Historic England

Preserving Archaeological Remains

Decision-taking for Sites under Development

This guidance note has been prepared by Jim Williams (Historic England),
Claire Howarth (Mott MacDonald), Jane Sidell (Historic England),
Ian Panter (York Archaeological Trust) and Glyn Davies (ArcHeritage).

Please refer to this document as:
Historic England 2016 Preserving archaeological remains: Decision-taking for sites under development. Swindon. Historic England.

This edition published by Historic England October 2016.

HistoricEngland.org.uk/advice/technical-advice/archaeological-science/preservation-in-situ/

Front cover: The Rose Theatre
The red lights show the outline of the 16th Century building preserved beneath the current development.

Summary

This advice is for developers, owners, archaeologists and planners working on projects where the intention is to retain and protect archaeological sites beneath or within the development. It can also be read in relation to other land-use or site management work. It has a particular focus on decision-taking on waterlogged archaeological sites.

The emphasis throughout is on the benefits gained, both to sustainable development and the archaeological resource from understanding:

- the significance and current state of preservation of the archaeological material
- the potential development impacts of the proposed scheme
- (in relation to sites containing waterlogged archaeological remains) the availability and quality of water necessary to sustain the long-term future of those sites.

It also highlights the likely range of information needed to fully assess these issues and the benefits of pre-application discussion and assessment to promote a viable way forward for sustainable development on what can often be complex sites. Whilst particular sections of this document are focused on waterlogged archaeological sites, the core themes within this advice note, of prior preservation and impact assessment are relevant to all sites.

Additional methodological detail and technical advice is provided in the following appendices:

Appendix 1 – Case Studies
Appendix 2 – Preservation assessment techniques
Appendix 3 – Water environment assessment techniques
Appendix 4 – Water monitoring for archaeological sites
Appendix 5 – Materials for use in the reburial of sites

Contents

Introduction

The purpose of this advice note is to assist local authorities, archaeological and other consultants, owners and applicants when taking decisions about how the significance of archaeological remains can be sustained and managed through retention within a development, a process colloquially termed preservation *in situ*.

It is aimed at addressing two aspects of the decision-taking process:

- Understanding the state of preservation of archaeological material, as a contribution to the assessment of a site's significance; and
- Understanding the nature of potential impacts of a proposed development, to assist in the assessment of the degree of harm that might be caused to the site and its significance

There is a particular focus on waterlogged archaeological sites in this document because they are rare and in many cases nationally important. Decision-taking about these sites involves particularly complex issues as certain environmental conditions must be maintained to ensure the survival of waterlogged archaeological material. As a result there is often a higher requirement for information about the significance of these sites, and the degree of harm that development or other land-use change might cause. However, the main points of assessing the state of preservation and development impacts are relevant to decision-taking about the long-term future of all archaeological sites.

This document should be read alongside the *National Planning Policy Framework* – NPPF (DCLG 2012), the *Planning Practice Guidance* – PPG (DCLG 2014) and the Historic Environment Good Practice Advice Note on *Managing significance in decision-taking in the historic environment* – GPA2 (Historic England 2015a).

This present document (Preserving archaeological remains: Decision-taking for sites under development) acknowledges the primacy of relevant legislation, government planning policy in the NPPF and the related guidance given in the PPG, and is intended to support the implementation of national policy. It does not constitute a statement of Government policy, nor does it seek to prescribe a single methodology.

Although this document focuses on the decision-taking process associated with development management, it is equally applicable to other types of land-use change, such as change to agricultural practice or habitat management. Additionally, the technical appendices on preservation assessment, the water environment and monitoring will be relevant to the long-term management of sites where no development or land-use changes are occurring.

GPA 2 recommends that development discussions and subsequent applications usually benefit from a structured approach to the assembly and analysis of relevant information. The stages below indicate the order in which this process can be approached.

- Understand the significance of the affected assets
- Understand the impact of the proposal on that significance
- Avoid, minimise and mitigate impacts in a way that meets the objectives of the NPPF
- Look for opportunities to better reveal or enhance significance
- Justify any harmful impacts in terms of the sustainable development objective of conserving significance and the need for change
- Offset negative impacts on significance through recording, disseminating and archiving the archaeological and historical interest of the important elements of the heritage assets affected

Good practice for the most important sites, particularly waterlogged archaeological or complex deeply stratified urban sites, would ensure that the understanding of significance (the first stage of the process) is informed by an assessment of:

- the state of preservation of the site, its deposits and finds
- past disturbance / development and the impact this may have had on the site's significance

To assess the level of impact / harm that may occur on the most important sites, particularly waterlogged and/or other complex archaeological sites (the second stage of the process), it is necessary to understand:

- the nature, extent and significance of the site and its archaeological importance
- the proposed construction methods (for example pile design)
- for waterlogged sites, the availability and quality of water on site and in the wider catchment

These central themes covering the investigation of the state of preservation of archaeological materials and the deposits in which they are found, assessment of the potential impacts from construction, and assessment of water quality and availability are explored in the remainder of this document.

Understanding burial environments

To inform the assessment of significance it is necessary to have an appropriate understanding of the burial environment on site, since the survival of archaeological materials depends on the maintenance of stable below-ground conditions.

Archaeological materials are prone to biological, physical and chemical decay. Major factors which influence such decay are temperature, pH, and the presence of oxygen, water and micro-organisms (English Heritage 2012).

The survival into the present day of any given archaeological material depends on the burial environment in which it was first deposited. Some materials survive better in an acidic environment; others in an alkaline one. For example, pollen is preserved better in locations with acidic soils, while mollusc (for example snail shells) preservation is improved in an alkaline site (English Heritage 2011).

The most common inorganic materials (such as pottery and stone) survive in almost all situations, although low fired pottery is more easily damaged by mechanical forces and susceptible to water damage. Whilst bones are also fairly ubiquitous finds on neutral to alkaline sites, they are less commonly preserved on free-draining sand and gravel sites and on acidic (older, volcanic origin) deposits of the north and south west side of the country. The survival of metal is also influenced by soil type (English Heritage 2008); for example, in acidic sandy soils, iron objects are usually heavily corroded.

Almost all types of archaeological material will be much better preserved where oxygen is excluded, in saturated (waterlogged) deposits. In the absence of oxygen, most soil fauna (insects, moulds and micro-organisms) and fungi which feed on organic matter cannot operate. The corrosion of iron is also reduced in anoxic (lacking oxygen) environments.

Waterlogged archaeological deposits are not common in England and as a result, organic materials are relatively rare in the archaeological record (*see* Figure 1). They are of great importance for the information they provide about everyday objects such as drinking and eating vessels (wooden bowls, leather bottles, horn cups), clothing (fabric, shoes), modes of transport (boats, trackways) and equipment of subsistence (fishtraps). They are also the primary source of evidence relating to the natural environment in which human populations lived and of the plants which they consumed. Such evidence is less commonly recovered from dry sites.

To maintain the preservation of organic materials, it is essential that the conditions which contributed to their survival (waterlogged; anoxic) remain the same during and after any development. If waterlogged deposits dry out, oxygen will enter and degradation of organic remains will occur. More information on the survival of different archaeological materials is given in Figure 2 and Table 3. An introduction to soil chemistry is provided in Appendix 2.

> Within this advice note the terms deposits and finds are used as a convenient short-hand to describe all archaeological sediments, materials and environmental remains recovered from archaeological sites.

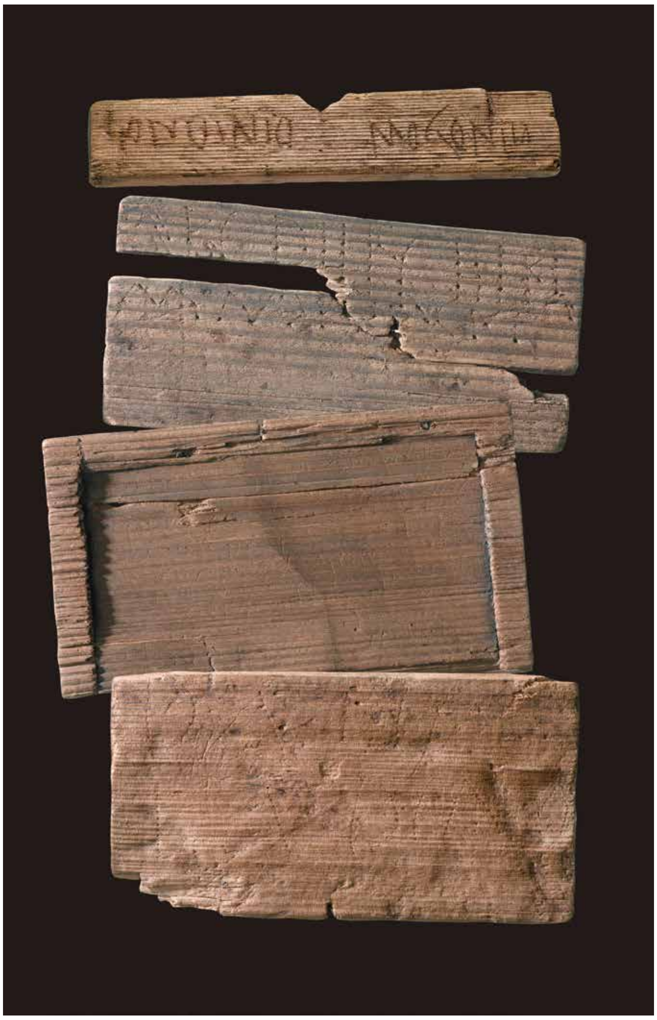


Figure 1
Roman wooden writing tablets preserved within an urban waterlogged deposit.

