Land Contamination and Archaeology

Good Practice Guidance
# Table of Contents

## Table of Contents

Summary ................................................................................................................................................................................. 4

Introduction ........................................................................................................................................................................... 5

  Background ....................................................................................................................................................................... 5
  Structure of this Report ................................................................................................................................................... 5

Legislation, Planning Policy and Guidance .......................................................................................................................... 6

Land Contamination Assessment ..................................................................................................................................... 8

  Conceptual Site Model .................................................................................................................................................... 9

Archaeological Assessment .............................................................................................................................................. 10

  Identifying scheduled monuments ............................................................................................................................ 10
  Part 2A regime and scheduled monument consent ............................................................................................... 10
  Archaeological information gathered during the planning process ................................................................ 11

Contaminated Land Risk Assessment and Archaeology Assessment ........................................................................ 13

Archaeological assets as a Source of Contamination ................................................................................................. 15

  CASE STUDY 1 Steetley Chemical Works, Hartlepool ............................................................................................. 15
  CASE STUDY 2 Hungate, York ....................................................................................................................................... 18
  CASE STUDY 3 The Royal Arsenal, Woolwich ............................................................................................................ 20

Archaeology as a Pathway for Contamination ............................................................................................................. 23

  CASE STUDY 4 Penistone, South Yorkshire ............................................................................................................... 23

Archaeology as a Receptor of Contamination .............................................................................................................. 25

  CASE STUDY 5 Newhaven ............................................................................................................................................. 25

Site investigation techniques ........................................................................................................................................... 27

  Site Investigation combined survey ........................................................................................................................... 27
  Site Investigation design............................................................................................................................................... 28
  Potential issues to consider ......................................................................................................................................... 30

Remedial options ................................................................................................................................................................ 30

  Remediation design and impacts to archaeology .................................................................................................. 31
  Measures to mitigate impacts to archaeology ......................................................................................................... 32
Summary

With a national drive to redevelop brownfield land across the country, planners and developers are increasingly faced with sites that may have been contaminated through previous industrial, commercial or agricultural use. The early identification of archaeological remains within a development site is an important step in understanding how this can influence remediation strategies and affect construction timescales.

This updated guidance is intended to offer advice primarily to those involved in the assessment and management of land contamination, but also to archaeologists, planning and archaeological officers, and developers and their consultants. The guidance has been updated in response to the increase in brownfield redevelopment and also to reflect current legislation, planning policy and guidance that is relevant to contaminated land and archaeology.

The guidance aims to raise awareness of the need to consider archaeology during land contamination assessment and management. Through the use of case study evidence, the guidance demonstrates how archaeology can be a receptor, a source of contamination, or a pathway for the transfer of contamination to another part of site. The guidance recommends steps to make sure that the level of risk is identified at an early stage, through a systematic process of assessment, site investigation, and stakeholder consultation, so that archaeological remains are considered during remediation design.

Author details

AECOM Infrastructure & Environment UK Ltd

This edition published by Historic England TBC

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HistoricEngland.org.uk/advice/... [TBC]
Introduction

Background
This guidance has been commissioned by Historic England as part of their contribution to Heritage 2020 through the Historic England Action Plan. It aims to provide guidance to those involved in the assessment and management of land contamination, and also to archaeologists, planning and archaeological officers, developers and their consultants.

The original publication “Guidance on Assessing the Risk Posed by Land contamination and its Remediation on Archaeological Resource Management”, Science Report PS-077/SR, was published in April 2003. Although the guidance is several years old, it deals mainly in principles that have remained constant for contaminated land professionals, the most important of these being that contaminated land assessment is risk based.

With a national drive to redevelop brownfield land across the country, planners and developers are increasingly faced with sites that may have been contaminated through previous industrial, commercial or agricultural use. Even if operations on site have ceased, waste materials and residues can still be present within subsurface soils and groundwater, and can not only impact project development, but can cause harm to human health and the wider environment.

The renewed interest in brownfield site development prompts the need for an understanding within the development community of archaeological assets and how best to avoid or mitigate their loss. In addition, planning policy and Part 2a Contaminated Land guidance have evolved since publication of the 2003 guidance and there is a need to address the diversity and sensitivity of archaeological assets within the context of current legislation, policy and guidance.

The document summarises the approaches to the assessment of contaminated land and the assessment of archaeological potential. Case study evidence has been included to demonstrate how archaeological assets can be a source of contamination, a receptor, or a pathway for the transfer of contamination to another receptor. The case studies also seek to demonstrate how the early consideration and awareness of archaeological assets can result in successful and unhindered remediation strategies where archaeological conservation or mitigation is carried out in advance of, or concurrent with, remediation works.

Structure of this Report
The guidance summarises the legislative and planning policy framework for contaminated land and archaeology, and provides a summary of the assessment stages for both. Case studies provide examples of archaeological assets as a source, a pathway and a receptor of contamination, and demonstrate why archaeological remains should and can be considered alongside contamination issues. A summary of site investigation techniques explains the usefulness of primary site data and how surveys can be combined to not only enhance the understanding of a site’s issues, but also to inform the scope of further site investigation. Finally the guidance provides a summary of some of the impacts to archaeology that can arise from remediation and puts forward options to avoid, reduce or compensate for these impacts.

Acknowledgements
Thanks to the following organisations for providing case study materials and survey feedback:

Atkins, CIRIA, MoLAS, Mott Macdonald, Oxford Archaeology South, Parsons Brinkerhoff, RSK Group, Sirius Ground Investigation, Tees Archaeology, West Yorkshire Archaeological Services, York Archaeological Trust, York Museums Trust.
Legislation, Planning Policy and Guidance

Contaminated Land

UK legislation aims to address the issue of historic contamination of land and the risks it can pose to human health by identifying the presence of a source, a pathway and a receptor. The Environment Act 1995 introduced Part 2A into the Environmental Protection Act 1990, and statutory guidance was issued to explain how the Part 2A regime should operate. In the context of Part 2A, land is contaminated if it poses a significant possibility of significant harm, and harm is defined as harm to the health of living organisms or other interference with the ecological systems. Also referenced is the avoidance of harm to property, which includes scheduled monuments.

Current best practice generally follows the approach as set out in Model Procedures for the Management of Land Contamination (Contaminated Land Report (CLR) 11), which provides a specific framework for land contamination and contains an extensive list of guidance covering most stages of land contamination management. Annex 1 of Defra Circular 01/2006 also provides a useful summary of the principal regimes affecting land contamination and how they interact.

The model procedures incorporate existing good technical practice, including the use of risk assessment and risk management techniques, into a systematic process (including producing a hierarchy of documents) for identifying, making decisions about and taking appropriate action to deal with contamination, in a way that is consistent with policy and legislative requirements.

The Local Planning Authority is the principal regulator for assessing ground contamination, and therefore contamination issues are a material concern in development control. Section 11, paragraph 109 of the National Planning Policy Framework (NPPF) states that the planning system should contribute to and enhance the environment by preventing new and existing developments from being affected by unacceptable levels of soil, air or water pollution, and to remediate and mitigate despoiled, degraded, derelict, contaminated and unstable land where appropriate. For planning purposes therefore, the NPPF requires that the assessment of the risks arising from contamination should be considered in the context of the current environmental setting. In this respect the underlying principle of identifying and dealing with risk in order to safeguard human health is similar to the Part 2A regime.

