuhn	bracken	leaf fragment	w							x												
Wetland (e.g. bog, fen, marsh)																						
Carex	sedge	caryopsis	w						x			x			x	x	x	x	x	x	x	x
Carex	sedge	caryopsis with utriculus	w								x									x		
Eleocharis	spike-rush	nut	w									x					x		x	x		x
Lycopus europaeus L.	gypsywort	nutlet	w									x	x									
Mentha	mint	nutlet	w								x									x		
Oenanthe	water-dropwort	mericarp	w									x										
Polygonum hydropiper (L.) Spach	water-pepper	achene with perianth	w								x											
Ranunculus flammula L.	lesser spearwort	achene	w								x	x	x		x					x		
Ranunculus sceleratus L.	celery-leaved buttercup	achene	w								x			x			x	x	x	x	x	
Other wild plant taxa																						

Sample				**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**N7**	**N8**	**N9**	**N10**	**N11**	**N12**	**N13**	**N14**	**N15**	**N16**	**N17**	**N18**	**N19**
Apiaceae	carrot family	mericarp	w																x			
Persicaria	knotweed	achene	w							x	x	x	x	x								
Potentilla	cinquefoil	achene	w									x					x				x	
Ranunculus subg. *Ranunculus*	buttercup	achene	w										x						x	x	x	
Rumex	dock	achene	w						x	x	x	x						x				
Other botanical remains																						
bark fragments													x			x						
charcoal									x		x	x	x	x	x	x	x	x	x	x	x	x
culm fragments											x	x	x									
modern rootlets				x	x	x			x	x	x	x	x	x	x		x	x	x	x		
mosses (Bryophyta)									x	x	x	x	x	x	x		x	x				
‘straw’											x		x							x		
twig fragments										x	x	x	x	x	x	x	x	x	x			x
unidentifiable plant fibres																				x		
wood fragments									x	x	x	x	x	x	x	x	x	x	x	x	x	
Animal remains																						
bone fragments																					x	
earthworm egg capsules												x					x		x	x	x	x
fly puparia												x	x							x		
?fish bone																						x
Inorganic material																						
sand				x	x	x			x	x	x	x		x	x	x	x		x		x	x

Table 10. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: List of identified plant remains from subsamples from Borehole P, with notes on the presence of other components. Key: 'c' = charred; 'w' = waterlogged.

Sample				**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**
Crop plants															
Avena	oat	caryopsis	c							x			x	x	x
Gathered plants															
Corylus avellana L.	hazel	nut shell	w						x	x	x	x			
Corylus avellana L.	hazel	nut shell	c											x	
Malus/Pyrus	apple/pear	seed	w							x					
Prunus avium (L.) L./*P. cerasus* L./ *P. spinosa* L.	wild/dwarf cherry/sloe	fruit stone	w							x					
Rubus fruticosus L. agg./*R. idaeus* L.	blackberry/raspberry	fruit stone	w				x	x	x	x			x		
Sambucus nigra L.	elder	seed	w						x	x			x	x	
Disturbed/cultivated ground															
Agrostemma githago L.	corncockle	seed	w							x					
Atriplex/Chenopodium	orache/goosefoot	seed	w				x		x	x				x	
Brassica/Sinapis	cabbage/mustard	seed	w							x					
Chrysanthemum segetum L.	corn marigold	achene	w						x						
Euphorbia helioscopia L.	sun spurge	seed	w											x	
Fallopia convolvulus (L.) Á. Löve	black-bindweed	achene	w							x					
Lapsana communis L.	nipplewort	achene	w						x						
Polygonum aviculare L.	knotgrass	achene	w							x					
Sonchus asper (L.) Hill	prickly sow-thistle	achene	w						x	x					
Stellaria media (L.) Vill.	chickweed	seeds	w						x	x					
Urtica dioica L.	common nettle	achene	w							x					
Urtica urens L.	small nettle	achene	w						x	x	x				
Vicia hirsuta (L.) Gray/*V. tetrasperma* (L.) Schreb.	tare	seed	c											x	
Viola	violet	seed	w						x						

Sample				**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**
Grassland															
Carduus/Cirsium	thistle	achene	w							x					
Galeopsis speciosa Mill./*G. tetrahit* L.	large-flowered/common hemp-nettle	nutlet	w						x						
Lamium album L./*L. purpureum* L	white/red dead-nettle	nutlet	w						x						
Ranunculus acris L./*R. repens* L.	meadow/creeping buttercup	achene	w				x			x					
Rumex acetosella L.	sheep's sorrel	achene	w				x		x						
Heath/moor															
Menyanthes trifoliata L.	bogbean	seed	w							x					
Wetlands (e.g. bog, fen, marsh)															
Carex	sedge	caryopsis	w				x	x	x	x	x	x			
Ranunculus sceleratus L.	celery-leaved buttercup	achene	w				x	x		x					
Zannichellia palustris L.	horned pondweed	achene	w				x								
Other wild plant taxa															
Persicaria	knotweed	achene	w							x	x				
Poaceae	grass family	caryopsis	w						x						
Rumex	dock	achene	w				x		x	x					
Other botanical remains															
bark fragments											x	x			
charcoal						x	x	x	x	x	x	x	x	x	x
culm fragments											x				
modern rootlets											x	x	x		
mosses (Bryophyta)									x	x					
'straw'										x	x				
twig fragments										x	x	x			
wood fragments							x		x	x	x	x	x		
unidentifiable plant fibres									x						

Sample				**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**
Animal remains															
bone fragments							x		x	x		x	x	x	x
Daphnia							x								
earthworm egg capsules							x		x	x		x	x		
?fish bone									x				x	x	x
fly puparia									x	x	x	x			
Artefactual and inorganic material															
coal					x										x
leather fragments												x			
sand				x	x	x	x	x	x	x			x		x
stones				x											

Table 11. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Invertebrate (other than unidentified mollusc shell) macrofossil remains from the washovers (no remains were recorded from subsamples not included in this table). Key: 'wt (kg)' = weight of processed subsample in kilos; 'w/o (ml/g)' = volume or weight of washover in ml or g; 'res (kg)' = weight of residue in kilos; 'Desc' = description; 'Ab' = abundance; 'Div' = diversity; 'Pres' = preservation.

Subsample	Depth (cm)	wt (kg)	w/o (ml/g)	res (kg)	Desc	Ab	Div	Pres	Notes
F2	186 - 196	0.600	20	0.373	4	2	2	2	A few scraps of insect cuticle (probably beetle), one staphylinid elytron, one ant (Formicidae) head (very pale), a few pieces of fly puparia (one species, all fragments very pale)
F3	150 - 186	2.280	125	0.749	5	3	3	2	Numerous pieces of beetle cuticle but almost all small unidentified and eroded fragments, with an occasional better preserved sclerite. At least three beetle species were present – a staphylinid, at least one ground beetle (Carabidae) and two or more individuals of woodworm beetle (*Anobium punctatum* (Degeer)). Also some fly puparia fragments (two species) showing relatively little erosion and very pale and fragmented mites (Acarina). There were a few cladoceran ephippia (probably *Daphnia*)
F4	125 - 150	1.700	125	0.373	5	4	2	2	Numerous unidentified and very eroded fragments of insect cuticle, with an occasional slightly better preserved beetle sclerite (one species) and a few fragments of poorly preserved fly puparia (one species)
F5	100 - 125	1.180	250	0.059	5	4	2	2	Numerous unidentified and very eroded fragments of insect cuticle, with an occasional slightly better preserved beetle sclerite (two species – a ground beetle and *Anobium punctatum*)
F6	76 - 100	1.350	500	0.059	5	3	1	1	Numerous fragments of extremely eroded and fragmented insect cuticle none of which could be identified
N8	246 - 261	1.000	350	0.050	5	3	1	1	Numerous fragments of extremely eroded and fragmented ('filmy') insect cuticle none of which could be identified
N9	200 - 246	1.300	500	wo/res	4	3	2	2	Numerous unidentified and very eroded fragments of ('filmy') insect cuticle, with an occasional slightly better preserved beetle sclerite including elytra representing at least two species and some undiagnostic body parts (e.g. leg sclerites)
P4	234 - 267	2.000	150	0.650	3	3	2	4	Some quite well preserved *Daphnia* ephippia but no other ancient invertebrate remains recorded
U1	217 - 300	1.360	75	0.838	5	3	1	1	Numerous fragments of extremely eroded and fragmented ('filmy') insect

Subsample	Depth (cm)	wt (kg)	w/o (ml/g)	res (kg)	Desc	Ab	Div	Pres	Notes
									cuticle none of which could be identified

Table 12. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Microfossil remains from the investigated deposits. Key: 'Desc' = description; 'Ab' = abundance; 'Div' = diversity; 'Pres' = preservation; 'N' = semi-quantitative numbers; 'f. hy.' = fungal hyphae; 'f' = few (1-5); 's' = some (6-20); 'm' = many (20-100); 'vm' = very many (100s); 'vvm' = very very many (1000s).

						Diatoms		**Fungal spores**		**Pollen**		**'Phytoliths'**					
Sample	**Depth (cm)**	**Desc**	**Ab**	**Div**	**Pres**	**N**	**types**	**N**	**types**	**N**	**types**	**N**	**types**	**Trichuris**	**Ascaris**	**f. hy.**	**plant tissue frags**
B1	~350	3	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
B2	244 - 264	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
B3	264 - 300	3	2	2	2	f	2	f	1	-	-	-	-	-	-	s	-
C1	~350	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
C2	209 - 219	2	2	2	2	s	3	f	1	-	-	-	-	-	-	f	-
C3	190 - 195	4	2	3	3	m	8	-	-	-	-	-	-	-	-	-	s
D1	237 - 300	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
D2	200 - 209	3	3	3	2	-	-	-	-	s	5	f	1	-	-	-	-
E1	~265	2	2	2	1	-	-	f	1	-	-	-	-	-	-	-	-
E2	~218	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
F1	196 - 200	2	2	2	1	-	-	s	1	-	-	s	1	-	-	f	-
F2	186 - 196	2	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
F3	~168	3	3	3	2	f	1	m	3	s	3	s	1	1	-	f	s
F4	125 - 150	3	3	3	3	s	3	m	3	s	3	f	1	-	-	f	s
F5	100 - 125	5	2	2	2	-	-	-	-	f	1	-	-	1	-	f	vm
F6	76 - 100	5	4	3	3	-	-	m	3	m	5	f	1	1	-	-	vm
F7	~72	2	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
G1	235 - 244	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
G2	125 - 148	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
G3	56 - 100	3	2	2	3	s	3	s	2	-	-	-	-	-	-	f	-
M1	~211	3	3	3	3	s	5	f	1	f	1	f	1	-	-	-	-
M2	~142	3	2	2	2	f	2	-	-	-	-	-	-	-	-	-	-
N1	398 - 400	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-

						Diatoms		Fungal spores		Pollen		'Phytoliths'					
Sample	**Depth (cm)**	**Desc**	**Ab**	**Div**	**Pres**	**N**	**types**	**N**	**types**	**N**	**types**	**N**	**types**	**Trichuris**	**Ascaris**	**f. hy.**	**plant tissue frags**
N2	~390	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
N3	~365	2	1	2	2	-	-	-	-	f	1	-	-	-	-	-	-
N4	~338	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
N5	~313	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
N6	272 - 285	3	3	3	2	-	-	-	-	m	3	-	-	-	-	f	-
N7	261 - 272	4	3	2	2	-	-	-	-	m	3	-	-	-	-	-	s
N8	246 - 261	5	4	4	4	vm	4	s	1	vm	8	-	-	1	-	s	vm
N9	200 - 241	4	3	3	2	f	1	f	1	s	3	f	1	-	-	f	m
N10	191 - 200	5	3	3	2	f	1	m	2	m	3	-	-	-	-	s	vm
N11	188 - 191	5	3	3	2	f	1	m	2	s	2	-	-	2	-	-	m
N12	~184	3	2	2	2	-	-	m	2	s	2	-	-	-	-	m	s
N13	175 - 180	2	2	2	1	-	-	s	2	f	1	-	-	-	-	-	s
N14	~168	2	2	1	1	-	-	f	1	-	-	-	-	-	-	f	-
N15	158 - 160	2	2	2	2	-	-	f	1	s	4	-	-	-	-	-	s
N16	~145	2	2	2	2	-	-	s	1	-	-	-	-	-	-	s	s
N17	122 - 129	5	4	4	3	m	6	vvm	3	m	3	s	1	-	-	-	vm
N18	~115	3	3	2	2	-	-	s	2	f	1	-	-	-	-	s	s
N19	~82	2	2	1	1	-	-	f	-	-	-	-	-	-	-	-	-
P1	350 - 400	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
P2	300 - 350	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
P3	267 - 300	1	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
P4	~250	2	3	4	3	s	3	f	1	s	6	s	1	-	-	s	-
P5	~217	2	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
P6	191 - 200	4	4	4	3	vm	7	m	3	m	5	m	2	1	-	f	s
P7	173 - 191	5	5	4	3	vm	4	m	3	vm	7	f	1	2	-	f	f
P8	163 - 173	5	5	4	4	m	4	vvm	3	vm	4	-	-	-	-	s	m
P9	150 - 163	5	4	4	3	vm	9	vm	5	s	2	f	1	6	-	s	vm
P10	131 - 150	4	3	4	3	s	3	vm	5	-	-	m	2	5	1	f	s

						Diatoms		Fungal spores		Pollen		'Phytoliths'					
Sample	**Depth (cm)**	**Desc**	**Ab**	**Div**	**Pres**	**N**	**types**	**N**	**types**	**N**	**types**	**N**	**types**	**Trichuris**	**Ascaris**	**f. hy.**	**plant tissue frags**
P11	113 - 131	5	2	2	2	f	2	-	-	-	-	vm	2	-	-	f	-
P12	100 - 113	2	2	2	2	f	1	s	2	f	1	-	-	1	-	f	-
Q1	~293	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Q2	163 - 183	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Q3	100 - 147	3	2	2	2	s	3	-	-	-	-	-	-	-	-	f	s
R1	187 – 200	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
R2	174 - 187	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
S1	328 – 400	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
S2	262 – 328	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
S3	255 – 262	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
S4	128 - 200	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
T1	~385	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
T2	180 - 370	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
T3	160 - 180	3	2	2	1	-	-	-	-	-	-	f	1	-	-	s	-
U1	217 - 300	2	2	2	2	f	2	-	-	f	1	-	-	-	-	f	m
U2	177 - 196	3	1	1	1	-	-	-	-	-	-	-	-	-	-	s	-
V1	200 - 250	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
V2	~190	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
V3	170 - 179	2	2	2	2	s	2	s	2	-	-	f	1	-	-	f	-
V4	151 - 170	2	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
Y1	~387	1	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
Y2	212 - 275	1	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
AC1	~293	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
AC2	158 – 200	3	1	1	1	-	-	-	-	-	-	-	-	-	-	f	-
AD	bulk	2	1	1	1	-	-	-	-	-	-	-	-	-	-	-	s

Table 13. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Summary abundance and diversity data for the plant assemblages from Boreholes BH F, N and P.