Understanding preservation and harm

The assessment of the state of preservation and possible impacts is best progressed through a series of managed stages regardless of whether the driver for the work is development, land-use change (for example as part of an agri-environment scheme, or integrated land management project), or the management of a known wetland site.

At an early stage it may be clear that the harm to archaeological remains is too great to ensure their continued conservation, or that potential harm to their significance is outweighed by public benefits in the NPPF planning balance. In these cases, negative impacts on significance are best offset through an appropriate level of archaeological investigation proportionate to the relative significance and potential of the site.

Equally, it may be obvious from the outset that the site is likely to be of such significance that the applicant must avoid or minimise any harm to that significance by designing their development in order to ensure the continued conservation of the site (that is preservation *in situ*). In these cases, it is advantageous to follow a series of actions, which include:

- Early consideration of how the site or area of significance will be retained and managed as part of the development / land-use change (*see* Section 1)
- Staged preservation assessment and characterisation of environmental conditions of deposits – with more information at each stage of assessment (Section 2)
- Continuous process of evaluation of potential development impacts (Section 3)
- Staged assessment of water levels, quality and availability (Section 4)
- Final assessment of available information and decision-taking (Section 5)

More information about each of these actions is described in the following chapters, with further supplementary detail (for example techniques of assessment and monitoring) provided in the relevant appendices.

1 Early Engagement

It is good practice for pre-application discussions to be held by the applicant or their archaeological consultant / contractor with the local authority's archaeologist at the initial phase of any development led project. Where pre-application discussions are not held, the applicant runs the risk that pre-determination requirements for desk-based assessment (DBA), and for evaluation, including work to assess the state of preservation, may have an impact on timescales for submission and determination of any planning application. The local authority's archaeologist will also be best placed to advise on any specific local planning policies relating to the historic environment. Early and thorough pre-application discussion is therefore in the best interest of the applicant as well as those managing the archaeological resource.

At the point at which pre-application discussions are held, basic information about the site and development proposals should already be known. An archaeological contractor / consultant familiar with a county or a city is likely to have a reasonable idea of the archaeological potential of an area (and should consult the HER (Historic Environment Record) and the Local Authority Archaeologist (LAA)). The applicant should ensure that the proposals are clear in outline form (for example office; housing; distribution centre), even if the exact design details are not yet known.

In some urban locations, particularly towns and smaller cities, development economics have in the past encouraged developers to propose schemes which retain the archaeological sites beneath them from the outset. This is because the potential cost of excavation and post-excavation of large quantities of archaeological material may be greater than the funds available.

Whilst such a 'lowest cost' option might initially seem to be attractive, it is essential that the significance of archaeological deposits and their state of preservation are fully understood, and harm adequately assessed. This provides sufficient information for decision-taking, and helps to minimise the risk of unexpected impacts and costs later in the process.

Another aspect that needs to be considered is the indirect impact the proposed scheme may have on adjacent or even more remote sites. For example, change to the hydrological regime could affect the conservation of adjacent areas of archaeological significance, which are not part of the development site itself.

Questions that all parties should be trying to address at this early stage include:

- What is on site?
- Is it designated?
- Is it potentially nationally important?
- Is it potentially complex?
- Is it potentially waterlogged?
- What was the impact of past development or land use, (including contamination)?
- What impacts will the proposed development / land-use change have on the site's significance?
- Will the proposal have an indirect impact outside the development site?
- Are the archaeological costs / risks likely to be high?
- Is the project viable in its current state?

Even at this early point in pre-application discussions it may be relevant to refer to advice on construction impacts, as summarised in section 3, including Historic England advice on *Piling and archaeology* (2015c) and more general documentation on the mitigation of construction impacts (Davis *et al* 2004).

The pre-application discussions described above are likely to result in one of the following outcomes:

- The original development / land-use change proposal is deemed unviable. Either no further work takes place or the scheme is re-designed to avoid harm to the site's significance.
- The development / land-use change proposal may be viable, and further information collection / pre-application work needs to take place in advance of the determination of any planning application.

This additional pre-application work is likely to include:

Further discussion with the LAA – it is essential to involve them in discussions early and throughout the process.

Commissioning desk-based assessment and non-intrusive surveys – in addition to identifying presence and significance of archaeological remains, the Desk-Based Assessment (DBA) can begin the process of preservation assessment (*see* Section 2 below). Standards and guidance for DBAs are provided by the Chartered Institute for Archaeologists - CIfA (2014a).

Archaeological assessment of geotechnical borehole logs, land quality assessments and hydrological studies if available – work by geotechnical specialists which can be used to provide further below-ground information, for example on water levels, and survival of organic material, such as peat.

Archaeological observation of geotechnical or land quality test pits.

Where justified by the significance of the site and scale of the development, the LAA may produce a brief for evaluation on site. This evaluation could begin with trial trenching, or in complex areas, may be preceded by a bespoke geoarchaeological assessment to begin to characterise below-ground deposits before excavation takes place. It is advisable that all evaluation work is completed before submission of the planning application (that is pre-determination evaluation) so that the local authority has sufficient information on which to determine the application.

A Written Scheme of Investigation (WSI) or specification for the work is produced by the archaeological contractor, for agreement by the LAA. For sites where continued preservation has already been the focus of pre-application discussions, it is good practice for the WSI to contain specific sections setting out the types of preservation analysis which will be undertaken in the evaluation. If the retention of archaeological remains within the development (that is preservation *in situ*) is not considered at this early stage, new discoveries during the evaluation may result in a reassessment of project priorities, and require additional work / sampling to be undertaken to support preservation assessment.

Table 1 sets out a series of project planning phases for sites where the continued conservation of archaeological remains (ie preservation *in situ*) has been identified as the most appropriate way to meet the objectives of the NPPF. It shows how these actions fit within the conception, undertaking and completion of a project, whether that is part of a scheme of development / land-use change or long-term site management. The project planning phases (based on MoRPHE (*Management of Research Projects in the Historic Environment*), Historic England 2015b) are also included.

It is recognised that tasks identified in Table 1 are not always undertaken, or do not always occur at the times recommended. It is, however, the purpose of this document to recommend good practice; adherence to this advice is likely to result in fewer delays and potentially lower costs as a result.

Planning process stages	Project phase (from MoRPHE)	Tasks
Pre-application	Start-up	▪ Pre-application discussions between developer and local authority archaeologist, including potential to retain site within development ▪ Rapid review of significance and harm ▪ Decision to withdraw proposals, amend scheme and/or collect further information ▪ Issue of brief by LAA for DBA / geoarchaeological study / evaluation excavation
Pre-application	Initiation	▪ Written scheme of investigation (WSI) / specification produced ▪ Relevant specialists contacted to provide input to WSI / advise on site ▪ Preservation assessment techniques integrated into site and analysis methodology
Pre-determination	Project execution/ fieldwork	▪ Adequate investigation and recording of site ▪ Sampling of key materials and deposits on site (including possible specialist involvement)
Pre-determination/ Pre-commencement	Project execution/ assessment of preservation and harm	▪ Specialist analysis of materials and deposits for preservation assessment (as part of regular assessment of potential) ▪ Assessment of water availability, quality and stresses to understand potential impacts on sites containing waterlogged material ▪ Reporting of state of preservation and water environment information ▪ Consideration of impacts of development
Pre-commencement/ Post-excavation	Project execution/ mitigation	▪ Decision on whether site can be successfully conserved within the development, design of any mitigation and management schemes, possibly including monitoring ▪ Review of effectiveness of mitigation scheme, ie monitoring results

Table 1
Preservation and harm assessment project planning tasks.

1.1 Pre-determination evaluation

It is good practice when undertaking evaluation excavations to ensure that the horizontal and vertical extent of the area containing archaeological remains is investigated and adequate samples taken to characterise the archaeological remains present in sufficient detail.

This, in turn, will help to inform the understanding and assessment of any potential harm resulting from the development proposals. Evaluation of areas within the development site but outside the footprint of any proposed buildings can assist with micro-siting, which is a useful way of managing potential risks to those parts of the site of greatest archaeological significance.

Where it is possible or probable that the site will be retained within the development, preservation assessments should apply to those materials and deposits (including human remains, waterlogged wood and peat deposits) which contribute to the site's significance.

The decision to halt evaluation without fully characterising the site would need to be justified. In some situations, it may be appropriate to stop once the formation level of a proposed development has been reached. However these instances need to be considered carefully, as it will often be necessary to understand these lower deposits and the archaeological materials they contain, in order to assess any physical or hydrological impacts on them, as a result of being integrated within a development.

In all cases, the amount of evaluation work undertaken should be proportionate to the importance of the site affected and the impact of any proposed development on its significance. The extent of intrusive investigations also needs to be balanced against the need to maintain, as far as possible, the archaeological integrity of the deposit (including taking into account the risk of prolonged exposure of waterlogged remains to oxygen).

Additionally, it is good practice for consideration to be given to the need to ensure that all aspects of the archaeological programme can and will be progressed, including archiving, in the event that a planning application is refused. LAAs and contractors will need to reflect on these issues on a site by site basis.