Policy 111 of the NPPF encourages the effective reuse of previously developed land, brownfield sites, which can create a direct conflict with the conservation of cultural heritage remains, such as industrial heritage features. The NPPF also states that, “Planning policies and decisions should also ensure that the site is suitable for its new use taking into account ground conditions and instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from remediation.”

The principal planning objective is therefore to make sure that unacceptable risks to human health, buildings, property and the natural and historic environment are identified and managed, and that planning decisions are informed by adequate site investigation information.

Cultural Heritage

Guidance to the Part 2A regime specifies that the type of receptors that should be taken into account in determining contaminated land include scheduled monuments.

The Ancient Monuments and Archaeological Areas Act 1979 is the central piece of legislation that protects scheduled monuments. A scheduled monument is a site of national importance and for the purposes of the Act is defined as “any monument which in the opinion of the Secretary of State is of public
interest by reason of the historic, architectural, traditional, artistic or archaeological interest attaching to it’ (Section 61 (12))."

A set of criteria, defined as survival/condition, period, rarity, fragility/vulnerability, diversity, documentation, group value and potential, assist in the decision making process as to whether an asset is of national importance and best managed by scheduling.

Archaeological assets are also a material consideration during the planning process. The conservation and enhancement of archaeological assets forms an important part of the NPPF and section 12 deals specifically with conserving and enhancing the historic environment which comprises archaeology, built heritage and historic landscape.

The NPPF makes clear the importance of being able to assess the significance of heritage assets that may be affected by a development, and states that when determining applications local authorities require an applicant to describe the significance of assets that may be affected. For sites where there are known heritage assets, or there is potential for heritage assets with archaeological interest, the NPPF directs local authorities to require developers to submit an appropriate desk-based assessment and, where necessary, field evaluation.

The identification of archaeological assets, or the risk of encountering archaeological assets, is therefore a material planning concern and planning decisions are informed by adequate site investigation information.
Land Contamination Assessment

Contamination is more likely to arise in former industrial areas but cannot be ruled out in other locations including in the countryside. In addition, some areas may be affected by the natural or background level of potentially hazardous substances, such as methane, radon or elevated concentrations of metallic elements, and only a specific investigation can establish whether there is contamination at a particular site.

The basic approach to the risk assessment process is described in the following sections. However, detailed guidance should be sought from CLR11 which recommends a tiered approach to risk assessment with the three tiers being:

- Tier 1 Preliminary: A qualitative assessment as part of a Phase 1 report.
- Tier 2 Generic: A quantitative assessment to screen site specific ground condition data as part of a Phase 2 report.
- Tier 3 Detailed: A quantitative assessment to generate site specific assessment criteria.

Each tier of the risk assessment process is iterative and can be divided into four main stages as shown in Table 1. Fundamental to this approach is the development of a conceptual site model and the consideration of the potential pollutant linkages identified therein.

Table 1: Land Contamination Risk Assessment Stages

<table>
<thead>
<tr>
<th>Stages</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 Hazard identification</td>
<td>Often referred to as the desk study. Identifies potential contaminants of concern on and off site, the potential receptors and pathways that may link the two i.e. the pollutant linkage. The initial CSM is developed.</td>
</tr>
<tr>
<td>Information collection stage</td>
<td></td>
</tr>
<tr>
<td>Stage 2 Hazard assessment</td>
<td>Considers the plausibility of these potential pollutant linkages, What pollutant linkages could result and what could the effects be (CLR11). May involve an exploratory site investigation, based on contamination sources identified or the presence of naturally occurring contamination (metals etc.).</td>
</tr>
<tr>
<td>Analysing the potential for unacceptable risks</td>
<td></td>
</tr>
<tr>
<td>Stage 3 Risk estimation</td>
<td>This comprises the main site investigation (if required) to gather data to investigate the uncertainty in the CSM. The risk to the receptor identified in the pollutant linkage can then be estimated with more accuracy. Risk Assessment using Generic Assessment Criteria, or Site Specific Criteria will be used at this stage.</td>
</tr>
<tr>
<td>What degree of harm or pollution might result and to what receptors, and how likely is it that this may arise as a result of a hazard (CLR11)</td>
<td></td>
</tr>
<tr>
<td>Stage 4 Risk evaluation</td>
<td>Information from the previous stages for each pollutant linkage is analysed, the uncertainties in the process identified and a decision is made as to whether or not the site poses an unacceptable risk to the receptor. If the site is found to pose an unacceptable risk it may be necessary to (a) revisit the earlier stages of the risk assessment, reduce the uncertainty and derive further site-specific assessment criteria or (b) instigate appropriate risk management measures (produce an Options Appraisal and/or Remediation Strategy).</td>
</tr>
<tr>
<td>Deciding whether a risk is unacceptable</td>
<td></td>
</tr>
</tbody>
</table>
A risk assessment is supplemented by a conceptual site model (CSM). A CSM is a textual or graphical representation of the relationship(s) between contaminant source(s), pathway(s) and receptor(s) (known as "pollutant linkage") that are relevant to the site and helps identify gaps in information and understand the site’s sensitivity.

The pollutant linkage is developed on the basis of hazard identification (i.e. at the start of the risk assessment process), and is refined during the project cycle. The type of contaminant, environmental setting and ground conditions play a key part in identifying the presence of a potential pollutant linkage. It is also important to recognise that for a risk to exist to a receptor all three elements must be present. The CSM should also include any uncertainties identified and assumptions made about the site.

In the context of archaeological resources, the resource may be present as a potential source of contamination, a potential receptor or as a potential pathway for the transfer of contamination to a receptor. In addition, the archaeological resource present on a site (or adjacent to the site) may not form part of a pollutant linkage but may still need to be considered in terms of the potential impact on works carried out to investigate the pollutant linkages present. In particular the archaeology of the industrial age provides a significant challenge since the building fabric and wastes may be significantly contaminated with respect to exposure for archaeologists, development workers, future site users and the environment including water resources.

One of the key advantages to having a comprehensive CSM is that it can aid communication within the stakeholder group for the site. Where many different parties are involved with a site, each with their own aims and objectives, the CSM is a valuable tool in ensuring that all have the same understanding (or at least a framework for discussion) of the issues relevant to the site.
Archaeological Assessment

The assessment of archaeological assets may take place within the Part 2A regime or as part of the planning process.

Identifying scheduled monuments

Designated archaeological assets are identified in a desk-top study and the information is usually taken from web sources such as the Multi-Agency Geographic Information for the Countryside which provides information relating to world heritage sites, scheduled monuments, listed buildings and also non-statutory heritage assets. More detailed information about these asset types can be found by using the map search facility on the National Heritage List for England. This site is maintained by Historic England and will provide a reference number for the asset, a description of the remains and the reasons for its designation. The map will locate the asset, including any applicable buffer zone, and the asset’s spatial extent can be downloaded as a GIS shapefile.