					Identifiable charred plant remains		Identifiable waterlogged plant remains		
Subsample	**Depth (cm)**	**weight (kg)**	**washover**	**residue**	**number of plant taxa**	**abundance (items/sample)**	**number of plant taxa**	**abundance (items/sample)**	**density (items/kg)**
F1	196 - 200	0.150	10 ml	0.037 kg	-	-	21	56	373
F2	186 - 196	0.600	20 ml	0.373 kg	2	2	15	30	50
F3	150 - 186	2.280	125 ml	0.749 kg	-	-	38	200	88
F4	125 - 150	1.700	125 ml	0.373 kg	1	1	20	96	56
F5	100 - 125	1.180	250 ml	0.059 kg	-	-	23	69	58
F6	76 - 100	1.350	500 ml	0.059 kg	2	4	25	240	178
F7	67 - 76	0.450	15 g	0.083 kg	1	1	-	-	-
N1	398 - 400	0.153	10ml	wo/res	-	-	-	-	-
N2	380 - 398	1.450	20 ml	0.065 kg	-	-	-	-	-
N3	350 - 380	1.700	<10 ml	0.061 kg	-	-	-	-	-
N4	325 - 350	1.950	residue only	0.057 kg	-	-	-	-	-
N5	300 - 325	1.800	residue only	0.067 kg	-	-	-	-	-
N6	272 - 285	1.500	50 ml	0.525 kg	-	-	8	11	7
N7	261 - 272	0.500	150 g	0.045 kg	-	-	4	6	12
N8	246 - 261	1.000	350 g	0.050 kg	1	1	17	45	45
N9	200 - 241	1.300	500 ml	wo/res	-	-	14	24	18
N10	191 - 200	0.400	350 ml	wo/res	-	-	11	16	40
N11	188 - 191	0.200	60 ml	wo/res	-	-	6	13	65
N12	180 - 188	0.025	60 ml	0.016 kg	-	-	10	12	480
N13	175 - 180	0.475	250 ml	wo/res	-	-	4	4	8
N14	160 - 175	0.400	50 ml	0.063 kg	-	-	12	21	53
N15	158 - 160	0.132	60 ml	0.011 kg	-	-	5	7	53
N16	132 - 158	0.640	150 g	0.054 kg	-	-	10	19	30
N17	122 - 129	0.285	275 ml	wo/res	1	1	14	35	123
N18	107 - 122	0.730	250 ml	wo/res	-	-	8	16	22
N19	63 - 100	1.330	150 ml	0. 160 kg	2	2	3	18	14
P1	350 - 400	2.200	32 g	1.425 kg	-	-	-	-	-
P2	300 - 350	3.100	29 g	1.225 kg	-	-	-	-	-
P3	267 - 300	2.000	21 g	0.675 kg	-	-	-	-	-

					Identifiable charred plant remains		Identifiable waterlogged plant remains		
Subsample	**Depth (cm)**	**weight (kg)**	**washover**	**residue**	**number of plant taxa**	**abundance (items/sample)**	**number of plant taxa**	**abundance (items/sample)**	**density (items/kg)**
P4	234 - 267	2.000	150 ml	0.650 kg	-	-	8	74	37
P5	200 -234	1.470	26 g	0.425 kg	-	-	3	10	7
P6	191 - 200	1.300	75 ml	none	-	-	16	96	74
P7	173 - 191	0.840	250 ml	wo/res	1	1	21	87	104
P8	163 - 173	0.420	250 ml	wo/res	-	-	4	9	21
P9	150 - 163	0.355	250 ml	wo/res	-	-	2	3	8
P10	131 - 150	0.750	250 ml	0.052 kg	1	2	2	4	5
P11	113 - 131	0.680	110 g	wo/res	3	4	3	4	6
P12	100 - 113	0.240	42 g	wo/res	1	2	-	-	-

Figure 1. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Plant biodiversity in subsamples from Borehole BH F, N and P.

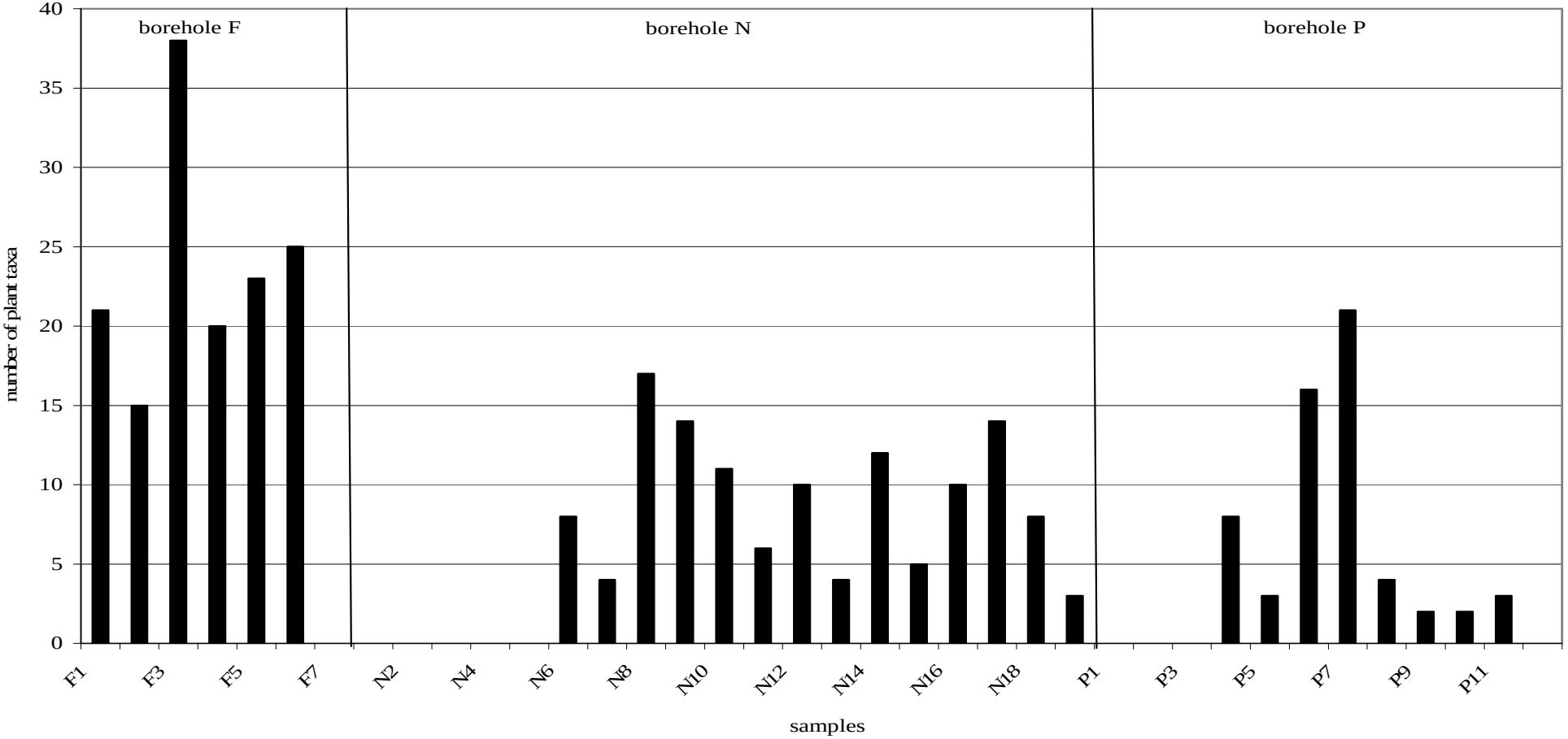

borehole F
borehole N
borehole P
number of plant taxa
0
5
10
15
20
25
30
35
40
F1
F3
F5
F7
N2
N4
N6
N8
N10
N12
N14
N16
N18
P1
P3
P5
P7
P9
P11
samples

Figure 2. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Plant biodiversity and abundance in subsamples from Borehole BH F, N and P.

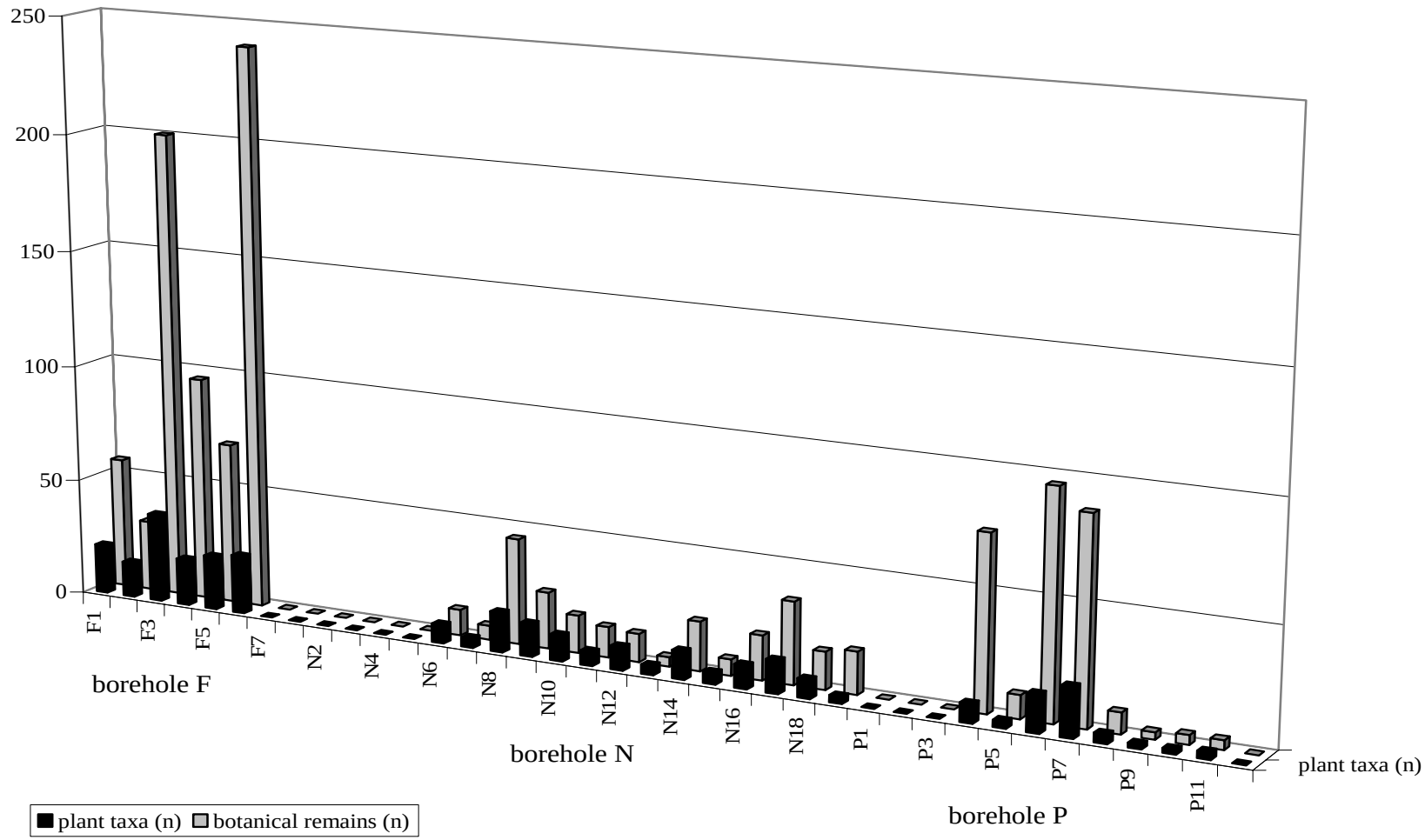
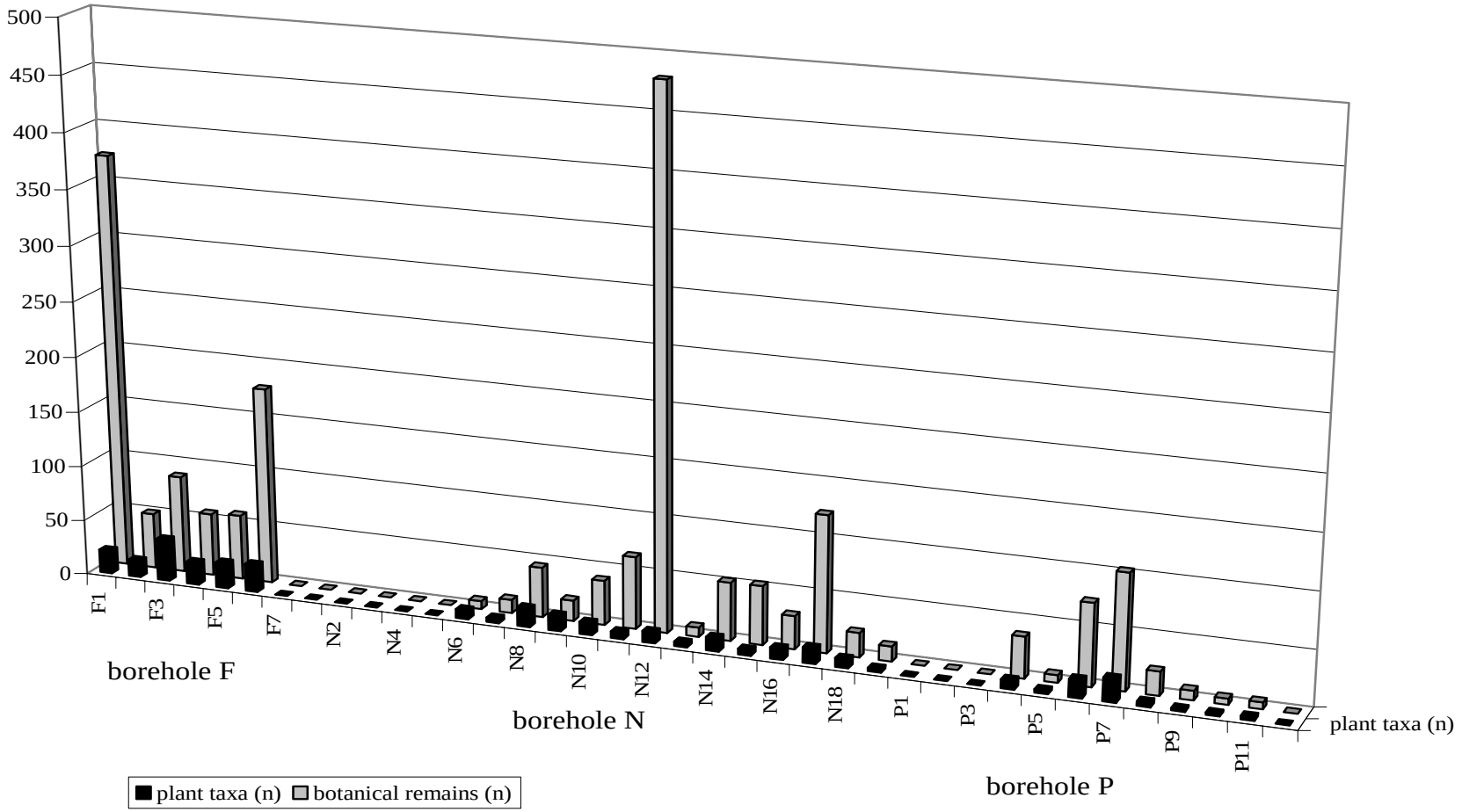

250
200
150
100
50
0
F1
F3
F5
F7
N2
N4
N6
N8
N10
N12
N14
N16
N18
P1
P3
P5
P7
P9
P11
borehole F
borehole N
borehole P
plant taxa (n)
plant taxa (n)
botanical remains (n)

Figure 3. Borehole investigations of the nature and extent of sub-surface deposits, Nantwich, Cheshire: Plant biodiversity and density (items per kilo) in subsamples from Borehole BH F, N and P.