Recommendations in this advice note do not represent a substantial departure from current evaluation practice. The CIfA *Standard and guidance for archaeological field evaluation* (2014b) identifies 'state of preservation' as one of the items of information that result from a field evaluation. This advice builds on those standards, highlighting the need for material to be more routinely sampled for preservation assessment at the evaluation stage to inform an understanding of the site's significance.

To ensure that sufficient budget and time is allocated to preservation assessment, the earlier it is identified in the evaluation process and included within WSIs, the easier it will be to integrate it seamlessly into current practice. This comes back to the amount of prior information collected and available at the time that the WSI is produced.

1.2 Timetabling preservation assessment and water availability studies

Where the evaluation has confirmed or established that the site is of complex significance and/or high importance, specialist examination of materials to assess their state of preservation is needed to inform discussions about the potential harm to the site from the proposed development. Specialist work following evaluation might sometimes take place a little while after the site work has finished, but to assist rapid decision-making, may need to be brought forward so that results can feed into planning decisions. Methods and techniques of preservation assessment are provided in Section 2 and Appendix 2.

If evaluation has shown that the site contains waterlogged deposits and artefacts, then as the preservation assessment progresses, it is best for work to also begin on assessing water availability and water stresses, *see* Section 4 for more details.

1.3 Unexpected discoveries

Despite good project planning, important and well preserved archaeological remains may turn up unexpectedly during an excavation, where the initial intention was to address the harmful impacts on significance through recording, disseminating and archiving the archaeological interest of the site. These newly discovered remains may be important enough to warrant conservation in their current location rather than excavation.

Equally, perhaps due to the unforeseen complexity of a site, the costs of excavation, post-excavation analysis and conservation may be greater than had been set aside for the project and on-site retention is the only potential option. In both of these circumstances, it could be possible for the site to be retained as part of the development. However, it would require the same assessment steps described above to be followed within a shortened time frame.

1.4 Long-term management of known wetland sites

This advice note is predominantly aimed at land-use changes for sites being considered within the planning process, or in other land-management contexts. Nonetheless, the methods and approaches outlined in this document and its technical appendices are also relevant for those wishing to investigate and understand further the state of preservation of known wetland sites, and to measure the success of any measures designed to prolong their survival.

Those undertaking projects of this nature may find it helpful to follow the project planning stages set out in MoRPHE (Historic England 2015b) or similar project management guidance. This begins with a project proposal, is followed by a review stage to consider the proposal and then the initiation of the project, starting with a detailed project design phase. Similar information about the site should be collected as is suggested above. This includes prior information about the site, its significance and state of preservation, as well as any existing data on current or past water levels.

Once the project design is finalised, the project execution stages can then be carried out, which might include some form of intrusive evaluation (to locate the site and recover samples for preservation assessment), an assessment stage (including the preservation assessment), as well as an examination of water availability and water stresses in the local area. A balance will need to be found between the threats of introducing oxygen and pathways for oxygen ingress during intrusive evaluation, versus the benefits of gaining valuable data about the deposits though such investigative work.

Having collected this information, it may be the case that water levels on site do not currently provide sufficient protection, or that water quality issues mean the site is at risk of deterioration. If the state of preservation of the site is good enough to sustain further burial, then mechanisms need to be sought to improve the burial environment. The importance of fully understanding the whole water environment (and not just water levels directly adjacent to the site) should not be underestimated. The advice of hydrogeological specialists in assessing the feasibility of these sorts of issues has been shown to be beneficial (*see* case study on Flag Fen in Appendix 1).

Sometimes, it is not feasible, or financially possible to alter the water environment on site. In this case, final excavation may be necessary, as has occurred at Star Carr (Conneller *et al* 2012) and was recommended for some sites covered in the Monuments at Risk in Somerset's Peatlands project (*see* Appendix 1).

2 Preservation Assessment and Deposit Characterisation

Archaeological sites, deposits and artefacts, particularly if they are well preserved, are sensitive to change. To be able to consider the potential harm of any proposed change, it is necessary to understand the current state of preservation of archaeological remains, and that of the deposits in which they are buried. Without this information, it is not possible to understand fully the impacts that development or other land-use changes will have on current burial conditions and thus the site's significance.

Assessing particular key materials will provide clear evidence of their current state of preservation and potential to sustain a further period of burial. Analysis of the deposits containing these significant finds identifies if suitable below-ground conditions for preservation exist and demonstrates how far, above, below and around, these conditions extend.

Various opportunities exist to collect information about the state of preservation of sites and artefacts during the DBA and evaluation process. This includes information from past excavations, geotechnical, hydrological and land quality data, as well as from adjacent sites and the wider landscape. Once on site, simple observations may provide basic data: for example, the presence or absence of particular materials, or whether the site is waterlogged, or if present, peat is well preserved or humified (has dried out and degraded). Some advice about simple on-site assessment techniques is given below.

However, most assessment work will need to be carried out by appropriately qualified specialists, working on samples and artefacts retrieved from evaluation excavations. Detailed techniques for the laboratory analysis of bone, wood, metal, fabric and leather, waterlogged plant and invertebrate remains, and sampled deposits (soil analysis) are described in Appendix 2.

2.1 Selection of techniques

Not all of the preservation assessment methods described below need to be carried out on every site. The choice of technique will be guided by the significance of the site and the proportionality of analysis to that significance, as well as available material, specialists and timescales. On many sites it will be clear at an early stage of field work or laboratory analysis that neither the significance nor the state of preservation of the site justify detailed preservation assessment.

Conversely, for very complex sites, a range of techniques may be needed; undertaking this work will need to be carefully planned to ensure that sufficient time is available.

2.2 Preservation assessment in desk-based assessments

Even before on-site work takes place, it should be possible to build a picture of the significance of the site and its state of preservation from information routinely collected for desk-based assessments, as is shown in Table 2 below. It would be good practice for this information to be summarised in a specific DBA report section on 'state of preservation' so that it is easily seen and readily accessible.

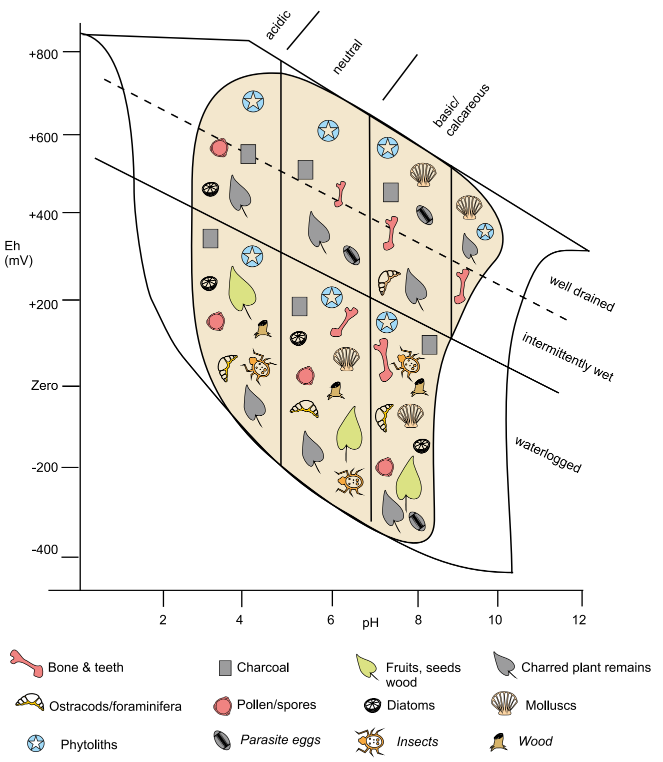
The differential survival of materials within different geologies, soil types and levels of waterlogging is outlined in the introduction above (Understanding burial environments). Using this information and that contained in Table 3 and Figure 2, it should be possible to suggest the types of artefacts that might, in usual circumstances, be present and make judgments about whether or not any parts of the site might contain waterlogged deposits. Collecting this information will not just aid decision-taking as part of any planning application/EIA submission, but will also assist with project planning when the on-site evaluation work begins.

Some of these assumptions could be further tested by a preliminary stage of borehole survey before evaluation takes place, with data drawn together to create deposit models to visualise the below-ground environment and predict how conditions might vary across the site.

DBA sources	Possible information relating to a site's state of preservation
Topography	Is site at the top of a hill (might be dry) or in a river valley (could be wet)? Are there natural springs nearby?
Solid / drift geology & soils	Geology and soils influence pH, and therefore the potential range of materials present on site
Borehole / geotechnical data	Below-ground deposit classification; some indication of past waterlogging eg presence of peat, or fine grained deposits like silts or clay
Existing water monitoring, ie Environment Agency, Internal Drainage Boards	Current water table + records which would indicate past water table fluctuations
Previous archaeological excavation in the area	Range of materials likely to be present; if site use / history is similar to previous site, may be a guide to possible condition

Table 2
Sources of information already collected at Desk-Based Assessment stage and the information they might yield relating to site and artefact preservation.