Plate 1: National Heritage List for England © Historic England

Part 2A regime and scheduled monument consent

Impacts to a scheduled monument can arise from activities that may alter the monument’s physical preservation, resulting in alteration or destruction. This includes damage to, removal or displacement of artefacts and deposits. Impact can also occur from works in the vicinity of a scheduled monument, for example works that result in changes to local hydrology can affect the preservation of scheduled waterlogged remains.

If a scheduled monument is present within a site, or adjacent to a site, early engagement with the regional officer for Historic England is recommended so that the potential for impacts can be discussed. Contact details for your regional HE officer can be found here.

In accordance with the Part 2A regime, any activity likely to affect a scheduled monument will require scheduled monument consent. The timescale for receiving scheduled monument consent can vary; an
initial response should be provided within 14 working days. However, a final decision can take up to 4 months from receipt of the application. It is important therefore that scheduled monuments are identified as early as possible in the risk assessment process, so that the timetable for consent (if required) can be accommodated in the programme for site investigations.

Applications for scheduled monument consent are submitted to Historic England and information about how to apply and the level of supporting information required can be found on the Historic England website.

**Archaeological information gathered during the planning process**

Understanding a site’s history is important for assessing potential impacts to archaeological assets from site investigations or remediation. Also, if the archaeological asset is also a potential source of contamination then its early identification will enable mitigation to be included in the remediation design, avoiding duplication of effort and saving the developer time and money.

The application of land quality and contamination guidance for new developments is primarily controlled by the planning system where a staged approach to site assessment and investigation with a risk based methodology is recommended. A similar approach is applied in the planning system to the identification of archaeological assets, where the developer must submit sufficient information relating to the potential for a site to contain archaeology, so that the likely impact can be determined. This information is gathered through a staged programme of archaeological investigation consisting of desk-based assessment and, where necessary, invasive and non-invasive methods of field evaluation. The results of these investigations can produce detailed site information which can inform the cost and scope of a site’s remediation strategy.

The principal types of archaeological information that maybe available are summarised in Table 2.

Table 2: Types of archaeological investigation

<table>
<thead>
<tr>
<th>Investigation</th>
<th>When is this type of survey carried out?</th>
<th>What type of information is gathered by this survey?</th>
<th>If available, where can I find this report?</th>
</tr>
</thead>
</table>
| Desk-based Assessment | For proposed development sites if requested by the local authority’s Archaeology Advisor                  | Site/asset identification: Location of known heritage assets within the site and within close proximity to the site | Local authority’s planning portal – supporting documents associated with planning application
|                       | Part of evidence base to support a planning application and to inform requirement for further investigation | Historic maps, detailed history of the site including previous land-uses                                               | Local authority’s Historic Environment Record (appointment is required), or search online reports Archaeological Date Service
<p>|                       |                                                                                                         | Historic aerial photography and recent images and site description from a walkover survey                             | Developer will have copy on file, either as commissioning body or successor in title.                                                                                                        |</p>
<table>
<thead>
<tr>
<th>Modern disturbance review</th>
<th>For brownfield sites where significant levels of ground disturbance are expected. Part of evidence base to support a planning application and to inform further investigation / scope of planning condition.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Detailed site history: Historic maps and map regression Historic photos Description of historic borehole logs Cross-section through site showing depths of sediments Plan of site identifying zones of greatest disturbance and zones of archaeological potential.</td>
</tr>
<tr>
<td></td>
<td>Developer will have copy on file, either as commissioning body or successor in title. May form part of planning application evidence base, check local authority’s planning portal.</td>
</tr>
<tr>
<td>Geophysical survey</td>
<td>Usually as part of pre-application site evaluation. To inform scope of further evaluation and/or enable a planning application to be determined. Site/asset identification: Multiple techniques depending on ground conditions and soil type. Will identify and interpret buried archaeological features.</td>
</tr>
<tr>
<td></td>
<td>Site/asset characterisation: trenches will target sites of known/potential archaeology in order to gather more information about character and extent of remains. Report will provide information about depth and composition of deposit sequence within the site.</td>
</tr>
<tr>
<td></td>
<td>Developer Local authority’s Historic Environment Record (appointment is required), or search online reports Archaeological Date Service Planning application evidence base, check local authority’s planning portal.</td>
</tr>
<tr>
<td>Trial trenching/ test pitting</td>
<td>Usually as part of pre-application site evaluation; also often in response to a planning condition, especially on urban sites where access for evaluation prior to planning consent is problematic. Site/asset characterisation: trenches will target sites of known/potential archaeology in order to gather more information about character and extent of remains. Report will provide information about depth and composition of deposit sequence within the site.</td>
</tr>
<tr>
<td></td>
<td>Developer Local authority’s Historic Environment Record (appointment is required), or search online reports Archaeological Date Service Planning application evidence base, check local authority’s planning portal.</td>
</tr>
</tbody>
</table>
Contaminated Land Risk Assessment and Archaeology Assessment

There is evidently a commonality in approach to risk assessment for both disciplines, and information gathered for one discipline may enhance the understanding and management of the other. Archaeological remains can be quite difficult to identify, and can range in character from deeply buried deposits to relatively recent extant structures. Understanding the archaeological issues associated with a site, and being able to access available archaeological information, is important if best practice in land contamination and remediation is to be achieved.

Table 3 is a diagram of the four stages of contaminated land risk assessment and how each stage corresponds with the traditional stages of archaeological assessment. The diagram also illustrates key communication and consultation points, when engagement with stakeholders could occur.

Table 3: Summary of contaminated land assessment and archaeological assessment processes

<table>
<thead>
<tr>
<th>Contamination risk assessment process</th>
<th>Archaeology assessment</th>
<th>Consult</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stage</strong></td>
<td><strong>Process</strong></td>
<td><strong>Activity</strong></td>
</tr>
<tr>
<td>Hazard Identification</td>
<td>Develop Initial CSM</td>
<td>Identify potential Source Pathways and Receptors</td>
</tr>
<tr>
<td>Hazard Assessment</td>
<td>Identify plausible pollutant linkages and refine CSM</td>
<td>Establish former uses of the site and identify potential contaminants by consulting historical maps, aerial photos, geological maps, historical documents, trade directories etc.</td>
</tr>
<tr>
<td>Risk Estimation</td>
<td>Design &amp; undertake main site investigation to investigate plausible pollutant linkages and uncertainties identified in the CSM</td>
<td>Analyse potential for unacceptable risks (what pathways and receptors are present, what pollutant linkages could result and potential effects). Consider possibility of the pollutant linkages. May include basic site investigation.</td>
</tr>
<tr>
<td>Risk Evaluation</td>
<td>Identify and evaluate uncertainty</td>
<td>Detailed site investigation, collection of samples (soil, water, gas), further characterisation of the site including extent and nature of contamination, determination of representative contaminant concentrations in relevant media, comparison with generic guideline values or site-specific assessment criteria.</td>
</tr>
<tr>
<td></td>
<td>Identify unacceptable risks from the pollutant linkages</td>
<td>Evaluate uncertainty in risk assessment process. Determine acceptability of risk to the receptor. Is risk unacceptable? Do you need to return to the risk assessment process to reduce uncertainty, or investigate risk management options, and develop remediation strategy?</td>
</tr>
<tr>
<td></td>
<td>Identify and evaluate risk management options</td>
<td></td>
</tr>
</tbody>
</table>