500
450
400
350
300
250
200
150
100
50
0
F1
F3
F5
F7
N2
N4
N6
N8
N10
N12
N14
N16
N18
P1
P3
P5
P7
P9
P11
borehole F
borehole N
borehole P
plant taxa (n)
plant taxa (n)
botanical remains (n)

APPENDIX 4

Tabulated data: geochemical assessment

Appendix 4: geochemical analysis of sediment samples from Nantwich: raw data

Bore hole	Depth (mbgs) From	To	AOD (m)		pH	LOI	TOC	Natural Moisture Content Ratio	Total Sulphur	Total Sulphate	Acid Soluble Sulphide	Carbonate	Carbonate alkalinity as CaCO3	Phosphate	Nitrate
AB	1.80	1.85	36.13	36.08	6.75	8.0	4.0	39	0.13	1200	<50	18	-	2	<1
AC	1.80	1.85	34.62	34.57	7.70	6.4	3.3	26	0.14	2000	<50	9.1	-	4	<1
AC	3.30	3.40	33.12	33.02	7.88	7.8	4.1	47	1.2	1900	180	8.9	-	<1	<1
A	0.95	1.00	32.34	32.29	7.78	1.6	0.3	17	-	270	<50	-	<10	<1	1
A	3.80	3.90	29.49	29.39	5.97	1.7	0.3	24	-	420	270	-	<10	<1	<1
B	1.80	1.85	34.82	34.77	7.60	3.6	2.2	26	-	710	160	-	<10	<1	<1
B	3.90	4.00	32.72	32.62	7.69	3.1	1.1	33	-	750	<50	-	<10	5	<1
B	5.80		30.82		7.63	1.6	0.4	23	-	680	67	-	<10	<1	<1
C	1.72	1.74	33.15	33.13	7.54	4.6	3.1	30	-	560	<50	-	<10	<1	<1
C	2.90	3.00	31.97	31.87	7.45	7.1	2.6	53	-	860	330	-	<10	2	<1
D	1.98	2.00	33.05	33.03	7.82	8.7	5.2	45	-	960	<50	-	<10	10	3
D	2.00	2.09	33.03	32.94	8.00	5.1	3.8	34	-	770	<50	-	<10	9	4
D	2.45	2.50	32.58	32.53	6.72	5.0	1.7	30	-	660	<50	-	<10	<1	<1
D	3.90	4.00	31.13	31.03	7.59	0.6	<0.2	20	-	110	64	-	<10	18	9

Bore hole	Depth (mbgs) From	To	AOD (m)		pH	LOI	TOC	Natural Moisture Content Ratio	Total Sulphur	Total Sulphate	Acid Soluble Sulphide	Carbonate	Carbonate alkalinity as CaCO3	Phosphate	Nitrate
E	2.33	2.38	33.01	32.96	7.38	4.9	3.2	24	-	1100	<50	-	<10	<1	57
E	3.90	3.98	31.44	31.36	7.28	2.2	0.6	25	-	350	<50	-	<10	<1	<1
F	0.76	0.82	38.98	38.92	7.78	36	22	110	-	1700	<50	-	<10	<1	2
F	1.80	1.85	37.94	37.89	7.35	4.1	2.3	38	-	600	73	-	<10	8	<1
G	0.65	0.70	38.95	38.90	7.77	9.7	9.3	45	-	800	<50	-	<10	10	25
G	1.75	1.80	37.85	37.80	7.50	2.4	1.0	19	-	320	<50	-	<10	22	16
I	0.80	0.86	38.16	38.10	7.87	6.9	8.6	18	-	530	<50	-	<10	4	<1
I	1.28	1.32	37.68	37.64	7.57	0.9	0.4	20	-	180	<50	-	<10	2	<1
J	0.90	1.00	39.14	39.04	8.33	8.5	3.7	20	-	750	<50	-	<10	55	7
J	1.20	1.26	38.84	38.78	8.63	1.3	0.8	15	-	230	<50	-	<10	58	2
L	0.85	0.92	37.87	37.79	7.99	5.2	5.8	25	0.15	550	<50	4.6	-	36	15
M	1.60	1.65	36.21	36.16	7.61	6.2	7.5	37	0.10	620	<50	4.6	-	7	<1
M	2.10	2.20	35.71	35.61	7.54	5.0	2.7	29	0.10	420	<50	2.5	-	5	2
N	0.75	0.80	38.42	38.37	7.74	8.8	5.6	48	0.54	2500	<50	25	-	<1	<1
N	1.35	1.40	37.82	37.77	7.63	9.8	4.2	61	0.09	1600	290	19	-	6	26
N	2.10	2.15	37.07	37.02	7.88	8.5	10	120	1.0	3700	190	32	-	<1	<1

Bore hole	Depth (mbgs) From	To	AOD (m)		pH	LOI	TOC	Natural Moisture Content Ratio	Total Sulphur	Total Sulphate	Acid Soluble Sulphide	Carbonate	Carbonate alkalinity as CaCO3	Phosphate	Nitrate
N	2.65	2.70	36.52	36.47	8.21	7.4	1.3	34	0.89	2300	<50	3.6	-	<1	<1
O	1.30	1.35	38.34	38.29	7.08	7.2	5.5	30	0.10	1100	<50	4.1	-	9	21
O	2.70	2.75	36.94	36.89	8.04	2.2	0.7	26	0.18	480	<50	0.91	-	2	<1
P	1.45	1.50	38.48	38.43	5.64	37	16	85	1.7	42000	<50	21	-	<1	60
P	1.50	1.55	38.43	38.38	4.88	40	24	120	1.7	40000	<50	6.1	-	4	47
P	1.91	1.96	38.02	37.97	7.33	22	8.8	63	0.43	1700	<50	7.3	-	12	11
P	2.00	2.55	37.93	37.38	7.36	3.2	1.5	27	0.68	950	100	2.7	-	23	1
Q	1.50	1.55	37.72	37.67	7.62	5.2	4.8	35	0.13	1200	<50	7.3	-	25	110
R	1.40	1.45	37.78	37.73	7.31	1.5	0.7	20	0.03	360	<50	1.6	-	20	14
S	1.50	1.55	38.27	38.22	7.76	2.9	1.5	18	0.10	1700	<50	2.2	-	11	9
S	2.30	2.35	37.47	37.42	7.64	2.4	1.5	19	0.12	1800	<50	0.21	-	9	13
T	1.65	1.70	37.85	37.80	7.44	6.7	3.5	30	0.11	1700	<50	6.3	-	9	21
U	2.05	2.12	37.38	37.31	7.17	9.1	3.5	53	0.37	960	<50	4.1	-	7	7
U	1.65	1.75	37.78	37.68	7.08	4.8	4.1	28	0.18	2500	<50	5.0	-	3	3
V	1.50	1.55	37.89	37.84	4.79	3.4	1.3	20	0.16	3800	<50	2.3	-	4	3

Notes:

Soil analysis undertaken by AlControl Chester using in house test methods:

TEST	METHOD	UNITS	METHOD DETECTION LIMIT
Total Sulphate	TM129	mg/kg	<100
Carbonate Alkalinity as CaCO3	TM043	mg/kg	<10
Nitrate (soluble)	TM102	mg/kg	<1
Acid Soluble Sulphide	TM101	mg/kg	<50
Phosphate (Ortho as PO4)	TM100	mg/Kg	<1
Total Organic Carbon (TOC)	TM132	%	<0.2
Loss On Ignition (LOI)	TM018	%	<0.3
Natural Moisture Content Ratio	TM024	%	
pH Value	TM133	pH Units	<1.00
Total Sulphur	TM068	%	<0.01
Acid Soluble Carbonate	TM077	%	<0.01

Validated ✓
Preliminary

ALcontrol Geochem Analytical Services
Table Of Results

[#] ISO 17025 accredited
[M] MCERTS accredited
* Subcontracted test
» Shown on prev. report

Job Number: 07/18671/02/01 **Matrix:** LIQUID
Client: SLR Consulting Ltd **Location:** NANTWICH
Client Ref. No.: 406/0889/00003/005 **Client Contact:** John Matthews

Sample Identity	BHAB	BHAC	BHL	BHM	BHN	BHO	BHP	BHQ	BHS	Method Code	LoD/Units
Depth (m)				1.58	1.37						
Sample Type	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID		
Sampled Date											
Sample Received Date	22.11.07	22.11.07	22.11.07	22.11.07	22.11.07	22.11.07	22.11.07	22.11.07	22.11.07		
Batch	2	2	2	2	2	2	2	2	2		
Sample Number(s)	**10-15**	**16-21**	**22-27**	**28-33**	**34-39**	**40-45**	**46-51**	**52-57**	**58-63**		
Iron Dissolved (ICP-MS)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	TM152[#]	<0.005 mg/l
Manganese Dissolved (ICP-MS)	0.028	3.4	0.30	0.53	0.61	2.0	6.8	1.4	0.25	TM152[#]	<0.001 mg/l
Iron Dissolved	<0.05	19	2.3	0.21	1.0	0.71	0.52	<0.05	0.25	TM129	<0.05 mg/l
Total Alkalinity as CaCO3	530	480	330	310	320	600	270	390	260	TM043[#]	<2 mg/l
Nitrate as NO3	26	<0.3	66	0.8	8.0	2.0	27	9.3	5.3	TM102[#]	<0.3 mg/l
Sulphate (soluble)	77	180	170	41	58	38	560	26	68	TM098[#]	<3 mg/l
Phosphate (Ortho as PO4)	10	<0.08	0.78	13	1.3	2.4	22	13	4.9	TM100[#]	<0.08 mg/l
Sulphide	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	TM101	<0.5 mg/l
Total Organic Carbon	8	8	8	9	7	17	12	7	5	TM090[#]	<1 mg/l
Manganese II	<0.2	3.0	0.3	0.3	0.8	1.3	3.8	0.3	0.2	TM005	<0.2 mg/l
Ferrous Iron	<0.1	15	<0.1	<0.1	0.6	0.2	<0.1	<0.1	<0.1	TM125	<0.1 mg/l
Ferric Iron	<0.1	4.0	2.3	0.2	0.4	0.5	0.5	<0.1	0.3	TM125	<0.1 mg/l
Free Sulphur	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	TM136[#]	<0.05 mg/l
Methane Dissolved	<0.001	0.051	0.003	0.008	2.9	2.2	0.004	0.001	0.005	TM147	<0.001 mg/l

Date 10.12.2007

Validated ✓
Preliminary

ALcontrol Geochem Analytical Services
Table Of Results

[#] ISO 17025 accredited
[M] MCERTS accredited
[*] Subcontracted test
[»] Shown on prev. report

Job Number: 07/18671/02/01 **Matrix:** LIQUID
Client: SLR Consulting Ltd **Location:** NANTWICH
Client Ref. No.: 406/0889/00003/005 **Client Contact:** John Matthews

Sample Identity	BHT	BHV								Method Code	LoD/Units
Depth (m)											
Sample Type	LIQUID	LIQUID									
Sampled Date											
Sample Received Date	22.11.07	22.11.07									
Batch	2	2									
Sample Number(s)	**64-69**	**70-75**									
Iron Dissolved (ICP-MS)	<0.005	<0.005								TM152[#]	<0.005 mg/l
Manganese Dissolved (ICP-MS)	1.6	2.6								TM152[#]	<0.001 mg/l
Iron Dissolved	1.9	18								TM129	<0.05 mg/l
Total Alkalinity as CaCO3	430	170								TM043[#]	<2 mg/l
Nitrate as NO3	<0.3	0.5								TM102[#]	<0.3 mg/l
Sulphate (soluble)	15	86								TM098[#]	<3 mg/l
Phosphate (Ortho as PO4)	23	0.11								TM100[#]	<0.08 mg/l
Sulphide	<0.5	<0.5								TM101	<0.5 mg/l
Total Organic Carbon	15	6								TM090[#]	<1 mg/l
Manganese II	0.4	0.2								TM005	<0.2 mg/l
Ferrous Iron	1.2	13								TM125	<0.1 mg/l
Ferric Iron	0.7	5.0								TM125	<0.1 mg/l
Free Sulphur	<0.05	<0.05								TM136[#]	<0.05 mg/l
Methane Dissolved	2.6	0.039								TM147	<0.001 mg/l

Date 10.12.2007

ALcontrol Geochem Analytical Services
Table Of Results - Appendix

Job Number: 07/18671/02/01
Client: SLR Consulting Ltd
Client Ref. No.: 406/0889/00003/005

Report Key :

Results expressed as (e.g.) 1.03E-07 is equivalent to 1.03×10^{-7}

NDP	No Determination Possible	*	Subcontracted test
NFD	No Fibres Detected	»	Result previously reported (Incremental reports only)
#	ISO 17025 accredited	M	MCERTS Accredited
PFD	Possible Fibres Detected	EC	Equivalent Carbon (Aromatics C8-C35)

Note: Method detection limits are not always achievable due to various circumstances beyond our control.

Summary of Method Codes contained within report :

Method No.	Reference	Description	ISO 17025 Accredited	MCERTS Accredited	Wet/Dry Sample [1]	Surrogate Corrected
TM005	.	Manganese II by spectrophotometer			NA	
TM043	Method 2320B, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part109 1984	Determination of alkalinity in aqueous samples	✓		NA	
TM090	Method 5310, AWWA/APHA, 20th Ed., 1999 / Modified: US EPA Method 415.1 & 9060	Determination of Total Organic Carbon/Total Inorganic Carbon in Water and Waste Water	✓		NA	
TM098	Method 4500E, AWWA/APHA, 20th Ed., 1999	Determination of Sulphate using the Kone Analyser	✓		NA	
TM100	BS 2690: Part 105:1983	Determination of Phosphate using the Kone Analyser	✓		NA	
TM101	Method 4500B & C, AWWA/APHA, 20th Ed., 1999	Determination of Sulphide in soil and water samples using the Kone Analyser			NA	
TM102	Method 4500H, AWWA/APHA, 20th Ed., 1999	Determination of Total Oxidised Nitrogen using the Kone Analyser	✓		NA	
TM125	DIN 38405 D17	Determination of Ferrous Iron			NA	
TM129	Method 3120B, AWWA/APHA, 20th Ed., 1999 / Modified: US EPA Method 3050B	Determination of Metal Cations by IRIS Emission Spectrometer			NA	
TM136	Method 17.10, Second Site property, March 2003	Determination of Sulphur by HPLC	✓		NA	
TM147	ASTM D-1945-91	Determination of C1-C7 Hydrocarbons in Gas Samples			NA	
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS	✓		NA	

[1] Applies to Solid samples only. **DRY** indicates samples have been dried at 35°C. **NA** = not applicable.