Burial environment	Main soil and sediment types	Some typical situations	Materials that may survive
very acid pH below 5.5, oxic	podzols and other leached soils, drained peatlands	heathlands, upland moors some gravels	Metalwork is heavily corroded and organic materials may be preserved by metal salts, or as a soil stain. Pollen, spores, and phytoliths may be present.
slightly acid to neutral pH 5.5-7.0, oxic	rendzinas (but can be acid in the topsoil) lake marls, tufa, alluvium, shell-sand	clay vales and lowland plains	Depending on the circumstances of burial, metalwork, bone, antler and ivory, molluscs, ostracods, foraminifera can survive in these conditions. Pollen and spores (rarely).
basic pH above 7.0, oxic	brown earths and gleys, river gravels, alluvium	chalk and other limestone	Metalwork is well preserved, as well as bone, antler, ivory, molluscs, and spores. Wood, leather and textiles are rare.
acid to basic, anoxic	peats and organic deposits, eg lake sediments and alluvium, gleys	some well-sealed stratigraphy, including organic urban deposits, wetlands, river floodplains, wells, wet ditches, upland moors	Leather, wood and bog bodies are preserved to differing degrees. Bone and similar materials are only preserved in alkaline environments, although collagen can survive in slightly acid soils. Metalwork can be well preserved, sometimes with uncorroded surfaces. Waterlogged plant remains, insects, molluscs, ostracods, foraminifera, pollen, spores and diatoms.
acid, anoxic	as above	as above	Animal fibres, silk, wool will survive in an acidic but not basic anoxic environment.
basic, anoxic	as above	as above	Plant fibres, flax, hemp will survive in an basic but not acidic anoxic environment.



Schematic representation indicating under which depositional environments specific categories of environmental remain can be expected to survive and hence be recovered using appropriate sampling techniques.

Filled area = envelope into which most naturally derived sediments fit. Material outside these limits tends to reflect human activity, eg. basic slag and other industrial deposits.

Modified from Retallack, 1984

Table 3
Survival of metals and organic materials in different soil conditions (Adapted from English Heritage 2011 and 2008).

Figure 2
Different depositional environments and the organic materials that survive in them.

2.3 On-site preservation assessment

As the state of preservation of sites can vary considerably over short distances, it is important that intrusive evaluation gains as complete an understanding of the archaeological remains as is possible. This needs to include:

- the vertical and horizontal extent of the archaeological remains
- the range (materials and date) of archaeological remains
- the significance of the site, and/or specific elements of the archaeological or palaeoenvironmental assemblages (for example highly significant metal finds or an important pollen sequence)

The past practice of evaluations stopping at the top of 'significant' deposits rarely allows for proper assessment to take place, so is not considered good practice, as these deposits will usually need to be investigated to characterise their significance and so that samples can be taken for preservation assessment.

Once fieldwork starts, assumptions made in the DBA, WSI and deposit models about the possible state of preservation, range of materials and environmental condition of the deposits can be tested through a series of questions.

Firstly, what range of materials is present? Figure 2 shows the types of remains likely to survive in different burial environments. At a very basic level, the presence and thus survival of materials will provide some information about the nature of the burial environment. For example, the presence of wood or other organic remains might suggest that the deposit is waterlogged or has been so some time in the recent past. Further examples of classes of material likely to survive in different burial environments are given in First Aid for Finds (Watkinson and Neal 2001).

Secondly, what is the general state of preservation and vulnerability of the archaeological material that has been excavated?

- Is the bone in good physical condition, or does it show signs of surface delamination/cracking etc?
- If wood is present, is it firm to the touch, or squishy and distorted? If present, are tool marks well defined? Is the wood cracked and dry?
- If iron objects are present, are they heavily corroded or is surface detail still visible?

It is important to remember that the state of preservation of any material reflects not just the current burial environment, but past below-ground changes, as well as the condition of the material before burial and the burial environment into which it was deposited.

2.4 Characterisation of environmental conditions of deposits

During fieldwork, information about site preservation may also be revealed through study of the deposits. Most obviously, the absence of any organic materials (including palaeoenvironmental material) or high degrees of damage to artefacts (heavily corroded metals, fragile bones etc) would suggest the preservation potential of the deposits was low. Conversely, the presence of peat or other organic-rich deposits indicates that at least parts of the site are waterlogged, or have been in the recent past (last 10 to 20 years perhaps). On site, it may be possible to see in section which parts of organic deposits are still regularly waterlogged, or whether there are parts in the upper levels where the organic deposits have humified (dried out and disintegrated) and no longer hold water. In low permeability sediments (such as clay which has small soil pore spaces through which water moves slowly) preservation can occur above permanently waterlogged deposits due to capillary action. This is explained further in Section 4 (*see* soil moisture).

Simple observations on site

It may be possible to see a colour change in organic deposits when they are first exposed. This occurs, for example, when fresh peat comes in to contact with oxygen in the air and oxidises. Peat deposits exposed in fields (or bags at the garden centre) appear quite dark and friable, but when it is fresh, it will be much wetter and can be a lighter colour (*see* Figure 3).

If no colour change occurs at all, the material may have already oxidised; it is therefore possible that these deposits are no longer waterlogged and oxygen has already entered the soil. If, on the other hand, a colour change from light to dark is seen, one can conclude that oxygen has not yet penetrated these deposits and that the peat and other organic components could be well preserved.

In clayey, and sometimes even sandy deposits, reducing conditions are recognisable by a blue-grey colour as opposed to yellowish/orange-brown soil colours found in oxidised horizons (if iron is present). In reducing conditions (when sulphides are present), the soil may turn jet-black (Huisman and Deeben 2009).

Figure 3
Fresh peat from Lower Lancarrow, Cornwall.

Smell can also be a useful indicator of below ground environmental conditions and organic preservation (Riksantikvaren 2012). Sometimes when waterlogged deposits are first exposed, cores taken or water samples recovered from boreholes, hydrogen sulphide (H_2S) is smelled. H_2S is produced when organic matter is decomposed by sulphate-reducing bacteria. The bacteria derive energy from oxidising organic molecules by reducing sulphur or sulphate to hydrogen sulphide. This reaction takes place in the absence of oxygen, so any deposits which have a H_2S smell (rotten eggs) are anoxic (lack oxygen). The rate of anoxic decomposition of organic matter is normally low.

On the other hand, the absence of a H_2S smell in organic deposits does not mean that the deposits are not anoxic; merely that sulphate reducing bacteria are not active, or that their activity has not led to the production of H_2S gas at detectable levels.

Whilst these basic on-site methods can provide a starting point for understanding the environmental condition of the deposits and possible state of preservation of any archaeological or palaeoenvironmental materials they contain, they may need to be confirmed by further specialist assessment or site visits.

2.5 Recording peat and other organic-rich deposits

Peat and similar organic deposits are not usually encountered on archaeological excavations, and the context recording sheets of some archaeological contractors may not contain all of the information needed to assess complex waterlogged sites. Where a more detailed recording system is needed, the record sheet at the back of Appendix 2 could be used.

2.6 On-site review

Before any evaluation excavation is completed, it is important to think about whether sufficient material has been recovered from the site for preservation assessment, or if further sampling is needed. For example, where waterlogged deposits have been encountered, have samples been taken across the horizontal and vertical extent of the site? Equally, where an assemblage of human remains and associated samples have been recovered for assessment, has the excavation and sampling been conducted to take into account potential variation in preservation across the site (again, horizontally and vertically)?

Whilst it is easier to know that samples for preservation assessment will be needed if discussions about the retention of the site as part of the development (that is preservation *in situ*) have already taken place before the evaluation excavation, if nationally important and potentially unexpected material is revealed by excavation, the option of preservation *in situ* should be brought up as soon possible, and the WSI/specification for the evaluation adapted accordingly.

2.7 Post-fieldwork review and detailed preservation assessment

Following fieldwork, and initial assessment, it may already be clear that the immediate post-depositional environment into which artefacts were deposited was not conducive to their long-term preservation. In these instances, where organic materials don't survive, metals are absent or highly corroded, and only the most robust archaeological materials are present, detailed preservation assessment is unlikely to be necessary. Exceptions to this may occur where development or land-use change will result in changes to the water environment (wetter or drier; changes to groundwater chemistry) or an increase in loading (*see* next section) which might cause currently stable materials (bone, corroded metals) to deteriorate further. Where this type of site retains sufficient significance to justify its retention within the development (or other scheme of land-use change), then preservation assessments may be appropriate.

In other instances, excavation and analysis will highlight that although a wide range of archaeological materials had survived the burial process, subsequent (most likely, recent) changes have caused them to deteriorate and they are now in a poor state of preservation. Where deposits that were once well preserved are now dry and humified and archaeological materials degraded, it is probable that the site's former significance will be much reduced. Further detailed preservation analysis will not usually be necessary (except where it forms part of existing post-excavation assessment and analysis procedures, that is assessment and reporting of the state of preservation as part of archaeological conservation work).

For development schemes, attempting a further period of burial of this deteriorating material as part of the development (or other type of land-use change) may lead to further loss of information. In these instances, excavation to retrieve the remaining information and evidential significance of the deposits is likely to be best option. Where there is no potential for immediate excavation, temporary mitigation measures to reduce the rate of degradation may be appropriate, but must only be seen as short term measures.

Where substantial degradation has taken place and nothing of significance survives, the value of further excavation will need to be carefully assessed.

Conversely, there will be occasions where well preserved archaeological material and environmental deposits are present on some, or all, of the site; the state of preservation of archaeological remains on any site is rarely uniform and can vary both horizontally across an area as well as vertically through a sediment sequence. One type of material may be well preserved whilst another may be in a poor state of preservation.

In these cases it will usually be necessary to carry out further, more detailed assessment of sediments and the preservation of the archaeological and palaeoenvironmental materials that they contain, before making a final decision about the significance of the site and the potential harm that could be caused by the development. More detail on appropriate techniques and the information they provide is set out in Appendix 2. As was highlighted above, in accordance with the NPPF the level of detail of these preservation assessments should be no more than is necessary to reach an informed decision and be proportionate to the significance of the site affected and the potential impact on that significance.