C1 C2 C3 C4 C5
Table 4: Consultation stages referenced in Table 3

<table>
<thead>
<tr>
<th>C1</th>
<th>Early Consultation – Pre-assessment Process</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Early engagement is key to providing a successful project.</td>
</tr>
<tr>
<td></td>
<td>• The stakeholder group involved with a site will vary. Where both contamination and archaeology issues are present/suspected the parties involved may include the developer/site owner, regulator, land contamination (and geotechnical consultant), subcontractors, engineer/architect and archaeologist etc.</td>
</tr>
<tr>
<td></td>
<td>• Early multi-disciplinary consultations allow the various parties to take account of concerns raised by others, which can be incorporated at the beginning of the assessment process.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C2</th>
<th>Hazard Identification and Hazard Assessment Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Consultation at this stage of the process between the archaeologist and contaminated land consultant is critical. The presence of archaeological evidence/contamination are likely to have time and cost implications for the project in subsequent phases of works and the earlier these are identified, the easier it is to accommodate them in the development plans for the site.</td>
</tr>
<tr>
<td></td>
<td>• Early consultation allows development of a more robust CSM and a reduction in the uncertainty associated with the site.</td>
</tr>
<tr>
<td></td>
<td>• There is the potential for information transfer between the land contamination and the archaeological assessment at this stage, e.g. data sources to be consulted in the hazard identification stage of the land contamination assessment and the desk-based assessment stage of the archaeological evaluation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C3</th>
<th>Risk Estimation Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Based on the robust CSM, continued communication and coordination will enable the development of a coherent site investigation and mitigation strategy to address the potential contamination issues and, where possible, protect the archaeological assets in-situ, reducing the likelihood of accidental impacts and harm to archaeological remains or the wider environment.</td>
</tr>
<tr>
<td></td>
<td>• Communication at site investigation design stage can lead to more effective management of the site investigation and can result in cost and time efficiencies. These may include, where possible, using the same investigative techniques for both contamination and archaeological purposes although the specific objectives may vary. Management efficiencies may include designing contamination investigation to minimise vehicle movements/people movements in areas of the site that are particularly vulnerable in terms of archaeological resources.</td>
</tr>
<tr>
<td></td>
<td>• As per Hazard Identification and Hazard Assessment Stage there is the potential for sharing of information at this stage that will aid the design of future remediation and/or archaeological mitigation strategies.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C4</th>
<th>Risk Evaluation Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• An appropriate remediation strategy for a site should take account of archaeological assets in addition to the requirement to break any pollutant linkage, whether or not the archaeology is part of the linkage. Communication between the archaeologist and contaminated land consultant should take place in order for an appropriate remediation strategy to be developed for the site (refer to Remedial Options section).</td>
</tr>
</tbody>
</table>
Archaeological assets as a Source of Contamination

Former industries can be an important part of a town’s economic history and development, and this interest gives the asset a level of heritage significance which can be protected in legislation (such as for scheduled monuments and listed buildings) or in the planning process (such as for non-designated assets of local interest). Any land-use will leave behind remnants of that use. However, in the case of some sites, such as former industrial buildings, these remnants can also be sources of contamination that is harmful to health if not identified and managed appropriately.

In addition to industrial heritage remains, other types of activity may also result in sources of contamination. For example, biological hazards may arise from the disposal of animal remains or from human interment. Biological substances are not recognised by the Part2A regime, however, the need to manage biological contamination arises increasingly where there is planning pressure to redevelop brownfield sites.

The following case studies demonstrate how relatively recent industrial structures can have an archaeological value and can also be a significant source of contamination. In these cases, early engagement between the developer’s Archaeological and Contaminated Land consultants was essential for ensuring that archaeological mitigation was considered alongside contamination issues.

CASE STUDY 1 Steetley Chemical Works, Hartlepool

Site history

The former Steetley Chemical Works in Hartlepool, known previously as the Magnesia Works, was built on the site of former defensive structures. The Palliser Battery dates to 1918, and included a shell store and the Cemetery Battery which dates to the late 19th century.

Hartlepool was a prime target during the first and second world wars. At the start of the First World War over 1,000 shells were fired at the town and the Cemetery Battery during a 40 minute bombardment by three German Battle Cruisers. An error resulted in the incorrect calibre ammunition being used which meant that the Battle Cruisers’ main guns had to fire with no elevation, causing the unexploded shells to skim across the ground or bury in the sand dunes. It is recorded that the local garrison spent several weeks collecting shells that were lying on the surface.

The Magnesia Works played a key role during World War II and during which the town was bombed on 43 occasions. The Works became the world’s first commercially viable producer of magnesia by extracting magnesia from sea water, and reacting it with dolomite to produce British magnesia.

Redevelopment and remediation of the site had the potential to impact buried structures associated with the Palliser Battery, and remove more recent industrial archaeology structures associated with the Magnesia Works.

Contamination issues

Geo-environmental investigations recorded elevated background concentrations of metals with several hotspots identified where levels exceed the site average. In addition, large quantities of bound asbestos cement were present across the site. Other contamination issues included ground gas and elevated levels of hydrocarbons from historic landfill, the potential for unexploded ordnance across the site and particularly in the shell store, and Magnesia Hydroxide residue in the tanks and chambers.
How contamination and archaeology were managed

An extensive programme of remediation was planned which involved the demolition of buildings of archaeological interest including the Palliser Battery shell store, and the settling tanks and reacting chambers associated with the later Magnesia Works. A Control Plan was produced following early consultation between the developer’s Archaeological and Contaminated Land consultants and the local authority’s Archaeology Officer, resulting in an agreed programme of archaeological mitigation works that were to be carried out alongside demolition and remediation.

The programme of remediation and archaeological works comprised:

- Asbestos removal from extant buildings and from existing rubble stockpiles.
- A programme of archaeological building recording of extant buildings in advance of main phase remediation.
- An archaeological watching brief during demolition and remediation.

The Control Plan set out PPE requirements comprising hi-vis clothing, safety boots and hard hat, eye protection, gloves and face masks. The Control Plan also specified that a qualified UXO Engineer was onsite for the duration of the demolition and remediation, and an Environmental Manager was also in attendance to carry out soil testing of areas of previously unknown contamination. In addition, gas monitors were used in the areas of known hotspots.

Due to the high levels of contamination, the agreed archaeological mitigation comprised a Level 2 photographic record only. All structures and archaeological finds were photographed and located on plan. No finds were retained due to the risks from contamination, and the risk to archaeological staff who would process the finds off site.
Lessons:

- Early consultation with project stakeholders allowed for remediation and demolition to be planned in conjunction with the necessary archaeological works, avoiding delays to the programme and reducing site risks to an acceptable level;

- The methodology for the archaeological works was informed by contaminated land Control Plan, minimising risks to site personnel during groundworks and off site staff involved in processing stage;

- The Control Plan enabled the discovery of unforeseen contaminated remains within the site to be dealt with in a safe manner whilst still fulfilling the requirements of the archaeological works.
CASE STUDY 2 Hungate, York

Site history

York Archaeological Trust (YAT) carried out two excavations in advance of development of the site of the former York Union Gas Light Company (YUGLC) gas works in Hungate, York. The site had also been occupied by a sawmill and a flour mill. The industrial remains were assessed to be of historic interest, and archaeological mitigation, comprising preservation by record, was required for the retort house, associated condensers, purifiers, gas holders and connecting pipe networks.