Validated ✓
Preliminary

ALcontrol Geochem Analytical Services
Table Of Results

[#] ISO 17025 accredited
[M] MCERTS accredited
* Subcontracted test
» Shown on prev. report

Job Number: 07/13395/02/01 **Matrix:** SOLID
Client: SLR Consulting **Location:** NANTWICH
Client Ref. No.: 406/0889/00003 **Client Contact:** John Matthews

Sample Identity	BH 7	BHA 4	BHA 5	BHB 1	BHB 2	BHB 3	BHC 12	BHC 13	BHD 8	Method Code	LoD/Units
Depth (m)	3.90-3.98	0.95-1.00	3.80-3.90	1.80-1.85	3.90-4.00	5.80	1.72-1.74	2.90-3.00	1.98-2.00		
Sample Type	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID		
Sampled Date	31.07.07	30.07.07	30.07.07	30.07.07	30.07.07	30.07.07	31.07.07	31.07.07	31.07.07		
Sample Received Date	04.08.07	04.08.07	04.08.07	04.08.07	04.08.07	04.08.07	04.08.07	04.08.07	04.08.07		
Batch	1	1	1	1	1	1	1	1	1		
Sample Number(s)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**		
Total Sulphate	350	270	420	710	750	680	560	860	960	TM129[#M]	<100 mg/kg
Carbonate Alkalinity as CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	TM043[#]	<10 mg/kg
Nitrate (soluble) as NO3	<1	1	<1	<1	<1	<1	<1	<1	3	TM102[#]	<1 mg/kg
Acid Soluble Sulphide	<50	<50	270	160	<50	67	<50	330	<50	TM101	<50 mg/kg
Phosphate (Ortho as PO4)	<1	<1	<1	<1	5	<1	<1	2	10	TM100[#]	<1 mg/kg
Total Organic Carbon	0.6	0.3	0.3	2.2	1.1	0.4	3.1	2.6	5.2	TM132[#M]	<0.2 %
Loss on Ignition	2.2	1.6	1.7	3.6	3.1	1.6	4.6	7.1	8.7	TM018[#M]	<0.3 %
Natural Moisture Content Ratio	25	17	24	26	33	23	30	53	45	PM024	%
pH Value	7.28	7.78	5.97	7.60	7.69	7.63	7.54	7.45	7.82	TM133[#M]	<1.00 pH Units

All results expressed on a dry weight basis.

Date 16.08.2007

Validated ✓
Preliminary

ALcontrol Geochem Analytical Services
Table Of Results

[#] ISO 17025 accredited
[M] MCERTS accredited
* Subcontracted test
» Shown on prev. report

Job Number: 07/13395/02/01 **Matrix:** SOLID
Client: SLR Consulting **Location:** NANTWICH
Client Ref. No.: 406/0889/00003 **Client Contact:** John Matthews

Sample Identity	BHD 9	BHD 10	BHD 11	BHE 6	BHF 20	BHF 21	BHG 18	BHG 19	BHI 16	Method Code	LoD/Units
Depth (m)	2.00-2.09	2.45-2.50	3.90-4.00	2.33-2.38	0.76-0.82	1.80-1.85	0.65-0.70	1.75-1.80	0.80-0.86		
Sample Type	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID		
Sampled Date	31.07.07	31.07.07	31.07.07	31.07.07	01.08.07	01.08.07	01.08.07	01.08.07	01.08.07		
Sample Received Date	04.08.07	04.08.07	04.08.07	04.08.07	04.08.07	04.08.07	04.08.07	04.08.07	04.08.07		
Batch	1	1	1	1	1	1	1	1	1		
Sample Number(s)	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**		
Total Sulphate	770	660	110	1100	1700	600	800	320	530	TM129[#M]	<100 mg/kg
Carbonate Alkalinity as CaCO3	<10	<10	<10	<10	<10	<10	<10	<10	<10	TM043[#]	<10 mg/kg
Nitrate (soluble) as NO3	4	<1	9	57	2	<1	25	16	<1	TM102[#]	<1 mg/kg
Acid Soluble Sulphide	<50	<50	64	<50	<50	73	<50	<50	<50	TM101	<50 mg/kg
Phosphate (Ortho as PO4)	9	<1	18	<1	<1	8	10	22	4	TM100[#]	<1 mg/kg
Total Organic Carbon	3.8	1.7	<0.2	3.2	22	2.3	9.3	1.0	8.6	TM132[#M]	<0.2 %
Loss on Ignition	5.1	5.0	0.6	4.9	36	4.1	9.7	2.4	6.9	TM018[#M]	<0.3 %
Natural Moisture Content Ratio	34	30	20	24	110	38	45	19	18	PM024	%
pH Value	8.00	6.72	7.59	7.38	7.78	7.35	7.77	7.50	7.87	TM133[#M]	<1.00 pH Units

All results expressed on a dry weight basis.

Date 16.08.2007

Validated ✓
Preliminary

ALcontrol Geochem Analytical Services
Table Of Results

[#] ISO 17025 accredited
[M] MCERTS accredited
* Subcontracted test
» Shown on prev. report

Job Number: 07/13395/02/01 **Matrix:** SOLID
Client: SLR Consulting **Location:** NANTWICH
Client Ref. No.: 406/0889/00003 **Client Contact:** John Matthews

Sample Identity	BHI 17	BHJ 14	BHJ 15							Method Code	LoD/Units
Depth (m)	1.28-1.32	0.90-1.00	1.20-1.26								
Sample Type	SOLID	SOLID	SOLID								
Sampled Date	01.08.07	31.07.07	31.07.07								
Sample Received Date	04.08.07	04.08.07	04.08.07								
Batch	1	1	1								
Sample Number(s)	**19**	**20**	**21**								
Total Sulphate	180	750	230							TM129[#M]	<100 mg/kg
Carbonate Alkalinity as CaCO3	<10	<10	<10							TM043[#]	<10 mg/kg
Nitrate (soluble) as NO3	<1	7	2							TM102[#]	<1 mg/kg
Acid Soluble Sulphide	<50	<50	<50							TM101	<50 mg/kg
Phosphate (Ortho as PO4)	2	55	58							TM100[#]	<1 mg/kg
Total Organic Carbon	0.4	3.7	0.8							TM132[#M]	<0.2 %
Loss on Ignition	0.9	8.5	1.3							TM018[#M]	<0.3 %
Natural Moisture Content Ratio	20	20	15							PM024	%
pH Value	7.57	8.33	8.63							TM133[#M]	<1.00 pH Units

All results expressed on a dry weight basis.

Date 16.08.2007

ALcontrol Geochem Analytical Services
Table Of Results - Appendix

Job Number: 07/13395/02/01
Client: SLR Consulting
Client Ref. No.: 406/0889/00003

Report Key :

Results expressed as (e.g.) 1.03E-07 is equivalent to 1.03×10^{-7}

NDP	No Determination Possible	*	Subcontracted test
NFD	No Fibres Detected	»	Result previously reported (Incremental reports only)
#	ISO 17025 accredited	M	MCERTS Accredited
PFD	Possible Fibres Detected	EC	Equivalent Carbon (Aromatics C8-C35)

Note: Method detection limits are not always achievable due to various circumstances beyond our control.

Summary of Method Codes contained within report :

Method No.	Reference	Description	ISO 17025 Accredited	MCERTS Accredited	Wet/Dry Sample [1]	Surrogate Corrected
PM024	Modified BS 1377	Soil preparation including homogenisation, moisture content and description			WET	
TM018	BS 1377: Part 3 1990	Determination of Loss on Ignition	✓	✓	WET	
TM043	Method 2320B, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part109 1984	Determination of alkalinity in aqueous samples	✓		WET	
TM100	BS 2690: Part 105:1983	Determination of Phosphate using the Kone Analyser	✓		DRY	
TM101	Method 4500B & C, AWWA/APHA, 20th Ed., 1999	Determination of Sulphide in soil and water samples using the Kone Analyser			WET	
TM102	Method 4500H, AWWA/APHA, 20th Ed., 1999	Determination of Total Oxidised Nitrogen using the Kone Analyser	✓		DRY	
TM129	Method 3120B, AWWA/APHA, 20th Ed., 1999 / Modified: US EPA Method 3050B	Determination of Metal Cations by IRIS Emission Spectrometer	✓	✓	DRY	
TM132	In - house Method	ELTRA CS800 Operators Guide	✓	✓	DRY	
TM133	BS 1377: Part 3 1990	Determination of pH in Soil and Water using the GLpH pH Meter	✓	✓	WET	

[1] Applies to Solid samples only. **DRY** indicates samples have been dried at 35°C. **NA** = not applicable.

Validated ✓
Preliminary

ALcontrol Geochem Analytical Services
Table Of Results

[#] ISO 17025 accredited
[M] MCERTS accredited
* Subcontracted test
» Shown on prev. report

Job Number: 07/16288/02/01 **Matrix:** SOLID
Client: SLR Consulting **Location:** NANTWICH
Client Ref. No.: 406/0889/00003 **Client Contact:** John Matthews

Sample Identity	BH5 27	BHM 22	BHM 23	BHN 29	BHN 30	BHN 31	BHN 32	BHO 24	BHO 25	Method Code	LoD/Units
Depth (m)	1.5-1.55	1.6-1.65	2.1-2.2	0.75-0.8	1.35-1.4	2.1-2.15	2.65-2.7	1.3-1.35	2.7-2.75		
Sample Type	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID		
Sampled Date											
Sample Received Date	15.09.07	15.09.07	15.09.07	15.09.07	15.09.07	15.09.07	15.09.07	15.09.07	15.09.07		
Batch	1	1	1	1	1	1	1	1	1		
Sample Number(s)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**		
Total Sulphate	1700	620	420	2500	1600	3700	2300	1100	480	TM129[#M]	<100 mg/kg
Nitrate (soluble) as NO3	9	<1	2	<1	26	<1	<1	21	<1	TM102[#]	<1 mg/kg
Acid Soluble Sulphide	<50	<50	<50	<50	290	190	<50	<50	<50	TM101	<50 mg/kg
Phosphate (Ortho as PO4)	11	7	5	<1	6	<1	<1	9	2	TM100[#]	<1 mg/kg
Total Organic Carbon	1.5	7.5	2.7	5.6	4.2	10	1.3	5.5	0.7	TM132[#M]	<0.2 %
Acid Soluble Carbonate	2.2	4.6	2.5	25	19	32	3.6	4.1	0.91	TM077	<0.01 %
Loss on Ignition	2.9	6.2	5.0	8.8	9.8	8.5	7.4	7.2	2.2	TM018[#M]	<0.3 %
Natural Moisture Content Ratio	18	37	29	48	61	120	34	30	26	PM024	%
pH Value	7.76	7.61	7.54	7.74	7.63	7.88	8.21	7.08	8.04	TM133[#M]	<1.00 pH Units
Total Sulphur	0.10	0.10	0.10	0.54	0.09	1.0	0.89	0.10	0.18	TM068[#]	<0.01 %

All results expressed on a dry weight basis.

Date 28.09.2007

Validated ✓
Preliminary

ALcontrol Geochem Analytical Services
Table Of Results

[#] ISO 17025 accredited
[M] MCERTS accredited
* Subcontracted test
» Shown on prev. report

Job Number: 07/16288/02/01 **Matrix:** SOLID
Client: SLR Consulting **Location:** NANTWICH
Client Ref. No.: 406/0889/00003 **Client Contact:** John Matthews

Sample Identity	BHP 33	BHP 34	BHP 35	BHP 36	BHR 26	BHS 28				Method Code	LoD/Units
Depth (m)	1.45-1.5	1.5-1.55	1.91-1.96	2.0-2.55	1.4-1.45	2.3-2.35					
Sample Type	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID					
Sampled Date											
Sample Received Date	15.09.07	15.09.07	15.09.07	15.09.07	15.09.07	15.09.07					
Batch	1	1	1	1	1	1					
Sample Number(s)	**10**	**11**	**12**	**13**	**14**	**15**					
Total Sulphate	42000	40000	1700	950	360	1800				TM129[#M]	<100 mg/kg
Nitrate (soluble) as NO3	60	47	11	1	14	13				TM102[#]	<1 mg/kg
Acid Soluble Sulphide	<50	<50	<50	100	<50	<50				TM101	<50 mg/kg
Phosphate (Ortho as PO4)	<1	4	12	23	20	9				TM100[#]	<1 mg/kg
Total Organic Carbon	16	24	8.8	1.5	0.7	1.5				TM132[#M]	<0.2 %
Acid Soluble Carbonate	21	6.1	7.3	2.7	1.6	0.21				TM077	<0.01 %
Loss on Ignition	37	40	22	3.2	1.5	2.4				TM018[#M]	<0.3 %
Natural Moisture Content Ratio	85	120	63	27	20	19				PM024	%
pH Value	5.64	4.88	7.33	7.36	7.31	7.64				TM133[#M]	<1.00 pH Units
Total Sulphur	1.7	1.7	0.43	0.68	0.03	0.12				TM068[#]	<0.01 %

All results expressed on a dry weight basis.

Date 28.09.2007

ALcontrol Geochem Analytical Services
Table Of Results - Appendix

Job Number: 07/16288/02/01
Client: SLR Consulting
Client Ref. No.: 406/0889/00003

Report Key :

Results expressed as (e.g.) 1.03E-07 is equivalent to 1.03×10^{-7}

NDP	No Determination Possible	*	Subcontracted test
NFD	No Fibres Detected	»	Result previously reported (Incremental reports only)
#	ISO 17025 accredited	M	MCERTS Accredited
PFD	Possible Fibres Detected	EC	Equivalent Carbon (Aromatics C8-C35)

Note: Method detection limits are not always achievable due to various circumstances beyond our control.

Summary of Method Codes contained within report :

Method No.	Reference	Description	ISO 17025 Accredited	MCERTS Accredited	Wet/Dry Sample [1]	Surrogate Corrected
PM024	Modified BS 1377	Soil preparation including homogenisation, moisture content and description			WET	
TM018	BS 1377: Part 3 1990	Determination of Loss on Ignition	✓	✓	WET	
TM068	ASTM D-1552	Total sulphur determination by combustion method	✓		DRY	
TM077	In - house Method	Carbonate content of rock/soil samples (as acid soluble weight loss)			DRY	
TM100	BS 2690: Part 105:1983	Determination of Phosphate using the Kone Analyser	✓		DRY	
TM101	Method 4500B & C, AWWA/APHA, 20th Ed., 1999	Determination of Sulphide in soil and water samples using the Kone Analyser			WET	
TM102	Method 4500H, AWWA/APHA, 20th Ed., 1999	Determination of Total Oxidised Nitrogen using the Kone Analyser	✓		DRY	
TM129	Method 3120B, AWWA/APHA, 20th Ed., 1999 / Modified: US EPA Method 3050B	Determination of Metal Cations by IRIS Emission Spectrometer	✓	✓	DRY	
TM132	In - house Method	ELTRA CS800 Operators Guide	✓	✓	DRY	
TM133	BS 1377: Part 3 1990	Determination of pH in Soil and Water using the GLpH pH Meter	✓	✓	WET	

[1] Applies to Solid samples only. **DRY** indicates samples have been dried at 35°C. **NA** = not applicable.

