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Archaeological Sensitivity Pilot Projects

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Cover image: Medieval earthworks at Scorborough, East Yorkshire, including two moats, settlement and ridge and furrow. RAF/540/1750 0007 21-DEC-1955 © Historic England Archive

Summary

This document sets out the context and methodology for Historic England's approach to developing sensitivity mapping for archaeology. Sensitivity mapping aims to assist planners and land managers to understand the potential impact of large-scale development or other landscape change on the historic environment. It indicates the likelihood of encountering significant archaeological remains in a given area, providing more upfront information for local plans and allocations than is usually available at present. Historic England's vision for sensitivity mapping is set out in Ch 1. This section describes the genesis of the project in relation to the 2020 planning white paper (1.1.1) and sets out the purpose of the work in terms of moving from a 'dots on map' approach to a continuous characterisation (1.1.2).

In landscape assessment, sensitivity mapping combines judgements of the value of a defined aspect of the landscape resource and its susceptibility to a proposed or envisaged change. For archaeological purposes that value is seen as a combination of the potential for an asset to be present with its likely condition and significance, while the impact of any given change scenario is a combination of an asset's vulnerability to harm and the opportunity for positive change, including the possibility of gaining new understanding of the past.

There have been numerous previous studies, both academic and for heritage management purposes, attempting to extrapolate from the known archaeological resource and other characteristics of the landscape in order to predict, model or characterise the potential for as yet unknown archaeological remains in a given area. However, no consistent methodology has yet been established. Various such approaches are reviewed in Ch 2, distinguishing archaeological characterisations (2.1), local authority alert mapping (2.2) and predictive models (2.3). (Note that some images are reproduced from digital reports for illustrative purposes only and not all details may be legible.)

The aim of our approach is to understand the different likelihoods of any area of land within a given study area containing significant archaeology. To be suitable for early engagement with strategic planners an output must be relatively easy both to deliver and to understand. Our model considers four components or parameters which contribute to sensitivity:

- Presence: the probability of a heritage asset occurring
- Condition: the likely state of preservation if an asset is present
- Significance: the value ascribed to a heritage asset if present
- Vulnerability and Opportunity: the potential implications (negative and positive) of land use change for a heritage asset.

The scope of these components and how they might be assessed are set out in Ch 3:

- The long history of human occupation in Britain means that archaeological presence has to be considered as a series of broad chronological layers. For each period known assets should be mapped in order to identify broad spatial patterns and assess the degree of correlation with a variety of environmental and cultural indicators. These results can then be used to build understanding of the likelihood of unknown assets being present in different parts of the landscape, which might be presented in terms of a series of levels (3.2.1).
- The likely condition of assets yet to be discovered is a combination of their potential physical preservation, as a result of later land use, and their potential for preserving different categories of evidence, as a result of soil chemistry (3.2.2). The application of the conceptual framework starts with assigning scores to known assets.
- Significance is a judgement of the values that can be ascribed to certain assets because they hold attributes deemed as important (e.g. by designation as scheduled monuments) or make a contribution to current research frameworks. What constitutes an asset in this context and how significance is assigned are covered in section 3.2.3.
- Vulnerability and opportunity are scenario-based and relate to the nature of proposed change. Thus a sensitivity model for development through the planning process may be different to one for tree-planting in the same landscape, for example. Developing this aspect of the model requires further work (3.2.4).

Chs 4 to 7 outline a series of case studies, each covering an area between 150 and 300 sq km, that apply the basic methodology to landscapes of different character with differing availability of prior archaeological evidence. These work through the modelling process in slightly different ways depending on the nature of the available data, accompanied by GIS outputs that illustrate the working process. Scales are shown on the first figure in each chapter and north is to the top unless stated.

The areas covered are the Vale of Aylesbury (Buckinghamshire), London Gateway (Essex), Holderness (East Yorkshire) and the Eden Valley (Cumbria). In each case the nature of the archaeological record, as recorded in the relevant Historic Environment Record, is quantified by period and type, with period-based analysis of the distribution and density of assets. Condition mapping is largely based on Historic Landscape Characterisation, geological mapping and land-use. In the Vale of Aylesbury and London Gateway, where the area of development-led excavation is greater, a number of case studies inform the detail and quantitative aspects of the model. Additionally the Vale of Aylesbury study includes a test of the model using new data from HS2, which demonstrates the broad validity of the sensitivity model (4.8).

The main conclusions of the Vale of Aylesbury study (Ch 4) are as follows:

- The Bucks HER already identifies 12.4% of the study area as having known archaeological interest, but at least 75% of pre-medieval heritage assets are not currently known.
- Typically large greenfield development sites have significant archaeology covering 5–20% of their area.
- Neolithic and Early Bronze Age archaeology is correlated with chalk and limestone geologies but later prehistoric, Roman and medieval archaeology is found across all geologies and topographical locations.
- Proximity to known heritage assets (such as medieval churches and SMs) is a good predictor of new discoveries.
- The medieval and post-medieval landscapes can be mapped with tolerable accuracy to provide a spatial predictive model of archaeological character.
- The Chilterns AONB has a distinctive archaeological character providing an appropriate zonal boundary for management purposes.
- The potential condition of remains can be mapped with tolerable accuracy regardless of whether an asset has been confirmed in that location.

The main conclusions of the London Gateway study (Ch 5) are as follows:

- Heritage assets of archaeological interest are widespread but show strong patterning, particularly in relation to local geology and topography.
- The case-studies show considerable variation.
- The area divides into four broad zones with different sensitivity characteristics: a coastal zone where well-preserved archaeology is likely to survive beneath alluvial deposits; gravel terraces with a high density of significant archaeology but severe truncation by arable cultivation; other geologies with lower densities of archaeology and variable preservation; and a modern development zone where archaeological potential has been destroyed or fragmented.
- Positive indicators for archaeological presence include conservation areas, proximity to designated assets, and local high points.

The main conclusions of the Holderness study (Ch 6) are as follows:

- Differences in sensitivity characteristics are evident between three zones: the Wolds edge, the alluviated Hull valley and central Holderness, linked primarily to topography and geology. Local character areas therefore have some value in defining archaeological presence.
- SHINE data is more representative of the archaeology of the study area than designations; this highlights Iron Age/Roman cropmarks in the Hull valley and medieval settlement in the other zones. However, the limited number of open-area excavations severely reduces the level of certainty with which judgements of sensitivity can be made.
- Earlier prehistoric archaeology shows a focus on a major palaeochannel, later followed by a canal; aerial mapping in part of the study area has revealed a broad distribution of later prehistoric and Roman field systems and trackways.
- Medieval archaeology is widely found except for alluviated areas of the Hull floodplain, onto which settlement only spread in the post-medieval period (post-drainage). It is likely that the majority of medieval settlement locations have been identified.
- Although there are few known wetland archaeological sites in the area, there is clear potential for the preservation of wooden trackways, evidence of woodland management and palaeoenvironmental sequences.

The main conclusions of the Eden Valley study (Ch 6) are as follows:

- The data are limited compared to other areas, but some differences in distributions are evident between the east and west of the study area (in certain periods) and between river valley and interfluve.
- The scheduled monuments within the study area represent a reasonable selection of the known archaeology, but the very limited number of open-area excavations severely reduces the level of certainty with which judgements of sensitivity can be made; however, other work in the vicinity gives a sense of the likely density of assets.
- Aerial mapping has contributed significantly to our understanding of later prehistoric and Roman archaeology, while the late medieval/early post-medieval landscape can be tolerably well defined through a combination of HLC (relict land use) and ridge and furrow mapped from the air.

While some of the studies' conclusions may appear 'obvious' to experienced practitioners, in defence of the methodology it is suggested that others are not, and that statistical analysis can confirm, refute or refine personal impressions which may be coloured by psychological factors such as confirmation bias. This approach also has the merit of providing a basis for structured 'expert system' approaches which will help less experienced practitioners to rapidly appreciate local patterning without the need to study every detail of the increasingly voluminous literature.

Chs 8 and 9 summarise the key results of the pilot studies and outline a number of issues still to be resolved along with recommendations for further work. The discussion covers the identification of assets and the need for different treatment and thresholds in different areas (8.2), the locational factors relevant to different periods (8.3), the value of case studies (8.4), issues with condition modelling (8.5) and the verification of the models (8.6).

The recommendations relate to three main areas and can be summarised as follows:

Building the model (9.2.1)

1. Explain sensitivity mapping more widely and ensure a consistent approach to terminology
2. Explore different approaches to the presentation of models
3. Develop protocols for filtering heritage assets
4. Assess potential for mapping survival patterns
5. Encourage more objective descriptions of condition
6. Work through specific change scenarios
7. Scope the potential applications of machine learning approaches
8. Explore the spatial limits of rules identified for the pilot study areas
9. Use infrastructure projects to test other pilot study models

Dealing with data (9.2.2)

10. Explore statistical methods of correcting for sampling bias
11. Develop guidelines for using undated records
12. Trial a programme of HER enhancement in a suitable area
13. Incorporate sensitivity mapping into an aerial investigation and mapping project
14. Better understand the character, representativeness and variability of the NHLE
15. Experiment with mapping cultural heritage capital and/or community values
16. Consider how research frameworks can inform significance
17. Develop a method of summing multiple sensitivities
18. Explore use of other datasets
19. Explore links with sensitivity assessment for historic landscape

Using the model, especially in a planning context (9.2.3)

20 Review the use of previous predictive modelling outputs
21 Consult potential users about how to present the models
22 Explore the interface between sensitivity 'tiers' and planning rules
23 Explore processes for keeping models up to date
24 Consider how to assess the efficiency of a model.

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Archive location

Relevant data generated by the project will be deposited with the Historic England Archive.

Date of research

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Contents

1 Introduction

1.1 Project vision

Archaeological sensitivity mapping aims to assist planners and land managers to understand the potential impact of large-scale development or other landscape change on the historic environment. It indicates the likelihood of encountering significant[1] archaeological remains in a given area, providing more upfront information for local plans and allocations than is usually available at present. Sensitivity mapping does not remove the need for archaeological assessment and mitigation in advance of development, but supports sustainability by saving resources if development can be located to avoid areas where significant archaeology is more likely to be encountered. Early recognition of archaeological sensitivity will also help the public benefit of the historic environment to be better realised in design codes and masterplans. This document sets out the context and methodology for Historic England's approach to developing sensitivity mapping for archaeology, including four pilot studies from different areas of England.

1.1.1 The planning context

The National Planning Policy Framework (NPPF)[2] emphasises the positive contributions the historic environment can make to sustainable development and recognises that heritage assets are 'an irreplaceable resource, and should be conserved in a manner appropriate to their significance, so that they can be enjoyed for their contribution to the quality of life of existing and future generations'. As a subset of those heritage assets, archaeological remains are often buried and hidden but their role in shaping the present landscape is important both intrinsically, informing our collective understanding of the places where we live today, and instrumentally, since understanding trajectories of past changes in environment, climate and society is relevant to how we shape the present and imagine the future, whether assets comprise physical features that still serve a purpose in the landscape or simply contribute to narratives that promote resilience.

In March 2020 the Planning for the Future white paper[3] proposed replacing the present discretionary planning process in England with a rules-based system. Despite concerns about some of the proposals, Historic England welcomed the opportunity it presented to

[1] see 3.2 for a discussion of what is considered 'significant' in this context

[2] https://www.gov.uk/government/publications/national-planning-policy-framework--2

[3] https://www.gov.uk/government/publications/planning-for-the-future

develop better local plans, improve public participation in the planning process, and provide greater certainty regarding what development takes place in an area. For the historic environment sector the key proposal was the introduction of an area-based system that would place land in one of three categories (‘growth’, ‘renewal’ and ‘protected’), potentially requiring a change in our approach to archaeological assessment and mitigation. The main concern was to ensure that archaeological data would help inform decisions about the allocation of land to particular zones, while maintaining an appropriate process of field evaluation and mitigation even in areas earmarked for ‘growth’. However, having greater certainty about the principles of development would also present opportunities to improve certain aspects of development-led archaeology, including an enhanced focus on research, synthesis and outreach (with the corresponding public benefit).

Although it now appears that there will not be a Planning Bill in the form envisaged by the 2020 white paper, nor wholesale change to a rules- or area-based system, the subsequent Levelling Up white paper[4] has confirmed the government’s commitment to reforming the planning system. Depending on the details, this could still both produce risks to the provision for archaeological investigation and provide opportunities to improve practice in development-led archaeology, along the lines set out by CIfA and Historic England’s 21st Century Challenges initiative[5]. Prefiguring some elements of the response to the Planning for the Future white paper, the report on the initial discussion workshops (Wills 2018) recognises the importance of ‘front loading’ the system by ‘providing high quality information from HERs to input to Local Plans, Neighbourhood Plans and other strategies, so that better information is available when the principle of development is considered.’

Ensuring that archaeology is managed appropriately within a reformed planning system with a greater focus on plan-making would require, among many other things, the adequate resourcing of Historic Environment Records (HERs). This would facilitate the provision of data and tools so local authorities could carry out the enhanced role such a system would require, in particular the increased amount of work that would need to be done at the allocation stage to model the archaeological sensitivity of any given area. That in turn would provide greater levels of certainty at the consent stage, allowing local authorities to balance their dual responsibilities for protecting heritage and enabling (sustainable) growth. We envisage a model HER not as a single dataset with point data in a GIS, but a collection of GIS data sources which are primarily designed to be used by

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[4] https://www.gov.uk/government/publications/levelling-up-the-united-kingdom

[5] https://www.archaeologists.net/projects/21st-century-challenges-archaeology

local authority historic environment specialists. Historic England's sensitivity mapping project aims to contribute to this by assessing the potential of different techniques and approaches to produce mapping necessary to ensure archaeology is managed appropriately and proportionately at a strategic planning level, or when other forms of large-scale landscape change are proposed.

1.1.2 Archaeological sensitivity

Ever since archaeology was embedded in the planning system there have been efforts to reduce the likelihood of unexpected discoveries by the development of area-based approaches to mapping, characterising, modelling or predicting archaeological sensitivity, potential or risk. The choice of terminology is often dependent on whether the viewpoint is that of the researcher, heritage manager or developer, but here we refer to archaeological character, potential and (where specific change scenarios are implied) sensitivity. Because we are concerned with the unrecorded resource (see 3.1), here we define archaeology specifically as buried remains (structures, deposits and artefacts) that may or may not be associated with visible features such as earthworks; the question of which aspects of the archaeological record reach the threshold of significance in order to be defined as 'heritage assets' is explored below (3.2.3). However, it is important to note that many other elements of the wider historic environment, including recorded archaeology, buildings and landscape features, will have a bearing on understanding the archaeological sensitivity of a given area, as the pilot studies presented in this report demonstrate.

In a broader environmental context, 'sensitivity' is often defined as the degree to which a particular characteristic of an area is vulnerable to harm. In landscape assessment it combines judgements of the value of a defined aspect of the landscape resource and its susceptibility to a proposed or envisaged change (or ability to accommodate change, which can also be termed 'capacity': see Herring 2022). When considering archaeological sites we tend to think in binary terms of preservation vs destruction (and recording) rather than an asset's 'ability to accommodate change', but some kinds of archaeological asset might be accommodated within different change scenarios. We should also recognise that change can be positive for the historic environment: for example, if an at-risk site is brought out of cultivation into public open space in a new development.

The NPPF is not insistent on mapping known heritage assets of archaeological interest. However, it does say that HERs should be used to 'assess the significance of heritage assets' and 'predict the likelihood that currently unidentified heritage assets, particularly sites of historic and archaeological interest, will be discovered in the future'. At least since the 1980s some planning archaeologists have drawn up maps showing where 'significant' non-designated archaeological sites are known or believed to exist. However, no specific guidance was given to local authorities on how to enact these policies nor was financial support made available specifically for such mapping. Hence current methods for local archaeological alert or constraint mapping is extremely variable and there has been little research into its practice or efficacy. Accordingly a separate project was set up to investigate this and the interim results are summarised below (2.2).

Whatever the availability of existing alert maps and the methods used to produce them, we have a wide and growing range of historic environment data to draw on for sensitivity mapping, not only from previous commercial work but also remote sensing and ground-based surveys, as well as the long history of investigations prior to the introduction of developer funding. However, the lack of an established approach to such modelling reflects a number of difficulties related both to the nature of the archaeological record and the uneven distribution of current knowledge. While many distribution maps record the presence of known assets ('dots on maps'), for the blank areas in between they generally fail to distinguish between genuine absences (areas which are known – as far as possible – to be lacking in significant remains) and pseudo-absences (areas which have yet to be investigated).

The 'dots on maps' approach can be contrasted with a method like historic landscape characterisation (HLC), which assigns the entire (visible) landscape to a category based on extant historic character, i.e. there are no blank areas. On the other hand, although HLC includes some time depth ('previous character') this is generally restricted to what can be inferred from post-medieval maps. Developing a form of characterisation for archaeological potential, if we could deal with the patchy nature of the evidence, would emphasise the deep history of the landscape and help move away from a binary division of sites and 'non-sites'; after all, even where we have no remains of permanent settlement, over millennia the paths of hunter-gatherers, droves of pastoralists and fields of farmers have spread across almost the entire surface of Britain. Remains may vary hugely in significance, survival/condition and visibility but they will (almost) always be present. The question is: can we develop sufficient understanding of the character of the (continuous) archaeological record to say in advance of development where 'hotspots' of presence and significance are more likely to be, and thereby target research and conservation efforts accordingly? While the focus of this paper is on decision-making in planning, which inevitably emphasises 'assets' (of a defined significance) over the background landscape signature or 'fingerprint' (see Thomas and Darvill 2022), as archaeologists we nevertheless recognise the validity and contribution of the latter. Archaeological sensitivity mapping therefore needs to assign value, in some form, to all areas of the landscape, based on understanding of the known resource and its correlation with various landscape variables, both natural and cultural.

1.2 Aims and objectives

The work reported here had two stages: the first reviewed existing approaches, including a range of work previously undertaken or commissioned by Historic England, and 'big data' projects undertaken by academic institutions, in order to clearly define sensitivity and develop a methodology for testing in a small number of pilot areas with different levels of baseline understanding. The second stage involved pursuing those pilot projects to investigate the feasibility of producing maps and/or models of archaeological sensitivity. The intention is that these could inform local plans, protect archaeology within areas proposed for growth (or other forms of large-scale change), and improve the public benefits of development-led archaeology. Consultation with key sector partners (professional and academic) forms part of the evaluation of the pilot projects. The report also identifies issues to be resolved and potential next steps.

The specific aims of the project were:

1. To develop a vision for how mapping archaeological sensitivity could work in practice, explaining the context and aims of the project – this is summarised in the discussion above (1.1)
2. To review existing case studies and approaches to mapping and modelling archaeological sensitivity on a landscape basis in order to develop a trial methodology and define pilot areas – this is summarised below in sections 2.1 (review) and 3 (methodology)
3. To undertake a small number of desk-based pilot projects in the selected areas, using GIS analysis of HER data and other extant datasets in order to investigate the feasibility and value of producing maps of archaeological potential, character and/or sensitivity. These are described in sections 4–7 and reviewed in sections 8–9.

2 Review of approaches

2.1 Archaeological characterisations

There are two broad types of approach to mapping archaeological potential or sensitivity beyond simply recording the location of known assets. The first, as mentioned above, is characterisation, building on HLC and equivalent approaches. However, despite its origins in the landscape archaeology tradition (Herring 2012), HLC has rarely incorporated archaeological remains in any systematic manner, concentrating instead on the (visible) historic character of the extant landscape and to a more limited extent its immediate precursors in the medieval and post-medieval periods. The Extensive Urban Surveys (EUS) are a form of characterisation that does explicitly include archaeology, but a recent review found that only half of those studied included what may be considered true maps of 'archaeological character', and the number doing so had declined over time (LUC 2020).

Whilst the core HLC methodology does not include buried archaeology, whether as known assets or predictions of potential, some studies have sought to extend the basic method by assigning archaeological significance and sensitivity scores to particular HLC Types (e.g. Buckinghamshire, the Chilterns AONB, Oxfordshire and West Berkshire). For example, the Chilterns HLC assigned separate scores to each Type for the heritage values set out in Conservation Principles[6] (evidential, historical, aesthetic and communal) using peer-reviewed professional judgement (Green 2009; Fig. 2.1). As evidential value is similar to archaeological interest the other values may be, at least initially, set aside for the purpose of assessing archaeological sensitivity. However, such an approach does not take into account the variety of other factors that might mean some areas assigned to a particular HLC Type have greater archaeological potential than others.

A more sophisticated effort at this kind of integration was the Lowland Cornwall project, which analysed statistically the relationships between archaeological sites of different type and particular HLC Types (Fig. 2.2) or Zones (simplified and generalised from the Types), and then devised formal predictive models for each site type, with varying degrees of accuracy and precision (Young 2015). The approach is particularly suited to a county where the visible landscape has a relatively high degree of time depth – in this case 60% of the landscape falls into the HLC Zone termed Anciently Enclosed Land, which is 'interpreted as the medieval farming and settlement heartland and, by inference, the prehistoric and Romano-British farming heartland'.

[6] https://historicengland.org.uk/images-books/publications/conservation-principles-sustainable-management-historic-environment/

HLC Type	Evidential		Historic		Aesthetic		Communal		Summed Score	Significance
Government and Civic Offices	1	86%	2	71%	2	57%	3	43%	8	M
Hospitals, Schools & Universities	1	86%	2	71%	1	86%	3	71%	7	L/M
Utitlites	1	71%	1	100%	1	100%	1	100%	4	L
Airfields (Civil)	2	57%	2	57%	1	100%	1	57%	6	L/M
Motorways & Canals	2		2		1		2		7	L/M
Assarts	2	71%	3	57%	3	43%	2	71%	10	M/H
Enclosure (19th Century)	2	86%	2	57%	2	43%	1	71%	7	L/M
Enclosure (20th Century Fields)	2	71%	1	57%	1	86%	1	71%	5	L
Enclosure (20th Century Prairie Field)	1	57%	1	86%	1	86%	1	100%	4	L
Enclosure (Coaxial Fields)	3	100%	3	86%	2	57%	1	57%	9	M/H
Enclosure (Crofts)	3	86%	3	71%	2	57%	2	71%	10	M/H
Enclosure (Parliamentary Enclosure)	2	71%	3	86%	2	100%	1	57%	8	M
Enclosure (Parliamentary Enclosure) Modified boundaries	2	86%	3	71%	2	100%	1	57%	8	M
Enclosure (Pre 18th Century Irregular Enclosure)	2	71%	2	71%	2	86%	2	57%	8	M
Enclosure (Pre 18th Century Regular Enclosure)	2	71%	2	71%	2	100%	1	57%	7	L/M
Enclosure (Pre 18th Century Sinuous)	2	71%	3	57%	3	57%	2	71%	10	M/H
Fossilised Strips	3	71%	3	86%	3	57%	2	71%	11	H
Meadows	3	86%	3	71%	3	86%	2	57%	11	H

Figure 2.1: Heritage value scores assigned to different HLC types in the Chilterns (extracted from Green 2009, 97)

A different approach to characterisation is local Landscape Character Assessment (LCA), which, rather than assigning land parcels to pre-defined Types, aims to define areas with unique combinations of key landscape characteristics. The National Character Areas[7] (NCAs) represent a high-level version of this approach but most local authorities also have their own finer-scale LCAs (though they are rarely available digitally). In some cases character areas with historical relevance have been derived from HLC mapping, e.g. in Northamptonshire where a number of geographically discrete Historic Character Areas were defined (Northamptonshire County Council 2005; Fig. 2.3). While the definition of the character areas in this case was based solely on the visible fieldscape, such an approach

[7] https://www.gov.uk/government/publications/national-character-area-profiles-data-for-local-decision-making/national-character-area-profiles

could be made more archaeologically relevant. In Essex the DCMS Principles of Selection for Scheduled Monuments[8] have been adapted to assess local Historic Environment Character Areas (HECAs) that were defined using other criteria, while in Hampshire, Buckinghamshire and elsewhere, both HER and HLC data were used to inform the definition of local landscape character areas.