Contamination issues

The archaeological desk-based assessment identified the location and use of the former structures within the site, and the geotechnical desk-study identified the likely sources of contamination. Due to the likelihood of archaeological remains being present that were also a source of contamination, initial site investigations were designed to target the site of known heritage structures. The results provided an assessment of the level and type of contamination at the site, which informed the scope of archaeological mitigation and measures to protect human health. The site investigation identified elevated levels of hydrocarbon and heavy metals contamination. In particular, the area associated with the condensers and purifiers was found to be significantly contaminated by benzene. The condenser removed volatile tars, ammonia and other by products from the gas and it was assessed that an in-situ feature, buried below the condenser, was likely to contain high levels of contamination. The material in this buried feature had contaminated an area of ground water around it, which had migrated across the site.

How contamination and archaeology were managed

The results of the geotechnical intrusive site investigation informed the method statement and risk assessment for the archaeology works. The investigations had highlighted that the local ground water had been contaminated by the in-situ material beneath the condensers and as a result the archaeology team had to follow strict health and safety protocols which included the wearing of protective suits and gloves which met the following specifications: EN14605 Type 4 Spray Tight, EN13982-1(&2) Type 5
Particulate protection, and EN13034 Type 6 Reduced Spray. Each member of the team was also issued with a ToxiRAE Personal Ionisation Detector (PID) (Plate 4).

The PIDs were set to detect low levels of dangerous Volatile Organic Compounds (VOCs) such as benzene, and to alarm if they recorded readings in excess of strict minimum levels stipulated in HSE guidelines, EH40. Procedures for site evacuation in the event of a serious alarm were communicated to the archaeology team in advance of work starting and formed part of the site induction for new staff and site visitors.

Very little evidence for significant contamination was encountered during the excavations, although a continuous low-level presence of VOCs was recorded. The PIDs recorded both exposure levels and duration of exposure and at no time did these levels exceed the limits specified by HSE guidance EH40. There were only three occasions during the archaeological work that the alarm built into the PID was activated, indicating levels of VOCs in excess of the short term exposure limit. In all three encounters the work was immediately abandoned, the material left in-situ, and the client informed of the incident. Analyses of the PID data revealed that the long-term exposure limit for the three individuals concerned was not exceeded and de-contamination steps were carried out to clean the equipment and PPE used in these encounters.

Lessons:

- Early appreciation that contaminated remains were also of industrial archaeological interest allowed the site investigations to be designed for both contaminated land and archaeology.

- Collaboration between developer’s archaeologists and contaminated land consultants enabled information to be gathered which informed the scope of archaeological mitigation and made sure safeguards for staff were put in place in advance of work starting.
CASE STUDY 3 The Royal Arsenal, Woolwich

Site history

The Royal Arsenal in Woolwich, which covers 76 acres, was the site of ongoing major urban regeneration since 1999. It occupies 76 acres, includes a conservation area and is a site of national importance in terms of its history, architecture and archaeological remains.

The core of the site was purchased by the crown in 1671 and was then steadily expanded and developed into a significant centre of armament manufacture and military stores. Works included the development and testing of new technologies, and the Napoleonic and Crimean wars added extra impetus and funding to the Arsenal’s activities. During the First World War over 80,000 people were employed at the site and 32,000 people were still employed during the Second World War. The site contains a large number of listed buildings of national importance associated with the site’s military industrial past as well as industrial archaeology features and archaeology from the Roman and medieval periods.

Contamination issues

During its history the Arsenal manufactured canons and explosive mortars, large guns for battleships, bullets and shells and was therefore a site of significant industrial activity. There were extensive smithy workshops, steam engines and hammers and quenching pits filled with oil. The Arsenal even had its own railway system for transportation inside the site. Areas of the site were reserved for casting metals and various chemical processes associated with the manufacturing, resulting in the production of large quantities of contaminated waste. Adjacent marshland was reclaimed as part of the expansion of the Arsenal, and the made ground came from industrial waste material generated within the site which also included potentially explosive charges. The potential for archaeological remains to be a source of contamination, or a receptor of contamination, was assessed to be very high.

Plate 5: recording the brass furnace © Oxford Archaeology
How contamination and archaeology were managed

Geotechnical surveys collected general information on contamination and also targeted specific areas to test levels of contamination and archaeological survival based on the results of the desk study. The geotechnical surveys were monitored by an archaeologist so that the depths of made ground and archaeological levels could be recorded to inform the scope of archaeological mitigation.

Following a site wide archaeological trial trench evaluation, a programme of remediation was instigated which combined the archaeological mitigation works with the removal of contaminated deposits. When the source of contamination was also of archaeological interest, the archaeology team had to work in accordance with the methodology approved by the contaminated land consultant. This entailed routine testing of areas of potential contamination by an on-site Environmental Manager, resulting in a reduced scope of archaeological recording for areas where elevated levels of contamination were recorded.

Routine risk management measures included all site personnel wearing PPE such as masks, gloves and hazard suits, and following strict hygiene procedures, exclusion zones, and dust suppression measures. In some contamination ‘hot spots’ no archaeological work was possible due to the potential hazards, and in these cases mitigation was restricted to a photographic record and plan where possible.
In order to manage the risk of contamination being transported off-site, a finds and environmental strategy was developed which focused on appropriate levels of artefact and sample retrieval to inform the archaeology being recorded. The archaeology team adopted a ‘record and discard’ policy on site for certain categories of finds in order to reduce the quantity of potentially contaminated material removed to OAs offices. Specific mitigation protocols were employed for office-based staff who were to be involved in the processing of finds and environmental samples from the site.

Lessons:

- Carrying out archaeological work in contaminated conditions was time consuming and expensive. It was therefore essential to maintain an open dialogue between the remediation team the archaeological contractor, the developer and Historic England, to make sure that decisions regarding the scope of work were made quickly.

- Collaborative working and use of appropriate specialists: Due to the potential for UXO, all staff were briefed by a munitions specialist on how to identify potential hazards, particularly from discarded charges and gunpowder filled mortars. The specialist maintained a watching brief on site for the duration of the works.
Archaeology as a Pathway for Contamination

In some cases, archaeological assets may provide a pathway for the transfer of contamination from one source to a potential receptor. For example, archaeological excavation may disturb naturally formed lagoons or voids that have acted to contain contaminants, or breach structures such as buried pipes, reservoirs or storage tanks, containing contaminated material. The risk is particularly high on brownfield sites and highlights the need for detailed documentary research to confirm the presence and location of such structures prior to the start of site investigation.

In addition, buried structures such as culverts, may provide a pathway for contamination to another part of the site. The following case study illustrates the importance of site workers being aware of the presence of archaeological assets within a development site; even after all agreed archaeological recording has been completed.

CASE STUDY 4 Penistone, South Yorkshire

Site history

Structures of archaeological interest, including a 19th century paper mill and a race (Plate 7), were present within a proposed development site. The race was associated with the mill’s power transmission. powered the mill; it was a part buried structure which carried water from the river to power the water wheel, which then re-entered the watercourse via a sluice (Plate 8).