3 Identifying Impacts

The main site development and land-use changes likely to cause harm to the significance of archaeological remains arise from the following activities:

- Construction
- Mineral extraction
- Water extraction
- Farming (including land drainage and the use of agrichemicals)
- Habitat creation and management
- Flood risk management

Construction impacts on archaeological sites are described in detail in the volume 'Mitigation of construction impacts on archaeological remains' (Davis *et al* 2004), *see* Figure 4. This report identified four stages of the construction process for which impacts were likely to occur. These stages and a summary of the likely operations carried out at each stage are shown in Table 4. Such activities can result in both physical and hydrological changes, discussed below.

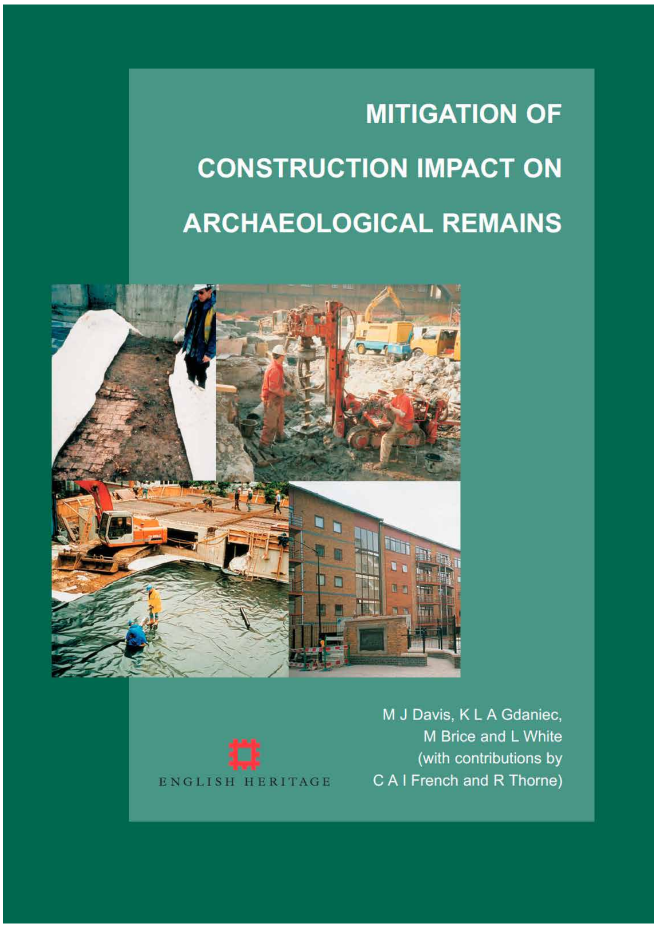


Figure 4
More information on construction impacts is provided in this report.

Table 4
Construction stages and operations (after Davis *et al* 2004).

Stage		Summary of operations
1	Pre-construction ground investigation	Intrusive geotechnical / geochemical ground investigation
2	Pre-construction activities	Engineering operations to prepare site for constructions, including removal of obstructions and ground stabilisation; construction of piling mat, installation of retaining walls
3	Construction activities	Excavation, foundation and buried service installation; construction of embankments
4	Post-construction remedial and maintenance activities	Intrusive operations relating to the repair, maintenance and improvement of any site

3.1 Excavation

Removal of soil by excavation for construction, mineral extraction, habitat creation, landscaping, ditch digging etc removes archaeological deposits and any protection that the soil provides to deposits buried below, or in adjacent areas. It is not just the impact of the excavation itself that needs to be considered but also the potential impact of the machinery (*see* Figure 5).

3.2 Piling

Piling causes impacts in the footprint of the pile (as shown in Figure 6) and depending on the type of pile used, may cause damage to the adjacent area of up to four times the area of the pile. The grouping of piles in clusters has the effect of making the area within the pile group inaccessible to future investigation and is thus equivalent to the total loss of this material. Pile probing (using a machine to test for obstructions) can also cause high levels of often uncontrolled damage.

Figure 5
Construction vehicle load and rutting from wheels can cause damage to archaeological deposits.

Some harm to archaeological deposits through piling may be seen as a necessary trade-off to ensure the remainder of the site can be retained beneath a new development. In these cases, detailed consideration should be given to the siting of these piles away from those areas of the site which are of greatest importance. To be able to take decisions about suitable locations for piling it is therefore necessary to have sufficient understanding of archaeological remains present on site. Piling impacts on archaeological sites are covered in more detail in the Historic England advice on Piling and archaeology (2015c).

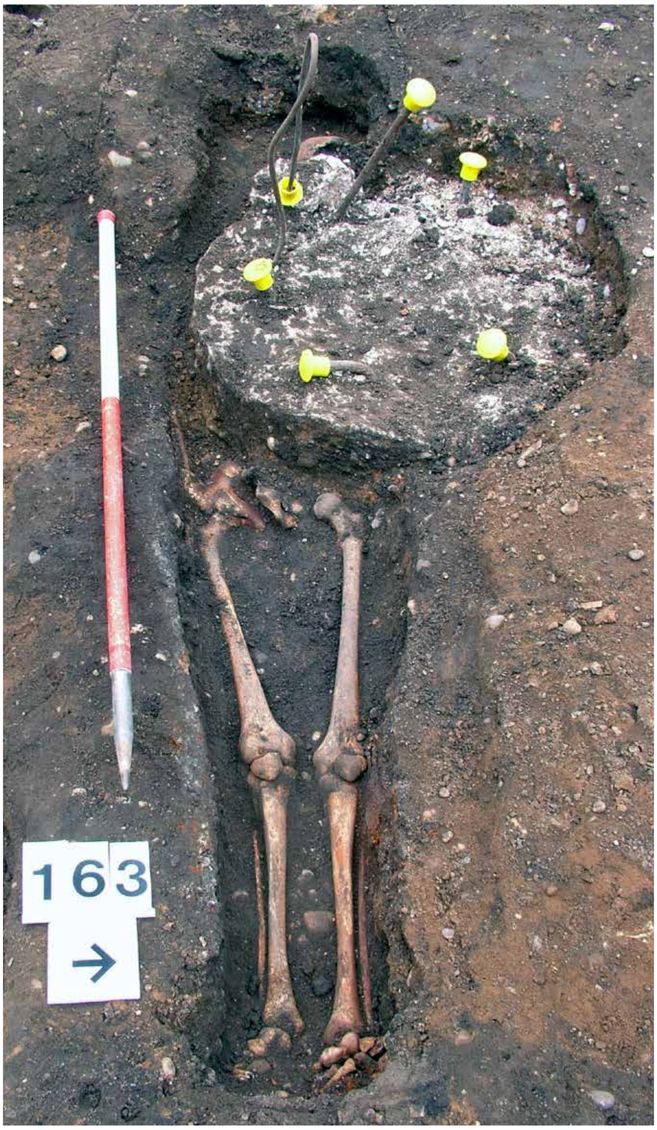


Figure 6
Piling can cause considerable impacts to archaeological remains.

3.3 Imposed loads

Construction of buildings and embankments, and heavy vehicle tracking (including in arable cultivation) can cause significant loading and potentially lead to sediment deformation and damage to artefacts. Some valuable research on loading impacts on archaeological remains has been carried out in the last ten years (Sidell *et al* 2004; Hyde 2004) and this is an area where further observations, research and synthesis could be undertaken.

As the design stage progresses, developers and their engineers will start to collect the information they need to understand how deposits below their buildings or embankments will perform. They will be able to calculate the amount of deposit consolidation (compaction) that they expect to occur within the different soil horizons. These figures will assist decision making as to the potential impact of that load on any buried archaeological material present.

3.4 Hydrological impacts

Changes to water levels have the potential to cause the greatest level of harm to waterlogged archaeological sites. To ensure their long-term survival, waterlogged archaeological sites need to remain waterlogged year round. This significantly reduces the diffusion of oxygen required for most bacterial decay and aerobic corrosion reactions. The following section outlines the key hydrogeological threats, termed 'stresses' and explains how they can be investigated.

4 Water Availability and Stresses

This section is relevant to waterlogged archaeological sites (and those sites with limited localised waterlogging) where it is the intention to retain the site within and/or beneath the development and proactively manage it for the future (that is preservation *in situ*).

At the same time that preservation assessment work begins and as soon as waterlogged deposits are encountered during evaluation (or their likely presence flagged by the DBA), work should begin on assessing the water availability and water stresses for the site. This will demonstrate whether there is sufficient water available on site (and of a suitable quality) to sustain waterlogged deposits in the long-term. This is particularly important if land-use or development plans involve or are likely to cause changes to the local hydrology. The study of water environment systems, as the local water regime is termed, is discussed below. Details of the assessment methods needed to understand these water environment systems along with additional definitions of terms used in this section and extended case studies can be found in Appendix 3.

4.1 Water environment stresses

Given the right environmental conditions, archaeological features that lie buried beneath the water table can remain in a stable condition for many years. However, they are susceptible to rapid deterioration if the water table is lowered for a significant length of time. Lowering the water table not only changes the moisture and oxygen content of the soils but can also induce changes in redox, pH and temperature. These changes in turn influence other chemical and biological processes.