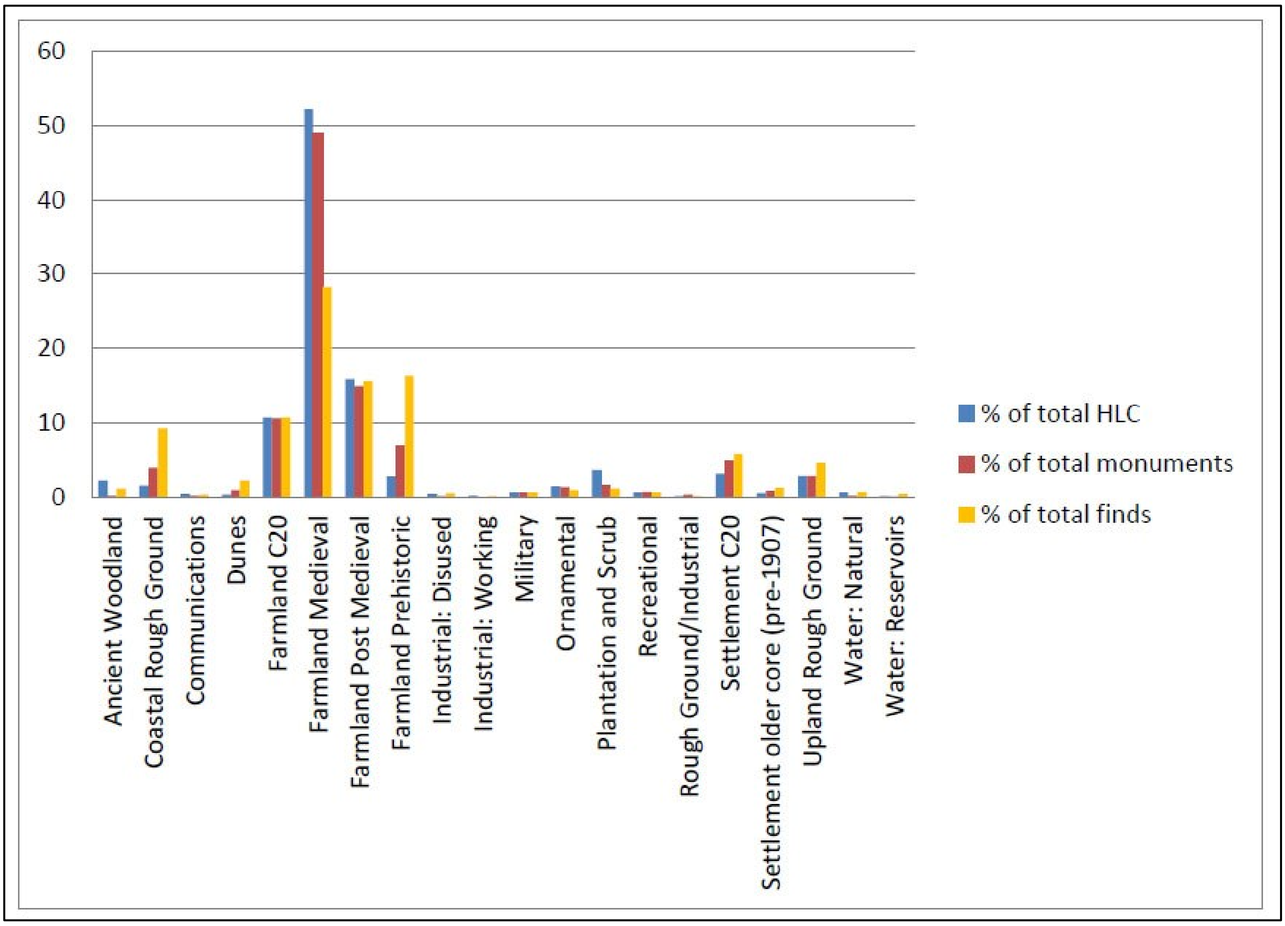


Figure 2.2: Graph showing HLC Types in lowland Cornwall, the percentage of monuments and find spots recorded from each, and the percentage of the project area taken up by each HLC Type (from Young 2015)

At a larger scale, the current iteration of the Dutch Archaeological Landscapes Map divides the country into landscapes (similar to character areas; Fig. 2.4) and landscape zones (geomorphological units), each of which is scored for the main archaeological periods as a basis for deciding their archaeological relevance (Rensink *et al.* 2017).

[8] https://www.gov.uk/government/publications/scheduled-monuments-policy-statement

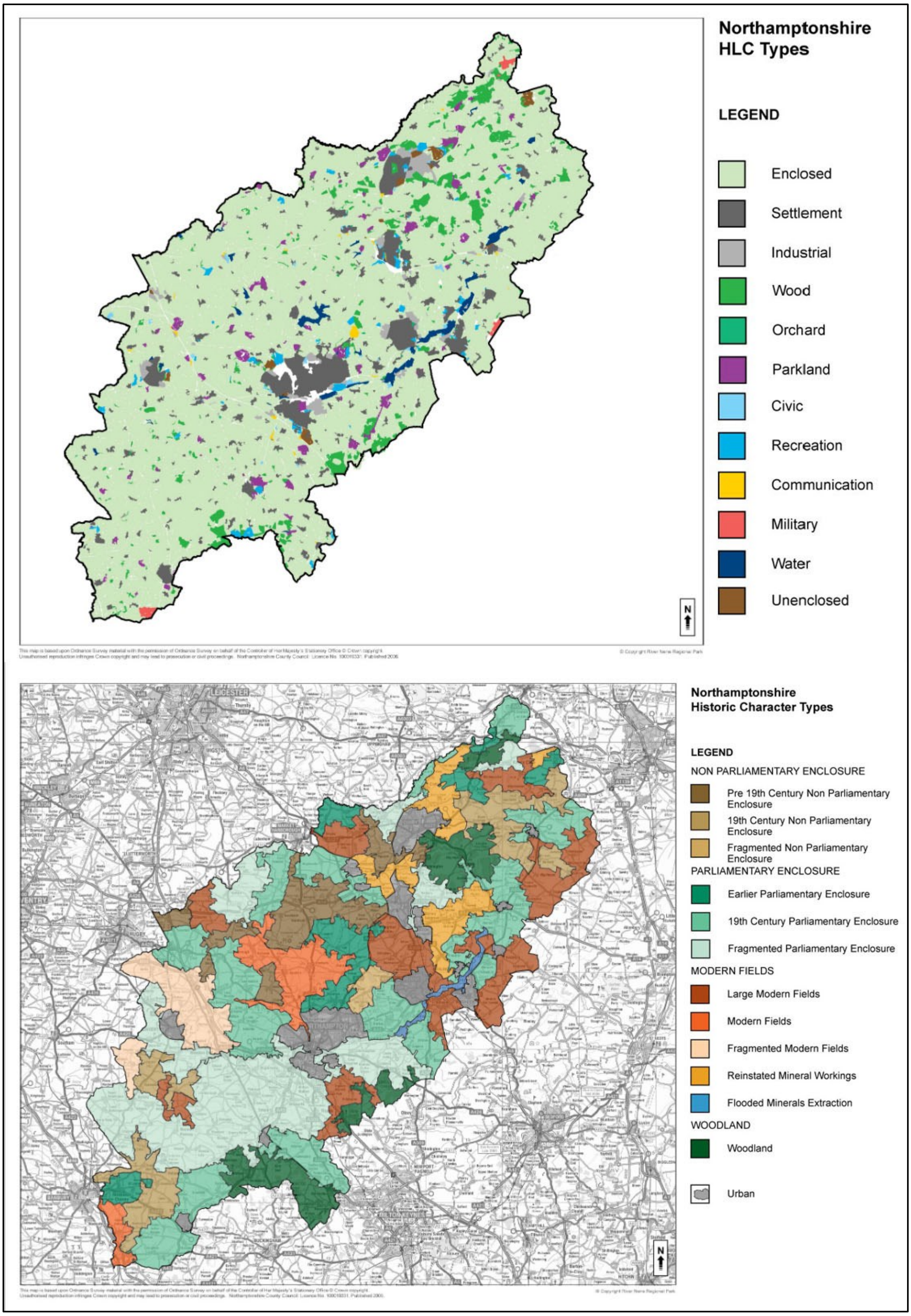


Figure 2.3: Comparison of HLC and Historic Character Areas in Northamptonshire (adapted from Northamptonshire County Council 2005, via Archaeology Data Service)

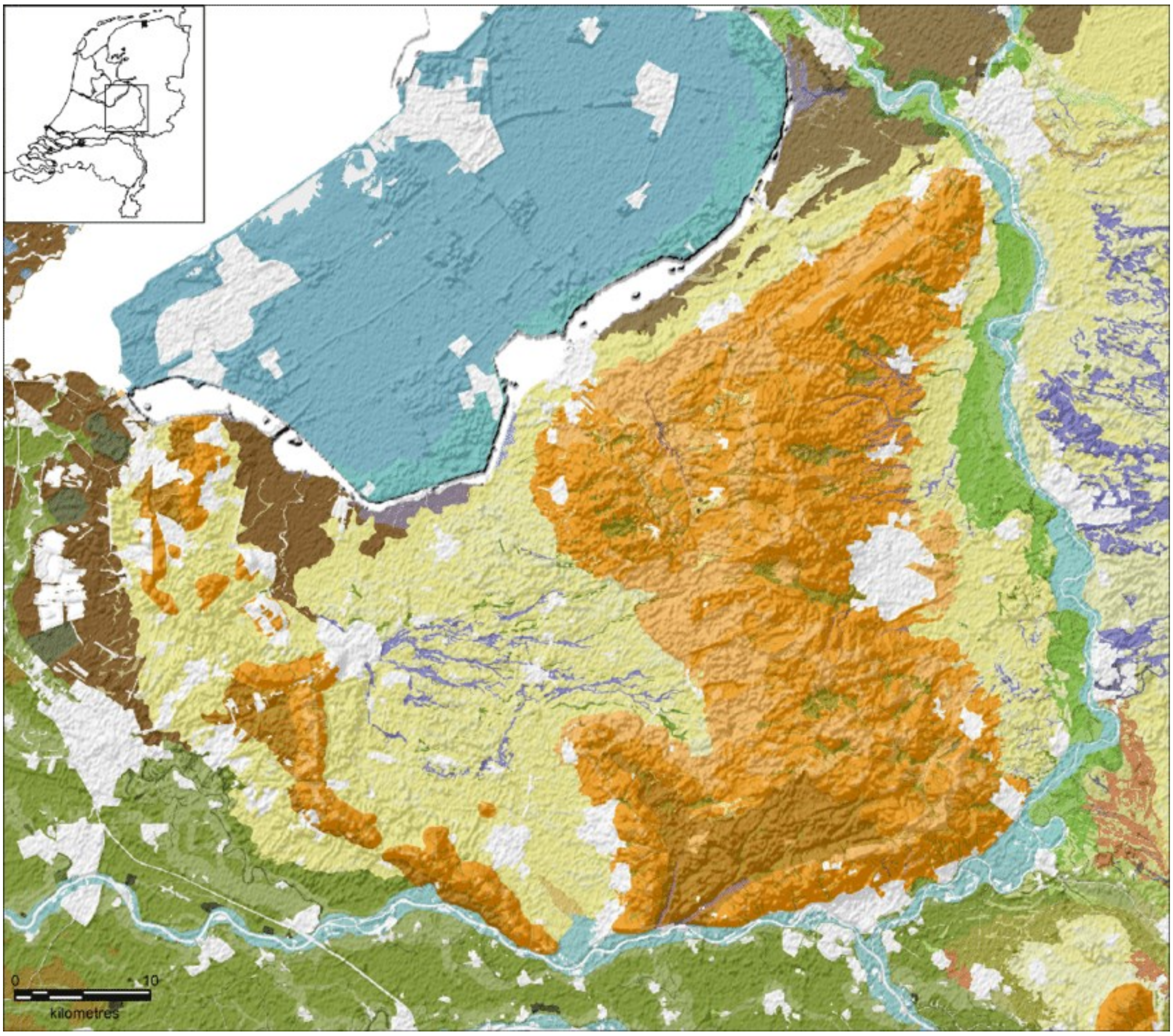


Figure 2.4: Section of the Archaeological Landscapes Map of the Netherlands depicting landscape units in the Veluwe region, especially the characteristic moraines (light and dark orange; from Vletter and van Lanen 2018, fig. 1; Creative Commons Attribution 4.0 International)

This kind of approach might be especially useful for early prehistory where human activity and/or archaeological presence are more likely to have been influenced by geological or topographic factors. The Essex Pleistocene project, for example, built on non-archaeological approaches like the Tendring geodiversity characterisation to define lithological units that were then compared with known Palaeolithic archaeological and Pleistocene palaeoenvironmental remains to create areas of Palaeolithic potential (O'Connor 2015). A national project to map the Palaeolithic archaeological potential of Pleistocene deposits in England is now nearing completion[9].

[9] https://www.winchester.ac.uk/research/our-impactful-research/research-in-humanities-and-social-sciences/research-projects/the-palaeolithic-archaeological-potential-of-pleistocene-deposits-in-england-project/

The variety of characterisation-type approaches that have been attempted in a planning context is illustrated by the response to plans for large-scale house-building across four ‘Growth Areas’ in south-east England announced by the then Labour Government in 2003. To a greater or lesser degree the Growth Area studies expanded from basic HLC to encompass built heritage and archaeology. They also used or created character areas to provide complete coverage without ‘blank areas’ – at the time an innovative move away from the ‘dots on maps’ produced by scheduling, listing and alert maps. For this study work from the Thames Gateway, the Harlow-Stansted area (part of the London-Stansted-Cambridge Growth Area) and Aylesbury and Milton Keynes (parts of the Milton Keynes and South Midlands Growth Area) was reviewed. Discussions were held with local authority archaeologists and individuals involved in these studies to better understand their impact and the lessons that can be learnt from them.

By far the largest and most ambitious study was that by Chris Blandford Associates of the entire Thames Gateway Growth Area, covering around 1800 km^2. The archaeological characterisation was the most challenging aspect of the whole study because of the wide range of periods and asset types covered and the fragmentary and partial nature of the known and recorded dataset (Chris Blandford Associates 2004; Essex County Council 2007; Fig. 2.5). A complex scoring system was applied to HER data and some geological and topographical factors that might have affected an area’s favourability for settlement in the past and archaeological visibility in the present, in order to define a series of archaeological character areas. However, characterisation’s essentially descriptive approach proved less helpful for decision-makers seeking guidance on the location of new development so a sensitivity model was also produced, based on judgement of the relative significance of heritage assets and their vulnerability to the type of change envisaged.

Discussion with local government archaeologists for Essex, Kent and Greater London established that they had little confidence in this ‘algorithm-based’ approach at the time and felt the consultants lacked local knowledge. As a consequence the characterisation had not been maintained and was hardly used subsequently. Prompted by concerns about the Chris Blandford Associates study, Essex developed the district-based HECA system referred to above, which now covers most of the county and provides an evidence base for Local Plans (see also section 5), while Greater London and Kent are engaged in comprehensive updates of their respective alert/constraint map systems. Viewed from this perspective, despite the failure of the CBA method the wider Thames Gateway has subsequently remained proactive in the broad field of sensitivity mapping.

The Milton Keynes and Aylesbury Urban Expansion Historic Environment Assessments were carried out by the Buckinghamshire County Archaeological Service under the management of one of the present authors (Sandy Kidd) in 2004–5. They covered much smaller areas of potential urban expansion around each town (62 km^2 around Aylesbury) enabling a more detailed approach, particularly as they were written by or in collaboration with local experts. Each used an Environmental Impact Assessment method to assess risks and opportunities in relation to archaeological, historic landscape and built heritage assets, as well as 'setting' issues. In each case allocated development areas did broadly respect the sensitivity analysis, although the historic environment was only one consideration amongst many in those decisions, so a direct causal link is hard to prove.

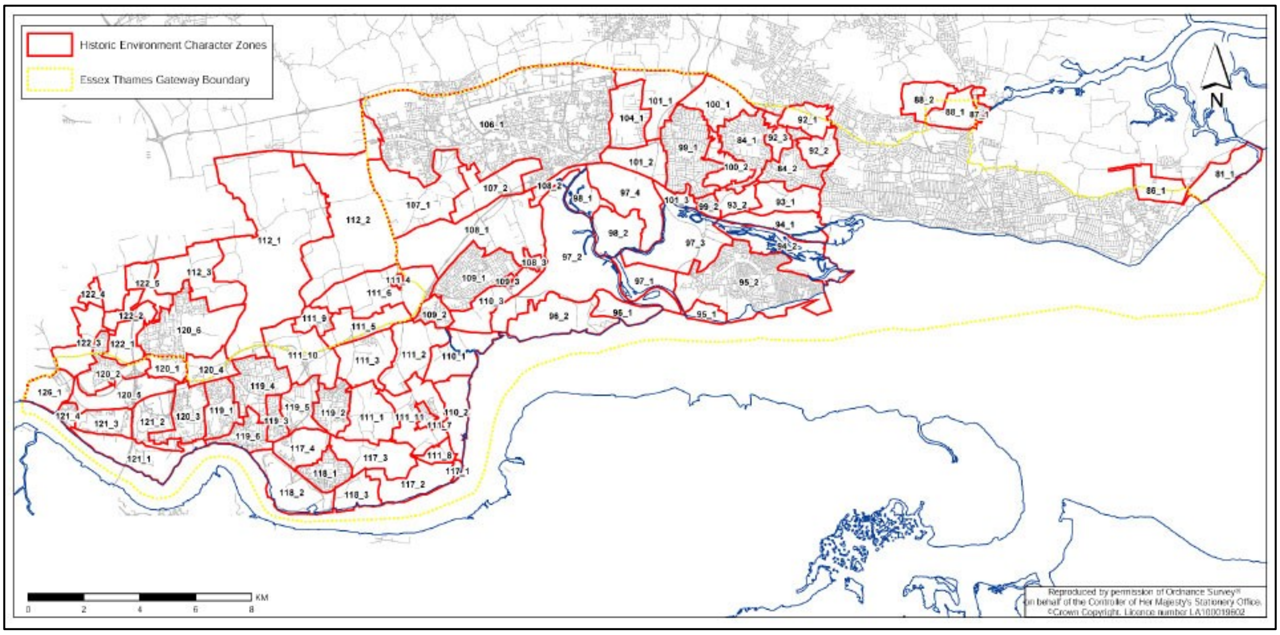


Figure 2.5: Historic environment character zones in the Thames Gateway (from Essex County Council 2007)

Finally, the Harlow-Stansted study (English Heritage 2003) essentially just considered historic landscape character, contrasting its comprehensive mapping approach with traditional scheduled monument-based archaeology maps. This study offered general guidance on the potential sensitivity of areas to broad types of change, such as large-scale development, using a GIS model to identify sensitive areas. With the subsequent abandonment of expansion plans at Stansted Airport the area has not yet seen the anticipated scale of development requiring application of the model.

Lessons arising out of these studies are the difficulties encountered in dealing with large areas and volumes of data in reasonable timescales, the value of local knowledge, lack of confidence in outputs of 'number-crunching' exercises, and the need to stay focussed on planning purpose and engagement to influence outcomes.

At the largest scales, however, number-crunching is essential. Although their primary purpose varies, there is a relationship between sensitivity mapping to inform strategic planning decision-making and various recent 'big data' academic projects aiming to understand past patterns of land use and social/economic organisation, particularly in providing pointers as to how to classify and analyse HER data. Unconnected to HLC or LCA, but undoubtedly the most ambitious archaeological characterisation-type project yet undertaken, is the AHRC-funded English Landscapes and Identities (EngLaId) project, which used HER and other data to build a grid-based national model (using kernel density estimates) of the quantity and type of known evidence for the period 1500 BC–AD 1086, incorporating an analysis of the affordances of different areas for the recovery of archaeological information. In other words the model aimed to help understand variation in the archaeological record as an artefact of both modern archaeological opportunity and practice on the one hand, as well as real differences in past practices and populations on the other (Green *et al*. 2017; Fig. 2.6). The difficulty for understanding archaeological potential lies in unpicking the influence of different 'affordances' on past activity from their influence on the present visibility of that activity.

Also worth noting is the Woodland Futures report commissioned by Historic England in 2016 in response to government ambitions, subsequently outlined in Defra's 25 Year Environment Plan[10], for creation of large-scale woodland and forest in order to secure various economic and environmental benefits. The aspiration is to plant 180,000 ha of new woodland in England by the end of 2042, with the aim of increasing woodland cover nationally from 10% to 12%, including a commitment by National Park Authorities and AONBs to increase tree planting in protected landscapes. The Historic England project mapped capacity and sensitivity to new planting on a 1 km grid across England and provided statements for each NCA. The study used a simple scoring system and only considered designated heritage assets, incidentally highlighting the difficulty in assembling useable data on non-designated assets to influence decision-making at a strategic scale (Newman 2018; Fig. 2.7).

Subsequent work has returned to a more local scale; for example, the Forestry Commission established a pilot project with Cumbria County Council Historic Environment Service to provide strategic GIS data that reflects the HER for the North East Cumbria Forestry Investment Zone (FIZ). Data was presented as four coloured mapping layers showing an area's historic environment sensitivity to woodland creation (Fig. 2.8), based on currently available HER data: red, amber, green and grey (where current HER data is

[10] https://www.gov.uk/government/publications/25-year-environment-plan

incomplete or inadequate). Further work is now in progress to assess the use of GIS to produce woodland creation historic environment opportunity or targeting maps.

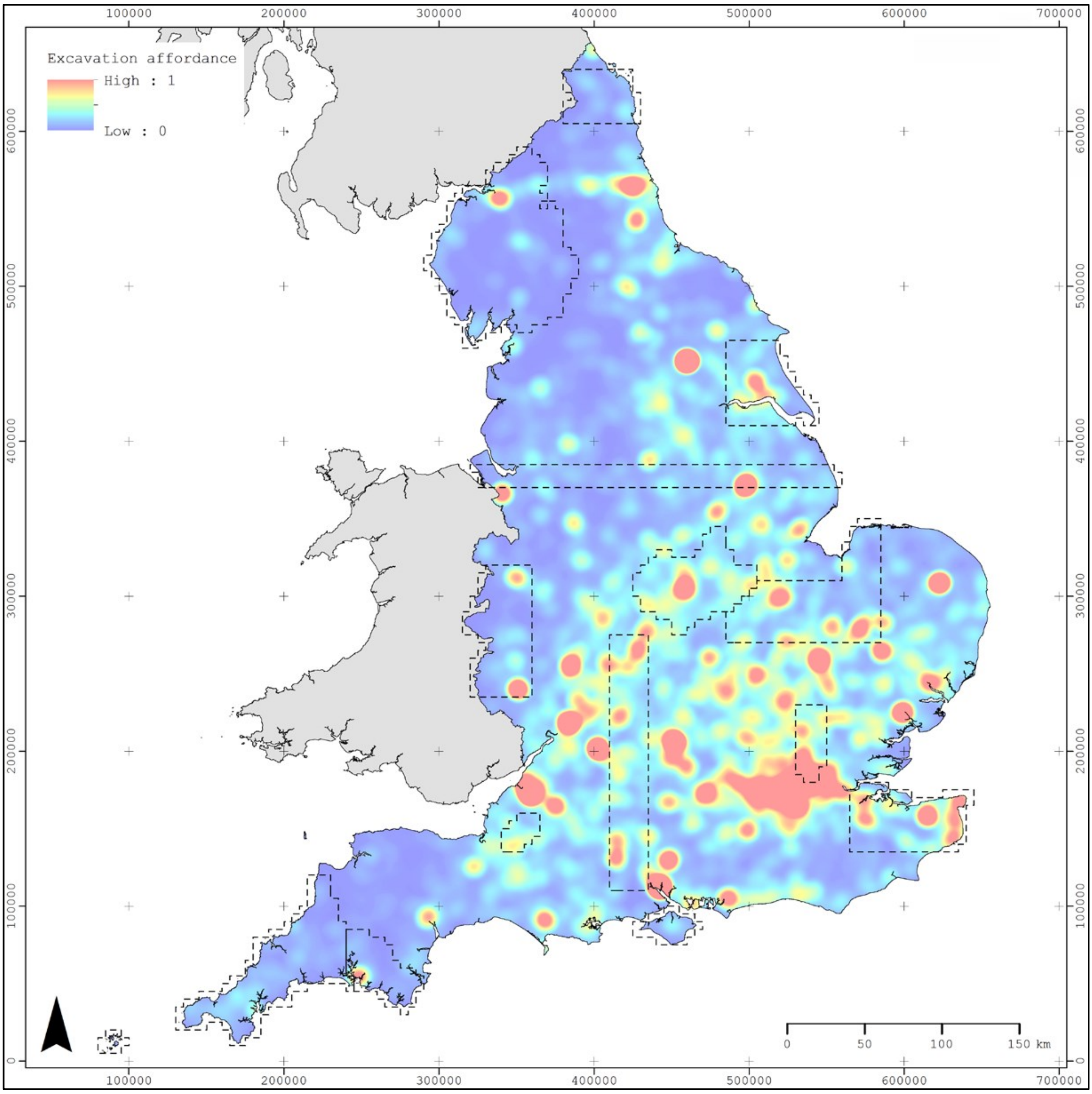


Figure 2.6: EngLaId excavation affordance model based on the density of excavations. Areas of high value in the model are more likely to see excavation take place (from Green and Creswell 2021, 6; Creative Commons Attribution 4.0 International)