An archaeological investigation, carried out in advance of construction, targeted the earliest phases of the paper mill including the water wheel pit and a section of the mill race. The archaeological works comprised a Level 2 building report and archaeological excavation and recording. The investigation area was left open upon completion and the site was handed over to the developer to enable construction to start.

Contamination issues
On the same site, to the north-west of the mill, was a former petrol station. The buried fuel tanks associated with the former garage site had corroded, and the desk-study and site investigation report carried out by the developer’s Geotechnical Engineer concluded that a significant degree of hydrocarbon contamination had migrated into the soils around the tanks and would require extensive remediation.

The tanks and the backfill material around the tanks were excavated and isolated in a part of the site pending disposal later that day. However, the remediation contractor had unknowingly stored the tanks above a section of the buried mill race (Plate 8). The weight of the stored material caused a breach in the roof of the mill race resulting in contaminated material entering the course of the race and being transferred to another part of the site. The contaminated material exited the race and migrated to topsoil bunds which had been stored in the southern part of the site, downslope from the race.

The topsoil had been stockpiled for re-use in gardens, roadside verges and planting schemes within the development site; however due to the level of contamination and potential risks to end-users the material had to be removed from the site and new topsoil material was imported to fulfil the landscaping design.

Plate 8: location of contamination, receptor and pathway

Lessons:

- The archaeological works were completed in advance of development, and before the appointment of a principal contractor. Archaeological information, including the trial trench report and excavation report, was included in the tender package for the site; however it was not referenced because archaeology was considered to have been ‘dealt with’ and was therefore not an issue for the contractor.

- A review of all site reports should be carried out as part of the bid preparation for a site. Archaeological reports can contain useful site information relating to the depth of soils across a site and will identify the location of known heritage assets.
Archeology as a Receptor of Contamination

Archaeological remains can be affected by much later land-use. Rural areas can contain deeply stratified sequences of archaeological deposits, particularly in areas where the surface topography has been altered by alluvial and colluvial processes, marine transgressions and regressions. In wetland areas such as the Fens, and upland areas such as parts of the South Pennines, waterlogged land surfaces, structures and features, can be preserved beneath blanket peat formation.

In urban environments, that can have hundreds of years of settlement-related history, archaeological deposits can also survive to significant depths. Often the most deeply buried deposits may include well-preserved organic materials if buried below the water table.

In order to avoid or minimise impacts to deeply buried archaeological deposits it is critical that a site’s underlying sedimentary sequence is understood in advance of a site investigation or remediation design. Further advice relating to the preservation of archaeological sites and their long-term management has been published by Historic England.

In urban environments buried heritage assets are susceptible to contamination either by downward movement or leaching of contamination from overlying deposits. Trench and piling foundations, cable systems, underground fuel storage and remediation works may introduce contamination into previously undisturbed archaeological remains sealed beneath contaminated ground. As part of a flood defence scheme for Newhaven, flood defence foundations had the potential to transfer contamination to underlying alluvium layers, which had been assessed as being a source of palaeoenvironmental potential.

CASE STUDY 5 Newhaven

Site history

The site comprised a 2km stretch of the east and west banks of the River Ouse. The principal sources of contamination derived from the site’s maritime heritage and industrial uses, fuel tanks, areas of landfill, and recycling and waste facilities and included evidence of elevated PAH, benzo(a)pyrene, benzo(a)anthracene and TPH along with elevated levels of carbon dioxide and methane.
ground may result in the migration of contaminated groundwater into the alluvial deposits, increasing pH levels and altering levels of archaeological preservation as a result. In addition, sheet piling along sections of the scheme, in advance of remediation, could result in changes in local hydrology which would have a dewatering effect on Holocene peat deposits with the potential to contain preserved archaeological data.

How archaeology and contamination were managed

Site surveys were carried out to inform the design of the proposed flood defences, which comprised new embankments and flood walls above sheet piling foundations.

In order to inform the impact assessment process and archaeological mitigation design, it was decided that the planned geotechnical site investigations should also be monitored by a geoarchaeologist. The geoarchaeologist produced detailed archaeological descriptions which generated a deposit model of the underlying sedimentary sequence and identified deposits of archaeological interest (Plate 10).

Plate 10: Archaeological deposit model from geotechnical investigation © Archaeology South East

The soil testing data from the geotechnical works confirmed the levels of contamination within the made ground deposits, and it was concluded that sheet piling driven through the made ground may
transfer hydrocarbons contamination to underlying alluvium and have an adverse effect on the preservation of palaeoenvironmental remains.

The construction plan concluded that contaminated made ground deposits would be excavated and disposed of in advance of the construction of flood defences, removing the source of contamination and avoiding impacts to buried archaeological deposits.

The results of the geoarchaeological assessment also noted that the insertion of interlocking sheet piling could cause displacement and compression of sub-surface archaeological deposits and compress material. In addition, the permanent installation of sheet piles in parts of the scheme would create a continuous barrier, which may result in de-watering impacts to waterlogged archaeological deposits. Design solutions, including artificial recharge, were proposed to mitigate potential impacts. Further information about piled foundation designs and their potential impact on archaeological assets has been published by Historic England.

**Site investigation techniques**

**Site Investigation combined survey**

If a development site is believed to have both contamination and archaeological issues, then there may be scope to combine site investigation surveys. This will generally involve an archaeologist monitoring the excavation of geotechnical test pits and producing their own site records. It can also entail a geotechnical engineer retrieving intact cores for an archaeologist to assess off site.

There are many benefits in combining surveys; the obvious benefits include cost and efficiency savings, other benefits include the quality of the primary record. Descriptions given to deposits by geotechnical engineers can be very different to the descriptions given by archaeologists, and therefore a less ambiguous and more relevant record will be collected if surveys were combined. For example, the term ‘made ground’, is frequently used by geotechnical engineers to describe ground which is something other than substrate, and is suggestive of relatively recent deposits. However, the term is often given to alluvium (waterlain sediment) and colluvium (sediment transported by slope processes). Both types of deposit have the potential to seal or contain archaeological assets and would be identified by a monitoring archaeologist as being of potential archaeological interest.

Therefore, combining geotechnical site investigation works with archaeological monitoring could enhance the quality of the site data, inform the risk assessment process for both contaminated land and archaeology, avoid duplication of effort and cost in terms of repeat site investigations, and help inform both the site’s remediation strategy and the scope of archaeological mitigation.

The output from a combined survey can produce a 3D stratigraphic model of the development site incorporating both geotechnical and archaeological data. This will show the areas of greatest archaeological potential and can therefore show where development will impact archaeological remains (Plate 11).
However, a combined survey will not be applicable to all sites, and the suitability of a combined survey will depend on several factors, including the nature of the underlying sediments, the type of information trying to be retrieved, and the nature of the site conditions. The decision to proceed with a combined survey when designing a site investigation should only be made following consultation between the developer’s geotechnical engineer and archaeologist.

Site Investigation design

When combining geotechnical and archaeological works, a good understanding of the risk of contamination is necessary. As the case studies have shown, archaeological remains can form part of a pollutant link and comprise a source, pathway or receptor.