Validated ☑
Preliminary ☐

ALcontrol Geochem Analytical Services
Table Of Results

[#] ISO 17025 accredited
[M] MCERTS accredited
* Subcontracted test
» Shown on prev. report

Job Number: 07/18671/02/01 **Matrix:** SOLID
Client: SLR Consulting **Location:** NANTWICH
Client Ref. No.: 406/0889/00003 **Client Contact:** John Matthews

Sample Identity	BHAB 43	BHAC 41	BHAC 42	BHL 45	BHQ 44	BHT 40	BHU 37	BHU 38	BHV 39	Method Code	LoD/Units
Depth (m)	1.8-1.85	1.8-1.85	3.3-3.4	0.85-0.92	1.5-1.55	1.65-1.7	2.05-2.12	1.65-1.75	1.5-1.55		
Sample Type	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID		
Sampled Date	16.10.07	16.10.07	16.10.07	16.10.07	16.10.07	16.10.07	16.10.07	16.10.07	16.10.07		
Sample Received Date	23.10.07	23.10.07	23.10.07	23.10.07	23.10.07	23.10.07	23.10.07	23.10.07	23.10.07		
Batch	1	1	1	1	1	1	1	1	1		
Sample Number(s)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**		
Total Sulphate	1200	2000	1900	550	1200	1700	960	2500	3800	TM129[#M]	<100 mg/kg
Nitrate (soluble) as NO3	<1	<1	<1	15	110	21	7	3	3	TM102[#]	<1 mg/kg
Acid Soluble Sulphide	<50	<50	180	<50	<50	<50	<50	<50	<50	TM101	<50 mg/kg
Phosphate (Ortho as PO4)	2	4	<1	36	25	9	7	3	4	TM100[#]	<1 mg/kg
Total Organic Carbon	4.0	3.3	4.1	5.8	4.8	3.5	3.5	4.1	1.3	TM132[#M]	<0.2 %
Acid Soluble Carbonate	18	9.1	8.9	4.6	7.3	6.3	4.1	5.0	2.3	TM077	<0.01 %
Loss on Ignition	8.0	6.4	7.8	5.2	5.2	6.7	9.1	4.8	3.4	TM018[#M]	<0.3 %
Natural Moisture Content Ratio	39	26	47	25	35	30	53	28	20	PM024	%
pH Value	6.75	7.70	7.88	7.99	7.62	7.44	7.17	7.08	4.79	TM133[#M]	<1.00 pH Units
Total Sulphur	0.13	0.14	1.2	0.15	0.13	0.11	0.37	0.18	0.16	TM068[#]	<0.01 %

All results expressed on a dry weight basis.

Date 08.11.2007

ALcontrol Geochem Analytical Services
Table Of Results - Appendix

Job Number: 07/18671/02/01
Client: SLR Consulting
Client Ref. No.: 406/0889/00003

Report Key :

Results expressed as (e.g.) 1.03E-07 is equivalent to 1.03×10^{-7}

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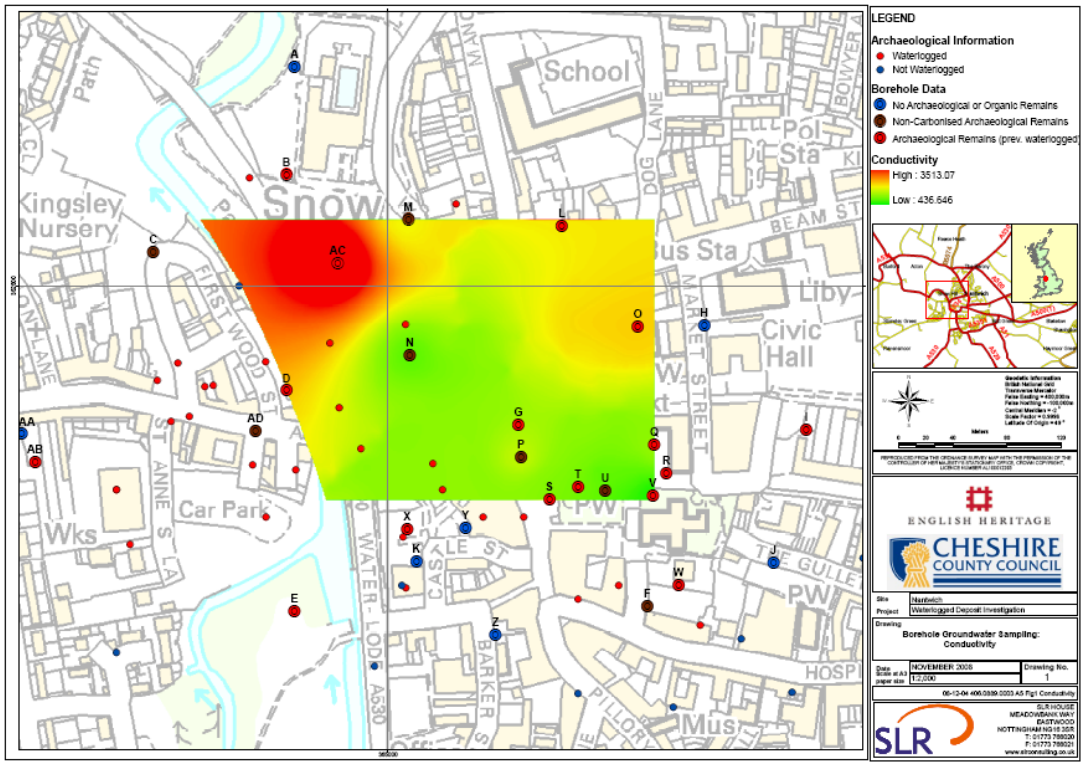
TM101	Method 4500B & C, AWWA/APHA, 20th Ed., 1999	Determination of Sulphide in soil and water samples using the Kone Analyser			WET	
TM102	Method 4500H, AWWA/APHA, 20th Ed., 1999	Determination of Total Oxidised Nitrogen using the Kone Analyser	✓		DRY	
TM129	Method 3120B, AWWA/APHA, 20th Ed., 1999 / Modified: US EPA Method 3050B	Determination of Metal Cations by IRIS Emission Spectrometer	✓	✓	DRY	
TM132	In - house Method	ELTRA CS800 Operators Guide	✓	✓	DRY	
TM133	BS 1377: Part 3 1990	Determination of pH in Soil and Water using the GLpH pH Meter	✓	✓	WET	

[1] Applies to Solid samples only. **DRY** indicates samples have been dried at 35°C. **NA** = not applicable.