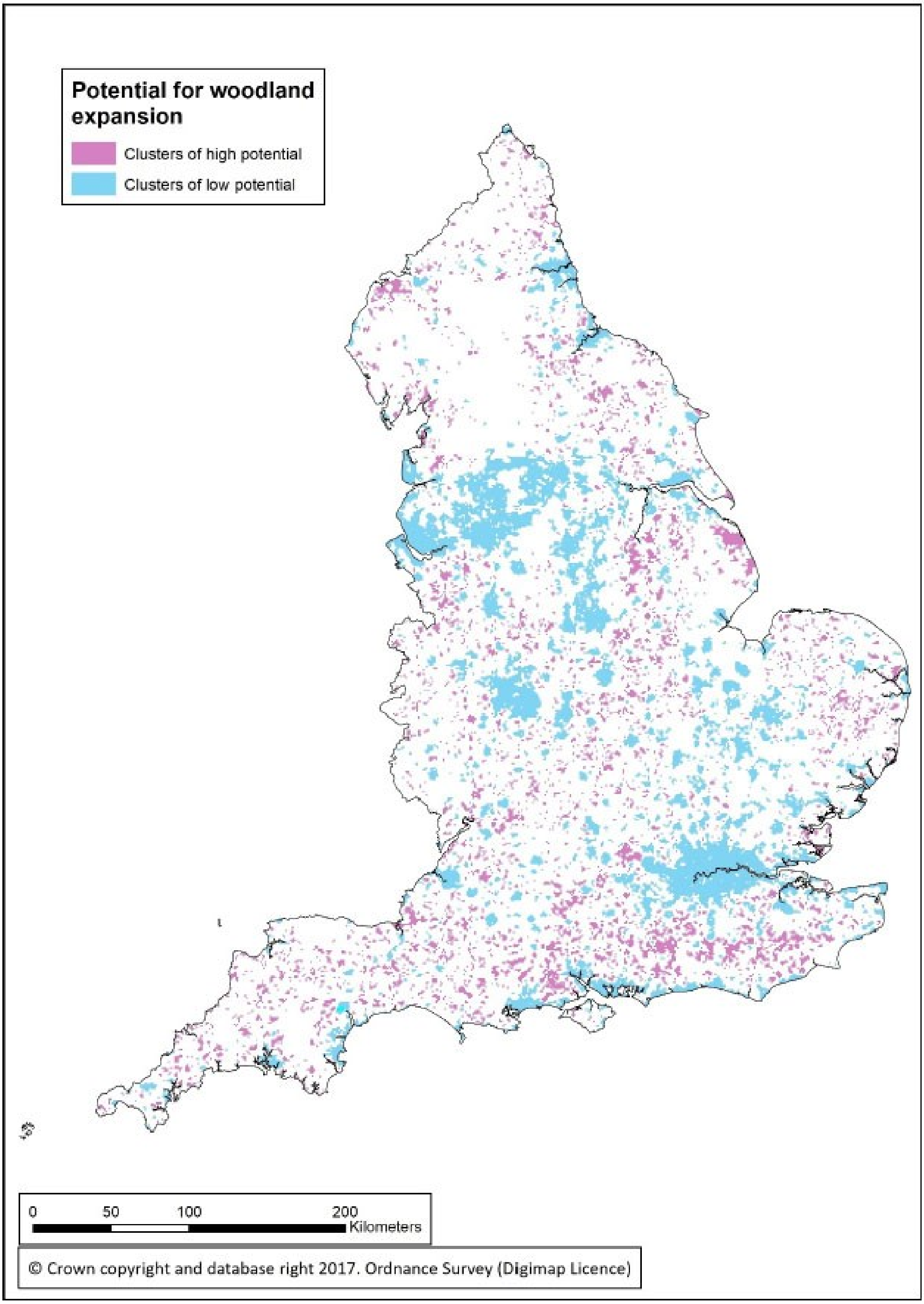


Figure 2.7: Clusters of high and low potential for new woodland across England (from Newman 2018)

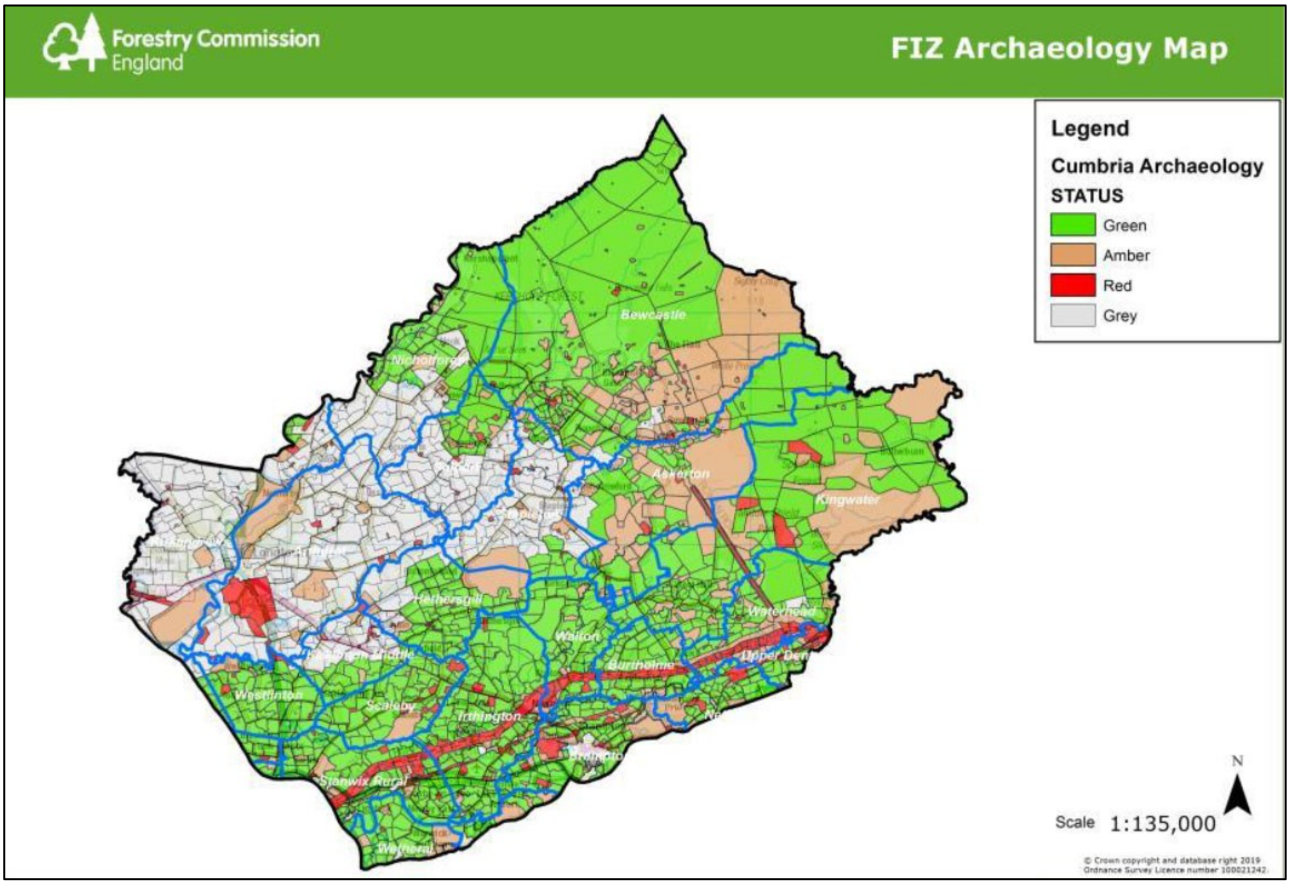


Figure 2.8: Archaeology Traffic Light layer from the Forestry Investment Zone (FIZ) North East Cumbria Pilot (© Forestry Commission and Cumbria County Council)

2.2 SPARS and SHINE

The variable practice of alert mapping among local planning authorities has, as mentioned above, been investigated through a separate project, the Strategic Planning Archaeological Resources Survey (SPARS), carried out by Place Services (2022). The research aimed to understand attitudes, coverage, issues and barriers to wider adoption of such mapping, as well as promoting dialogue within the sector and working towards identifying best practice. The current variability relates to a number of factors, including a lack of resources to complete the task, other priorities for enhancing HERs, a feeling that the evident incompleteness of the documented archaeological record made the exercise problematic, and/or finding that alert maps could be counterproductive if planning policy was then only applied to known sites.

Results suggest that at present less than 50% of authorities use any form of alert mapping (Fig. 2.9), but there is a much higher percentage (over 80%) in London and the South-East, which fits the picture identified in the ALGAO national survey for 2018–19. Over 40% of maps are reviewed at least every five years but in 20% of cases the interval is more than 10 years. About half of the maps are publicly available but the associated data is rarely published.

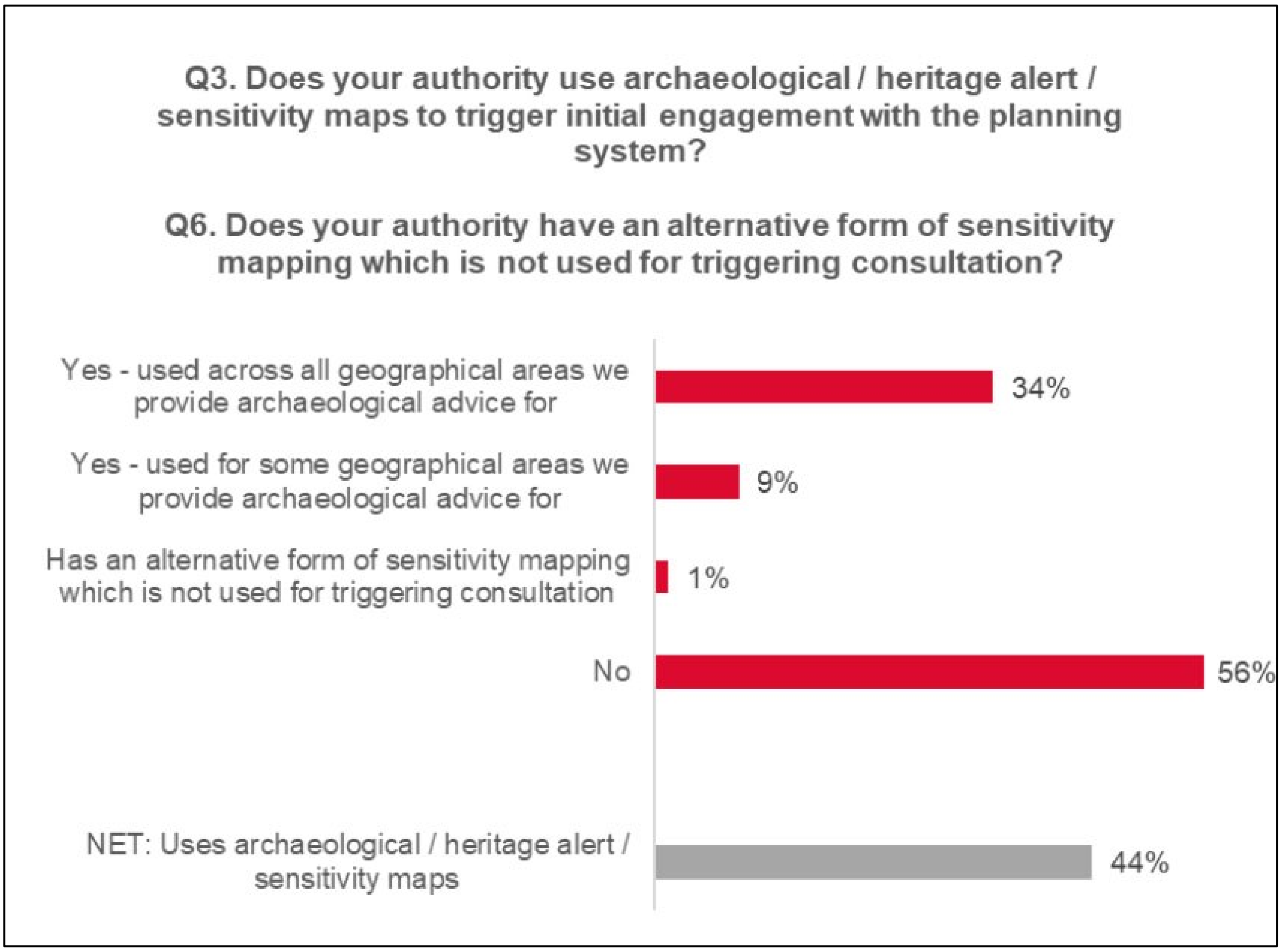


Figure 2.9: Archaeological Alert/Constraint Map usage in 2022 (70 respondents; Place Services 2022, fig 3)

The number of alert areas within a local authority varied greatly (from one to several thousand), as did the proportion of the authority area covered by them, suggesting very different approaches in different areas. However, the majority (over 70%) identify areas of potential as well as known assets. Overall the experience of using alert maps was positive (65%) and they were seen as useful for early engagement with strategic planners, though in some cases they received little recognition from the relevant planning authorities and in others there was a perceived risk that areas not included on an alert map would be taken as having no archaeological potential. The three most common reasons for not using alert maps were a preference to assess all applications against the HER, a lack of capacity to create them, and the perceived risk of misuse.

Further work therefore needs to consider how alert mapping could be combined with characterisation (the SPARS project found that around half of local authorities use HLC for strategic planning) and predictive approaches (see below) to produce comprehensive coverage, thus avoiding the pitfall of planning authorities interpreting 'blank areas' as meaning that because archaeology had not yet been shown to exist therefore archaeological policy did not need to be applied.

An allied consideration is the existence of SHINE[11] (the Selected Heritage Inventory for Natural England), a single, nationally consistent dataset of undesignated historic environment features from across England that could benefit from management within agri-environment schemes. The dataset was created by, and is supposed to be maintained by, HERs. SHINE is unique in both providing quality-assured national coverage of 'non-designated heritage assets' (albeit an incomplete dataset) and being aimed as much at positive management outcomes as simply avoiding or mitigating harm. In principle it could provide a building block for mapping known and manageable non-designated assets if non-agricultural land and missing asset types were added. However the SPARS study found that at present there is little confidence that SHINE could be used as the basis of alert maps.

Although ALGAO does not support the use of SHINE in its present form beyond its designed purpose, in the long run it cannot be efficient to maintain multiple management datasets aimed at different land management regimes. In the interests of consistency and simplicity one option would be for known non-designated archaeological assets to be added to a local list, potentially with a 'flag' to indicate sites of established, presumed or likely national importance. This would also provide flexibility for using locally determined selection criteria. Were such an approach to be progressed, the scope of assets to be included would need further consideration as it would likely extend beyond classic 'field monuments' to include artefact scatters, historic settlement cores and landscapes. The relationship between known assets and areas of potential (the crux of sensitivity mapping) would also need to be explored.

2.3 Predictive models

While characterisations of the types described above implicitly have a predictive element, scoring the potential of an area based on the known assets within it, or within areas of similar landscape character, a separate strand of work has aimed to develop explicitly predictive models. These have been produced at least since the 1980s, though the amount of work (as reflected in the literature) seems to have declined since the high point of the early 2000s (Fig. 2.10). Predictive modelling now appears more common in heritage management contexts than academic projects, perhaps reflecting changing fashions in

[11] https://www.myshinedata.org.uk/what-is-shine-1

archaeological theory, though the advent of computational techniques like AI and machine learning means this may change again in the years ahead. Certainly the use of predictive modelling extends to many other areas of both natural science, including geology and ecology, and social science, such as economics and politics. Archaeological applications tend to include elements of both human decision-making and environmental opportunities or constraints, though in spatial terms the closest parallels are probably in ecology, where machine-learning models are more advanced (see Yaworsky *et al*. 2020).

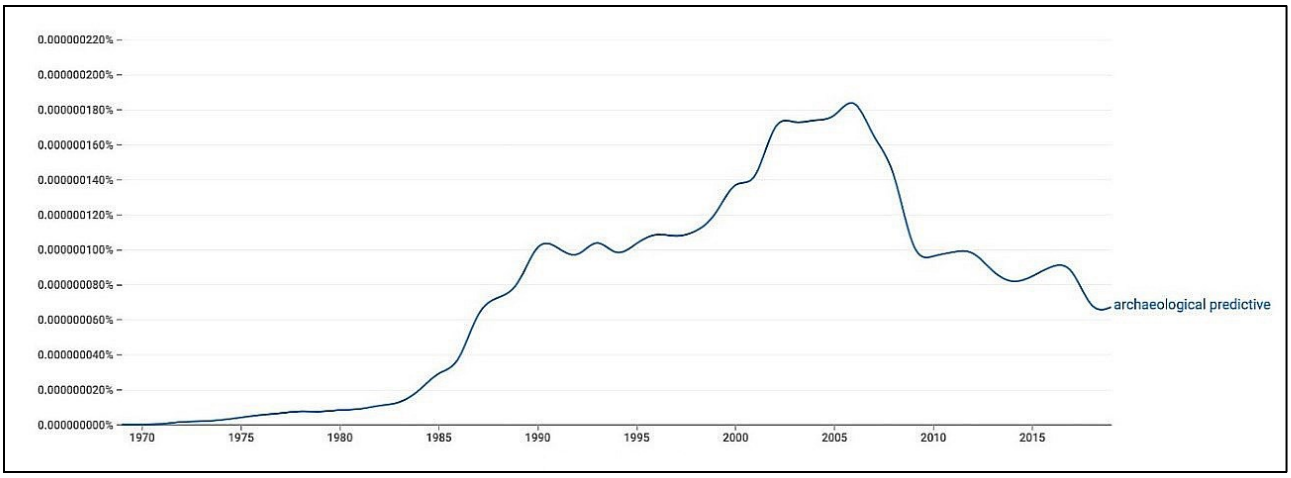


Figure 2.10: Graph from Google Ngram viewer showing frequency of the words ‘archaeological predictive’ in Google Books from 1970 to 2020

Historically, archaeological predictive modelling has been more commonly used in some countries, notably the USA and the Netherlands, than others, including the UK. Various different approaches have been distinguished, with a contrast often drawn between **inductive** (or ‘data-driven’) and **deductive** (or ‘rule-based’) modelling. The former are also termed **correlative**, as they use observed patterns in the correlation of archaeological data to other variables in order to identify further potential site locations, while the latter are **cognitive** (or explanatory), seeking to understand and explain the patterning and causality of those locations. The distinction may also be seen in terms of **pragmatic** models, as a relatively cheap and effective way of managing archaeological resources, and **idealist** ones, based on an assumption that we need to understand past behaviour before we can successfully predict it. While such concepts are useful in thinking about the objectives of any model, in practice the divisions are not very distinct and hybrid approaches are common, since supposedly ‘inductive’ models incorporate many assumptions about past human behaviour, while at least part of the archaeological expertise that goes into ‘deductive’ models is based on informal induction.

Even those who favour deductive, cognitive modelling because it produces better predictions see inductive, correlative methods as useful tools for exploratory data analysis prior to theory building. Others have argued for the need to incorporate human agency into predictive models in order to avoid approaches that might be characterised as environmental determinism. Theoretical considerations may appear of limited relevance to a heritage management context in which we want to know where sites might be found rather than why they are there, but it is worth recalling both that the development of research frameworks (and the language of the NPPF) reflects a wish to emphasise understanding in development-led projects rather than simply producing a record, and that any expert judgement used in development control is dependent on (usually implicit) theoretical understandings of past human behaviour. There may therefore be value in making some of this understanding more explicit in the development of models.

Another distinction that is often made contrasts **possibilistic** approaches, which indicate how suitable an area is for settlement or another modelled activity (without assuming all suitable areas will have been used for that activity), with **probabilistic** ones, which measure the likelihood of such activity being present in a given area. In practice nearly all models are of the former type, though they can sometimes be unhelpfully confused with the latter. Erring on the cautious side, possibilism aids heritage management by prioritising the reduction of incorrect predictions of site absence over the avoidance of incorrect predictions of presence (cf the precautionary principle in Environmental Impact Assessment). This would be far more problematic for an academic model seeking to explain site locations in a testable way, in which case probabilism seems more appropriate. However, the possibilistic approach raises the question of what is an acceptable level of confidence in a planning context.

Similarly, if our sample of known sites is not randomly distributed but reflects the location of past development activity, that may be a problem for academic understanding of past land use but less so for modelling sensitivity (how archaeological activity articulates with recent and future land use – assuming the pattern of future development will tend to focus on the same areas); in such a case the bias inherent in the data can be considered as a weighting factor for threat level, though the consequence is that areas with little data (and therefore greater uncertainty) would need to be treated more cautiously should development or other forms of landscape change be proposed there.

The statistical tests that could be applied to predictive models have also been subject to considerable discussion. The main problem is that the use of inappropriate techniques could lend spurious credibility to rather tenuous assumptions. This is often problematic because models violate certain key assumptions of the tests, particularly that of statistical normality, which does not apply to many of the variables typically used in predictive models; non-parametric tests are therefore usually to be preferred.

In the world of planning-related archaeology, however, the credibility of a model may not be primarily based on statistical significance but the extent to which it mirrors the expert local knowledge and experience of planning archaeologists. In a sense, therefore, sensitivity mapping is looking to provide a rapid, first-order representation of what an expert might say about an area, and success should be judged not just by robust modelling but also by how the model is presented and disseminated. It can be important simply to provide an 'eye-opener' for those not accustomed to thinking strategically about archaeology, showing that not only could remains be present virtually anywhere but also that archaeologists are able to give an indication of where things are more likely to be found and/or where they will be more significant if they are present.

Interestingly, in the Netherlands the trend in recent predictive modelling work has favoured expert judgement over quantitative analysis, although Bayesian inference and similar approaches can provide effective methods for formally integrating expert (prior) opinions into predictive models (Verhagen *et al*. 2011). The current, digital version of the Dutch national map aims to provide insights based on archaeological knowledge of past land use in specific areas of the Netherlands. It represents a break with the past, as it does not attempt to predict the density of sites in a particular area but rather gives a qualitative impression of land use that can alert users to the possibility of archaeological remains (Smit and Feiken 2017; Fig. 2.11). Users can 'translate' information on how an area was used in the past and the likely depth of archaeological remains into predictions. This system is used alongside local authority predictive maps, which are now ubiquitous in the Netherlands.

However, what is usually missing from any predictive model is a form of reality check by means of probabilistic sampling in the field or retrospective study of the results of past development-led work. This remains the case even in the Netherlands, where such testing is hampered by the lack of clarity as to what predictions on local authority maps are actually based on and how the archaeological value assessments were made. Since the method of assessment is not clearly described, it cannot be verified or reproduced by others (van Doesburg *et al*. 2017).

One problem already mentioned is the need to avoid conflating known absences (which are of archaeological interest: see Thomas and Darvill 2022) with uncertain pseudo-absences. The predictive model used in Minnesota addresses the question of whether areas have been assigned a low site probability because there are known to be few sites or simply because there have been no surveys (Hobbs 2019). Areas with both low site potential and low survey potential are classified as 'unknown' and thereby acquire a higher priority for archaeological survey than do low site potential areas in environments that have already been well surveyed. Alternatively, a model could specify that the level of fieldwork would not be different in high and low potential zones but the planners would at least be forewarned about the likely difference in mitigation issues and costs between the alternatives.