The design of any site investigation should be site-specific and driven by the conceptual model of the site. Some of the factors likely to influence the selection of investigation method(s) for both land contamination and archaeological assessments include:

- The objectives of the investigation and the effectiveness of the methods to achieve them, taking account of issues including ground type, sampling requirements, nature of archaeological asset and contaminant type.
- Environmental impact (e.g. potential effect on archaeological assets present on site or adjacent sites).
- Health and safety implications.
- Climate and wet/dry weather constraints.

There is a range of intrusive and non-intrusive methods of site investigation techniques that can be used in both the assessment of land contamination and the assessment of archaeology. However, in land contamination assessment, non-intrusive techniques tend not to be as widely used as intrusive methods, and where they are used it is generally in conjunction with, or as a precursor, to an intrusive investigation.
The principal techniques are listed in Table 5 and information relating to the advantages and limitations is available in Environment Agency (2000b and 2002c), Nathanail et al (2002) and CIRIA (2002).

Table 5: Types of site investigation

<table>
<thead>
<tr>
<th>Investigation type</th>
<th>Information obtained</th>
<th>Useful data for archaeologists</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-invasive surveys</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geophysical survey: Radar (Ground Penetrating Radar)</td>
<td>Utility mapping, detection of voids and chambers, bedrock location and structure and mapping of Made Ground and landfill thickness.</td>
<td>Particularly effective for detecting buried structures such as walls and for location of voids such as culverts or crypts.</td>
</tr>
<tr>
<td>Geophysical Survey: Topsoil magnetic susceptibility</td>
<td>Not commonly used.</td>
<td>Enhanced magnetization will identify buried features and objects.</td>
</tr>
<tr>
<td>Geophysical Survey: Gradiometer or magnetometer</td>
<td>Detection of buried structures and underground pipes. Characterisation of landfill depth and extent. Detection of certain geological formations and discontinuities.</td>
<td>Sub-soil cut features may be identified by difference in magnetic properties of their fill. Strongly heated features such as hearth and kilns produce strong, readily detected signatures.</td>
</tr>
<tr>
<td>Geophysical Survey: Soil conductivity</td>
<td>Detection of buried structures, voids, former landfill sites, contaminated ground and leachate plumes.</td>
<td>Provides rapid overview of sub-surface character.</td>
</tr>
<tr>
<td>Geophysical Survey: Soil resistivity</td>
<td>Detection of structures and voids, disturbed ground, contaminant spills and leachate plumes</td>
<td>Will identify structures that differ strongly in resistance to subsoil, such as walls and ditches.</td>
</tr>
<tr>
<td>Geophysical Survey: Resistivity Tomography</td>
<td>Location of foundations, infilled ditches and ponds. Landfill character.</td>
<td>Profiling buried features with strong resistance contrast to subsoil such as wall, pits or ditches.</td>
</tr>
<tr>
<td>Microgravity Surveys (gravity surveying)</td>
<td>Detection of buried voids or tanks</td>
<td>Detection of buried structures or features such as walls.</td>
</tr>
<tr>
<td>Topographical Survey</td>
<td>Characterisation of the site, identification of uses and structures.</td>
<td>Site characterisation. Mapping of structures and earthworks, areas of past disturbance and intrusive damage to archaeological deposits.</td>
</tr>
<tr>
<td>Soil Chemical Survey</td>
<td>Surface soil sample collection.</td>
<td>Identification of past occupation or activity areas, industrial practices, etc.</td>
</tr>
<tr>
<td><strong>Invasive surveys</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial pits or trenches</td>
<td>Visual inspection of the soil profile and geology. Collection of soil samples.</td>
<td>Visual inspection of stratigraphy</td>
</tr>
<tr>
<td></td>
<td>Determine depth to the water table. Use of <em>in-situ</em> tests.</td>
<td>Assessment of artefact concentration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assessment of the extent, character and preservation of archaeological remains</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collection of artefacts and soil samples.</td>
</tr>
</tbody>
</table>
Drilling - Cable percussion, Rotary cored/open hole, hand or power auger Flight auger, window sampling

Visual inspection of the soil profile and geological succession. Collection of samples.

Depth to the water table. Use of in-situ tests.

Assessment of soil and sediment stratigraphy, particularly in deep alluvial sediments

Recovery of samples.

Potential issues to consider

When planning or carrying out site investigation works, in addition to the consideration of the impact of the site investigation on the archaeological assets, it is also important to mitigate the potential impact of other activities to make sure that the archaeological resource is not impacted. Examples include:

- Vehicle and plant movement. The weight of heavy plant or other imposed loads may cause soil failure through shearing or compaction resulting in the displacement of and physical damage to archaeological remains. The use of loading plates, low pressure tyres or geotextile mats could all be considered.

- Radial stresses that can damage archaeological assets, including vibration impacts that can cause physical damage to structures of archaeological interest.

- Design of site investigation to make sure that no pathway is created from the investigation works; for example, the use of auger boring to assess the soil stratigraphy could create a pathway for the transfer of mobile contaminants to an underlying aquifer.

- Weather conditions, for example avoid carrying out site investigation in wet weather when soil strength is lower leaving any archaeological deposits more prone to impacts from wheel rutting or compaction.

To achieve mitigation of the site specific risks, it is important that early communications between all parties are entered into and potential risks from the site specific design elements of the investigations considered. Measures such as ensuring site personnel (including sub-contractors) are aware of the archaeologically sensitive nature of the site, provision of accurate site plans showing the location of proposed intrusive investigations, adequate supervision on site, the use of appropriate equipment and the proper reinstatement or disposal of waste arisings should all assist in ensuring that the archaeological resource is not impacted unnecessarily.

Remedial options

During the Stage 4 risk evaluation stage as itemised in Table 1, an appropriate remediation strategy for a site should take account of the archaeological resource in addition to the requirement to break any pollutant linkage, whether or not the archaeology is part of the linkage. The selection of appropriate remedial measures on a site must be made on a site-specific basis and will be dependent on a range of factors including:

- The nature of the pollutant linkages present.

- The contaminant(s) and receptor present, including archaeology.

- The nature of the pathway linking the contaminant and the receptor.

- Time and cost implications.

- Local issues such as noise, dust, lorry movements etc.
• Regulatory controls: why is the work being carried out? Remediation requirements under Part IIA must be reasonable.

• The remedial technology including the track record, requirement for regulatory control of the technology. For example, some remedial technologies require planning permission, discharge consents, waste management controls, or Scheduled Monument Consent.

• Aftercare and monitoring requirements.

Remediation design and impacts to archaeology
The design of an effective remedial strategy for a site can be complex in terms of achieving required standards and minimising the potential impact on the environment within the time frame allocated. The presence of more than one pollutant linkage and varying ground conditions may also lead to more than one remedial option within the overall strategy. Where archaeological assets are also a consideration, early consultation between the contaminated land consultant and the developer’s archaeologist is essential to avoid or reduce potential impacts to archaeological remains.