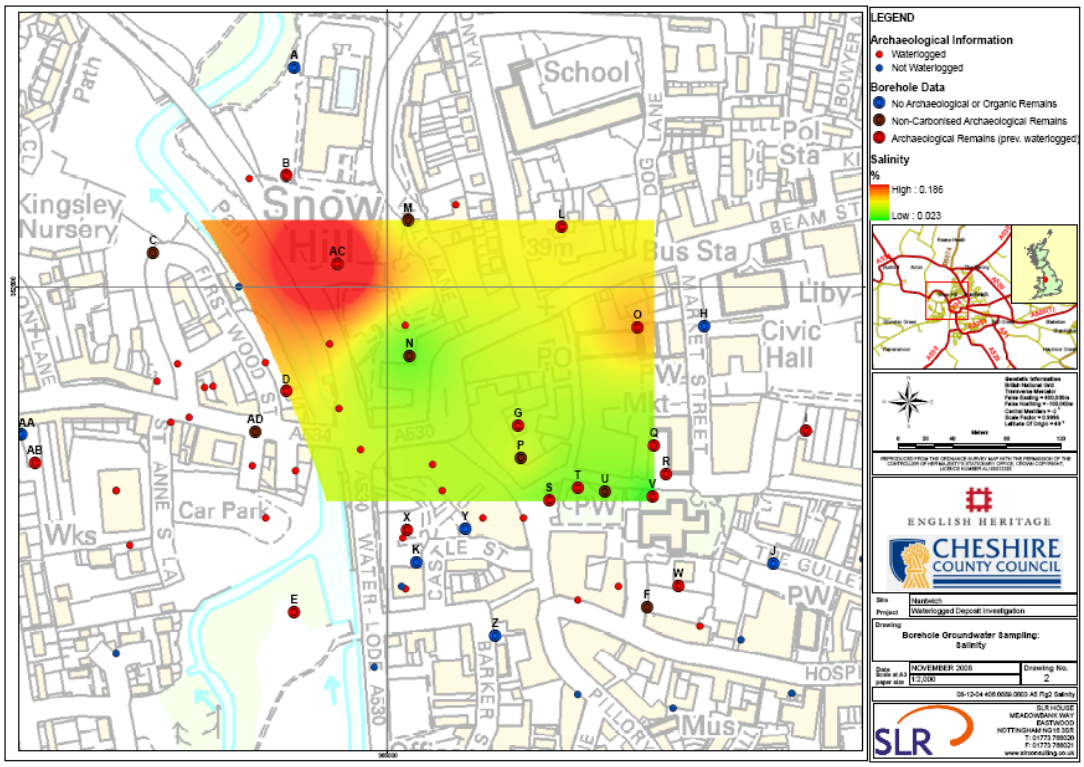
APPENDIX 5

Plots from water quality testing

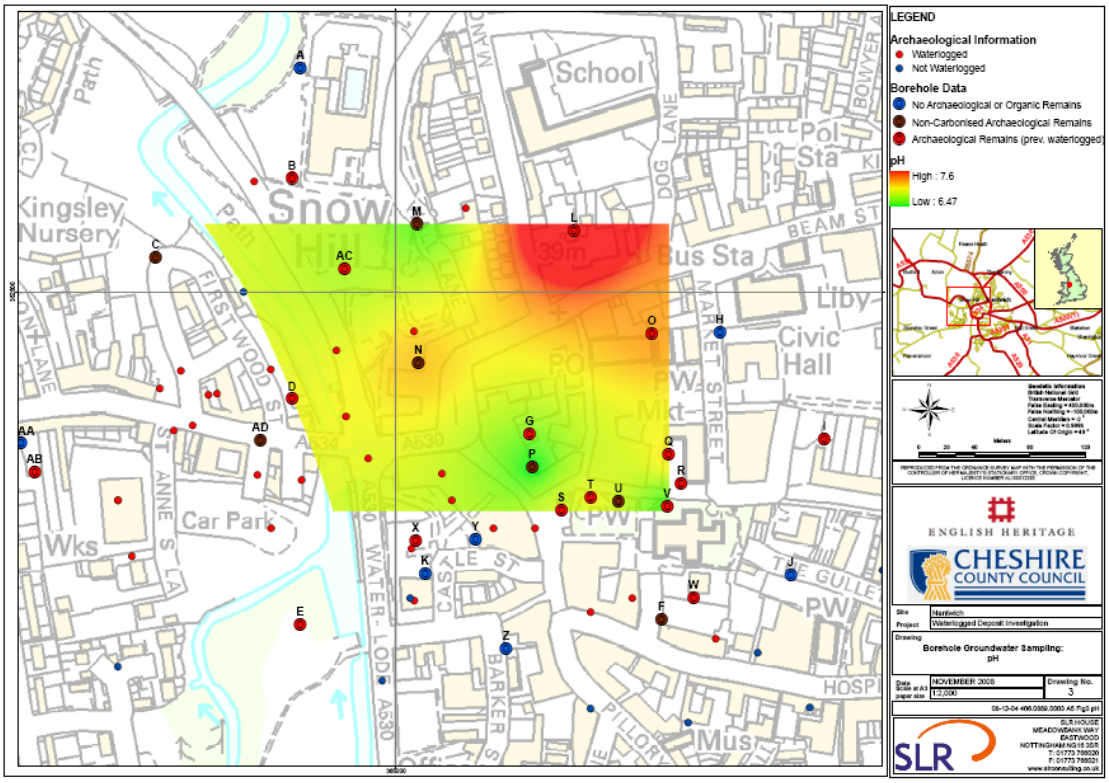
Appendix 5 Water Quality Plots



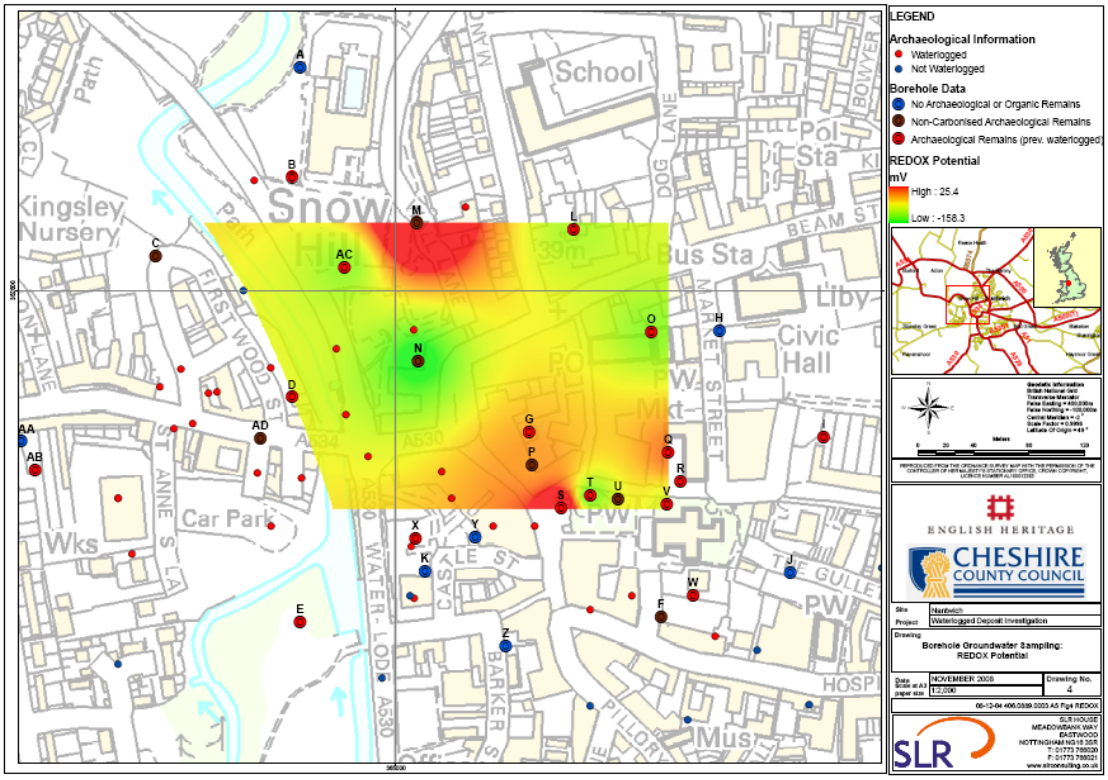
A5 Figure 1 Conductivity



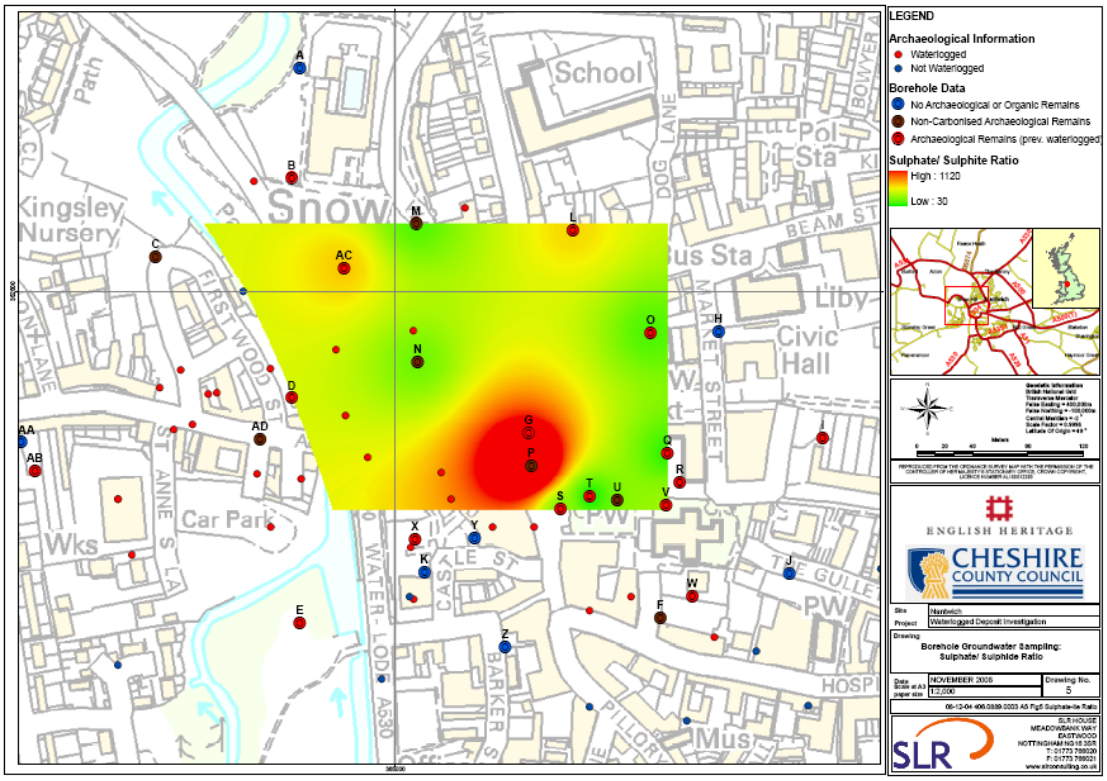
A5 Figure 2 Salinity



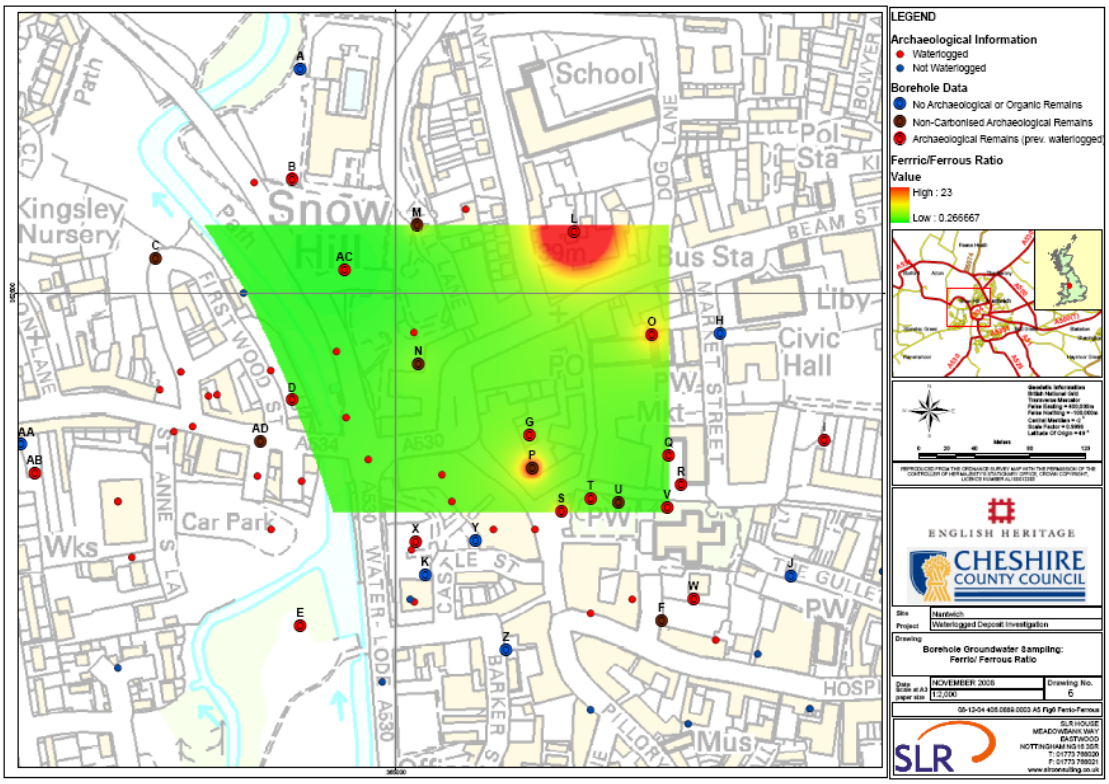
A5 Figure 3 pH



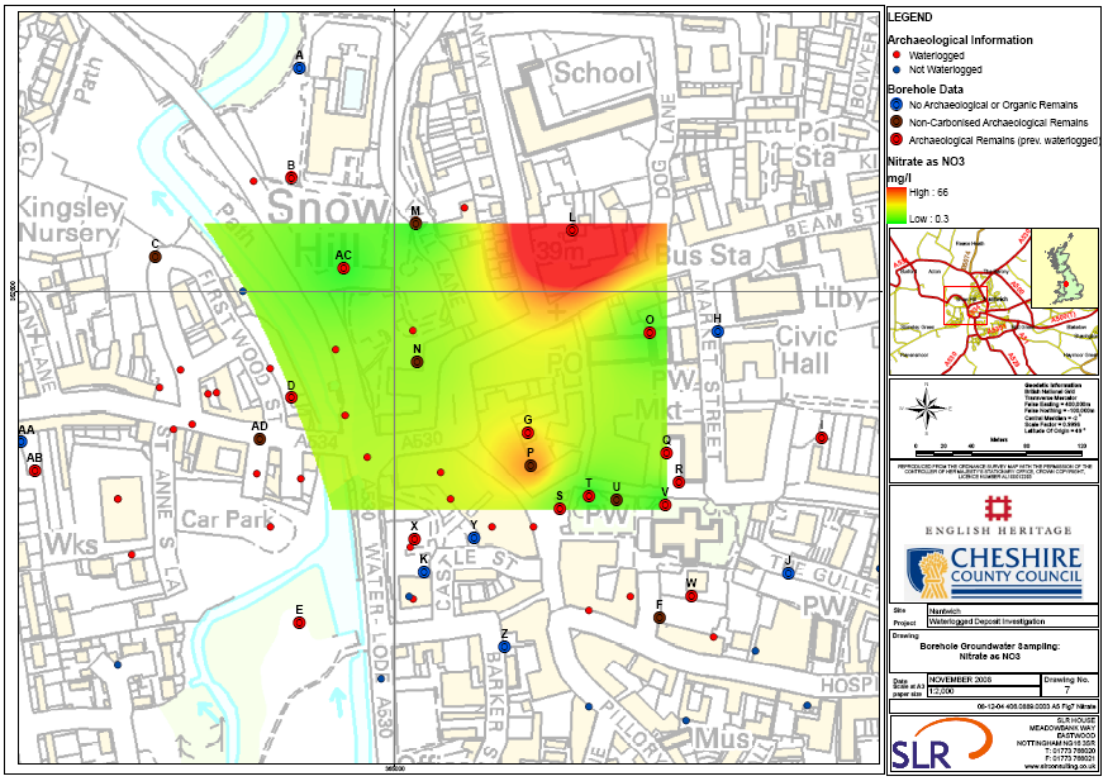
A5 Figure 4 Redox



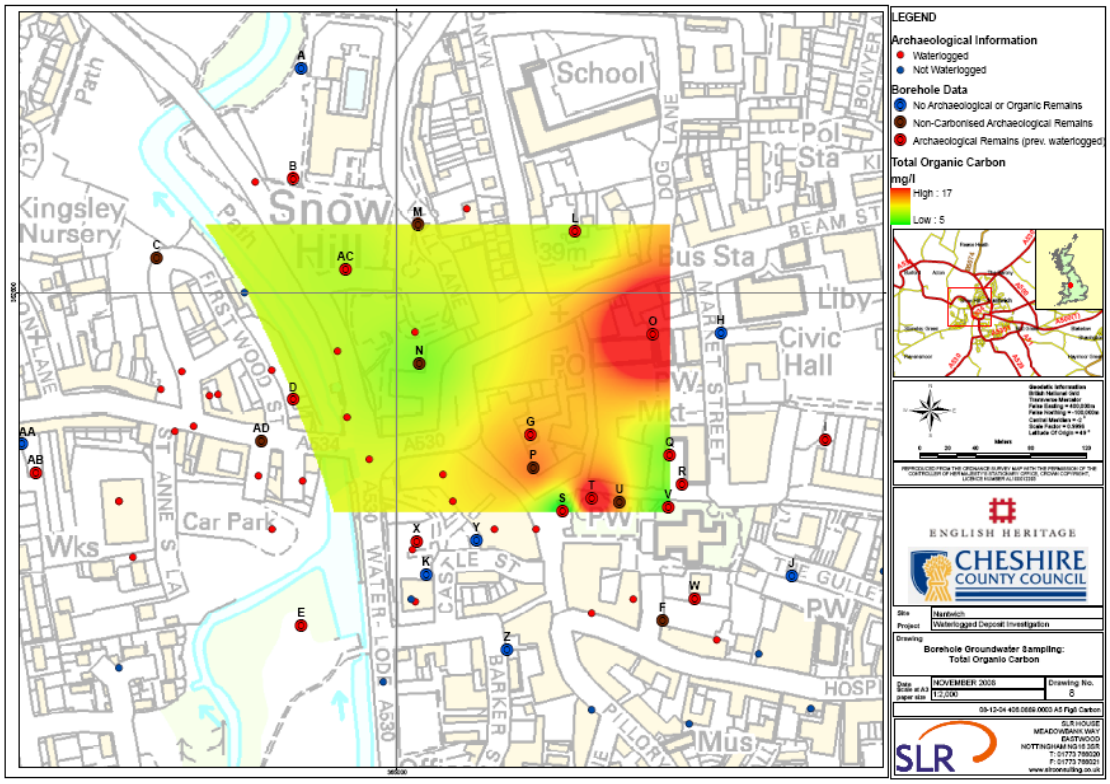
A5 Figure 5 Sulphide : Sulphate ratio



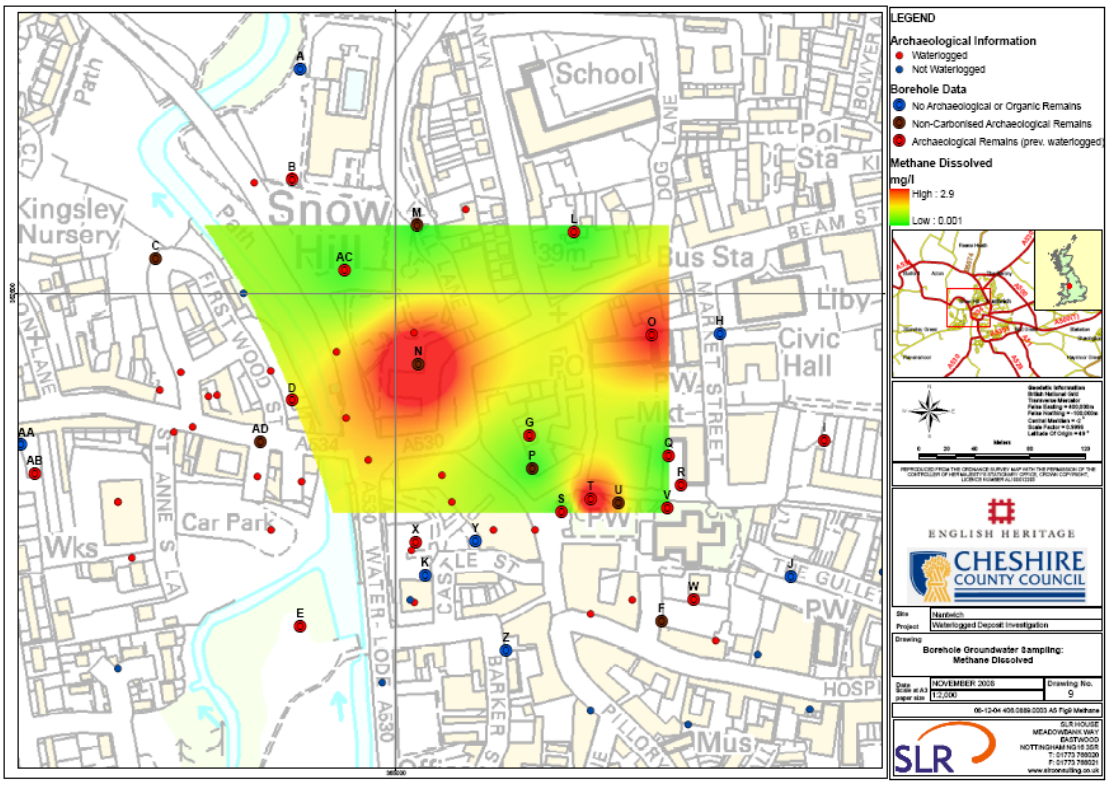
A5 Figure 6 Ferric : Ferrous ratio



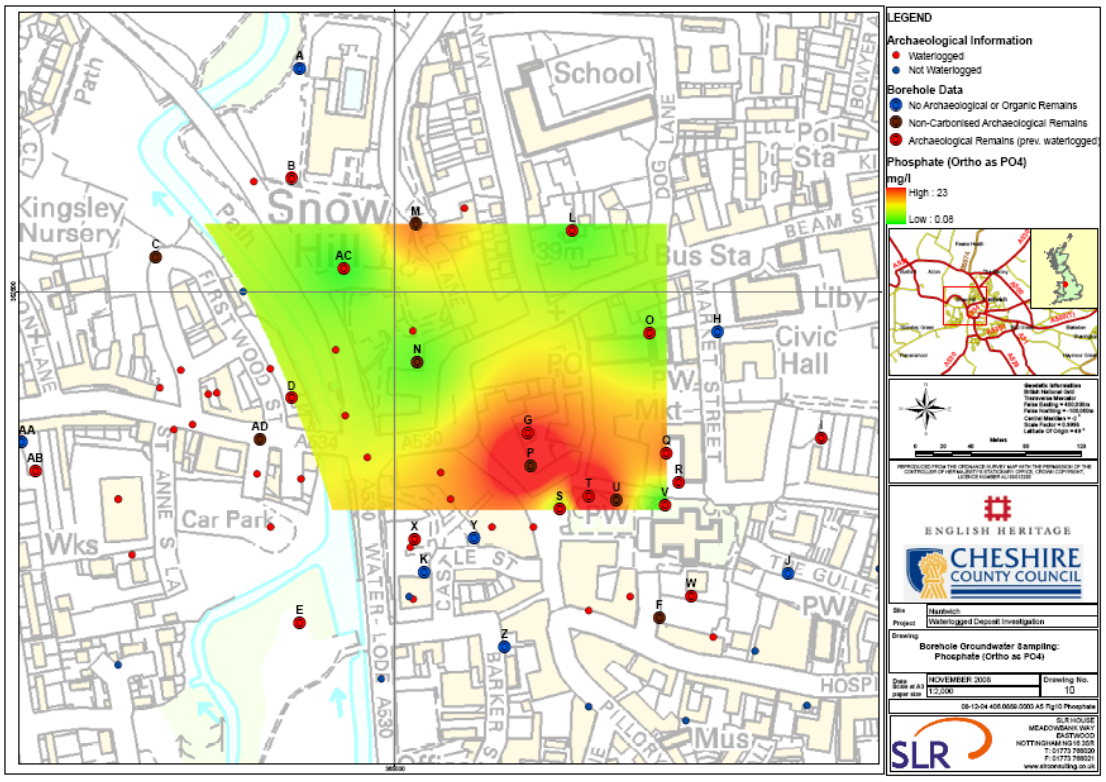
A5 Figure 7 Nitrate



A5 Figure 8 Organic carbon



A5 Figure 9 Dissolved Methane



A5 Figure 10 Phosphate

APPENDIX 6

Diatom assessment report

NANTWICH PALAEOENVIRONMENTAL ASSESSMENT

Diatom Analysis

By

Dr Tracy Yates-Sabren

&

Dr Malcolm Lillie FSA MIFA

October 2008

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Acknowledgements

Thanks are extended to Dr Steve Ellis for discussion of the Nantwich sedimentary history,to Ian Panter for discussions relating to hydrology and burial environments and to Tim Malim for general discussion and maps showing borehole locations.