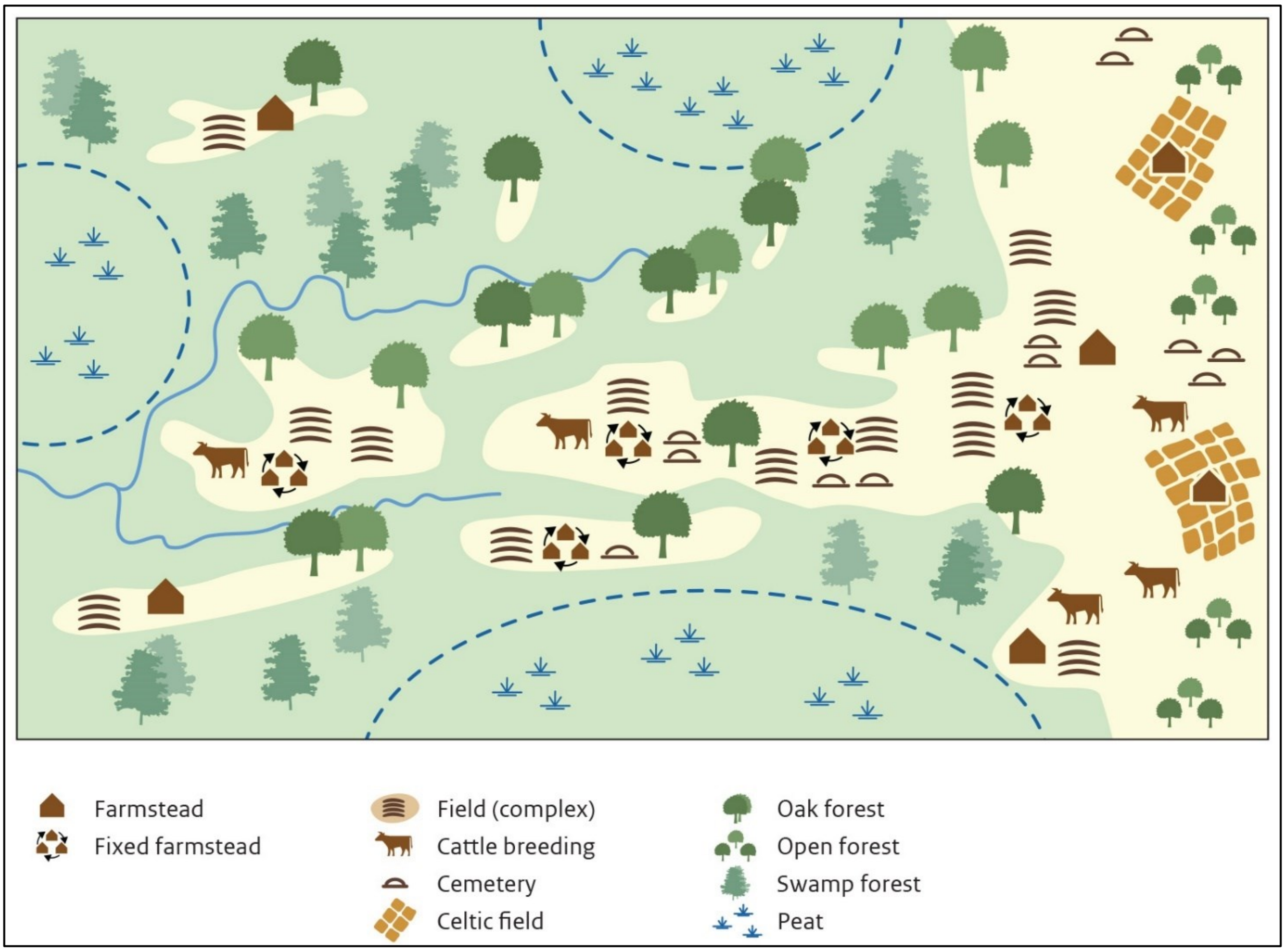


Figure 2.11: Land use model of occupation in the Gelderse Valley (eastern Netherlands) in the Late Iron Age (from Smit and Feiken 2017, fig 1)

We also need to remember that high and low potential or sensitivity is always relative rather than absolute; in Minnesota, for example, 5% of the sites in the model's database do not fall within the high probability areas. And one of the few models in the Netherlands to quantify probabilities calculated that the absolute chances of encountering a site in zones of high, medium, and low potential were respectively 4%, 2.5% and 1.5% of the total area excavated (van Leusen *et al*. 2005), i.e. significant but not order-of-magnitude differences. However, assessment of a risk model for Greater London found larger differences, with 59.2% of planning consultations in 'high risk' areas estimated to have caused any actual harm to archaeology, compared to 29.7% of 'medium risk' consultations, 17.3% of 'low risk' consultations and only 3.8% of 'negligible risk' consultations (Kidd 2017). However, it could be argued that the small number of sites in ‘low potential’ zones are of relatively greater interest, both intrinsically and in relation to refining models, so it is important not to overlook these areas.

Another issue is how many models we need to capture the full chronological range of the archaeological record. For all sorts of reasons, models for the Palaeolithic or Mesolithic are likely to be incommensurate with those for medieval settlements or industrial archaeology. The Dutch Archaeological Knowledge Kit programme produced a classification into four periods, a simplification that takes account of differences in both subsistence methods and archaeological (prospection) characteristics (Groenewoudt and Smit 2017):

1 Hunter-gatherers and early farmers from the Palaeolithic to Middle Neolithic A (3400 BC), characterised by small to large find scatters (palimpsests) of mainly stone and flint with archaeological features rare or difficult to identify.

2 Early farming societies from the Middle Neolithic B (3400 BC) to Middle Bronze Age A (1500 BC), characterised by find scatters, including pottery, with archaeological features rare or poorly visible, although funerary customs become more visible.

3 Late farming societies from the Middle Bronze Age B (1500 BC) to Early Middle Ages C (AD 900), characterised by more fixed settlements and extensive field complexes (‘Familiar Landscapes’) with remains of houses, pits, funerary practices and infrastructure.

4 State societies from the Early Middle Ages D (AD 900) to the modern period (1950), characterised by dense archaeological feature clusters and stone buildings, progressive Christianisation, elite residences, specialised crafts and conflict sites.

This in turn leads us to think about issues of data quality; HER data is an incredible resource (‘big data’ archaeological projects would hardly be feasible without it), but usually requires considerable cleaning or enhancement to provide suitable input for a model – although the EngLaId team suggests that at the broader spatial scales and relatively coarse period divisions there is little noticeable difference between analyses based upon human-cleaned and computer-processed data. They also acknowledge that the ‘characterfulness’ of archaeological datasets can itself be of value in understanding how the records we have reflect the history of the discipline (Cooper and Green 2016), though that is perhaps a rather different matter. However, it does relate to the evident need for expert knowledge to feed into models, which implies that HER data *per se* gives an incomplete or unsatisfactory picture of the archaeological record in an area, and/or that simple topographic or geological variables do not capture the essence of a landscape.

So far we have mainly considered the minimum aim of modelling the likely location of particular types of archaeological remains but a further step is to move from models of presence to predicting the condition and significance of those remains. For example, heavily plough-truncated sites may warrant a lower level of protection or investigation than well-preserved remains. In the Netherlands, for example, a model has been developed for estimating the probability that the soil in a particular land parcel has been disturbed (Lascaris and Huisman 2017). However, while the physical and chemical characteristics of soil may serve as an index of archaeological preservation potential (see below), we also need to remember the importance of cases where areas of good preservation 'off-site' provide information on the environment of nearby sites. For example, predictive modelling in the Middle Kennet Valley aimed to identify the likelihood of finding lithic sites in association with wetland deposits (Barnett *et al.* 2019).

With all this in mind, explicitly 'predictive' models have not been widely adopted in the development-led sector, though various projects have been funded by Historic England over the last 10–15 years. As well as the Lowland Cornwall and Middle Kennet projects, a number of deposit or landform models of various types have been devised, especially for riverine areas subject to large-scale aggregate extraction; the most ambitious of these attempted to predict potential by period, as well as the likely preservation and significance of archaeology, across areas of the Trent Valley, with varying levels of confidence in the results (Challis *et al*. 2011; Fig. 2.12). It would be useful to review whether and how such models have been used in the development management process in these areas (see 9.2.3).

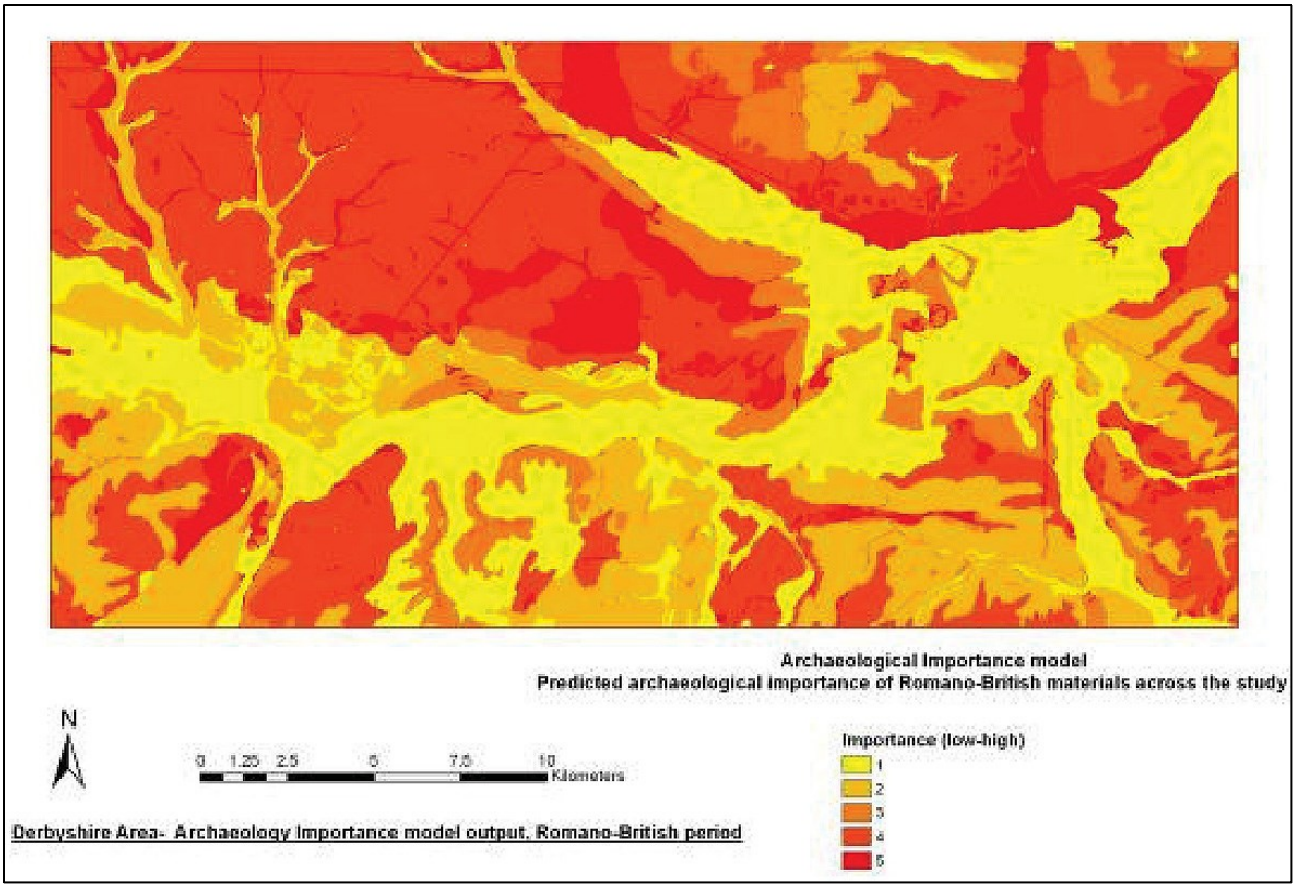


Figure 2.12: Part of the Middle Trent in Derbyshire showing predicted importance of Romano-British remains (red shading is higher; from Challis *et al.* 2011; image resolution same as source)

3 Methodology

This section sets out the methodology for sensitivity mapping used in the pilot studies, drawing on the literature review summarised above and discussions with colleagues from Historic England and local government archaeology, using data supplied by Buckinghamshire HER for prototype development.

3.1 The role of sensitivity mapping in a reformed English planning system

The principal aim is to provide a tool suitable for early engagement with strategic planning authorities and project promoters. Achieving this requires an output which:

- is relatively easy and quick to deliver
- is simple to understand by both archaeologists and non-archaeological professionals
- has clear policy implications; and
- engages with matters that should be considered by strategic decision-makers (without introducing extraneous detail better addressed at a later stage).

The key strategic questions that a model should answer for a given area are:

- What is the area's **archaeological character** – what types of heritage assets are known to occur, what form do they take and how likely are they to be discovered in the future?
- What are the area's principal historical and archaeological **research interests**?
- Where are heritage assets of **national importance** known to exist, what others might be present and where are they likely to occur?
- Is it possible to identify areas of **greater potential**, either because they were more attractive locations for past communities or because remains are better preserved or particularly significant for other reasons?
- Conversely, can areas of **lesser potential** be identified because they were less attractive for past occupation, or have less well preserved or fewer significant remains?

- What **risks and opportunities** would development or other landscape change present? How does archaeological sensitivity engage with other planning considerations such as protected landscapes, landscape or townscape character, design, green infrastructure or community engagement?

Because so much of England's archaeology is undiscovered or poorly understood, the methodology needs to engage with both known assets and the potential for new discoveries. And because most of England has some archaeological interest or potential this implies a whole-landscape rather than purely asset-based approach.

In principle the archaeological resource can be viewed in terms of recorded and unrecorded, extant and destroyed ('extinct') components (Fig. 3.1; note that the proportion of recorded to unrecorded resource would be much lower in reality than is implied by the diagram). We want to manage the extant resource (both recorded and unrecorded). A fundamental precondition of successful sensitivity mapping of the unrecorded extant resource must be that the recorded resource (extant and extinct) is sufficiently well known and representative of the area of study to enable plausible and tolerably reliable inferences to be made about the unrecorded resource. If that precondition is not met then only the recorded resource can be mapped – that essentially describes the situation across most of the country in the 1980s.

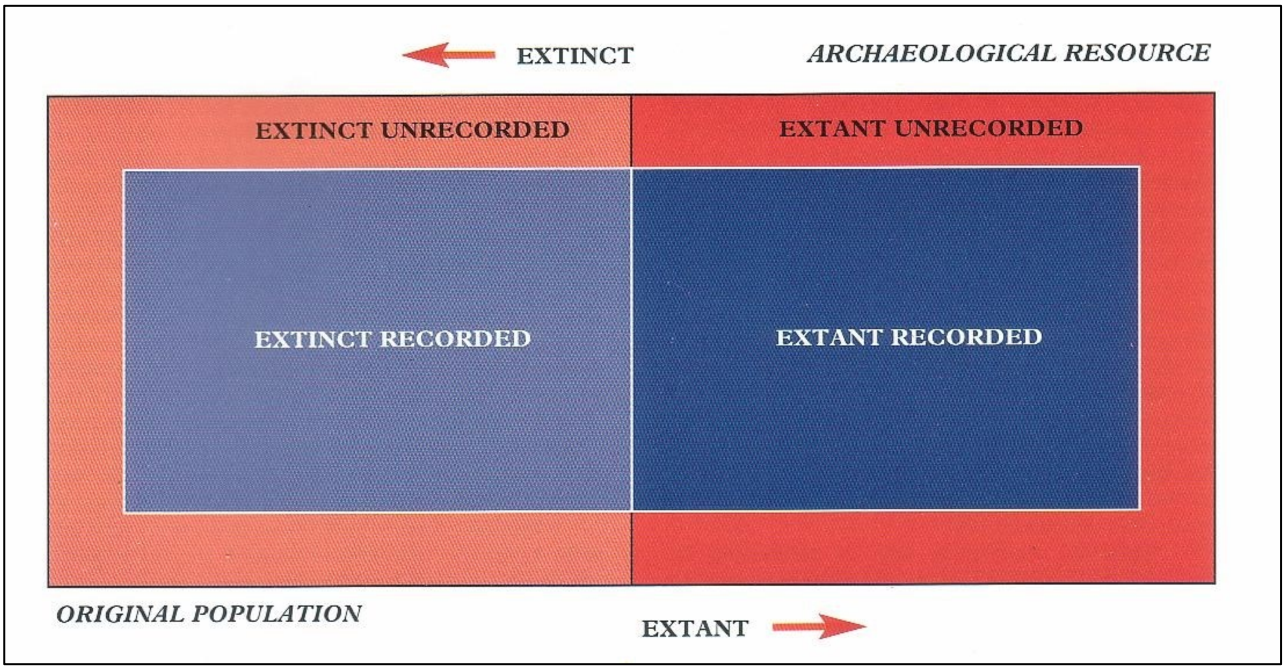


Figure 3.1: Conceptual model of the archaeological resource (from Darvill and Fulton 1998)

3.2 Developing the sensitivity model

For the purposes of this project our sensitivity model considers four parameters which contribute to sensitivity (Fig. 3.2):

- Presence: the probability of a heritage asset occurring
- Condition: the likely state of preservation if an asset is present
- Significance: the value ascribed to a heritage asset if present
- Vulnerability and Opportunity: the potential implications (negative and positive) of land use change for a heritage asset.

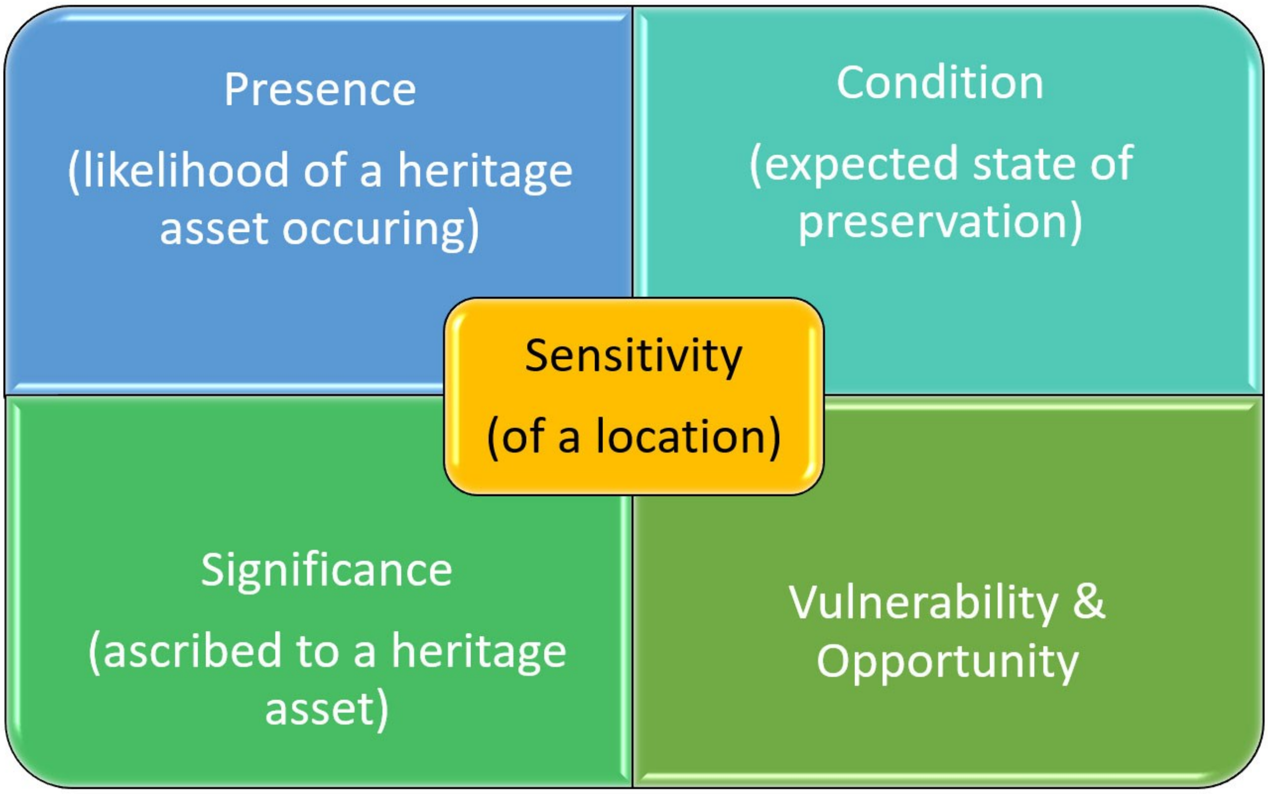


Figure 3.2: The parameters which contribute to sensitivity

Sensitivity is not defined in the NPPF. In common usage it implies responsiveness to a stimulus. For heritage it means the likelihood that proposed changes to land use will cause harm to assets and/or provide public benefits. A variety of subtly different definitions are quoted by Herring (2022) who settled on a definition of sensitivity that reflects 'the vulnerability, robustness and potentiality of the historic landscape and seascape [the subject of that document] in relation to the effects of a specified form of change.' Building on this, archaeological sensitivity therefore relates to an area of land and covers not only known assets but also the potential for new discoveries and ability to benefit the asset or wider public interest. All land parcels will have a level of archaeological sensitivity, although for some that will be nil or negligible.

Defining sensitivity also requires us to articulate how significance is attributed to archaeological remains. **Archaeological significance** (as defined in the NPPF) is a value ascribed to a heritage asset. In the context of this study a significant asset is one likely to influence decision-making, particularly at a strategic planning level. Assessing significance requires that we know enough about the asset to at least make a preliminary judgement about its value, although in the context of sensitivity mapping we may need to explore hypothetical scenarios about the likely significance a particular type of asset might hold if it were to be present in a given location.

While significance may be ascribed (for example through the DCMS Principles of Selection for Scheduled Monuments[8]) it is also contextual and variable, since it changes along with our research agendas (explicit or implicit). Because significance is attached to a heritage asset, it follows that a land parcel which contains multiple assets would have multiple significances attached to it, and there is need to explore how such complexity might be reflected in the overall sensitivity of a location, while recognising that decision-making would normally be dominated by the highest rated asset.

3.2.1 Considerations for assessing presence

Historic Environment Records contain spatial information ranging from discrete, manageable monuments through indicative evidence such as findspots to areas with only high-level historic characterisation. Sensitivity mapping therefore needs to take account of a wide range of prior knowledge. In principle, the likelihood of encountering (significant) archaeology within any given area varies from 0 (all archaeological interest is known to have been removed or its absence demonstrated conclusively) to 1 (the area is known to contain an archaeological asset whose significance is understood). All other land then falls into probabilistic categories in between, based on current knowledge e.g. it is unlikely, possible or probable that a heritage asset is present. Our approach to sensitivity mapping starts with the two extremes, then looks to divide remaining land into areas which have broadly average, high or low densities of assets.

Predictive modelling implies that it is possible to recognise ‘rules’ which correlate with preferred locations of sites across the study area. This implies that we can both recognise regions within which sites tend to conform to such rules and that those regions have sufficiently well-studied localities to enable such rules to be defined. A further complexity, however, is that since settlement patterns were influenced by different factors at different times, rules are likely to be different for each period, and the regions in which those rules apply could also vary by period and asset type. Additionally, later land use may differentially mask or reveal earlier layers, potentially skewing our models, while the major sources of evidence also vary by period. Similar to the Dutch classification outlined above, therefore, the landscape is analysed in broad 'layers' as follows, linked to Historic England's Periods List[12]:

1 Lower and Middle Palaeolithic: remains typically comprise deeply buried artefact (lithic) scatters and palaeoenvironmental deposits. For these periods there are established deposit-based approaches which are being developed for nationwide use[9] so they are not a key focus of the pilot studies, but Palaeolithic interest would need to be incorporated into the models at some point.
2 Upper Palaeolithic to Mesolithic: primarily lithic scatters, indicative of settlement mobility, in the ploughzone and/or subsoil; organic preservation is rare but highly significant.
3 Neolithic and Early Bronze Age: a similar settlement record to layer 2, although pits and other cut features are more frequent, and there is the important addition of monuments such as enclosures and barrows.
4 Middle Bronze Age to early medieval (the periods studied by the EngLaId project: Gosden *et al.* 2021): characterised by the development of more settled agricultural landscapes with enclosures, fields and routeways; subdivided into (a) later prehistoric, (b) Roman and (c) early medieval. Aerial photography is a key source of evidence.
5 Medieval and later: structured by the extant rural settlement pattern, as modified by processes like enclosure, urbanisation and industrialisation; subdivided into (a) later medieval (11th–early 16th centuries), (b) post-medieval (mid-16th–19th centuries) and (c) modern (20th century)[13]. Extant field patterns and historic maps are major sources of evidence.

All periods that are present, or likely to be present, within a 'region' should be covered by the sensitivity model unless their occurrence is so ephemeral that they are not likely to affect strategic planning decisions. The visibility of assets will depend upon the extent of survey and the nature of the asset. Tentatively, visibility might be understood in terms of an estimate of the proportion of assets which are known, e.g. in broad-brush terms:

[12] https://historicengland.org.uk/listing/the-list/historic-periods/

[13] in the Vale of Aylesbury pilot study the division between post-medieval and modern periods was taken as 1800

- Very good visibility: >95% of asset class is identified (e.g. medieval villages in champion landscape)
- Good visibility: 67–95% of asset class identified
- Fair visibility: 34–66% of asset class identified
- Poor visibility: 5–33% of asset class identified
- Very poor visibility: <5% of asset class identified.

An asset class with very good visibility can be mapped with confidence that there will be few false negatives, and contributes little to the sensitivity of parcels outside known assets (subject possibly to some 'buffering'). The visibility of post-medieval archaeology is generally good so a date threshold could be agreed after which the model would be based on known assets only. On the other hand, the lower the visibility the more an asset class will contribute to sensitivity across the area because there is greater potential for new discoveries.