Most forms of remediation have the potential for some adverse archaeological impact. This may be either a direct physical impact or an indirect impact for example on the burial environment. Methods that involve physical disturbance or removal of archaeological deposits will normally be totally destructive. Where important archaeological deposits exist, the need for physically intrusive remediation must be very clearly demonstrated. In-situ remediation almost always involves a level of physical disturbance and will have a varied impact on the burial environment. Some of the potential impacts of remediation techniques upon archaeological assets are summarised in Table 6.

Table 6: Remediation impacts and effects on archaeology

<table>
<thead>
<tr>
<th>Impact of remediation</th>
<th>Effect on archaeology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil disturbance</td>
<td>Will destroy features, artefacts and archaeological context</td>
</tr>
<tr>
<td>pH</td>
<td>Changes in pH levels can affect the preservation of archaeological data and artefacts resulting in:</td>
</tr>
<tr>
<td></td>
<td>• Corrosion of iron and copper-alloy (bronze) artefacts;</td>
</tr>
<tr>
<td></td>
<td>• Decay of organic remains such as leather, wood, textiles and bone</td>
</tr>
<tr>
<td></td>
<td>• Degradation of environmental evidence, such as molluscs with rise of acidity</td>
</tr>
<tr>
<td></td>
<td>• Glass may be affected by a rise in pH</td>
</tr>
<tr>
<td></td>
<td>• Compromise integrity of DNA evidence which is vest preserved at neutral pH</td>
</tr>
<tr>
<td>Addition of organisms</td>
<td>May affect degradation of organic artefacts and could promote corrosion of metals e.g. sulphate reducing bacteria</td>
</tr>
<tr>
<td></td>
<td>May promote the degradation of organic materials</td>
</tr>
<tr>
<td></td>
<td>Effects on scientific analysis: organic chemicals, bacteria and fungi may affect results of radio carbon dating, carbon / nitrogen ratios and DNA analysis etc. the redox and pH of the burial environment</td>
</tr>
<tr>
<td>Redox</td>
<td>Change in redox may affect preservation of organic materials. Aeration causing</td>
</tr>
</tbody>
</table>
shift in redox from anaerobic to aerobic conditions, resulting in loss of preserved waterlogged remains

<table>
<thead>
<tr>
<th>Addition of substances or transformation</th>
<th>May react with archaeological metal artefacts e.g. iron and copper, organic artefacts e.g. leather, wood, textiles e.g. with the addition of S2-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effects on scientific analysis: organic chemicals, bacteria and fungi may affect results of radio carbon dating, carbon / nitrogen rations and DNA analysis</td>
</tr>
</tbody>
</table>

| Changes in groundwater level | May affect archaeological metals e.g. iron and copper, organic artefacts e.g. leather, wood, textiles, and bone. Fluctuations in groundwater level may affect stone surfaces |

### Measures to mitigate impacts to archaeology

An appropriate remediation strategy should take account of archaeological assets in addition to the requirement to break any pollutant linkage, whether or not the archaeology is part of the linkage. There are two principal mitigation options available:

- Preserve the remains *in-situ*: The identification of archaeological assets early in the planning and development process can increase the success of preserving remains in situ, as a suitable design solution may be achieved. For example, if there are areas of high archaeological sensitivity, the archaeology areas can be chosen for low sensitivity end uses, thereby removing the need for remediation and avoiding archaeological impacts. Where an *in-situ* remedial technique is selected, additional measures to protect the remains may be required, for example, creating an effective barrier. Further information about the preservation *in-situ* of archaeological remains has been published by Historic England (forthcoming).

- Preserve the remains by record: Remediation techniques that are more intrusive on archaeological remains may be mitigated by an appropriate programme of archaeological investigation, which can be undertaken in advance of, during or after remediation.

Both mitigation options should be discussed with the developer’s archaeologist and agreed with the local authority’s Archaeology Officer.
Key points

**Early assessment**: A principal theme of archaeological and contaminated land assessments is the early identification of site constraints and characterisation of the underlying sedimentary sequence. To conserve archaeological assets, and to avoid impacts that could result in loss or harm, it is essential that the below-ground environment is understood.

**Early consultation**: Early contact with the regulator, local authority Contaminated Land Officer, Archaeology Officer, and Historic England if applicable, will help identify the key issues associated with a site and inform the scope, suitability and feasibility of further investigation and avoidance/preservation options.

**Information sharing**: Archaeological information can be vital for the construction programme in informing levels of risk and cost. Similarly, information about the type of contamination at a site is important for informing the scope of archaeological investigation and for protecting the health of on-site archaeologists and off-site archaeologists who may be handling or processing contaminated remains during post-excavation stages.

**Collaborative working**: Better collaboration between technical teams will enhance the site record and promote better understanding of site issues. The developer is often the common link and should make sure that site information is made available to all. In addition, it is essential that communication between disciplines is encouraged; pertinent information may be lost if a contaminated land specialist attempts to interpret an archaeological report. Similarly, an archaeologist is not qualified to understand the implications of the hazards identified in a contaminated land report.

**Combined surveys**: Combine geotechnical site investigation works with archaeological monitoring to enhance site data, inform risk assessment process for both contaminated land and archaeology, promote time and fee efficiencies by avoiding duplication of work.

Guidance and useful information

This page lists some of the mandatory and advisory guidance issued by the Environment Agency and other government departments along with useful sources of information. Other relevant documents are available on GOV.UK and from the archived Environment Agency page. Other documents referenced in CLR11 published by other organisations should be accessed through their websites directly.

Planning


Land Contamination

CIRIA 2001 *Contaminated land risk assessment – a guide to good practice C552*

CIRIA 2002 *Non-biological methods for assessment and remediation of contaminated land. Case studies report RP640*
CL:AIRE/EIH 2008 Guidance on Company Soil Contamination Data with a Critical Concentration

Contaminated Land (England) Regulations 2000

Contaminated Land (England) (Amendment) Regulations 2012

Defra Circular 01/2006 www.defra.gov.uk

Defra Circular 04/2012 Environmental Protection Act 1990: Part 2A. Contaminated Land Statutory Guidance

DETR 2000 Guidelines for Environmental Risk Assessment and Management

http://www.environmentagency.gov.uk/commondata/105385/model_procedures_881483.pdf CLR11 provides details of many other guidance documents and a full glossary of terms

Environment Agency 2000 Technical aspects of site investigation Volumes I and II
https://www.gov.uk/government/collections/land-contamination-technical-guidance

Environment Agency 2002 Guidance on the selection of non-intrusive techniques for groundwater pollution studies

Nathanail, J., Bardos, P., and Nathanail, C. P. 2002 Contaminated land management


Historic Environment

Historic England National Heritage List for England (NHLE)
https://historicengland.org.uk/advice/hpg/heritage-assets/nhle

Historic England National Record of the Historic Environment (NRHE) http://www.pastscape.org.uk

Historic England Archive http://archive.historicengland.org.uk

Archaeology Data Service http://archaeologydataservice.ac.uk/archives/archives.jsf

Historic mapping

Historical Map Archive https://www.old-maps.co.uk

Old Maps Online http://www.oldmapsonline.org

Miscellaneous

Durham Mining Museum http://www.dmm.org.uk

British Geological Society geology mapping http://mapapps.bgs.ac.uk/geologyofbritain/home.html

British Geological Society borehole data
http://mapapps.bgs.ac.uk/geologyofbritain/home.html?mode=boreholes