Summary

This report is an assessment of the diatom flora recovered from sampling in and around the town of Nantwich, and is undertaken on behalf of SLR Consulting Ltd.

The key aim of this study is the identification and assessment of diatom presence, state of preservation and indications on environment or water quality data. The samples were recovered from cores taken during an assessment of waterlogged preservation undertaken by PRS on behalf of SLR Consulting Ltd (Carrott *et al*. 2008). As such, the samples lack data relating to their specific archaeological context, and with the exception of the samples from borehole P, these samples are effectively 'spot' samples.

Although only one sample was recovered from the western side of the floodplain, the data reported here indicates that considerable differences occur between the west and the east sides of the River Weaver floodplain. This is commensurate with the results obtained from previous geochemical and palaeoenvironmental studies. In the areas to the east of the River Weaver, both within and above the floodplain area, it appears that the specific hydrological context (Upper River Terrace deposits away from the floodplain), and anthropogenic impacts (this area is more heavily developed), are producing compromised burial environments in relation diatom preservation. In the single location studied from the west of the floodplain, preservation appears to be good.

The strong freshwater component in these assemblages is likely to be associated with the river Weaver itself; many of the oligo-halophobous species are typical of river environments, and their presence suggests either normal environmental conditions associated with river function, or freshwater inputs from stream run-off and other sources such as precipitation etc. Whilst some of the species identified are tolerant of brackish conditions, the analysis undertaken in the current study cannot provide any indication of salinity and/or the spatial extent of brackish environments, as the samples studied were pre-selected, and not targeted from a sampling strategy designed to specifically identify these characteristics of the burial environment.

In addition, where a brackish environmental tolerance is suggested for the diatom species identified, this does not mean that brackish conditions prevailed, as these species are also influenced by substrate. *Pinnularia borealis* and *Cypatopleura solea*, for example, are diatoms associated with damp soil and it is possible that these species are derived from the surrounding substrate. Any attempts at inferring past salinity values for the samples analysed would be extremely limited due to the poor condition of the samples, the weak statistical representation of species in the dataset, and the lack of specific context in relation to brine springs and saltworkings. This latter observation reflects the fact that the precise location of brine springs and salt working areas were not targeted in the sampling strategy and, as such

Figures

Figure 3.1: Results of diatom analysis from Core P. 10

Tables

Table 3.1: The results of diatom analysis expressed as percentage counts. The number of species present, diversity and the preservation condition of diatom frustules is also marked for each sample. 9

1 Introduction

1.1 The current analysis is undertaken by the Wetland Archaeology & Environments Research Centre at the University of Hull, on behalf of SLR Consulting Ltd.

1.2 In the current study, fifteen samples recovered from boreholes excavated throughout Nantwich, are assessed. The assessment is aimed at the identification and assessment of diatom presence, state of preservation and indications on environment or water quality data. In addition, the data is compared against existing geochemical and palaeoenvironmental data from Nantwich in order to determine how the diatom assemblages investigated can inform studies of *in situ* preservation status.

1.3 In general, the analysis of diatoms may be useful in an archaeological context in order to assess past environmental conditions and produce a clearer picture of the immediate environment, thus providing information that may help to identify the preservation status of archaeological remains (Mannion, 1987). Fifteen sediment samples, taken from two predetermined preservation zones within Nantwich by PRS on behalf of SLR Consulting Ltd (i.e. Zone 1; the River Weaver floodplain and Zone 2; east of the river and above the floodplain), were processed and analysed with the aim of investigating whether the characteristics of the diatom assemblage can in fact provide useful information on the depositional environment, and to see if any differences in preservation can be detected both within and between sample points.

2 Methods

2.1 The samples were prepared following standard techniques (Battarbee 1986). Organic matter was oxidised in a 30% hydrogen peroxide (H_2O_2) solution, by placing samples in beakers on a hotplate at a temperature of 90ºC for approximately 2 hours. A few drops of concentrated hydrochloric acid (HCl) were added to each sample following oxidation in order to remove carbonates. The samples were then transferred to test tubes and washed with distilled water in a Centaur 2 centrifuge at a speed of 1200rpm for five minutes, to allow the clay particles to form in suspension while the diatoms and other silt-sized particles formed a pellet at the base of the test tubes. The water was decanted after each wash, leaving the pellet intact, and individually numbered plastic pipettes were used to re-mix each sample and avoid cross contamination. This process was repeated until all clays had been removed (i.e., when the supernatant ceased to be cloudy). Samples were then topped up with distilled water to 10ml.

2.2 Sample residues of two different concentrations were dried overnight on 40mm round cover slips then mounted onto microscope slides using Naphrax®, which has a suitable refractive index. Slides were heated on a hotplate in the fume cupboard at a temperature of 90˚C for ten minutes, to evaporate the toluene from the Naphrax®, and then cooled before counting.

2.3 Taxonomic identification was made using a Leica DMLS under oil immersion at a magnification of x 1000 and identification was determined to species level using Germain (1981) and Krammer and Lange-Bertalot (1986, 1988, 1991a, b). Approximately 200-300 valves were counted per slide so as to provide a statistically reliable estimate of species composition; the number counted was dependant on the frequency of diatom frustules in each sample. To indicate their relative abundance, the species counts for each sample were converted to a percentage of the whole sample count and species present at under 4% were disqualified.

2.4 The preservation of diatom frustules was noted and diversity was categorised based on the number of species present in each sample; 1 to 10 = low; 11 to 14 = low-medium; 15 to 19 = medium; 20 and over = medium-high. For borehole P the diatom data were displayed using TILIA (Grimm, 1991) and TG View (Grimm, 2004) to highlight changes in species composition through the profile. For the discussion, the environmental affinities of individual species were taken from Germain (1981) and Juggins (2008).

3 Results

3.1 *Zone 1; The River Weaver Floodplain*

BH C (C3/P (190-195cm) – south-west river bank)

Diatom preservation in sample C3/P was excellent, with a total of 25 taxa present at >4%. Table 3.1 gives the results of diatom analysis and indicates that the diatom assemblage was composed of large benthic forms typical of shallow, freshwater environments and associated with epiphytic and epilithic habitats. The diversity and frequency of diatom frustules was medium to high and dominated by *N. cryptotenella* at 14.6% and a range of *Nitszchia* and *Achnanthese* spp. (16.2% and 11.4% respectively). *Surirella ovalis* (3.5%) and *Diatoma vulgare* (4.9%) were also present.

3.2 *Zone 2; East of the River Weaver and above the river floodplain*

All samples in this zone demonstrated a high degree of frustules breakage and a high mineral content that was difficult to remove using conventional diatom preparation techniques (Table 3.1).

BH P (P4/P - 250cm; P5/P - 217cm; P6/P - 191-200cm; P7/P - 173-191; P8/P - 168cm; P9/P -150-163cm; P10/P - 131-150cm)

Diatom preservation in these samples was poor, particularly in P4/P and P5/P, taken from the deepest part of the borehole. At these locations the breakage was so extreme that diatoms could not be counted. The results of diatom analysis for the remaining samples (P6/P to P10/P), expressed as percentage counts for taxa present at <4%, are given in Table 3.1 and Figure 3.1. Sample P6/P displayed the lowest diversity with only 8 identifiable species, whilst all other samples exhibited low to medium diversity. All samples contained high frequencies of *N. cryptotenella*, *Nitszchia* spp., and *Melosira varians* with samples P6/P and P10/P dominated by *N. cryptotenella* (32.9 and 30.2% respectively), sample P8/P by *N. umbonata* (43.0%), sample P9/P by *Pinnularia* spp. (22.3%) and sample P7/P by *M. varians* (29.7%). A profile of the main taxa found in these samples is given in Figure 1 to highlight changes in species abundance and composition between 195cm and 140cm.

BH F (F4/P (125-150cm)

Although sample F4/P exhibited a high degree of breakage again, there was an overall improvement in diatom preservation compared to BH P with 15 species present, thus exhibiting medium diversity (Table 1). *Melosira varians* dominated at

25.2% followed by *N. hungarica* at17.0%. The total relative abundance of *Nitszchi*a spp. was high at 21.4% and *Achnanthese* spp. were also high at 17.6%. *Cympatopleura solea* and *Navicula cohnii* were also present in this sample at 2.5% and 1.9% respectively.

BH G (G3/P - 56-100cm)

Diatom preservation in sample G3/P was poor. This low to medium diversity assemblage, with 13 identifiable species, was dominated by *N. cryptotenella* (21.9%), followed by *N. hungarica* (16.6%). *C. solea* was present at 4.0% accompanied by a significantly high relative abundance of *M. varians* (13.9%) and *N. cohnii* (11.3%).

BH M (M1/P - 211cm, M2/P -142cm)

Diatom preservation in samples M1/P and M2/P was poor. Sample M1/P demonstrated low to medium diversity with 13 species present, whilst sample M2/P exhibited a low diversity assemblage containing only 10 species. Both samples were dominated by *N. cryptotenella* followed by *Pinnularia* spp. (17.5%) and *A. lanceolata* (13.5%) in sample M1/P and *Navicula cincta* (17.4%) and *N. palaea* (17.4%) in sample M2/P.

BH N (N8/P - 246-261cm, N17/P – 122-129cm)

Diatom preservation in samples N8/P and N17/P was poor with low to medium diversity assemblages containing 12 and 13 identifiable species respectively. Sample N8/P was dominated by *N. cryptotenella* at 53.7% followed by *Pinnularia* spp. at 20.6% and sample N17/P was dominated by *M. varians* at 44.5% presence. N17/P was the only sample where *Fragilaria pinnata* was clearly visible.

BH Q (Q3/P - 100-147)

Diatom preservation in this sample was also poor with a low to medium diversity assemblage of 12 species. Of these species *N. hungarica* dominated at 33.9%, followed by *M. varians* at 27%.

Environmental Tolerances of Diatom Species	Species Name	C3/P	P6/P	P7/P	P8/P	P9/P	P10/P	F4/P	G3/P	M1/P	M2/P	N8/P	N17/P	Q3/P
Mesohalobous (optimum brackish water)	***Nitszchia hungarica***		8.5	12.0	1.7	9.5	3.9	17.0	16.6	1.0	6.2	1.9	3.8	33.9
	***Surirella* ovalis**	3.5							1.3	1.5	1.2	1.9		0.5
Halophilous (optimum in slightly brackish water)	***Amphora ovalis***	1.1									1.2	2.8		4.8
	Cympatopleura solea							2.5	4.0					
	Melosira varians	0.3	16.6	29.7	12.0	9.1	29.9	25.2	13.9			2.8	44.5	27.0
	Navicula cincta		14.1	3.5	2.9	7.0	8.4			12.5	24.8			
	Navicula cohnii							1.9	11.3			1.4		4.2
	Navicula halophila	8.1						1.3	6.6	4.0	5.0			
	Nitszchia umbonata	4.3	16.6	20.8	43.0	7.9	11.2	2.5	3.3	8.5		5.6	5.5	
Oligohalobous (Freshwater with a tolerance of slightly brackish water)	***Achnanthese lanceolata***	3.8		4.2	2.3	9.1	1.7	9.4	2.0	13.5	5.0	1.4	5.9	2.1
	Achnanthese minutissima	5.4						6.3	2.6			1.4	4.2	
	Achnanthese saxonica	2.2	3.8	1.1				1.9	2.0					
	Caloneis bacillum	3.5			5.2	7.6	4.7			2.0			0.4	
	***Cocconeis* spp.**	2.7				1.8	0.6							1.1
	Cyclotella comta	0.8												
	Cymbella ventricosa	2.2												
	Diatoma vulgare	4.9												
	***Eunotia* spp.**						0.6						3.4	
	Fragilaria brevistraiata	0.5		1.1	1.7			1.3				1.9		
	Fragilaria construens	2.7												
	Fragilaria pinnata												1.3	
	Gomphonema angustatum	10.8				0.6		0.6		0.5			4.2	2.1
	Navicula capitata	1.6												
	Navicula radiosa	4.3					2.2	0.6	1.3		5.0	4.7	2.5	2.1
	Nitszchia palaea	9.7	0.9	3.9	5.7	3.0	1.7	1.9		3.5	17.4			
	***Pinnularia* spp.**	2.2	6.6	6.4	10.3	22.3	2.2	12.6	13.2	17.5		20.6	1.3	8.5
Halophobous (Freshwater)	***Fragilaria capucina***	1.1											5.1	
	Fragilaria virescens	5.9												
	Frustula rhomboides							0.6		1.5				1.6
	Navicula cryptocephala	3.2		2.5	5.2	0.6	2.8							
	Navicula cryptotenella	14.6	32.9	13.4	10.0	21.3	30.2	14.5	21.9	27.5	28.6	53.7	17.8	12.2
	Navicula sclevensis	0.8												
	Small Navicula			1.4						6.5	5.6			
	TOTAL %	100	100	100	100	100	100	100	100	100	100	100	100	100
	No. spp. present	25	8	12	11	12	13	15	13	13	10	12	13	12
	Diversity	Med-high	Low	Low-Med	Low-Med	Low-Med	Low-Med	Med	Low-Med	Low-Med	Low-Med	Low-Med	Low-Med	Low-Med
	Preservation of frustules	Excellent	Poor	Poor	Poor	Poor	Poor	Poor-Med	Poor	Poor	Poor	Poor	Poor	Poor

Table 3.1: The results of diatom analysis expressed as percentage counts. The number of species present, diversity and the preservation condition of diatom frustules is also marked for each sample. Note: In terms of environment, epilithic species are attached to rock, epipelic is soil derived, epiphytic is attached to plants and periphytic is living around plants.