As well as chronological layers, there is also the question of the appropriate spatial units of analysis (explored further in 3.3). Since the primary purpose of the sensitivity map will be to influence land-use planning, the pilot studies (see 3.5) explore the use of NCAs and local LCAs as structuring units for archaeological areas; in practice there will need to be some pragmatic balance between the precision gained by micro-definition of regions (and periods) and the need to generalise for use in real-world applications.

Whatever the structuring units, modelling where undiscovered archaeological assets might be found is problematic, other than to say that wherever you look there is a good chance of finding *something*. Darvill *et al.* (2019, fig. 8.8) note that, between 1990 and 2010, about 20% of evaluations produced negative results. This would mean that where potential has not been ruled out at an earlier stage, there is an 80% chance of finding archaeological remains in any given 5 ha area of land in England with our current techniques (taking the mean evaluation size, though it is quite possible that most of the negative results fall in the smallest size category of <1 ha, which includes 53% of all evaluations). We also need to remember that evaluation is a sampling exercise and never perfect. Across most of England it is therefore fair to say that above a certain size threshold there are very few greenfield development sites that lack any archaeological interest (though its significance will vary). Across the south and east this threshold probably varies between 10 and 100 ha but EngLaId showed that 'the southern and eastern half of England always seems to possess a higher relative density of settlement and finds than the northern and western half', so the threshold for encountering archaeological interest might be consistently higher in some parts of the country than others. Consequently, where they are available, large, well-recorded field evaluations or investigations provide useful case studies of the likely intensity and nature of archaeological remains associated with particular areas.

For the purposes of this study it will be assumed that (almost) no land can be excluded because there has never been any detectable human activity on it. Rather, the pilot studies explore the distinction between manageable heritage ‘assets’ (sufficient to merit consideration in strategic planning decisions) and landscape ‘background signature’, based on form, survival and significance. Modelling then aims to identify the factors that made some locations more or less attractive for activities likely to leave substantive archaeological remains.

A further conceptual issue is that English HERs are largely populated by data derived from non-systematic sources, including antiquarian and amateur studies as well as development-related interventions, all of which contain different innate assumptions and biases. There are some systematic field surveys from which predictive rules could be generated and tested elsewhere but this has not been central to their approach. For example, preferred locations for remains of periods 2 and 3 above could probably be modelled from the results of large-scale fieldwalking projects on downland and in the Fens. In other areas there are notable examples covering periods 3 to 5, such as the *Raunds Area Survey* (Parry 2006) and *Atlas of Northamptonshire* (Partida *et al*. 2013). Surveys in and around the Stonehenge and Avebury World Heritage Site have also been extensive although models from such an exceptional landscape might not prove readily transferable.

Historic England’s aerial archaeology mapping also provides extensive coverage[14] but is subject to largely unquantified biases related to land use, geology and coverage. As we cannot avoid using our existing imperfect datasets we must be aware of this as a form of ‘unconscious bias’ and if possible establish the limits of inference.

In the USA the underlying theoretical basis for predictive modelling is generally the hypothesis that environmental attributes can be correlated with archaeological site locations. Modelling projects initially measure a relatively large number of topographical, hydrological and geomorphological characteristics, filtering out those with low predictive power through the model development process. Such models may reasonably approximate behaviour for hunter-gatherer and early agricultural communities (though that would need to be demonstrated rather than assumed) but is acknowledged to break down for more complex societies. In Minnesota predictive modelling is only used up until 1821 when written records – and historical methods of investigation – become a more effective

[14] see https://historicengland.org.uk/research/results/aerial-archaeology-mapping-explorer/

avenue for determining site location. In the UK complex societies develop much earlier and further than in Minnesota so other socio-economic factors will have been more influential. For the EngLaId project, for example, the issue was how to model the effects of landscape on people without resorting to a simple but unrealistic environmental determinism.

The pilot studies below therefore use topographical indicators within models which identify potential favourable and unfavourable characteristics based on local knowledge and studies from elsewhere in the relevant region, but also test a small number of cultural indicators, such as medieval churches and Roman roads, that may have predictive power. In addition, written records mean that most medieval settlement locations can be identified and their landscapes can, at least in principle, be reconstructed. For example, in the 'champion' landscapes of Northamptonshire near-total reconstruction of the medieval and early modern landscapes has been possible, albeit drawing upon a unique lifetime resource of largely voluntary research (Partida *et al*. 2013). Where the threshold for historical methods ought to be set is explored by creating basic medieval and post-medieval landscape models, primarily from HLC.

In summary, therefore, the project explores how topographical and cultural indicators might be used to recognise locational 'rules' identifying places which could have been particularly favourable or unfavourable for past human activity – with an emphasis on those places where the formation of heritage assets over and above the expected background archaeological signature is more or less likely. Presence has to cover all periods but particular locations might be dominated by one or more, such as Mesolithic sites following the alluvial fringe around a floodplain. These rules could be set out in a table like Table 3.1, though it should be emphasised that these indicators are geographically specific, e.g. not all clay landscapes will be 'unfavourable', at least not to the same degree.

Table 3.1: Indicators of presence (examples)

Topographical		***Cultural***	
Favourable	***Unfavourable***	***Favourable***	***Unfavourable***
Sand & gravel geology	Clay geology	Proximity to medieval church	Commons & heaths mapped on HLC
Proximity to water-course	Moderate to steep slopes	Proximity to routeway junctions or river crossing	Land reclaimed from the sea
		Historic settlement core mapped on HLC	

Topographical and cultural GIS datasets are derived from appropriate modern sources but require 'cleaning' to remove e.g. canals from natural watercourses and railway embankments from steep slopes. It is important to note that 'unfavourable' indicators for the presence of archaeological assets of some types could be important for other reasons – for example, commons and heaths are culturally and historically important landscapes but at least in more recent times generally only attracted relatively 'ephemeral' or low-density land uses. An overall historic environment sensitivity map would have to give weight to such factors.

Each indicator is tested for correlation against the distribution of known sites and only moderate or strong performers taken forward into the sensitivity model, although weak performers might be capable of refinement and all should be tested for credibility by professional judgement. The size of buffers beyond which the influence of an indicator wanes also needs to be experimented with. At a larger scale, the spatial limits of rules will need to be explored, for example by investigating whether rules derived for one NCA might apply to a larger region. Further comparison of well-studied landscapes also ought to provide an indication of how widely rules derived from one place can be applied to another, though that is beyond the scope of the present study.

To feed into an overall sensitivity model the outputs of a presence model can be divided into levels, such as:

- Level 4: known heritage asset of archaeological interest, subdivided by significance (see 3.2.3).
- Level 3: favourable cultural and/or topographical indicators – expected above-average density of archaeological assets.
- Level 2: neutral cultural and/or topographical situation – expected broadly average density of archaeological assets.
- Level 1: unfavourable cultural and/or topographical situation – expected below-average density of archaeological assets.
- Level 0: site evaluated with negative results – low or no expectation of significant archaeology; or site known to have been cleared of all archaeological interest (equates with Condition Level 0: see below).

3.2.2 Considerations for assessing condition

The condition or state of preservation of archaeological assets is fundamental to their information content and management and derives from a combination of physical (structural) condition and soil chemistry.

In simple terms, archaeological stratigraphy can be divided physically into *above-ground visible remains* (earthworks and structures); *buried vertical stratigraphy* (layers above the natural geology, such as floors, middens, lower parts of structures, artefact scatters, demolition deposits etc); and *cut features* (pits, postholes, ditches etc, which might be subdivided into shallow and deep features, with the latter being less vulnerable to complete loss from shallow disturbance such as cultivation). Quaternary deposits of potential archaeological interest are also relevant but these can be assessed following deposit modelling guidance (Historic England 2020).

Different land uses will damage different types of deposit in different ways. Some impacts (such as cultivation or landscaping) will typically cause horizontal truncation over wide areas whilst others cause fragmentation by vertical intrusions over small areas (e.g. strip foundations, service trenches, tree planting). Modern quarries and infrastructure typically cause deep and extensive loss of archaeological remains (although deeply buried Palaeolithic deposits, caves/fissures or mines might still survive). Modern land cover maps and HLC therefore provide a basis for mapping survival, with adjustments needing to be made where remains are likely to have been protected by 'overburden' such as alluvium, colluvium or made ground.

Again in simple terms that could be mapped with some confidence at a strategic scale, soil chemistry can be divided into areas with good survival of anoxic deposits ('wetlands') and those with poor/patchy survival of such deposits ('drylands'). The latter can be further subdivided into alkaline/neutral drylands with a better range of material and environmental survival than acidic drylands. Wetlands represent one of the most important reserves of well-preserved archaeology while in contrast acidic drylands are an unfavourable indicator for many types of remains. Soil chemistry can be broadly mapped from geological maps and ground-truthed by consideration of actual excavation results, which will demonstrate the complex interaction of soil chemistry with archaeological structures, artefacts and environmental remains (e.g. Ward *et al*. 2009). 'Predicting the survival of environmental remains [and artefacts] in archaeological deposits is not an exact science' (English Heritage 2011, 5) but with knowledge of soil pH and redox 'it should be possible to suggest the types of artefacts [and environmental remains] that might, in usual circumstances, be present' (Historic England 2016, 11); indeed the general relationship between deposits and materials can be tabulated (Table 3.2), though depth of burial is also a significant factor. For example, comparison of national Roman Rural Settlement Project animal bone data with UK Soil Observatory (UKSO) soil chemistry indicates that highly acid soils with a pH of 6 or less display poor bone survival.

Table 3.2: Survival of archaeological materials in different soil conditions (adapted from English Heritage 2011, table 2; Historic England 2016, table 3); NB charcoal and other charred plant macrofossils can survive in all conditions

Burial environment	***Main soil and sediment types***	***Some typical situations***	***Material survival***
Very acid (pH below 5.5), oxic	Podzols and other leached soils, drained peatlands	Heathlands, upland moors, some gravels	Metalwork heavily corroded; 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	Brown earths and gleys, river gravels, alluvium	Clay vales and lowland plains	Depending on circumstances of burial, metalwork, bone, antler, molluscs, ostracods, foraminifera can survive; pollen and spores rare
Basic (pH above 7.0), oxic	Rendzinas (but can be acid in the topsoil), lake marls, tufa, alluvium, shell-sand	Chalk and other limestone	Metalwork well preserved; bone, antler, molluscs and spores present; wood, leather and textiles are rare
Acid to basic, anoxic	Peats and organic deposits, e.g. lake sediments and alluvium, gleys	Organic urban deposits, wetlands, river floodplains, wells, wet ditches, upland moors	Leather, wood and bog bodies preserved to differing degrees; bone etc only preserved in alkaline environments; metalwork can be well preserved; waterlogged plant remains, insects, molluscs, ostracods, foraminifera, pollen, spores and diatoms are present
Acid, anoxic	As above	As above	Animal fibres will survive
Basic, anoxic	As above	As above	Plant fibres will survive

The impact of condition on archaeological information allows a broad division into idealised classes of survival typical of different types of landscapes/locations (Table 3.3) and then into levels identifying comparative condition, given appropriate letter codes (Fig. 3.3). Localised fragmentation (**F**) by vertical intrusions such as foundations or services could reduce the level suggested above, e.g. a heavily impacted urban site could be coded VBF Level 2 (reduced from Level 3):

- Level 4: exceptional information survival expected – broadly typical of wetlands, unploughed chalk downland and deep anoxic urban deposits.
- Level 3: above-average information survival expected – broadly typical of uplands, ancient woodlands, permanent pasture, other areas with earthwork monuments, and urban deposits.
- Level 2: average information survival expected – broadly typical of agricultural landscapes and buried remains in historic settlements.

- Level 1: below-average survival expected – broadly typical of damaged modern landscapes, suburban areas and heavily cultivated land.
- Level 0: no meaningful survival – typical of areas extensively impacted by modern quarrying, infrastructure and heavy industry.

Table 3.3: Idealised condition classes

Condition: Chemical → ***Physical ↓***	***Wetland*** *(**A**noxic)*	***Dryland*** *(**B**asic)*	***Dryland*** *(a**C**idic)*
Upstanding: above ground earthworks and structures	Code = UA Level 4	Code = UB Level 4	Code = UC Level 3
Vertical stratigraphy	Code = VA Level 4	Code = VB Level 3	Code = VC Level 2
Shallow cut features	Code = SA Level 3	Code = SB Level 2	Code = SC Level 1
Deep cut features only	Code = DA Level 2	Code = DB Level 1	Code = DC Level 1
Widespread destruction (**X**)	Code = XA Level 1	Code = XB Level 0	Code = XC Level 0

Measuring the information content of archaeological monuments in these different states of preservation is not straightforward (or often attempted). Clearly it is related to the number and diversity of structural remains, artefacts and ecofacts and also to the degree of spatial patterning that survives. The Monuments at Risk Survey of England 1995 created ‘decay profiles’ for six excavated monuments (three long barrows and three Roman villas). Whilst not formulated in quite the terms outlined above, two long barrows that had surviving earthworks were considered to be at about 50% of their original condition compared to a largely levelled example at 10% (Darvill and Fulton 1998, fig. 2.6). In the above schema this might be equated to a decline from level 4 to level 2. The villa case studies had two with broadly level 3 survival (scored at 50% condition) whilst the heavily plough-damaged third example would have been level 2, or 30% condition (Darvill and Fulton 1998, fig 2.10). Clearly different types of monument will lose information at different rates, and information content does not translate directly into significance. Further research could be done to indicate the likely survival of structures, artefacts and ecofacts in the different scenarios which could help refine allocation to levels and provide a basis for weighting differences in condition more scientifically.

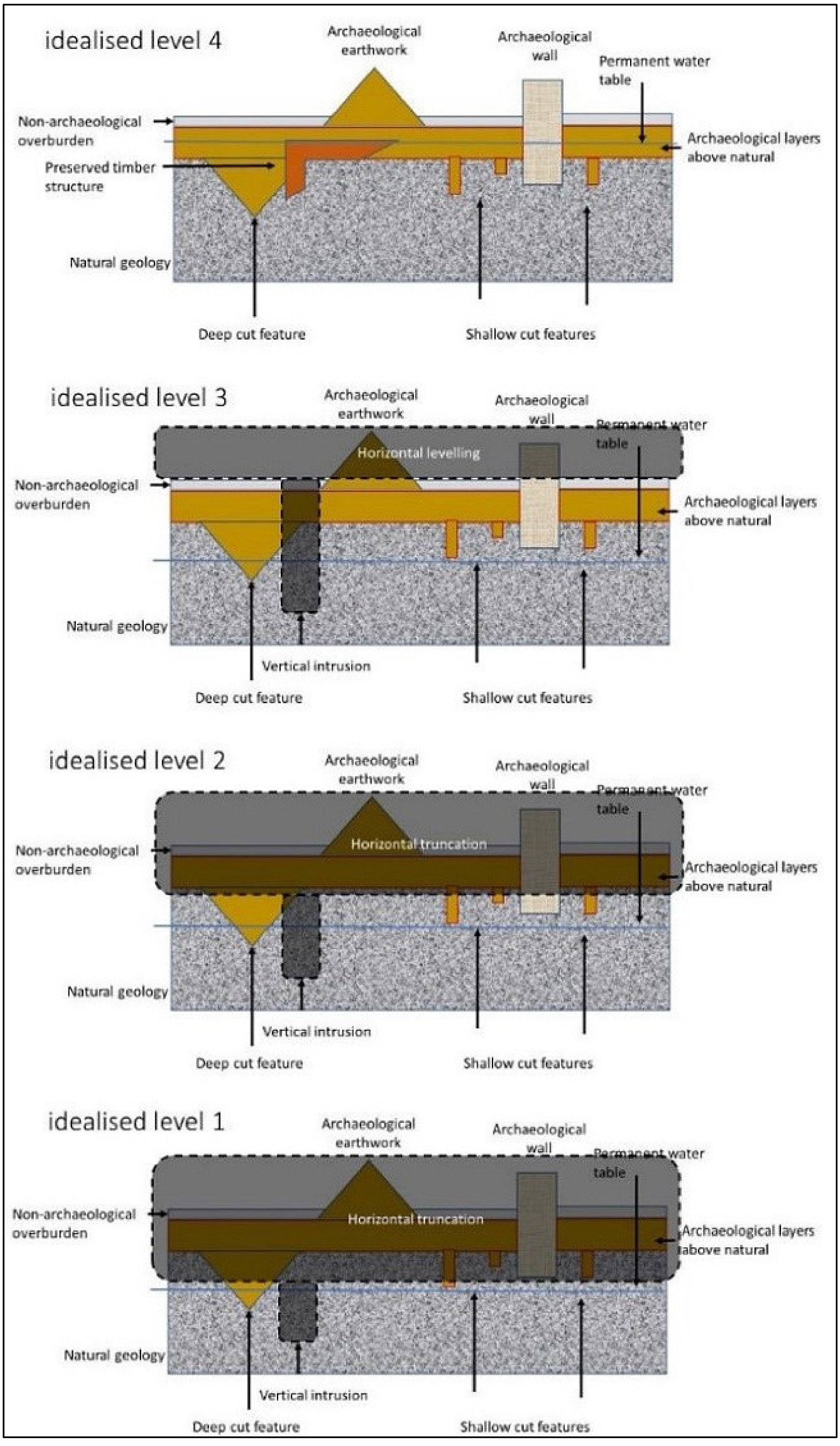


Figure 3.3: Conceptual model for levels of site survival

Having established a conceptual framework for survival and condition, the approach to assigning scores starts with known assets, whose form can be derived from or added to alert maps and maps of scheduled monuments (Table 3.4). In developing the methodology it may be useful to consider how detailed survival mapping has been attempted for Westminster and Whitehall UAD[15] and Heathrow, but there is potential for simplification to remove duplication arising from the combination of different approaches. These distinguish: areas of known archaeology; greenfield land with potential for archaeology; areas where archaeology has been removed, destroyed or built on; historic settlements and burial grounds; and previously evaluated land that may retain some archaeological evidence.

Table 3.4: Classification of form of known assets with equivalent condition code

Form		***Code***
built	Built-up area with buildings and structures of archaeological interest as well as below-ground deposits	U
land	Landscapes with upstanding structures, landforms or man-aged vegetation of archaeological interest as well as below-ground deposits	U
ewk	Visible earthworks, occasionally with ruined structures	U
flat	Buried remains with minimal or no visual component	V, S or D depending on land use etc
finds	Findspot(s) only	V, S or D depending on land use etc
doc	Documentary reference only	V, S or D depending on land use etc

3.2.3 Considerations for assessing significance

Significance is a judgement of the values that can be ascribed to a heritage asset (English Heritage 2008, 27–32). Under the NPPF a heritage asset is defined as any element of the historic environment which is identified as having a degree of significance meriting consideration in planning decisions, and those assets which are equivalent in significance to scheduled monuments should have the same weight in planning policy. Conversely, elements of the historic environment not defined as assets could potentially be ascribed no archaeological interest, even if recorded in a Historic Environment Record. Some HERs

[15] https://historicengland.org.uk/content/docs/planning/luad-phase3a-westminster-whitehall-survival-layer-user-guide/

have a structured approach to identifying selected known ‘monuments’ as heritage assets of archaeological interest, while others regard all monuments as heritage assets. This is a matter of wider sectoral debate at present but the view taken in this study is that it is unhelpful to strategic decision-making to regard all HER monument records, regardless of nature and quality, as non-designated heritage assets (NDHAs).

For the purposes of this study, therefore, the inclusion of a site in an HER is not deemed sufficient to identify it as a heritage asset (Historic England 2021, para 61). The question then arises which of these records might be identified as NDHAs of archaeological interest. On this point the NPPG (para 40) says that ‘It is important that all non-designated heritage assets are clearly identified as such’ while going on to acknowledge that local planning authorities may also identify non-designated heritage assets as part of the decision-making process, for example following archaeological investigations, and that it is also helpful if plans note areas with potential for the discovery of assets with archaeological interest.

It follows that sensitivity mapping would ideally identify known heritage assets as a subset of HER information and then further subdivide this set into nationally important assets and those of lesser significance. However, this is a non-trivial task and in practice, because most of the English landscape holds some archaeological interest, NDHAs could, as mentioned, be considered to divide into discrete manageable assets and landscape ‘background signature’ (the scoping exercise would aim to identify appropriate thresholds). This ‘background’ can, of course, be of archaeological interest, especially when interpreted at a landscape scale or in relation to a specific research agenda. However, such features very rarely prove to be of national significance (e.g. isolated hoards) and it will not normally be realistic or proportionate for them to influence strategic planning decisions, other than to recognise where provision is needed for their recognition and investigation. Note that the study avoids the loaded terminology of ‘local’ and ‘regional’ significance which has no foundation in the NPPF and could be used to imply that the ‘background’ is of no interest. It is also important that palaeoenvironmental sites are not automatically assigned to the ‘background’ and considered intrinsically less significant than other site types.

A greater problem, of course, is how to address the potential significance of assets which are yet to be discovered. What is proposed is a scoping exercise to identify key asset types (taking into account factors such as the composition of the schedule in an area, locally characteristic monuments, and research frameworks) as proxies for modelling the entire dataset. For these key assets the completeness of the dataset would be assessed, the frequency of occurrence and new discoveries set out, and the particular circumstances in which these monuments could be considered of national significance identified. Candidate nationally important sites or areas of search could then be proposed.

All surviving examples of rare monument types are likely to be significant but for the more typical and commonplace the state of preservation would be a determining factor. More common asset types will contribute more to sensitivity simply because they are more likely to be found in any given land parcel. However, this effect could be reduced once significance is introduced.

Some monument types cluster in favoured locations (e.g. Neolithic ceremonial monument complexes). Other examples of clustering effects could be proximity to Roman roads or medieval churches. As noted in the Presence section, identification of such effects will enhance the sensitivity of an area due to the higher potential for new discoveries. Significance might then be addressed spatially by dividing into levels along the following lines (with further thought needed in terms of relative weighting):

- Level 4 (exceptional): scheduled monument (SM) or other asset formally identified as nationally important (NI)
- Level 3 (high): candidate NI sites and areas where archaeology is associated with designated assets or landscapes (conservation areas, listed buildings, registered parks and battlefields), or areas with enhanced cultural heritage protection (National Parks and AONBs), identified as research priorities (which flags the need for research frameworks to develop a proper spatial dimension), or having demonstrably high potential for new discoveries of nationally important assets
- Level 2 (fair): baseline areas without known NI indicators but still with some potential for such new discoveries
- Level 1 (low): areas where survey has shown that archaeological NDHAs are likely to be sparse and fragmented or ‘background signature’.

Identifying the potential for NDHAs of national importance (equivalent in significance to SMs) to be present, and using this to inform the relevant Local Plan, could reduce the likelihood of scenarios where either assets are discovered (or recognised as nationally important) as a consequence of field evaluation undertaken to inform planning decisions, potentially necessitating substantial redesign of a proposed development, or where they are discovered during post-consent investigation, when options for physical preservation will often be constrained or foreclosed.

3.2.4 Considerations for assessing vulnerability and opportunity

If sensitivity is equated with vulnerability to harm, and its flipside, opportunity, with (public) benefit, then there will need to be an additional step to assess these in relation to the specific land use change proposals that come forward. Therefore in the pilot studies vulnerability and opportunity are not treated separately but rather as emergent properties of the sensitivity study, to be assessed in a scenario-based framework (cf. Herring 2022).

In practice the extent and depth of physical disturbance will usually be the main risk factor to consider in relation to archaeological sensitivity, so for most purposes the better the condition of the asset the more vulnerable it will be to damage, and the more significant it is the more serious that damage would be. Other considerations are the size of the asset and the current land use. Smaller monuments will normally be easier to protect and manage than larger ones – this effect is obvious in the case of Growth Areas where masterplans could protect a small site without affecting deliverability.

Conversely, sites currently at risk or in unfavourable uses (e.g. arable cultivation) could benefit from being taken into public open space in new development. In that sense formal recognition of vulnerability (e.g. through Heritage at Risk) can be seen as an opportunity to obtain funding for positive management or change of land use. The public benefit of knowledge gain from investigation could also be factored in (though the NPPF is clear that the ability to record evidence of our past should not be a factor in deciding whether loss of assets, in whole or part, should be permitted).

Note that effects on setting are not considered by this study except to the limited degree that so-called ‘immediate setting’ buffers may be included within alert map areas and are implicit in the buffering of known features used in the assessment of presence.