To promote the long-term preservation of organic material and also to reduce corrosion on metals, groundwater should be **reducing** rather than oxidising, and usually between **pH5 and pH8**. More information on these terms and other aspects of soil and water chemistry is provided in Appendix 2.

Fluctuations in groundwater level, causing deposits to dry and then become saturated again, can be particularly damaging to buried archaeological materials and palaeoenvironmental deposits (Williams *et al* 2008). These fluctuations can cause changes from reducing to oxidising conditions and lead to rapid degradation. This can be a particular problem for re-wetting schemes, where water levels may be raised for part of the year to meet natural environment targets, but still fall back below the level of the archaeology at other times.

Wherever feasible, groundwater fluctuations should be kept to a minimum (by permanently raising water levels, increasing surface infiltration etc) and if they do occur, any fluctuations should take place above the deposit containing archaeological remains. If this is not possible, then it is likely that the harm to the significance of the site's archaeological deposits will be too great.

Hydrological impacts can also occur as a result of the introduction of water onto sites. Flooding, when groundwater levels are low, can potentially introduce contaminated, and often nutrient-rich water into deposits that are not already waterlogged. Where this has occurred on two sites with ongoing monitoring projects, changes to the quality of the groundwater were recorded (Cheetham 2004; Lillie *et al* 2012) which lasted a number of months.

4.2 Water environment systems

The water environment is a dynamic system where water levels respond to any changes imposed upon it, whether they are natural or anthropogenic. Appreciating how the water environment system works helps us to understand whether archaeological features can be sustainably conserved in the long term. Such understanding enables management effort, including any monitoring, to be focused on those sites that are at more critical risk.

Mechanisms that influence absolute water levels or the daily / seasonal range of water levels include:

- Anthropogenic influences – development including impermeable surfaces preventing infiltration, impermeable underground structures, abstractions for water supply / dewatering, agricultural drainage, re-wetting and wetland creation schemes

- Natural variations – rainfall / evaporation trends, tidal changes, flooding responses, future climate change

In addition, lowering of the water table can lead to the physical settlement or compaction of overlying soils and deposits, particularly those which are highly compressible, such as peat. Where surface exposures of peat dry out, they are at risk of wind erosion.

Typical water environment considerations in urban and rural settings are discussed below and illustrated in Figures 7 and 8.

4.3 Urban setting

Shallow soils and drift deposits within urban settings are generally more heterogeneous in nature than those found in rural situations. Characterised by perched / localised groundwater systems they may be partly dependent on infiltration / seepage from utilities as a source of supply, in addition to natural precipitation. Changes in infiltration volumes (for example use of impermeable surfacing; leaks from utility systems), have the potential to impact groundwater inputs locally (Holden *et al* 2006).

Temporary construction activities, including dewatering, may occur for several weeks to months on a significant engineering project. Installation of barriers to flow (for example sheet piling or diaphragm walls) to enable safe excavation may lead to local increases in groundwater levels up-gradient and decrease in groundwater levels down-gradient of a site.

Dewatering is not only undertaken within the near-surface, but may be undertaken in deeper strata to alleviate groundwater pressures at depth. Such underdrainage may impact on shallower groundwaters potentially leading to a physical drop in water levels, or decrease in pressures / effective stress increasing the risk of settlement / compaction in certain types of deposit (for example peat).

Conversely the potential for flow enhancement exists (leading to increased or lowered groundwater levels) where aquitards are punctured (for example by piling, deep basements etc), introducing a pathway connecting a perched or shallow unconfined groundwater system to a wider or deeper groundwater system. Further guidance on the influence of piling on groundwater and archaeology is outlined in the Historic England advice note (2015c), and there are mitigation approaches in construction that can be taken to reduce this risk.

Urban water quality and levels in shallow soils and sediments are likely to be more varied over shorter distances than may be the case in a rural setting.

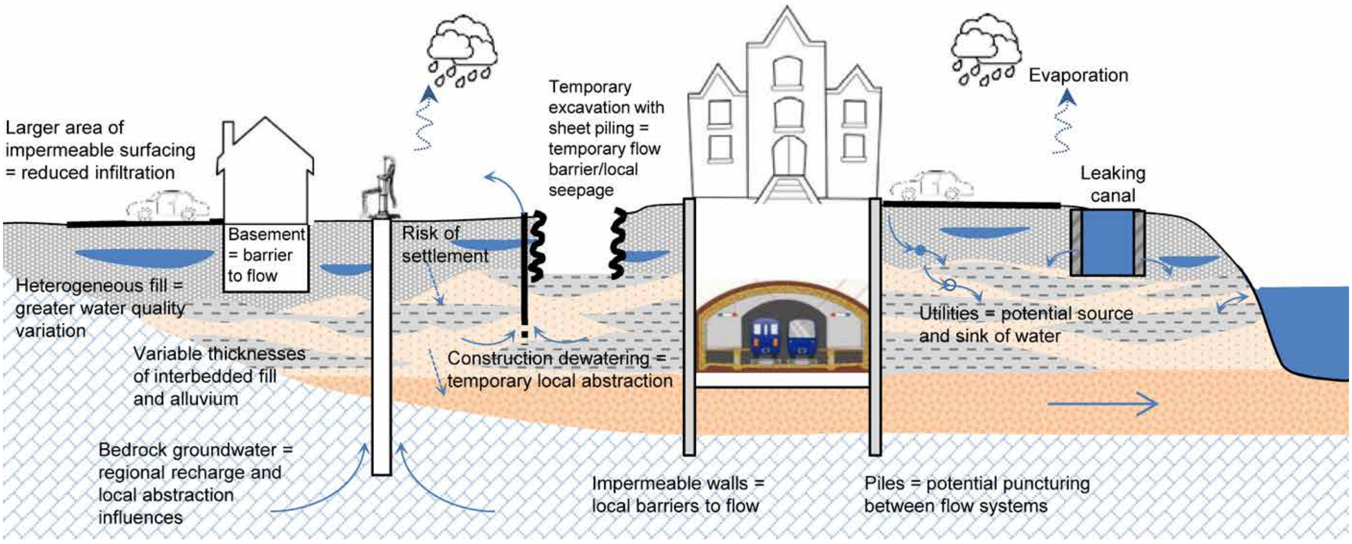


Figure 7
Urban hydrogeological influences.

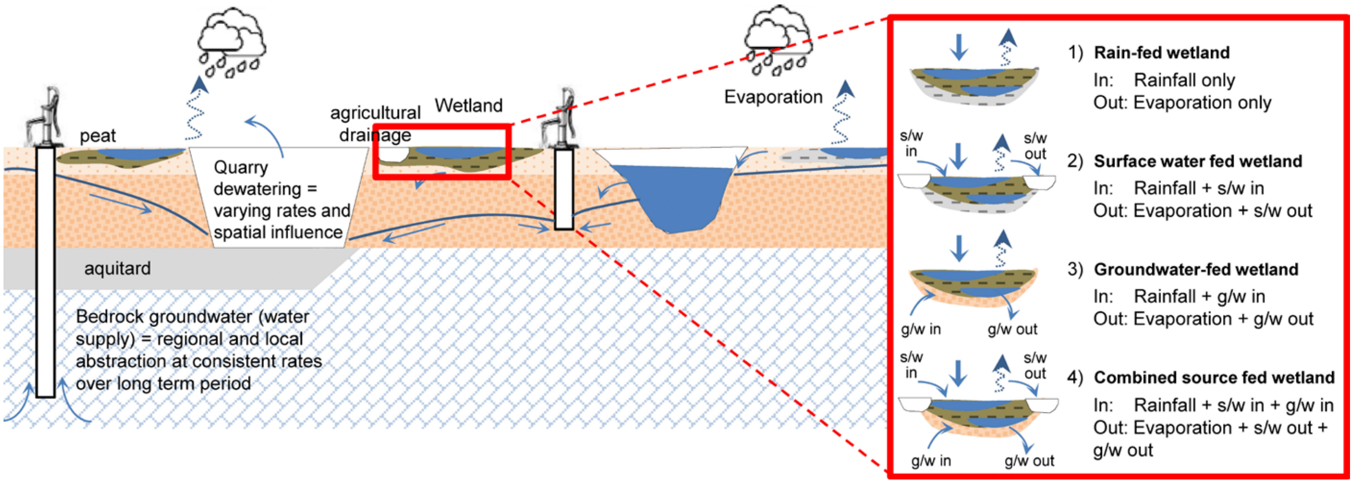


Figure 8
Rural hydrogeological influences.

4.4 Rural setting

In contrast to an urban setting, rural superficial deposits are generally more consistent in nature at a local scale. Often waterlogged archaeological sites tend to be associated with wetland systems, including peat deposits and alluvial / sand and gravel floodplains.

Appreciating the potential impact upon a wetland from changes in the surrounding water environment requires an understanding of the predominant water supply mechanisms to that wetland. These may be fed by rainfall, surface water or groundwater (or as a combination). Wetlands that are mainly rain (surface) water fed will be less susceptible to changes in groundwater levels than those that are dependent upon groundwater as a source of supply.

Key rural water environment stresses to consider are focused on activities that may increase the removal of water from the shallow groundwater system. Examples include abstraction impacts from public or private water supplies (regional to local scale effects), quarry dewatering, through to agricultural drainage (local- to field-scale effect).