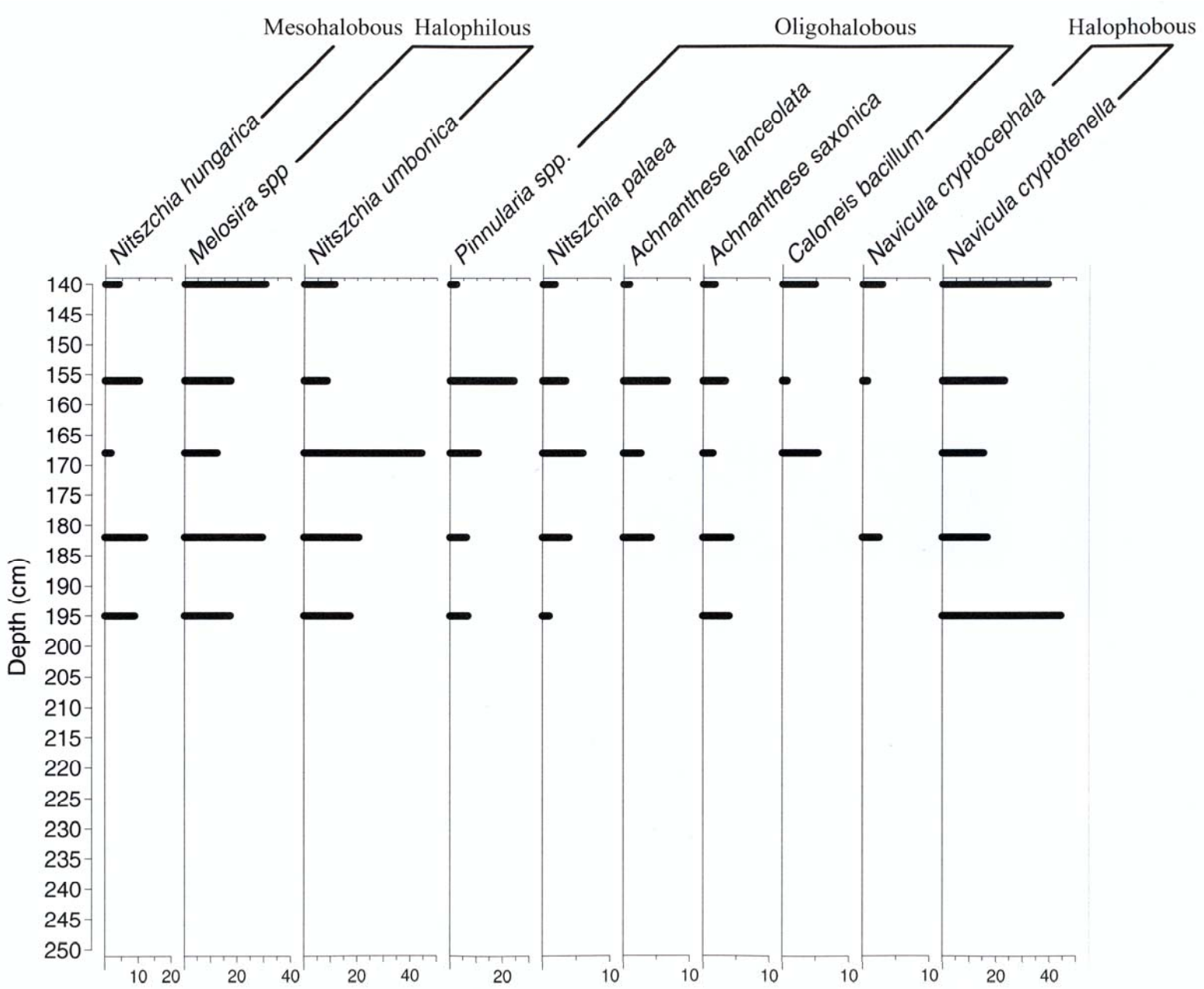

Figure 3.1: Analysis of samples from Borehole P – relative abundances and halobian preferences (see Table 3.1)

Finally, it should also be noted that, whilst there is a strong freshwater context in evidence in the samples, there are a broad range of non-planktonic species tolerant of slightly brackish conditions (Table 3.1, below). For instance, the presence of mesohalobian and oligohalobian species indicate the influence of dissolved salts on the diatom flora. The lack of marine influence (Nantwich is approx. 45km from the coast) suggests that samples with a high relative abundance of these latter species are directly influenced by the dissolved rock salts occurring in brine springs throughout the region (Penney and Shotter 1996). For example, sample Q3/P is dominated by *Nitzschia hungarica* (34%), samples P7/P and F4/P by *Melosira varians* and P8/P by *Nitzschia umbonata*. Although at low relative abundance, the presence of *Cympatopleura solea* and *Navicula cohnii* in samples F4/P and G3/P and *Surirella ovalis* in sample C3/P also indicates a salinity influence.

4 Discussion

4.1 Diatom analysis of samples taken from boreholes in the city of Nantwich has revealed two distinct categories of frustule preservation and sedimentary mineral content, corresponding to Zones 1 and 2 as determined by the preservation status of organic matter by PRS on behalf of SLR Consulting Ltd (Carrott *et al.* 2008). In terms of human impact and its effect on the sediment record, the results of this study have important implications for the *in situ* preservation of archaeological material.

4.2 In Zone 1, sample 3 from core C (C3/P), exhibited a low sedimentary mineral content which enabled clear assessment of species composition. Preservation of diatom frustules was of excellent quality, suggesting an undisturbed, post-depositional environment; even the more delicate species such as *Fragilaria capucina* and *Nitzschia palaea* were mostly intact. The diversity and frequency of diatoms was high (Table 3.1) with a dominance of *Navicula cryptotenella*, which is characteristic of British rivers and streams and was common in all of the samples from both Zones. There was a clear lack of planktonic taxa in this sample, and with the exception of *Cyclotella comta*, which was present at a low relative abundance of 0.8% and is more commonly found in shallow lakes or ponds with soils of high acidity, all taxa were benthic in nature and typical of fairly shallow, river habitats.

4.3 The character of the diatom assemblage was essentially freshwater, though some of the species present can also indicate brackish conditions (e.g. *Diatoma vulgare, Diploneis ovalis, Navicula halophila, Navicula sclevensis, Surirella ovalis*) suggesting either permanent, or the occasional influence of salinity, on the diatom flora (Table 3.1 above) (Cooper, 1999). The high proportion of periphytic and epiphytic forms (e.g, *Fragilaria*, *Cocconeis, Achnanthese, Navicula* spp.) also indicate a strong macrophyte influence on the diatom flora, which could suggest the presence of wetland areas where alluvial deposits are often prone to reducing conditions due to the anoxic nature of the sediments.

4.4 The presence of brackish water tolerant species in the samples from Nantwich is perhaps unsurprising given the fact that the Cheshire salt industry is based on the occurrence of thick Triassic rock salt beds which underlie a large part of the country (Penney and Shotter 1996:363). A salt production industry developed as early as the Iron Age in this region, in areas where the natural brine springs emerged at the surface under artesian pressure (*ibid*. 1996:363).

4.5 In Zone 2, when compared against sample C3/P from Zone 1, the diversity and frequency of diatom frustules in all of the samples was low (Table 3.1), with a high degree of frustules breakage. This situation can cause bias in the sub-fossil assemblage, and demonstrates a significant tendency towards the preservation of the more robust species (e.g. *Pinnularia* spp., *Melosira varians*). The differences in species composition between the samples could not be used to analyse differences in the immediate environment as there is a strong possibility that between-sample differences in breakage is occurring. Analysis of the full diatom assemblage was also inhibited by the extremely high mineral content, which is difficult to remove using standard techniques without further diluting the assemblage in the cleaning process, and probably introducing further bias.

Interestingly, and apparently in contrast to the geochemical data, the diatom samples from borehole N (N8/P & N17/P – Table 3.1), in the Weaver floodplain area, exhibit poor preservation and reduced species diversity in line with the general situation for all diatom samples from Zone 2. In addition, the palaeoenvironmental assessment of borehole N reports that preservation of waterlogged plant macrofossils was higher at this location than elsewhere in the study area, and that saturation occurred from *c*. 0.7m depth in the profile (Carrott *pers. comm*.). This suggests that the poor preservation occurring in samples N8 and N17 is not a reflection of the current *in situ* status of these samples, and may well reflect the conditions prevailing at the time of deposition of the diatom assemblage. However, the reported high sulphate/sulphide levels (depending on depth through the profile) may complicate this suggestion, as the diatoms may be more susceptible than the waterlogged plant macrofossil remains (Carrott *et al*. 2008:6 & 10) in relation to the specific geochemical composition of this depositional context.

4.6 Furthermore, the high mineral content of the samples in Zone 2 is likely to be implicated as a cause of frustules breakage; Flower (1993) states that dry, carbonate rich sediments, common in areas of human impact, are a major cause of diatom frustule fragmentation and that this can seriously bias the diatom record. When compared to the site map of borehole locations, it is clear that the high degree of breakage in samples from the east side of the River Weaver could be a direct reflection of human impact and the reworking of dry, mineral rich sediments.

4.7 The identifiable taxa in the samples from Zone 2 were all common components of freshwater assemblages, with species typical of river environments and particularly

characteristic of epilithic (e.g. *Gomphonema* spp., *Nitszchia* spp.) and epipelic (e.g. *Pinnularia borealis, Cymatopleura solea, Surirella ovalis*) substrates. The species *Navicula cryptotenella,* is in evidence, and whilst these species have little value in the assessment of specific environmental conditions, they do, unfortunately, dominate in the majority of the samples studied (e.g. M1, M2, C3, G3 and N8). Of the five remaining samples two (F4 and N17) are dominated by *Melosira varians*. This species is often found in slow moving waters, and has been found to increase during periods of flooding (Biggs, 2006). Its presence in diatom flora is also common under brackish conditions often reflecting estuarine conditions or, as noted for Nantwich, saltworkings (Juggins, 1992).

4.8 On the whole the sample from borehole C (sample 3) from Zone 1, reflects excellent potential for the *in situ* preservation of organic remains, and further analysis of samples from the boreholes on the western side of the river floodplain is recommended in order to reconstruct any through-the-profile changes in the diatom assemblage character, and examine the causes of the changes identified.

A consideration of the reasons for the marked variability between the west and east sides of the River Weaver floodplain, in terms of diatom preservation status, suggests that hydrological conditions to the east of the river (wherein water levels occur up to *c*. 3m+ below the modern ground level [Panter *pers. comm*.]) alongside increased urban developmental impacts, are resulting in compromised conditions in the burial environments studied. In addition, the geochemical data indicates that reducing conditions occur in the alluvial floodplain sequences associated with borehole C, and that LOI values reflect relatively high organic content in this area (Panter *pers. comm*.).

4.9 The strong freshwater component in these assemblages is likely to be associated with the river Weaver; many of the oligo-halophobous species are typical of river environments and their presence suggests either normal environmental conditions associated with river function, or freshwater inputs from stream run-off and other sources such as precipitation etc. As noted above, some of the species are tolerant of brackish conditions, however, these species are also influenced by substrate. *Pinnularia borealis* and *Cypatopleura solea*, for example, are diatoms associated with damp soil and it is possible that these species are derived from the surrounding substrate. Any attempts at inferring past salinity values for the samples would be tentative due to the poor condition of the samples, the weak statistical representation

of species in the dataset, and the lack of specific context in relation to brine springs and saltworkings.

4.10 Finally, it should be noted that the rationale for the selection of samples for the analysis undertaken in this report is influenced by pre-determined conditions in the burial environment. This has resulted in a biased dataset, against Zone 1, where more favourable *in situ* conditions are suggested by the analyses undertaken to date. In addition, and compounding this bias, it should also be noted that the analysis of random 'spot' samples does not enable a full assessment of either the diatom assemblage or the environmental conditions relating to deposition over time (i.e. through-the-profile), and as such the analysis of these samples only provides a 'snap shot' in time, as opposed to the more informative aspects of environmental change over time, which can influence the diatom record.

Similarly, no insights into the main depositional processes responsible for the composition of the diatom assemblages are forthcoming from this approach. Essentially, this problem is only partly solved by the assessment of borehole P, and as is demonstrated by the stratigraphy and state of preservation in evidence from this borehole (Figure 3.1), there may be changes in species abundance throughout a sequence, as a result of differential depositional environments and specific *in situ* conditions such as geochemical status, that are missed by spot sampling. Identifying these changes using through-the-profile studies may help to better explain changes in the immediate environment.

5 Conclusions & Recommendations

5.1 The diatom analysis presented above has provided an extremely useful technique for identifying the preservation status of sediments from a series of boreholes in Nantwich. The results obtained correspond with the two preservation Zones predetermined by the analysis of organic matter by SLR Consulting Ltd.

5.2 Based on the diatom record, Zone 1 demonstrates excellent preservation status and suggests that there is a good potential in this zone for environmental reconstruction, in order to assess environmental change and the potential influencing factors impacting on the diatom record (e.g. salinity, wetland vegetation). Although a full evaluation of the character of the diatom assemblage in Zone 2 was not possible, due to the high breakage factor in this zone, this information in itself provides important evidence of the preservation status of the sediments and the possibility of reworking due to human impact. However, it should be noted that the specific environmental conditions during initial deposition could be an influencing factor in relation to the generally poor preservation in evidence at these locations.

5.3 In conclusion, the analysis of diatoms from the depositional contexts at Nantwich has provided an effective indicator of sedimentary preservation status. In addition, the differences in preservation states between Zones 1 (west side of River Weaver floodplain) and 2 (east side of floodplain and urbanised area) would appear to suggest that important information pertaining to the effect of human impact on the burial environment, and consequently any *in-situ* remains, may be forthcoming from these analyses, i.e. preservation is better away from the settlement areas, and elevation and development in Zone 2 appears to be resulting in compromised burial environments.

5.4 Recommendations

- If the analysis of samples from Zone 2 is considered important, the application of other methods of preparation (e.g. flotation) could be applied in order to isolate the mineral faction. However, it should be noted that the high degree of breakage indicates that the removal of the mineral component (which utilises harsh chemicals) may not assist in the diagnosis of the character of the diatom assemblage to any significant degree.

- The nature of this study, i.e. pre-selected samples aimed at assessing *in situ* preservation status inhibits the application of a salinity transfer function as full, targeted through-the-profile analysis of areas with known brine springs and/or salt-

workings were not being assessed. In addition, borehole survey and limited pre-assessment in order to identify areas with good preservation conditions would enable a more useful study to be carried out. As such, alongside further investigation of borehole C from Zone 1 (or other boreholes from within the western areas of the River Weaver floodplain), the analysis of full sequences from known areas of brine springs and/or salt workings, with a proven abundant/good representation and preservation of diatom species, would be required in the future should the incorporation of a salinity transfer function be of interest. Such a targeted approach, to both sampling and analysis, would be of great value in helping to identify changes in the diatom assemblage, tolerances and external influences on the diatom flora. The through-the-profile analysis of borehole P (Figure 3.1) highlights the greater validity of such approaches.

- Furthermore, comparison of the diatom and plant fossil records from the river floodplain in Zone 1 would help to identify the presence of varying wetland contexts, thereby providing an indication of the potential for reducing conditions and the preservation of organic material. Similarly, the identification of the specific contexts of deposition associated with the samples studied from the eastern side of the Weaver floodplain would assist in the identification of the specific factors responsible for the compromised preservation status in evidence in the samples from Zone 2.

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