3.3 Scale and resolution

In principle it is possible to consider undertaking sensitivity mapping at radically different scales, from a national overview (such as the EngLaId affordance mapping) down to land parcels within individual developments (Table 3.5). However, as the former would require a huge amount of work with disparate data sources and the latter would be predicated on detailed understanding of a site’s context, the ‘local area’ emerges as the ideal scale for sensitivity mapping to inform strategic planning (see 9.1). Accordingly the pilot studies examine such ‘local areas’, but each could be refined to consider how additional detail might be added in sub-areas subject to specific major projects, or conversely generalised to cover sub-regional development programmes. It will therefore be useful to think about what techniques might work at these different orders of magnitude.

Table 3.5: Notional scales of approach

Descriptor	***Size of study area (approx.)***	***Example of use***
National	100,000 km^2	EngLaId
Regional	10,000 km^2	Regional plan
Sub-regional	1000 km^2	Thames Gateway or Oxford-Cambridge Growth Arc
Local area	100 km^2	Local Plan growth area
Major project	10 km^2	EIA
Small project	1 km^2	Standard planning application
Site	hectares	Mitigation strategy

In archaeological modelling studies, the unit of investigation is a parcel of land. In the USA land parcels are defined by superimposing a regular grid over the study region. Where a fine-grained level of predictive resolution is called for, parcel size should be small; where the intent is to identify broad regions of higher or lower resource density, parcel size can be quite large. In general, high resolution models have parcel sizes equal to or less than 4 ha, while models of very low resolution have parcel sizes equal to or greater than about 100 ha.

In the UK application there will be a choice to be made between either a regular grid with parcels of a size to fit neatly within the 1 km grid (for example the National Historic Landscape Characterisation [NHLC][16], which divides the country into a 250 m and 500 m grid, giving parcels of 6.25 and 25 ha respectively) or the use of irregular polygons, either bespoke or derived from another study, such as (standard) HLC. There are advantages and disadvantages in all options, and ultimately choices will depend on the scale at which archaeological input into planning is required:

- High resolution (1 or 4 ha) grid: very precise but expensive to code and predictions more likely to be wrong.
- Medium resolution (25 ha) grid: the larger of two scales used by the NHLC; more manageable over a large area but each parcel is likely to contain multiple land characteristics and most will contain at least one asset.

[16] accessible through https://magic.defra.gov.uk/

- Low resolution (100 ha) grid: the smallest scale used by EngLaId (along with 3 km and 5 km hexes); each parcel is very likely to contain multiple land characteristics and multiple assets; useful for regional and national context but too coarse-grained for site allocation work.
- HLC polygons: aligned with recent historic land use but highly variable in size/resolution and shape, making quantitative analysis problematic, and not designed for this use so likely to require some enhancement and splitting; the variable quality of existing HLC is also a concern; therefore probably most suited to local area or major project scales.
- LCA or similar local area polygons: these cover larger areas than HLC polygons so may be more suited to sub-regional scales and above; LCAs are rarely available digitally at present, though the Landscape Institute (LI) is currently reviewing publicly available information.[17]
- Bespoke polygons: more time-consuming with added complexity and scope for professional judgement; useful for fine-grained work at masterplanning scale and could build up from existing designations and constraint areas giving a product more familiar to planners.

All the pilot projects (sections 4–7) make use of HLC polygons as these provide a readily available useful dataset related to actual land management units. The Holderness and Eden pilots (sections 6–7) also explore the gridded approach of the NHLC.

3.4 Testing, confidence and validation

The dependability of these models is a function of their performance, which can be examined and tested by comparing a predictive model to archaeological survey results. By comparing model predictions against known site locations, it is possible to examine how accurately a model performs. It is, in fact, this very approach that gives us confidence (to varying degrees) in a model and allows us to use it as a predictive tool. It is proposed to use recent major infrastructure fieldwork (where available) to provide an initial test of the models (see 4.8). It could also be useful to think about the visibility of the archaeological resource and confidence in sensitivity-based predictions, especially whether it is well enough understood for significance to be ascribed (Table 3.6).

[17] see https://www.landscapeinstitute.org/news/landscape-character-database-project-consultation-launch/

Table 3.6: Notional scales of confidence

Site potential	***Survey quality[18]***		***Tier (see below)***
High	Good	There is a high degree of confidence in these areas	1 or 2
High	Poor	There is less certainty about these areas	3
Medium-Low	Good	We feel confident that sites are less frequently found here (but not absent)	4
Unknown	Poor	We need surveys to help us understand these areas adequately	X

The pilot studies explore how the parameters of sensitivity outlined above (3.2) might be combined to generate ‘tiers’ of sensitivity mapping that are useable in the planning system, as undertaken for the adopted London Plan[19]. A tiered approach is not the only way to translate sensitivity mapping into policy but would be particularly relevant if a zonal planning system akin to that proposed in the Planning for the Future white paper were ever introduced. The tier system would steer development to areas with lower impact on archaeological resources (and consequently lower mitigation costs for developers). A provisional schema might distinguish:

- Tier 1: areas with assets of national significance where harm should be avoided
- Tier 2: areas where an informed judgement on allocation would be required balancing the scale of harm, the significance of the assets affected and the potential for appropriate mitigation (including offsetting public benefits)
- Tier 3: areas expected to contain NDHAs of archaeological interest which have yet to be discovered or adequately characterised
- Tier 4: areas that may contain residual areas of archaeological interest requiring mitigation

[18] positive indicators would include e.g. aerial mapping coverage, large-scale developments, fieldwalking coverage; negative indicators include e.g. woodland cover, recent alluviation

[19] see https://historicengland.org.uk/services-skills/our-planning-services/greater-london-archaeology-advisory-service/greater-london-archaeological-priority-areas/

- 'Tier X': areas where existing information is too poor to create a reliable sensitivity model, and a plan for addressing the information gap would be required.

In some cases one parameter of sensitivity will trump the others, if little or nothing survives, for example. The basic methodological process is as follows:

- Step 1: scoping the study area
- Step 2: mapping known heritage assets
- Step 3: the condition model
- Step 4: the presence model
- Step 5: the significance model
- Step 6: merging to create the sensitivity model
- Step 7: testing, adjustment and validation
- Step 8: planning implications: vulnerability and opportunity.

3.5 Selection of pilot study areas

Eleven candidate pilot areas were identified, one of which (the **Vale of Aylesbury**) was chosen for prototype development because the area and its archaeological resources are well known to one of the authors (Sandy Kidd) and the local authority archaeologists supported the study (4.2 and Table 3.7). This study straddles a lowland growth area and protected 'hill country' (the Chilterns AONB). It has good HLC and Alert Maps but lacks National Mapping Programme (NMP)[20] aerial coverage, wetlands, industrial and coastal landscapes. Some testing can be provided in relation to High Speed 2 (HS2) interim results (4.8). Three other areas were selected to examine contrasting landscapes and methodological issues (Table 3.7):

[20] the NMP no longer exists as a formal programme but remains a useful shorthand for aerial investigation and mapping projects carried out in accordance with Historic England standards

Table 3.7: Summary of pilot areas

Location County Area	***Topography***	***Archaeological focus***	***Development***	***Agri-forestry***	***Alert map HLC EUS NMP***
Vale of Aylesbury, Bucks 294 km^2	Lowland clay vale & chalk hills	Central & South Eastern Provinces[21] Later prehistoric to medieval	Urban expansion, Infrastructure (HS2)	Mixed agriculture; woodland in Chilterns	Yes Yes Yes No (but some local plots)
London Gateway, Essex 150 km^2	Lowland industrial & urban coastal landscape on former grazing marsh and gravel terrace	South Eastern Province Complex multi-period landscape from Neolithic to modern industry	Minerals, Infrastructure, Urban expansion, Freeport	Potato cultivation; no woodland	No Yes, poorly regarded Yes, marginal relevance Yes
Holderness, East Yorkshire 200 km^2	Lowland river valley, plain & coastal landscape; former wetland	Central Province Some Mesolithic, mostly later prehistoric to medieval	Flood alleviation, Coastal erosion	Potential Northern Forest component	No Yes No Part
Eden Valley, Cumbria 200 km^2	Lowland river valleys & upland fringe	Northern & Western Province Later prehistoric (inc. upstanding monuments) to medieval	Flood alleviation, Urban expansion	Pastoral to arable conversion	No Yes No Yes

The **London Gateway** has Essex HECA coverage and the pilot has the support of Essex Place Services. The area is covered by the Environment Agency's Thames Estuary 2100 Plan, addressing long-term climate change and sea-level rise trends, and includes part of the Thames Chase community forest. It is crossed by the planned Lower Thames Crossing, the surveys for which can be used to test and calibrate predictions.

Holderness and the **Eden Valley** balance the south-eastern bias of the other pilot studies. These areas have available digital aerial mapping (in whole or part) and local curatorial support. Both fall at least partly within EngLaId case study areas and have potential for connection with future forestry and flood management initiatives. The Eden Valley study area is crossed by the Carlisle Southern Link Road, the surveys for which could be used to test and calibrate predictions.

[21] see Roberts and Wrathmell 2002

Ideas for pilot studies not taken forward at this stage include areas of south Cambridgeshire and Huntingdonshire suggested by Cambridgeshire County Council; like the Vale of Aylesbury, these overlap with the Oxford-Cambridge Growth Arc which is the subject of a separate historic environment characterisation project, and could usefully be reviewed when that is complete – especially since Cambridgeshire currently lacks locally supported HLC coverage. Also considered in the south were another area of Essex around Harlow, potentially affected by urban expansion; part of the Middle Thames, which is an interesting but complex area with logistical difficulties; the Hoo Peninsula, which is similar to the London Gateway, albeit with a more detailed HLC available; and the Isle of Thanet, which is the subject of a separate HE-funded HER enhancement and characterisation project. In the north a further suggestion was part of the Cheshire Plain east of Chester which will be impacted by Phase 2a of HS2, and might be a useful follow-up to the HS2 test in the Vale of Aylesbury (4.8).

4 Vale of Aylesbury

4.1 The study area

The Vale of Aylesbury pilot area (Fig. 4.1) represents a fairly typical archaeological landscape for southern and eastern England but includes some variety, having both Midland 'champion' landscape in the Vale itself, and the South-Eastern 'ancient' or 'woodland' landscape of the Chiltern Hills to the south. The Chilterns are characterised by chalk and clay-with-flints geologies, with few watercourses, whilst the Vale has a mix of clay, limestone and sandstone geologies, and streams feeding the Thame that runs westward to the Thames (Fig. 4.2 and Table 4.1).

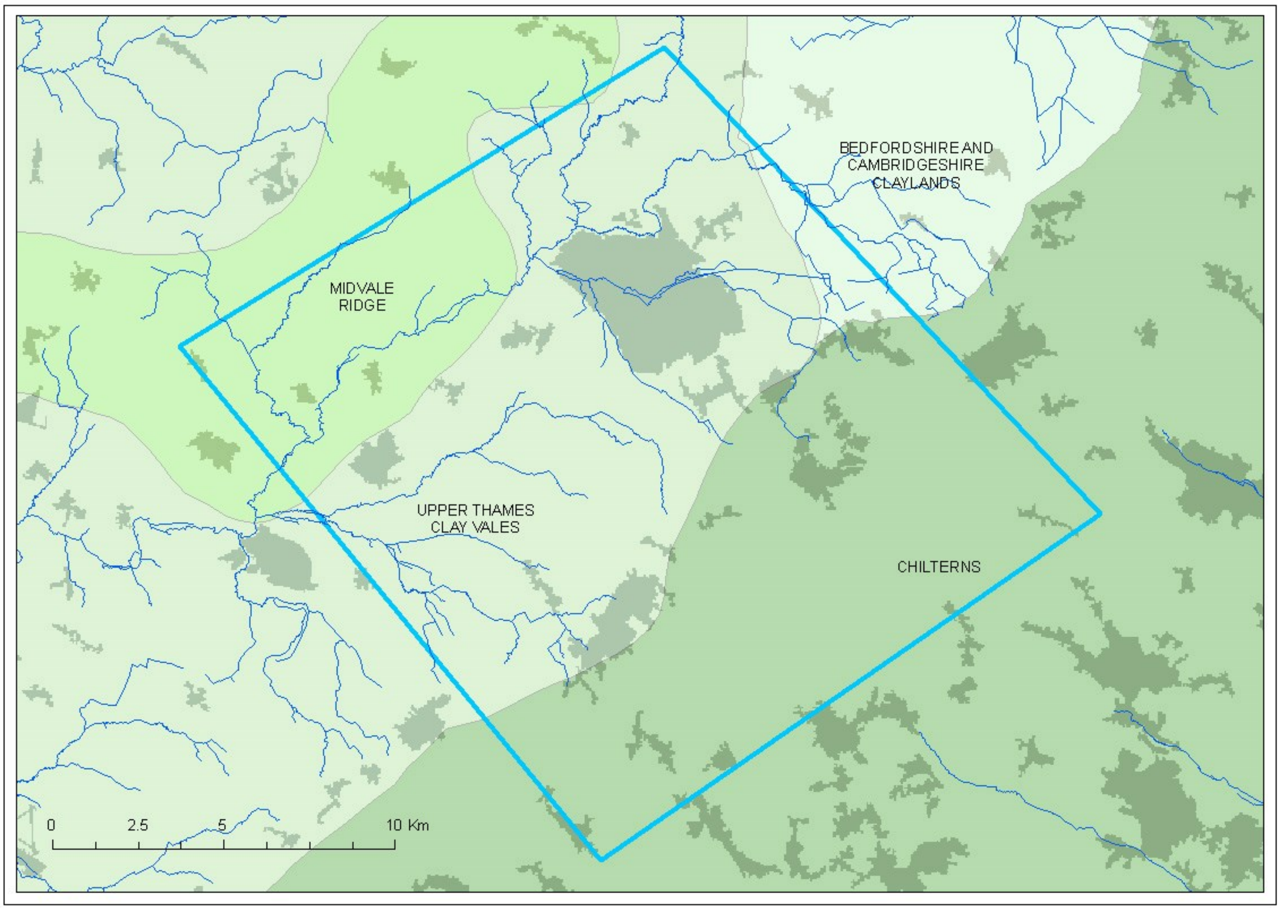


Figure 4.1: Location of the Vale of Aylesbury pilot study showing National Character Areas, watercourses and built-up areas

The study area is roughly rectangular and covers 18.8 x 15.7 km (29,393 ha). It lies entirely within the modern unitary authority and historic county of Buckinghamshire, with the county town of Aylesbury in its north-east quadrant, around which is a greenfield urban growth area. It straddles four National Character Areas (Fig. 4.1) and the southern third lies within the Chilterns AONB. The route of HS2 runs south-east to north-west through the study area (see 4.8).

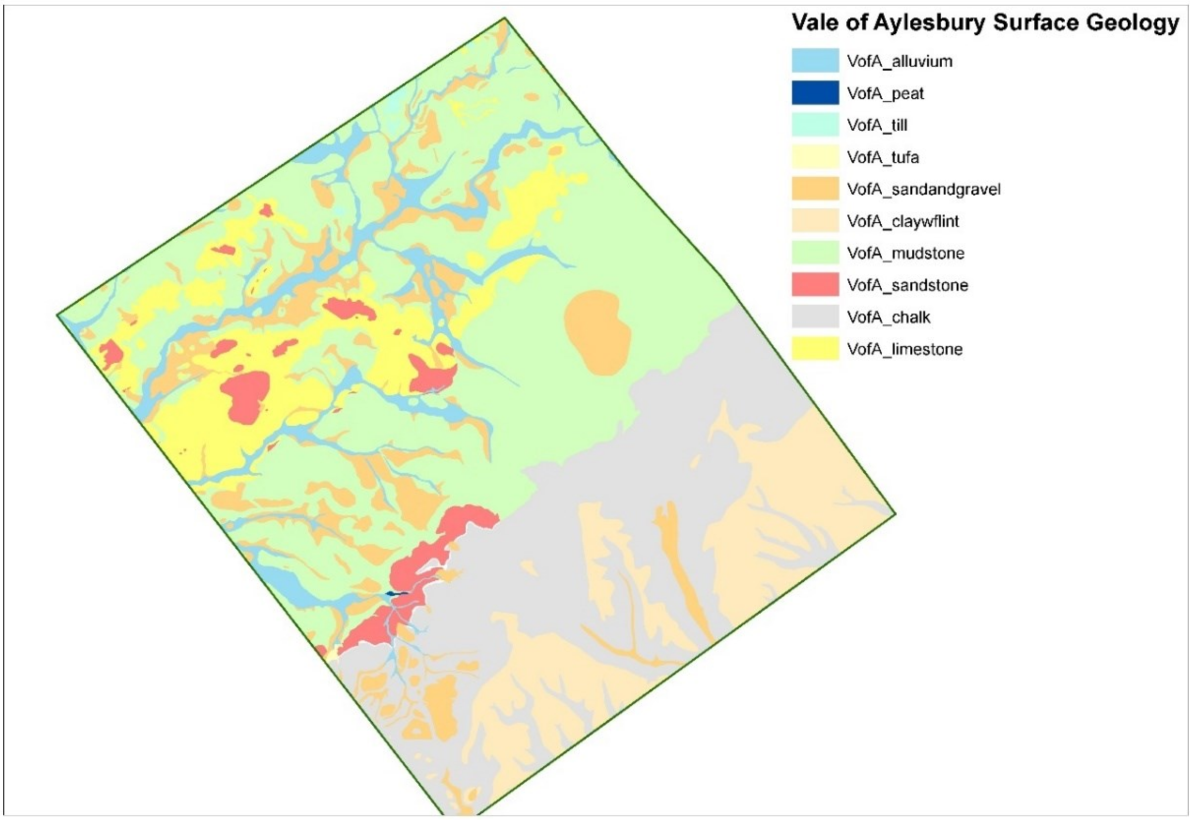


Figure 4.2: Simplified surface geology of the study area (derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

The eastern half of the study area has been covered by a recent interpretative synthesis for the two millennia from the later Bronze Age to the Norman conquest (Alqassar and Kidd 2018). Regional synthetic studies are available for all periods, as prepared for the Solent-Thames Regional Research Framework (Hey and Hind 2014), and for the county up to the medieval period (Farley 2010), as well as for medieval settlement (Lewis *et al*. 1997), the Chilterns landscape (Hepple and Doggett 1994) and the Iron Age to medieval periods (Rippon 2018). National studies conducted of historic rural settlement patterns (Roberts and Wrathmell 2003), the Roman Rural Settlement Project (Smith *et al*. 2016) and the EngLaId Project (Gosden *et al*. 2021) also provide invaluable context.

Buckinghamshire has full HLC coverage (Buckinghamshire County Archaeological Service 2007) which was subsequently enhanced to create Chilterns-wide coverage for the AONB (Green 2009). The county has also completed an EUS project but that was not used in this study. The area has yet to benefit from NMP-standard aerial investigation and mapping, although some aerial photographic plots are held by the HER. The north-eastern quadrant of the study area around Aylesbury itself has seen two studies prompted by major development land allocations under consideration for the District's Local Plan (see Green and Kidd 2005).

To establish the methodology, the pilot study deliberately did not seek out the latest results from HS2, the Chilterns AONB 'Beacons of the Past' project and ongoing development-led investigations so that these can be used for testing the approach. Thus the 'current' situation referred to in this section can be thought of as broadly the mid-2010s.

Table 4.1: Simplified surface geology classification. NB Greensand and Gault are combined because they are undifferentiated in the eastern part of the study area.

	Type	***Comprises Codes BGS_LEX***	***Notes***	***Area (ha)***
Superficial geology	Sand & Gravel	GFDM, HEAD, LOFT, ODT, PRSG, RTD1, RTD2, RTD3, SUPD, T1T2	Encompasses both river and glacial gravels plus head	3217.4
	Peat	PEAT	Classified A for Anoxic chemical preservation	4.5
	Alluvium	ALV	Classified A for Anoxic chemical preservation	1708.1
	Clay-with-Flints	CWF		3306.9
	Tufa	TUFA	Combine with bedrock limestone	11.4
	Till	TILMP	Undescribed mid-Pleistocene till	55.1
Bedrock geology	Chalk	CKR, HCK, HNCK, LECH, LESE, MR, NPCH, TTST, ZZCH, WZCK, WMCH	Chalk Group	6693.9
	Limestone	PB, OKLY, PL, POSA, POST	Portland and Purbeck	2805.9
	Mudstone	AMC, GLT, GUGS, KC, WWAC	Ampthill, Gault, Upper Green-sand, Undifferentiated Gault & Upper Greensand, Kimmeridge Clay	10676.4
	Sandstone	LGS, WHS, UGS	Upper & Lower Greensand, Whitchurch Sand	873.5

4.2 History of archaeological investigation and state of knowledge

In the study area, early and mid-20th century archaeological investigations were focused on the prominent monuments of the Chilterns, mainly hillforts and villas. From the 1970s to 1990s attention shifted to historic settlement cores, most notably Aylesbury and the nearby villages of Bierton and Walton. Since the mid-1990s large-scale investigations have taken place on greenfield land around Aylesbury and along the A41 corridor. Recently HS2 has extended this focus to the west and south of Aylesbury. There have been fewer investigations in the protected Chilterns AONB, where the masking effect of woodland is now being addressed by lidar survey as part of the 'Beacons of the Past' project[22].

For this study, the Bucks HER provided GIS 'Event' datasets in a combination of point and polygon format. Generally, more recent and larger investigations are mapped as polygons whilst older and smaller events are recorded as points. This data was manipulated to remove desk-based research and to classify fieldwork using the simplified investigation types defined by the EngLaId project (Table 4.2; Gosden *et al*. 2021, table 2.3). To avoid duplication, event point data within event polygons was deleted and a 50 m buffer was applied around remaining point data to give a nominal extent that felt appropriate for small-scale fieldwork.

Table 4.2: Categorisation and quantification of investigations (source: adjusted Bucks HER data)

Code	***Simplified EngLaId investigation type***	***Number***	***Est. area (ha)***
1	Intrusive: open area excavation (inc. strip, map and sample)	66	68
2	Intrusive: keyhole (evaluation trenches, test pits etc.)	306	1672
3	Non-intrusive survey (geophysics, aerial, earthwork)	189	4140
4	Fieldwalking/metal detecting	104	808
5	Other (includes historic building recording)	110	131
6*	Preservation in situ (decision to preserve identified archaeology within development)	10	25
Deleted	Desk-based research, syntheses	n/a	n/a
Total	Land in the study area subject to any form of investigation	785	3944 (14%)

Notes: investigations sometimes overlap giving a higher figure for coverage of investigations than for all land covered by any investigation

**not recorded in Bucks HER or EngLaId but added for this study*

[22] https://www.chilternsaonb.org/projects/beacons-of-the-past.html

This analysis shows that approximately 14% of the study area has been subject to some form of archaeological investigation recorded as such on the Bucks HER. From this set 14 case studies have been identified, covering 3.9% of the study area (see Appendix 1). However, investigations are spread unevenly across the study area with most focussed in the north-east quadrant in and around Aylesbury. The protected Chilterns AONB, particularly its woodlands, is much more sparsely covered (Fig. 4.3).