4.5 Investigating water environment systems

The investigation and assessment of a supporting water environment system is often a tiered and cyclic process. Detailed advice on hydrogeological assessment methods is given in Appendix 3. This outlines the tools and approaches needed to undertake or commission the first few levels of assessment of local and regional water tables, called Tiers 1 and 2. These levels of assessment will be sufficient for investigating the majority of waterlogged archaeological sites (*see* Appendix 1 for a Tier 1 and 2 case study from Nantwich).

For more complex sites, or those considered to be at critical risk, a comprehensive, Tier 3 assessment may be needed. The most detailed assessment (Tier 4) may be of benefit for those sites where mitigation measures are being designed to enhance the long-term survival of a waterlogged site. Amongst other things, the Tier 4 assessments are a way of modelling and assessing a range of different water management options to assist in the decision-making process for complex sites. An example of a Tier 4 assessment is provided in the Flag Fen case study in Appendix 1.

These hydrogeological assessments are a critical part of understanding the significance of waterlogged sites and their results provide an understanding of how the proposed development may harm this significance. Sufficient time will need to be set aside for these hydrogeological assessments to take place as when data need to be collected to understand water levels within a system or catchment, this work can take a number of months. Even initial desk-based and site visit work is likely to involve weeks of work, so will require careful timetabling to ensure sufficient information is available to inform the planning decision-taking process.

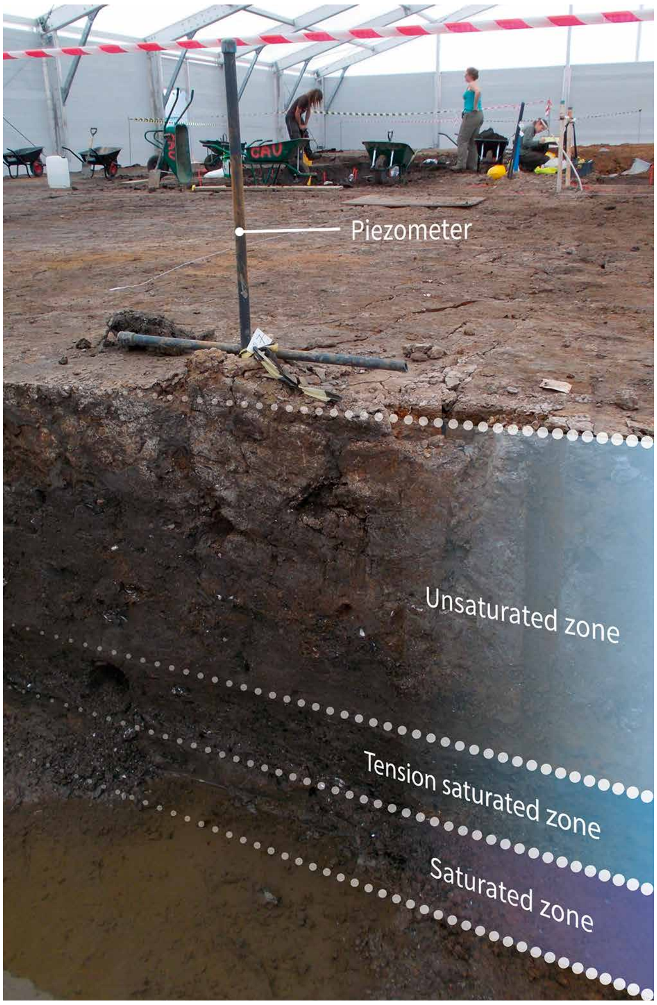


Figure 9
The tension saturated zone, or capillary fringe, sits above the saturated zone, highlighted on a section at Must Farm.

4.6 Soil moisture and archaeological preservation

Whilst it is largely true that waterlogged organic archaeological materials can only survive at or below the groundwater table, they can also be preserved by capillary action, in a part of the soil known as the tension saturated zone, or wetting front (*see* Figure 9). This is an area above the top of the water table, where moisture is present through a combination of:

- capillary rise – where water rises up through soil pores as a consequence of the water's surface tension
- cohesion – the attraction of water molecules to themselves
- adhesion – the attraction of water molecules to the soil.

The depth / thickness of the tension saturated zone depends on:

- soil texture (proportions of sand, silt and clay)
- soil pore size (the smaller the pores the greater the capillary rise)
- water retention properties of the soil
- organic matter content (which can enhance water retention)
- water flow rate though the soil

In lowland arable landscapes, particularly those influenced by land drainage, organic archaeological materials are not usually preserved through capillary action as this will usually occur only during winter months when water levels are higher. In the summer, crop growth and associated evapotranspiration will reduce available water, particularly in those areas of the country that regularly experience low rainfall rates.

In areas of pasture, land drainage (where present) still has a significant impact on groundwater levels. The extent of preservation from capillary action in these grassland environments is not easily predictable. In some cases, preservation can occur above the water table within the tension saturated zone, for example at Glastonbury Lake Village (Brunning 2013: 210).

In urban areas the risk of evaporation and water loss to plants is reduced by hard surfaces and other deposits higher in the sequence which help to reduce moisture loss to the surface. As a result, in isolated areas, often associated with previous occupation and the disposal of large quantities of organic waste, anoxic conditions can exist above the water table. These provide suitable environments for the preservation of organic archaeological materials. However, these modern hard surfaces also reduce rainwater infiltration, so recharge to these deposits is probably more limited than was the case when they were originally deposited (*see* Nantwich Case Study in Appendix 1).

In upland bogs and raised mires / peat deposits, water is often held, at least in part, by capillary action, as not all of the peat is below the water table. In these instances, the peat is acting like a sponge, and drawing water up by capillary action from the water table below. As these types of sites tend to be rainwater fed, rather than surface water fed, climatic variation and climate change are the greatest risks to loss of moisture and subsequent changes to permeability.

Figure 10
Images of survival of wood within the capillary fringe at Glastonbury Lake Village.

4.7 Managing sites in the tension saturated zone

Sites in the tension saturated zone are vulnerable to change. As they are not fully saturated, the pore spaces contain a mix of water, oxygen and other soil gases. Limited amounts of oxygen will be preferentially reduced (used) in soil redox reactions, mainly by aerobic bacteria, which explains why anoxic conditions can prevail outside the saturated zone. However, where soil air volumes rise above 15%, the potential for decay substantially increases.

Where it is the intention to retain important archaeological deposits within development which are solely or in part maintained by a tension saturated zone, the initial stages (Tiers 1 & 2) of a water environment assessment will provide information vital to assist in understanding these deposits. The results will demonstrate how water is getting into, leaving and sustaining these deposits. Additionally, it may be necessary to combine soil moisture measurement with the ‘standard’ water level investigation carried out in Tier 2, along with detailed sediment characterisation (including soil moisture content, soil texture, organic matter content and porosity), to fully understand the site (Matthiesen *et al* 2015; Panter and Davies 2014). Information on soil moisture measurement is given in Appendix 4.

5 Final Decision-taking

This section deals with the decision-taking process, once all of the information from the evaluation, preservation assessment, water environment studies and designs from the developer have been gathered.

On sites where a limited range of archaeological materials are present, and there is no evidence of large-scale or localised waterlogging of deposits, the level of information needed to inform the decision-taking process is likely to be less than that required for sites with a wider range of finds and conditions more favourable to their long-term preservation. On these more complex sites, if this information is not collected, it will not be possible for a planning authority to understand either the significance of the site or the potential impact of the proposals. It will therefore not be possible to assess whether the degree of harm could be considered to be justified.

Clear and convincing justification should be provided for any harm that the proposals will cause to the heritage asset. In line with the NPPF, when considering the impact of proposals on the significance of a designated heritage asset or undesignated heritage asset of equivalent significance, local planning authorities should give great weight to that heritage asset's conservation. Where the harm to the site is too great to ensure its continued conservation, and the harm to the significance **is not** outweighed by the public benefits of the proposals, then the development should be refused, or the areas of significance excluded from development. Where the harm to the site **is too great** to ensure its continued conservation, but the harm to the significance is outweighed by the public benefits of the proposals, any negative impacts on its significance should be offset through an appropriate level of archaeological excavation.

Alternatively, it may be clear from the preservation assessment (and where appropriate, water environment assessment) that the site and its artefacts are sufficiently robust and are capable of continued burial (or reburial) within the context of the proposed development without harm occurring. In these cases, it is good practice for a mitigation strategy to be drawn up and agreed by the local authority. This should identify the significance of the site, and what design measures are being taken to ensure that the significance is not harmed by the development.

Where there exists some element of doubt about the potential harm caused by the proposed development (particularly to well preserved deposits), three possible options are recommended:

- The development proposals are rejected until such time as less damaging options can be found
- Further analysis of the state of preservation of key archaeological materials, the deposits and the water environment is carried out until the uncertainty is resolved
- As part of a mitigation strategy, a programme of monitoring is devised to demonstrate that viable preservation conditions remain after the development has been built. Monitoring should only be undertaken where it is properly justified: for instance, the development is designed in such a way as to allow for manipulation and management of the water table, and/or subsequent 'rescue' excavation, if the monitoring data indicate that optimal preservation conditions are not being maintained

5.1 Mitigation strategies

Two main methods of reducing potential harm to significance are to avoid it (for example by excluding archaeological sites or their most important areas from development) or to use an engineered solution which seeks to minimise harm to the site's significance to appropriate levels. Detailed mitigation approaches are given in Chapter 4 of the Mitigation of Construction Impact on Archaeological Remains (Davis *et al* 2004) and Chapter 4 of Piling and archaeology (Historic England 2015c). Separate advice on materials for use in the reburial of sites, describing backfill and geotextile options, is provided in Appendix 5. Archaeologists are also encouraged to liaise with engineers working on the development as new techniques and engineering choices are evolving all of the time.