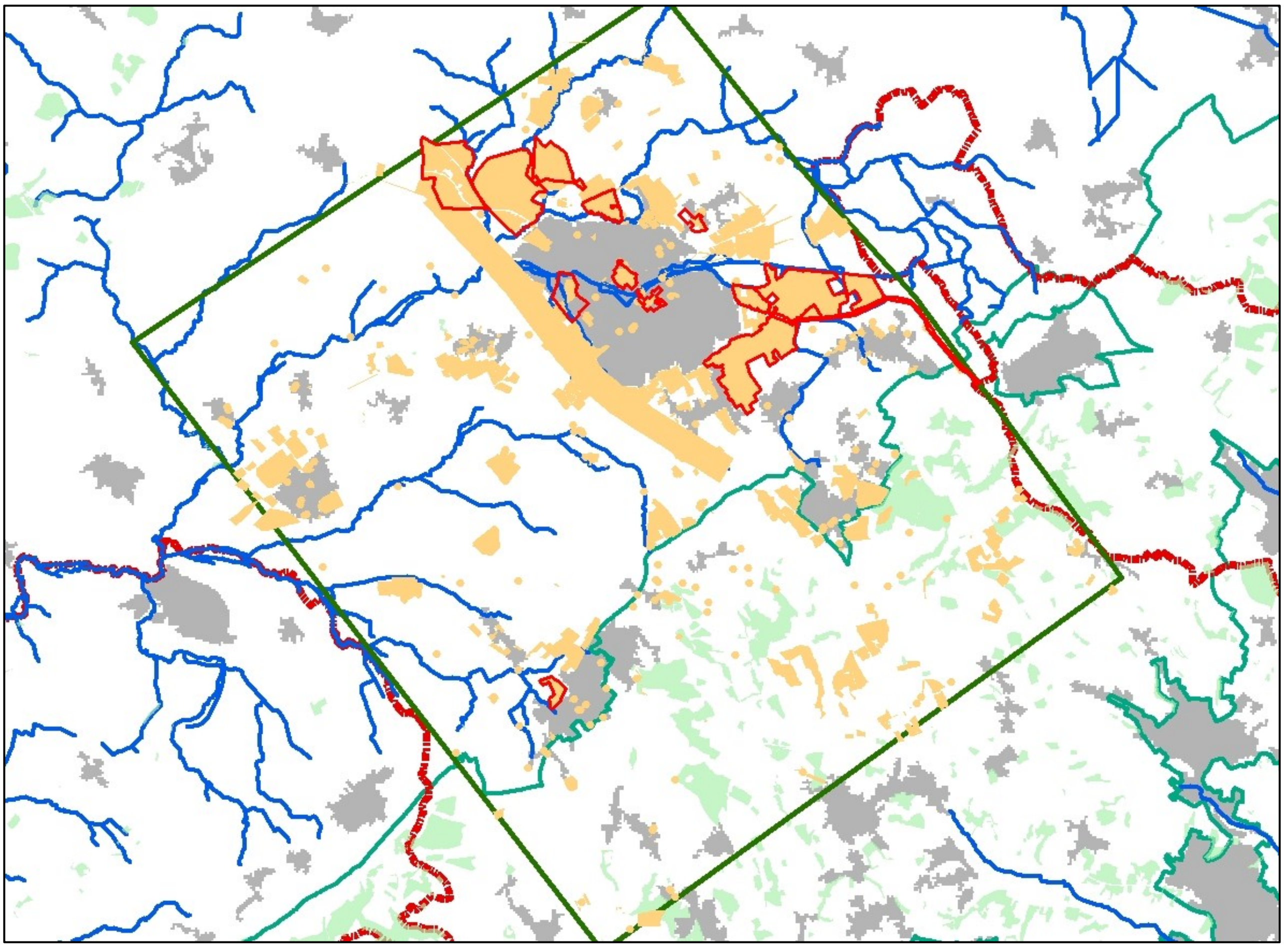


Figure 4.3: Extent of archaeological investigations (orange shading) with the Chilterns AONB boundary (green outline), ancient woodland (green shading) and case studies (red outline)

Thus the current state of knowledge can be broadly divided into three zones:

- NE quadrant: the Aylesbury environs, as far south as the AONB and west to the HS2 corridor, have good data quality from which it ought to be possible to make inferences about archaeological character and potential.
- NW quadrant: the area north of the AONB and west of the HS2 corridor has poor to moderate data quality but with similar physiography to the NE quadrant it may be possible to extend inferences from there into this area.

- The Chilterns AONB across the south: this zone has poor data quality, a different physiography and different (and less well understood) archaeological character and potential, so inferences from the NE quadrant may not be transferable.

4.3 Character of the archaeological resource

4.3.1 Categories

The intention of this section is to attempt to quantify what we know about that subset of the archaeological resource which (potentially) has some strategic significance. Rather than attempting to trawl the totality of the HER, the study focuses initially on heritage assets of archaeological interest identified through planning alert maps and scheduling or discovered during development consent procedures (evaluation and mitigation). It considers what we might infer from this data about as yet undiscovered assets, a process that relies on a proposition that the known dataset is a useful, albeit imperfect, indicator of the undocumented dataset. In order to analyse assets they have been allocated to ten broad periods and eight types, enabling data to be expressed as a grid.

The HER identifies 316 Archaeological Notification Areas (ANAs) within the study area, which vary in size from individual monuments to entire landscape parks or historic settlements (the mean area of those within the study area is 11.5 ha). For these only the principal aspects (period and type) defining each asset's significance have been classified except for a very few cases noted above where multiple aspects of high significance were counted (Table 4.3). The grid for ANAs can be compared to that for scheduled monuments (SMs), which emphasises substantial earthwork monuments in the form of prehistoric barrows, dykes and hillforts, and medieval moats and villages (Table 4.4). In contrast fieldwork discoveries in the case studies show a wider range of asset types and a stronger emphasis on Roman remains, reflecting their mainly greenfield locations away from historic settlements (Table 4.5).

Interestingly all three ways of looking at the resource identify very few archaeological assets of Palaeolithic, Mesolithic or modern periods, whilst the later prehistoric, Roman and late medieval periods are most prolific. Post-medieval assets are common in the study area but often recognised through other heritage designations, not always captured by ANAs or scheduling.

Table 4.3: Categorisation and quantification of assets within ANAs

Period	Settlement	Agriculture	Industry	Transport	Religious/ Funerary	Defensive/ Military	Recreation	Unclassified	**Total**
Modern	0	0	0	1	0	0	2	0	**3**
Post-medieval	9	2	7	0	1	0	12	0	**31**
Late medieval	70	16	3	0	24	4	0	4	**121**
Early medieval	1	0	0	0	7	0	0	5	**13**
Roman	21	0	1	3	2	0	0	29	**56**
Later Prehistoric	9	1	1	0	1	18	0	7	**37**
Neolithic/Early Bronze Age	0	0	0	0	19	0	0	8	**27**
Mesolithic	0	0	0	0	0	0	0	1	**1**
Palaeolithic	0	0	0	0	0	0	0	2	**2**
Undated	1	0	0	1	3	0	0	23	**28**
Total	**111**	**19**	**12**	**5**	**57**	**22**	**14**	**79**	**319**

Notes: Aylesbury (LP Defensive and LM Settlement), Walton (LP Settlement and EM Settlement) and Quarrendon (LM Settlement and PM Recreation) have two entries each; Bierton has three (Neo/EBA Religious, RB Settlement and LM Settlement)

Table 4.4: Categorisation and quantification of SMs

Period	Settlement	Agriculture	Industry	Transport	Religious/ Funerary	Defensive/ Military	Recreation	Unclassified	**Total**
Post-medieval	0	0	0	0	1	0	1	0	**2**
Late medieval	25	1	0	0	0	3	0	0	**29**
Early medieval	0	0	0	0	1	0	0	0	**1**
Roman	2	0	0	0	1	0	0	0	**3**
Later Prehistoric	0	0	0	0	0	20	0	0	**20**
Neolithic/Early Bronze Age	0	0	0	0	15	0	0	0	**15**
Total	**27**	**1**	**0**	**0**	**18**	**23**	**1**	**0**	**70**

Note: Quarrendon has two entries (LM Settlement and PM Recreation)

Table 4.5: Categorisation and quantification of assets within case study areas

Period	Settlement	Agriculture	Industry	Transport	Religious/ Funerary	Defensive/ Military	Recreation	Unclassified	**Total**
Modern	0	0	0	0	0	0	1	0	**1**
Post-medieval	2	4	0	1	1	2	1	0	**11**
Late medieval	7	10	1	2	2	0	0	1	**23**
Early medieval	2	0	0	0	2	0	0	2	**6**
Roman	13	17	3	13	4	0	0	0	**50**
Later Prehistoric	11	11	0	4	5	1	0	2	**34**
Neolithic/Early Bronze Age	1	0	0	0	1	0	0	5	**7**
Mesolithic	0	0	0	0	0	0	0	1	**1**
Palaeolithic	0	0	0	0	0	0	0	0	**0**
Undated	2	0	0	0	0	0	0	2	**4**
Total	**38**	**42**	**4**	**20**	**15**	**3**	**2**	**13**	**137**

When considering strategic issues it is helpful to identify patterning within each period and key monument types which are particularly relevant, whether because of their frequency within the study area, their good condition or high significance. This scoping exercise for the Vale of Aylesbury runs as follows:

4.3.2 Palaeolithic

Lower and Middle Palaeolithic finds and environmental evidence embedded in Pleistocene geology were simply classified as Palaeolithic Unclassified. The study area contains one nationally significant Pleistocene faunal and environmental site (at College Lake, Marsworth) but without a hominin presence. Very few other finds are known but, as mentioned above (2.1), a separate project is mapping potential for Palaeolithic discoveries nationally, the results of which will feed into sensitivity mapping once they are available.

4.3.3 Mesolithic

Individual Mesolithic flints are recorded across the Vale of Aylesbury but well-defined scatters are very rare (Farley 2009, 17). The Solent-Thames regional research framework noted the paucity of earlier Mesolithic finds in the Vale of Aylesbury compared to other more productive areas (Hey 2014, 72). In common with other researchers, Hey emphasises the riverine distribution of sites in the Solent-Thames region, which is particularly evident to the south of the study area where Mesolithic occupation sites are well attested along the Middle Thames, the Colne Valley and its Chilterns tributaries. There well-preserved sites with in-situ lithic scatters and associated environmental evidence are found in the river valleys, typically near the edge of alluvial deposits and sometimes sealed under shallow peat and tufa. Looking further afield an association with watercourses is widely recognised but also some other factors come into play; for example, in Hampshire the Greensand geology was favoured whilst in Northamptonshire light permeable soils and topographically prominent viewpoints are also emphasised.

Although a ‘background signature’ of occasional Mesolithic flints can be expected across the landscape, substantive occupation sites are generally thought to be more subject to environmental determinism than later periods. Normally lacking deep earth-cut features they are also very vulnerable to serious plough damage, with most in arable land having long ago been reduced to ploughzone artefact scatters. In-situ Mesolithic sites are most likely to be found in locations that have avoided cultivation, such as the alluvial riversides noted above, in ancient woodland or sealed under later earthworks or settlement – such sites are potentially of national significance.

Within the study area the Bucks HER only records seven Mesolithic findspots forming a ‘background signature’ (Fig. 4.4) but no in-situ sites are yet known. Their main focus is along the Portlandian Limestone ridge overlooking the Thame on its southern side (Fig. 4.5). Only one ANA is defined by Mesolithic finds, although six others have a Mesolithic component. Detecting Mesolithic sites is not easy, being reliant on fieldwalking (and good lithic identification), geoarchaeological modelling and test-pit evaluation, or serendipitous discovery during investigations aimed at other periods. It is noticeable that the Vale of Aylesbury planning case studies have minimal representation of Mesolithic sites with only one findspot in the 11 km^2 studied.

The density of known substantive Mesolithic occupation sites in the Vale of Aylesbury is therefore rated as ‘very rare’ (<1 per 100 km^2) but taking account of the very poor visibility of this period the actual density of in-situ sites and substantive ploughzone scatters could be somewhat higher. On this evidence it is suggested that the north-facing slopes of the ridge west of Aylesbury present the best prospect for further discoveries whilst, more generally, corridors along the alluvial spreads and watercourses and local high points on permeable geologies (particularly if also close to water) present preferred locations for testing by future fieldwork.

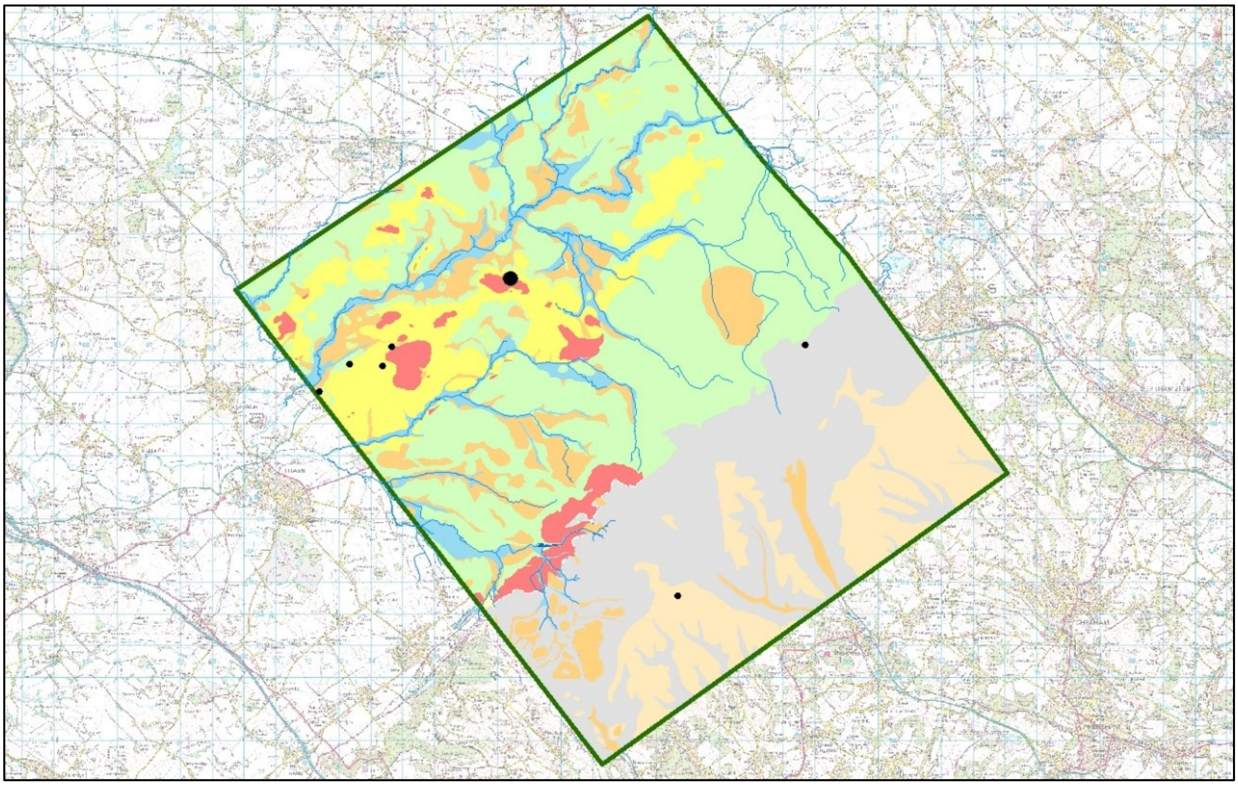


Figure 4.4: Mesolithic findspots on a background of geology (see Fig. 4.2; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved) and watercourses. Base map © Crown Copyright [and database rights] 2023. OS 100024900.

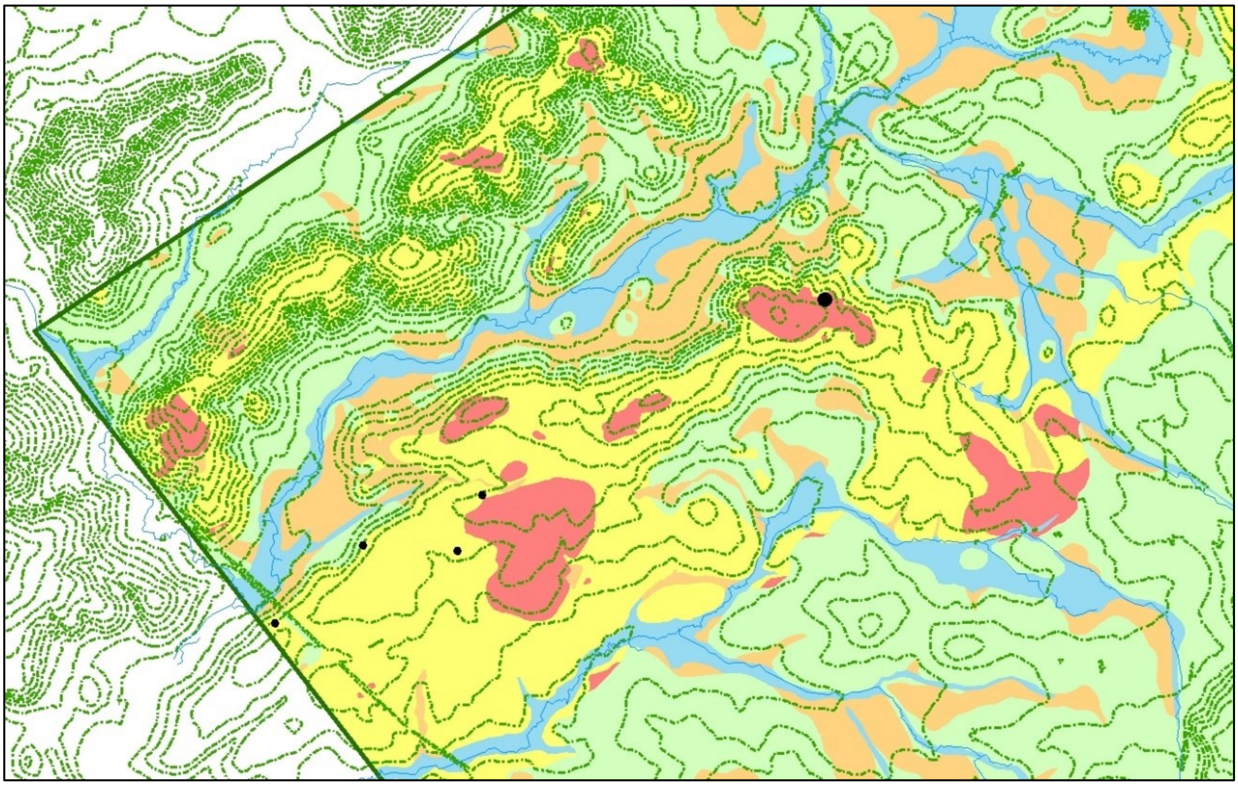


Figure 4.5 (previous page): Slight Mesolithic cluster along the north-facing slope of the limestone and sandstone ridge overlooking the Thame (geology derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved). Base map © Crown Copyright [and database rights] 2023. OS 100024900.

Conclusion: at present the Mesolithic of the Vale of Aylesbury would make minimal contribution to archaeological sensitivity in relation to strategic planning decisions, although it should feature in evaluation and research strategies where possibly favoured locations are affected. The lack of in-situ sites suggests low potential to engage national importance.

4.3.4 Neolithic and Early Bronze Age

The key monuments identified are religious and funerary assets (principally round barrows) and unclassified assets (mainly lithic scatters). The study area so far lacks major ceremonial monuments such as causewayed enclosures, henges and cursuses. However, such monuments are known elsewhere along the Icknield Belt, notably a causewayed enclosure discovered on the north-west side of Thame (Oxon), about 4 km west of the study area, which demonstrates they are a possibility in the study area.

There are 27 primarily Neolithic and Early Bronze Age ANAs (Fig. 4.6), covering 194.6 ha (0.66% of the study area) with a known asset density of 1 per 1089 ha. The case study sites were notably lacking in assets of these periods, except for Bierton on the Portlandian Limestone where a Beaker barrow and settlement evidence were found. Thus the case studies give a similar incidence of one asset per 1138 ha.

The distribution of known assets is skewed to the west, and particularly along the chalk geologies of the Chiltern scarp, following the supposed route of the Upper Icknield Way (from the National Record of the Historic Environment), and in the Saunderton Gap where there is a barrow cemetery (33.3% of the assets lie in a corridor covering 16.7% of the study area; Fig. 4.7). A lesser concentration of mainly lithic scatters can be seen in the north-west on the Portlandian Limestone, 2–5 km north-east of the Thame causewayed enclosure. No Neolithic and Early Bronze Age ANAs lie on the mudstones despite this geology covering over one third of the study area. A strong preference of sites of this period for permeable geologies is commonplace elsewhere (e.g. Harding and Healy 2008, ch 5).

Conclusion: the Neolithic and Early Bronze Age make a modest contribution to archaeological sensitivity. Known assets favour the permeable chalk and limestone geologies, are most evident along the Chiltern scarp and especially in the Icknield-Saunderton Gap cluster and also what is probably the eastern fringe of a Thame

cluster. Based on absence from most of the planning case studies and in line with wider evidence the clay geologies of the Vale itself appear unfavoured.

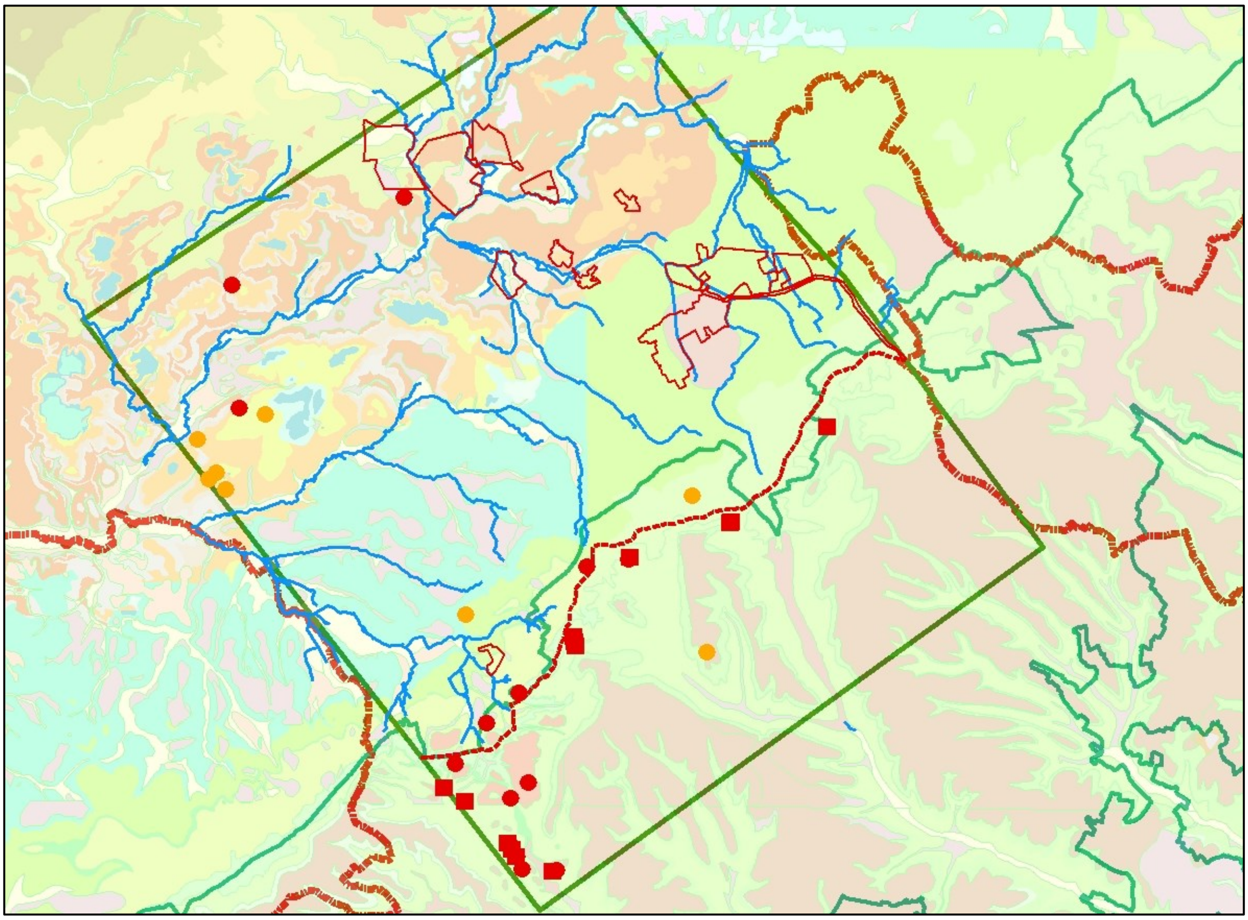


Figure 4.6: Neolithic–Early Bronze Age ANAs (red = religious & funerary; orange = unclassified) overlain on geology (see Fig. 4.2; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.). Case study areas outlined in red.

There are 15 scheduled barrows in the study area indicating potential for further nationally important discoveries, to which should be added the discoveries at Thame.

The overall average density of known assets is around 1 per 10 km^2 but is likely to be low to nil on the clayland and correspondingly higher on the chalk and limestone, particularly in the preferred areas noted above. As many assets are as yet undiscovered overall, their presence should probably be rated 'common' (1 per 1–10 km^2) on the permeable geologies. The density of major ceremonial monuments is impossible to estimate on evidence from the study area but to judge by evidence from elsewhere their presence would be rated 'very rare' (<1 per 100 km^2).