Whatever approach is used, it is good practice for the mitigation strategy to demonstrate how harm to significant deposits on or adjacent to the site will be reduced to acceptable levels within the development proposal or land-use change. This mitigation strategy might, for example, include information about foundation design, the depths of formation and services, as well as methods to ensure accidental damage does not occur during the construction phase. Where an area of the development site has been excluded to conserve archaeological remains, it should be properly demarcated (and perhaps fenced off), and its presence noted in any Construction Management Plans and engineering drawings, to avoid any unintentional damage during the construction. To ensure that the mitigation strategy is available if the site is redeveloped in the future, it is good practice for the version of the strategy representing the as-built form of the scheme to be provided to the HER.

For sites whose significance has been judged to be of demonstrable equivalent importance to scheduled monuments, where these sites have been excluded from development (or have been protected beneath part of the development) it may be appropriate to request that the site is assessed for scheduling. This would provide added recognition of the site's significance and encourage its positive conservation management.

When dealing with waterlogged sites, the long-term preservation of organic materials depends on the maintenance of reducing conditions. For these sites to be successfully retained within a development (that is preserved *in situ*) it is essential that:

- The state of preservation of archaeological materials that contribute to the site's significance is good
- Oxygen is excluded from the deposits and that reducing conditions (that is, redox values below +100mV) and appropriate (mildly alkaline to mildly acidic) pH exist
- Where saturated, archaeological deposits contributing to the site's significance remain permanently below the water table, and fluctuations in water levels are kept to a minimum

If these conditions cannot be met, then it is doubtful whether long-term conservation of the site as part of the development could be guaranteed.

5.2 Monitoring waterlogged sites

In certain situations monitoring equipment may be installed to observe whether or not a proposed engineering design and mitigation strategy is effective. However, this monitoring needs to be well planned, to an agreed set of objectives. If the goals of the monitoring work are not well thought out beforehand, the end result is often expensive schemes with unnecessary and unusable data.

Within the context of development schemes, it is good practice for monitoring to only be undertaken to demonstrate whether a mitigation scheme is working as proposed, and only in those circumstances where it is possible to manipulate groundwater levels, or access the site for excavation, if data indicate optimum preservation conditions are not being met. The case studies on Shardlow and Guy's Hospital Boat in Appendix 1 are both examples of where this is the case.

The type of monitoring equipment installed will depend upon the nature of the below-ground deposits and the available budget. Recommendations and detailed information about monitoring equipment and techniques are provided in Appendix 4.

Whatever the equipment, the purpose of the monitoring is to identify whether optimum environmental conditions for long-term preservation are present on site and check that fluctuations (moisture content, water level or redox for example) are kept to a minimum.

Very general distinctions can be drawn between the physical location of waterlogged archaeological deposits and the below-ground environmental conditions required for their future management.

In lowland rural wetland / waterlogged sites, the biggest impacts and causes of fluctuating water levels comes from land drainage and other agricultural activity. Water loss from the soil through evaporation and plant growth can cause significant seasonal variations in water levels, with low summer levels coinciding with a decrease in average rates of precipitation.

To reduce the impact of these fluctuations on waterlogged archaeological remains on rural sites it is recommended that:

- Water levels are kept at least 0.3m above the level of significant archaeological deposits all year round

- A reducing (anoxic) environment with a redox potential between +100 to -400mV with mildly alkaline to mildly acidic pH (pH8 – pH5.5) is constantly maintained. These terms are explained in detail in an introduction to soil chemistry in Appendix 2

On urban sites, water stresses are more difficult to predict. Construction activity can have a big impact on the water environment. An increase in hardstanding (tarmac surfaces) can reduce the amount of rainfall entering deposits and the construction of basements and other below ground structures can impede groundwater flow. In some instances, sites might not be permanently saturated, with perched water tables or capillary rise maintaining anoxic deposits.

To ensure continued survival of urban deposits it is recommended that:

- Water levels are maintained at levels no lower than established from initial site investigation

- A reducing (anoxic) environment with a redox potential between +100 to -400mV with mildly alkaline to mildly acidic pH (pH8 – pH5.5) is constantly maintained (where sufficient water exists for water quality measurements)

- Where reducing conditions are maintained through capillary action, that the air content of archaeological deposits that contribute to the site's significance is no greater than 15 per cent

It is good practice on all monitoring projects for trigger levels to be set which mark the limit of acceptable data, so that it is clear when below-ground changes are of concern. These should be based, wherever possible, on the criteria above. Monitoring projects should also have a fixed duration with regular reviews of data built into a clear project plan. Detailed guidance on managing monitoring projects is provided in Appendix 4.

As mitigation schemes with monitoring components are expensive (in terms of both equipment and the time to collect and analyse the data), if a water environment assessment indicates that suitable environmental conditions to guarantee the long-term preservation of the site might not exist, or that the state of preservation of archaeological materials is not high, funds may be better spent on excavation and the recovery of the site's remaining significance, rather than on other methods of mitigation and monitoring.

6 Summary Review

Before considering whether an archaeological site can be appropriately retained within a development (that is preserved *in situ*), it is good practice for three critical questions to be addressed. These are:

- What is the current state of preservation of the archaeological finds and deposits and how do they contribute to the site's significance?
- What are the likely development or land-use impacts and how will they affect the site's significance?
- In relation to sites containing waterlogged archaeological remains, what is the availability and quality of water on the site and in its wider catchment? How sensitive is this hydrological regime to change?

Other key messages in this document are that it is good practice for:

- Discussions about the retention of sites within / below developments (that is preservation *in situ*) and possible mitigation options to take place at the outset of project planning and be reviewed continually
- Preservation assessments to form a discrete part of desk-based assessments and evaluation reports
- Consideration to be given to the impact of any development proposal on off-site waterlogged deposits that could be potentially threatened through changes to the hydrological regime, water levels and quality
- Evaluation excavations to investigate the deposits and the artefacts they contain in sufficient detail to establish their significance, their state of preservation and their susceptibility to adverse impact from proposed development or land-use change
- Preservation assessments (including characterisation of the environmental conditions of the deposits) to become a regular part of the evaluation methodology for sites where retention within the development is likely to be the final mitigation outcome

Furthermore, when making decisions about the future management of these sites, it is suggested that:

- When the state of preservation of material is poor, and further burial following development or land-use change is likely to cause additional damage to that material, excavation of the archaeological remains to recover their remaining significance and evidential value is the most appropriate strategy

- Where sites contain waterlogged archaeological remains, water environment studies to determine water availability and water stresses may also be necessary

- If the condition of surviving material and deposits is good and development risks are not going to cause a change to below ground environments (including site or catchment hydrology), then harm to significance may be limited. In these instances the retention of the site and its future management as part of the development may be achievable. For such sites, monitoring will not normally be necessary

- Where there is concern about potential impacts of development on well preserved archaeological remains, it is good practice for monitoring to only be considered appropriate if a mitigation scheme is in place to manipulate water levels or provide access for future excavation if environmental conditions deteriorate

- The aim of a mitigation and monitoring project is to ensure that appropriate environmental conditions for long-term survival remain in place during and after development / land-use change

- For the long-term preservation of waterlogged archaeological remains to be a success, stable water or moisture levels are required, with reducing (anoxic) redox conditions and mildly alkaline to slightly acidic pH

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Contact Historic England

East Midlands
2nd Floor, Windsor House
Cliftonville
Northampton NN1 5BE
Tel: 01604 735460
Email: eastmidlands@HistoricEngland.org.uk

East of England
Brooklands
24 Brooklands Avenue
Cambridge CB2 8BU
Tel: 01223 582749
Email: eastofengland@HistoricEngland.org.uk

Fort Cumberland
Fort Cumberland Road
Eastney
Portsmouth PO4 9LD
Tel: 023 9285 6704
Email: fort.cumberland@HistoricEngland.org.uk

London
1 Waterhouse Square
138-142 Holborn
London EC1N 2ST
Tel: 020 7973 3700
Email: london@HistoricEngland.org.uk

North East
Bessie Surtees House
41-44 Sandhill
Newcastle Upon Tyne
NE1 3JF
Tel: 0191 269 1255
Email: northeast@HistoricEngland.org.uk

North West
3rd Floor, Canada House
3 Chepstow Street
Manchester M1 5FW
Tel: 0161 242 1416
Email: northwest@HistoricEngland.org.uk

South East
Eastgate Court
195-205 High Street
Guildford GU1 3EH
Tel: 01483 252020
Email: southeast@HistoricEngland.org.uk

South West
29 Queen Square
Bristol BS1 4ND
Tel: 0117 975 1308
Email: southwest@HistoricEngland.org.uk

Swindon
The Engine House
Fire Fly Avenue
Swindon SN2 2EH
Tel: 01793 445050
Email: swindon@HistoricEngland.org.uk

West Midlands
The Axis
10 Holliday Street
Birmingham B1 1TG
Tel: 0121 625 6870
Email: westmidlands@HistoricEngland.org.uk

Yorkshire
37 Tanner Row
York YO1 6WP
Tel: 01904 601948
Email: yorkshire@HistoricEngland.org.uk

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HEAG100
Publication date: v1.0 October 2016

Design: Historic England