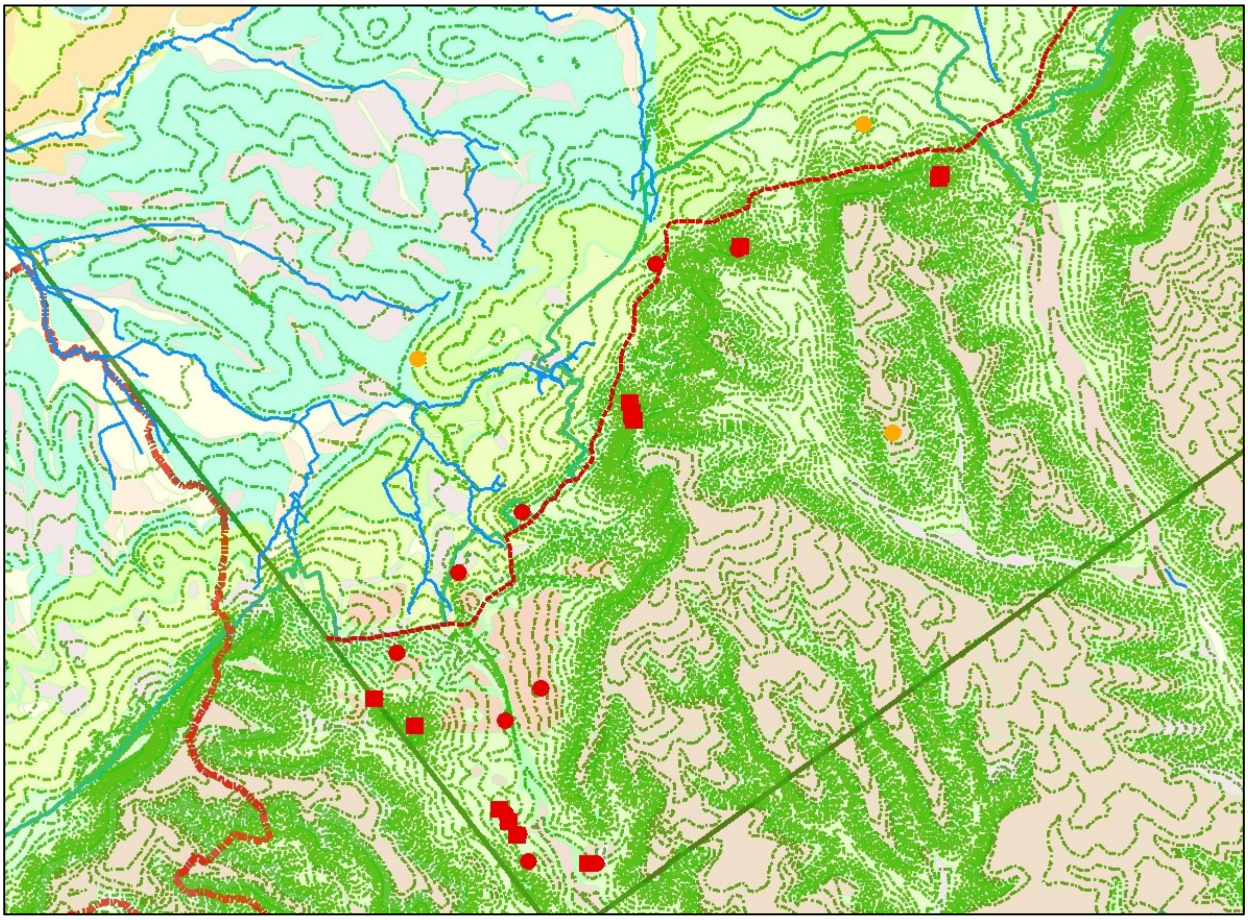


Figure 4.7: Icknield Way/Saunderton Gap barrow cluster: religious SMs (red squares), notification areas (red circles) and unclassified sites (orange); the dashed red line is the supposed route of the Upper Icknield Way (derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved). Base map © Crown Copyright [and database rights] 2023. OS 100024900.

4.3.5 Later prehistoric (Middle Bronze Age to Iron Age)

The key monuments identified are settlements and defensive monuments (hillforts and earthwork dykes). There are also a few agricultural, industrial, religious and unclassified assets. Trackways and stock enclosures are normally associated with settlements and it has been suggested that a coaxial framework of trackways aligned north-west to south-east developed through this period (Alqassar and Kidd 2018; Bull 1993).

The distribution is distinctive, with defensive earthworks in the Chilterns and settlements in the Vale, the latter mostly discovered in development-led fieldwork. For the first time assets appear on the clay geologies, most notably the Chiltern clay-with-flints, which is traversed by numerous segments of the Grim's Ditch linear boundary bank and ditch (Fig. 4.8). Curiously the previous clusters of activity around Haddenham and Saunderton are not perpetuated nor does the Upper Icknield Way seem such a focus but more activity is seen under and around Aylesbury.

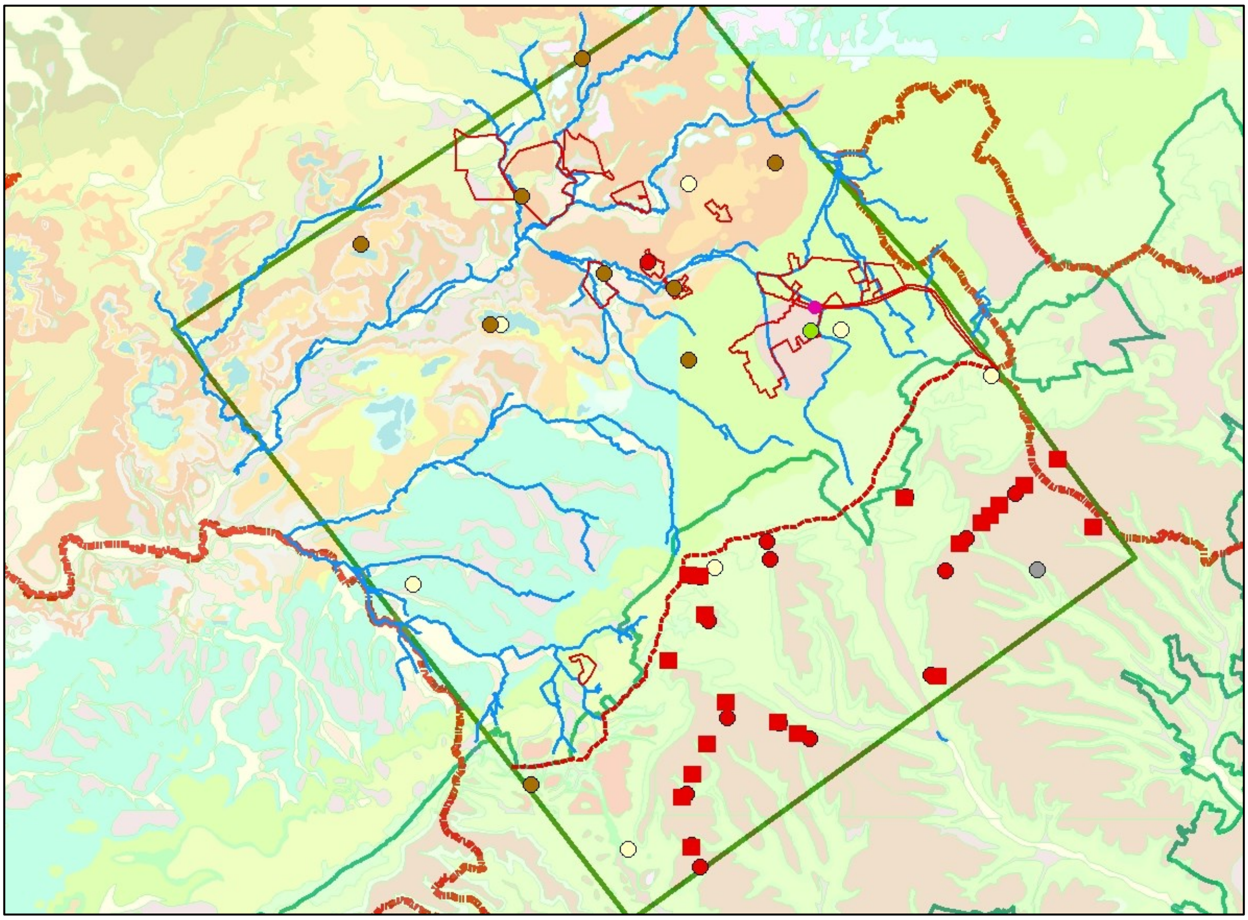


Figure 4.8: Later prehistoric sites overlain on geology (see Fig. 4.2; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.) with squares denoting SMs (red = defensive sites; brown = settlement; purple = religious and funerary; green = agriculture; grey = industry; yellow = unclassified)

Thirty-seven ANAs covering 282.9 ha (0.96% of the study area) are primarily of later prehistoric date, providing a baseline minimum of one asset per 8 km^2. However, we know that many later prehistoric assets are as yet undiscovered. The case studies have picked up six substantive assets covering 9.7 ha in total (0.85% of the case study area) implying a density of one asset per 1.9 km^2. It is also notable that only one of the 14 case studies produced no evidence for later prehistory.

Conclusion: the Later Bronze Age and Iron Age make a high contribution to archaeological sensitivity in the Chilterns due to the presence of scheduled earthwork monuments (20 in all). In the Vale, the contribution is more modest: settlements and field systems are dotted across the claylands, while some Roman settlements have Iron Age antecedents.

The case studies imply a density range towards the higher end of 'common' (one asset per 1–10 km^2), with a hint that proximity to water is favoured for open settlement in the Vale. Three hillforts are known in the study areas as well as tentative evidence for shrines and high-status Late Iron Age settlement. The case studies revealed three such sites: a hillfort under Aylesbury, high-status Late Iron Age occupation at Bierton and a shrine at Aston Clinton Bypass site A. While this could imply a density as high as one site per 4 km^2, that seems rather high; if only the greenfield sites are factored in then the density drops to around 1 per 11 km^2. Overall therefore, such 'special' sites are perhaps 'rare', occurring at a density of one asset per 10–100 km^2.

The difference between the ANA and case study site densities could imply a visibility of about 25% (i.e. about one in four actual sites is sufficiently defined to be an ANA). However, this may be an over-optimistic estimate given the lower figure arrived at for the Roman period (see below).

Apart from Grim's Ditch the more obviously significant assets appear to favour the permeable chalk and limestone geologies and are most evident along the Chiltern scarp and under the historic settlements of Aylesbury, Bierton and Walton.

4.3.6 Roman

The study area lies within the Roman Rural Settlement Project's Central Belt region – their largest area extending from the Severn Estuary to the Wash. Excavated rural settlement sites in the Thames & Avon Vales, Midvale Ridge and Chilterns landscape zones are 70–80% 'farmsteads', with the remainder made up of villas and roadside settlements (Smith *et al*. 2016, fig 5.5).

The key monuments identified are settlements – a single roadside nucleation (Fleet Marston), several villas and a larger number of 'Romanised' and 'native' farmsteads (Fig. 4.9). The distinction between these categories is not always clear-cut and many 'unclassified' Roman assets will be finds indicative of settlement. Settlements appear on most geologies in the Vale, but are rare in the Chilterns part of the study area away from the Chiltern scarp, and particularly so on the clay-with-flints. South of the study area in the Buckinghamshire Chilterns villas are found in the valley floors but only a few small poorly understood sites are recognised on the higher ground. Agricultural field systems and crop processing areas (notably maltings) are commonly associated with settlements, whereas religious and burial sites are rare and poorly defined.

The Roman road network is fairly well understood, comprising Akeman Street, the Lower Icknield Way and secondary roads emanating from Fleet Marston towards Dorchester, Thornborough and Magiovinium/Watling Street respectively. The roads towards Watling Street and Dorchester are still conjectural, although the route proposed by Margary (173A) is not supported by recent investigations at Berryfields and Fleet Marston; the former implies an alternative route shown on Fig. 4.9.

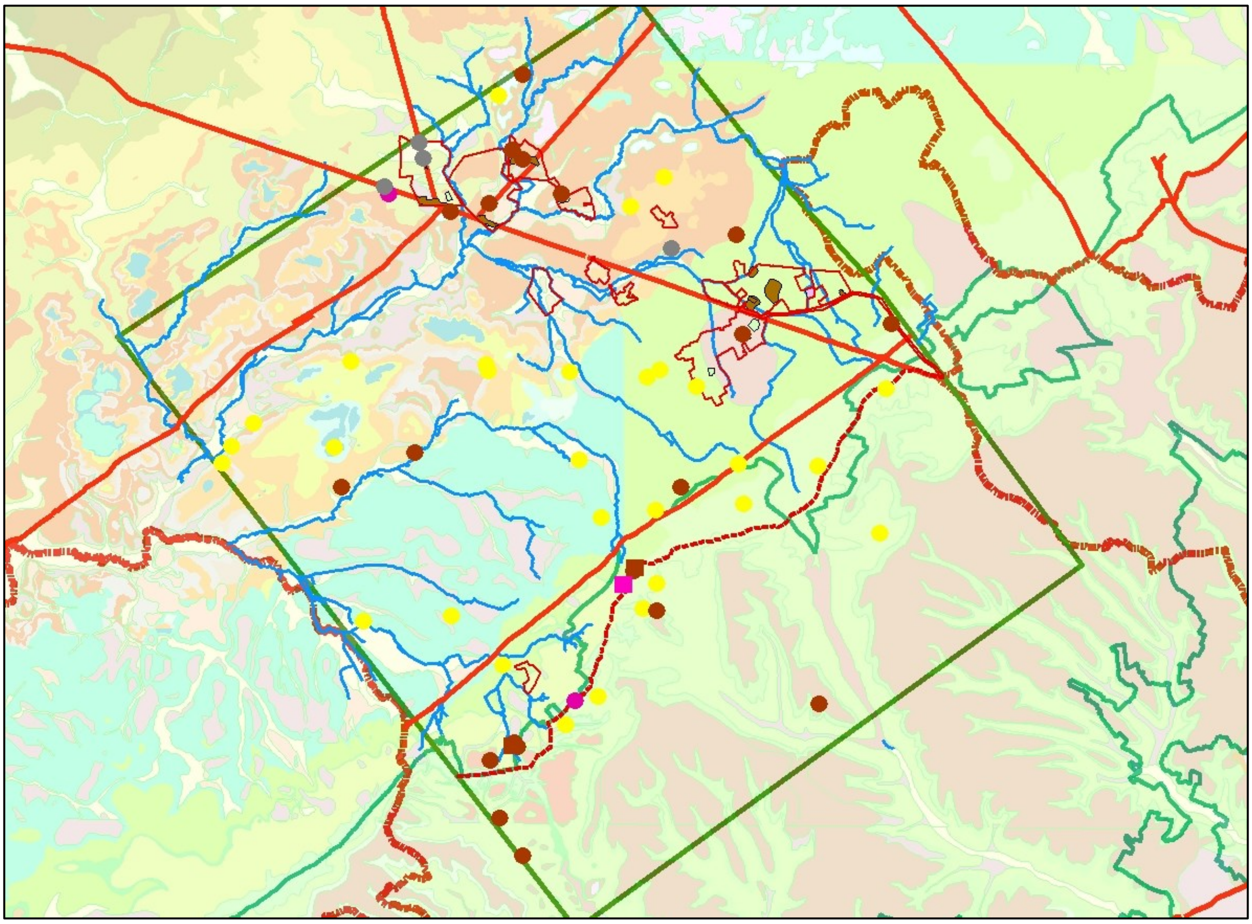


Figure 4.9: Roman settlement (brown), religious (purple), industry and transport (grey) and unclassified sites (yellow), Roman roads (modified from Bucks HER dataset) in red and supposed Upper Icknield Way route dashed red, overlain on geology (see Fig. 4.2; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

The distribution shows Roman assets clustering around Fleet Marston, along Akeman Street and in a corridor alongside both the Lower and Upper Icknield Ways but not along the secondary roads. Despite these observations, overall the data from known assets and the case-study discoveries suggest only a weak positive correlation between assets of all periods and proximity to Roman roads (Fig. 4.10). The RRSP notes that ‘the great majority of both farmsteads (77%) and villas (89%) in [the Central Belt] lie within 5 km of the road system’ (Smith *et al*. 2016, 177).

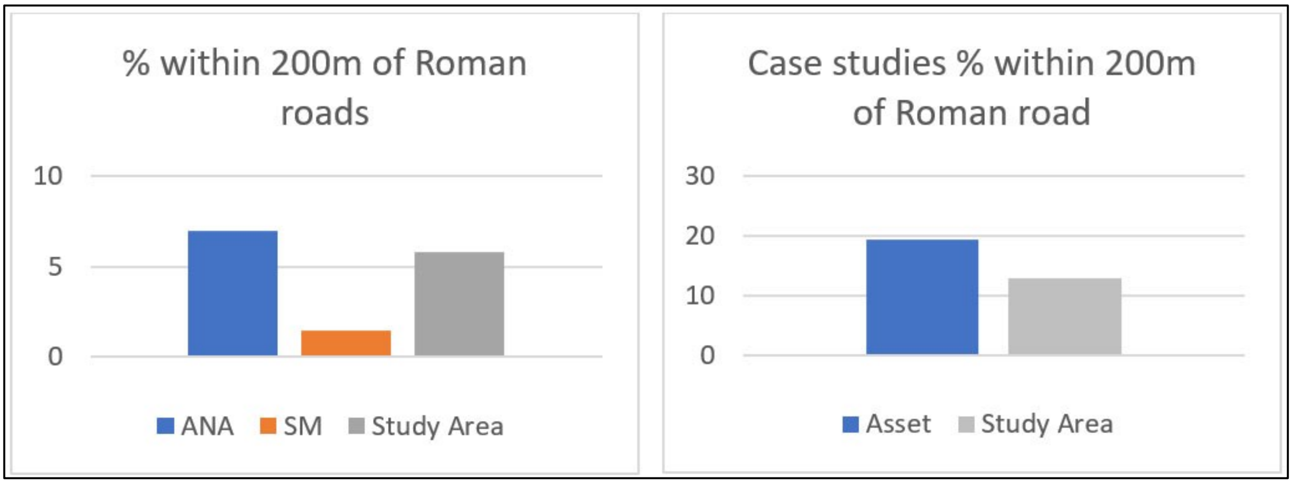


Figure 4.10: Graph showing the percentage of designated and non-designated assets (L) and case-study discoveries (R) within 200 m of a Roman road, compared to the proportion of the study area in similar proximity

The distribution shows Roman assets clustering around Fleet Marston, along Akeman Street and in a corridor alongside both the Lower and Upper Icknield Ways but not along the secondary roads. Despite these observations, overall the data from known assets and the case-study discoveries suggest only a weak positive correlation between assets of all periods and proximity to Roman roads (Fig. 4.10). The RRSP notes that ‘the great majority of both farmsteads (77%) and villas (89%) in [the Central Belt] lie within 5 km of the road system’ (Smith *et al*. 2016, 177).

Fifty-five ANAs covering 441 ha (1.5% of the study area) are primarily of Roman date providing a baseline minimum of one asset per 5.3 km^2. However, again we know that many Roman assets are as yet undiscovered. The case studies have picked up 20 substantive assets covering 101 ha in total (8.9% of the case study area) implying a density of one Roman-period asset per 0.6 km^2. Roman archaeology is by far the most common period encountered on the large greenfield development sites around Aylesbury. However, there are only three scheduled Roman sites in the study area, two villas and a barrow, presumably reflecting the virtual absence of recognised Roman earthwork monuments.

Conclusion: the Roman period makes a fairly high contribution to archaeological sensitivity in the Vale and Icknield Belt due to the high density of sites. In the Chilterns south of the Upper Icknield Way the density of sites appears to be much lower. The case studies imply a density range of ‘ubiquitous’ (one or more asset per 1 km^2) in the Icknield Belt and Vale. Most assets are farmsteads with associated fields, trackways, agricultural processing areas etc. but in addition to the two scheduled villas there are several other likely villa candidates plus the scheduled

barrow, a possible temple and a nucleated roadside settlement. Such 'special' sites are perhaps 'common', occurring at a density towards the higher end of the range of one such asset per 10–100 km^2. The difference between the ANA and case study site densities implies a visibility of about 10% (i.e. only about one in ten actual sites is sufficiently defined to be an ANA).

4.3.7 Early medieval

The key monuments identified are settlements, pagan burial grounds and the minster at Aylesbury (Fig. 4.11). Other types of site are little recognised. Parts of the Roman road network, notably Akeman Street and the Icknield Ways, remained in use, while a new road network (not shown) focused on Aylesbury.

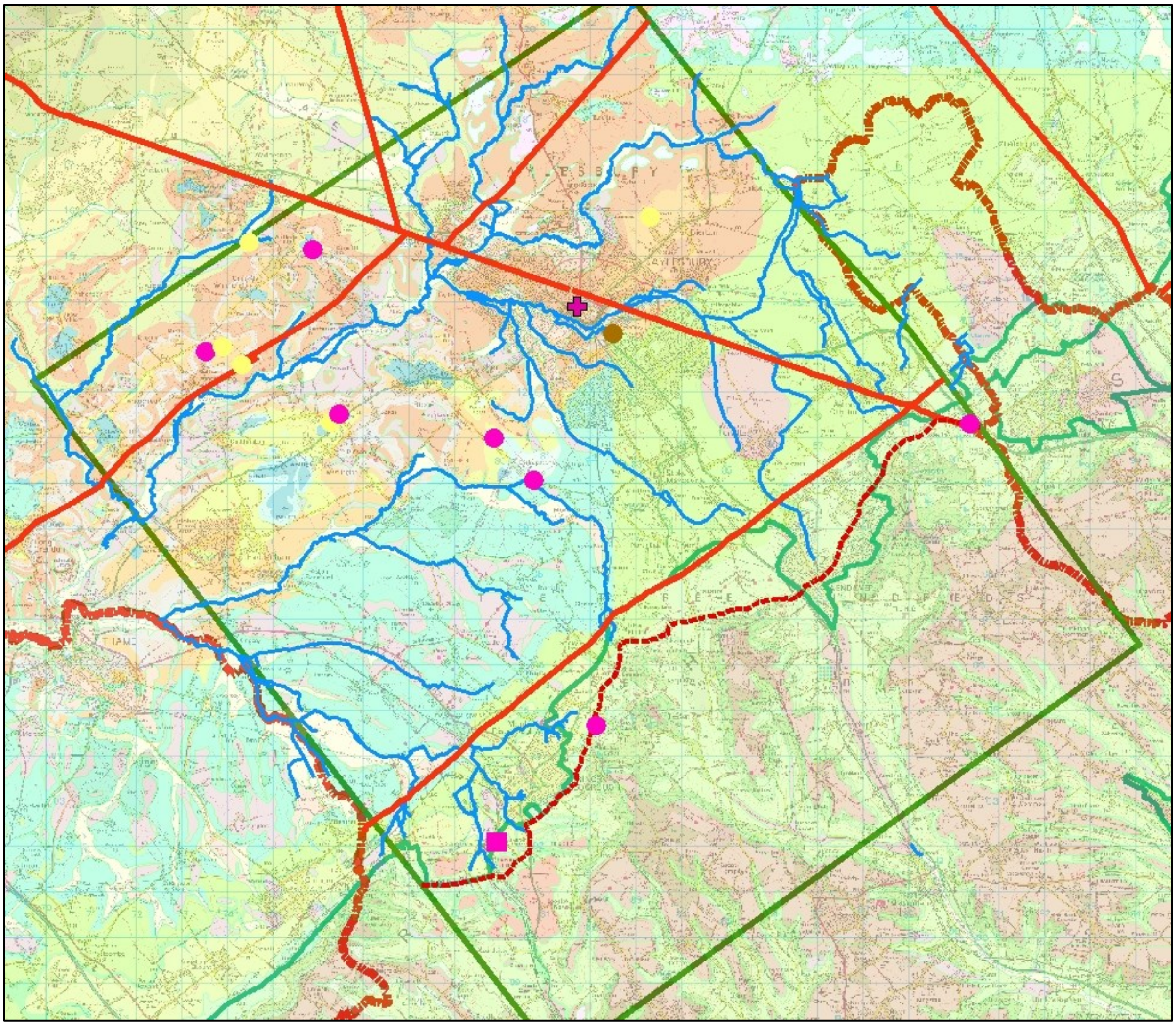


Figure 4.11 (previous page): Early medieval settlement (brown), religious (purple) and unclassified sites (yellow), overlain on geology (see Fig. 4.2; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved). Base map © Crown Copyright [and database rights] 2023. OS 100024900.

The distribution map shows the main focus at Aylesbury and assets elsewhere sporadically dotted around, with some clustering alongside roads. The clay geologies appear to be less favoured, as seen elsewhere in the Midlands. There is only one SM: an Anglo-Saxon cemetery. In the Chilterns south of the Icknield Way there is virtually no evidence for early medieval occupation nor, more surprisingly, is there north of the Thame around the large Roman settlement at Fleet Marston.

Only 14 ANAs covering 63.5 ha (0.2% of the study area) are primarily of early medieval date, providing a baseline minimum of one asset per 21 km^2. However, we know that many early medieval assets are as yet undiscovered and evidence of this period is found as a secondary element on some Roman and medieval sites. The case studies have picked up significant early medieval assets in all three of the historic cores but only on one of the greenfield sites (Aston Clinton Bypass) where two assets were found (an Anglo-Saxon cemetery and activity on a Roman settlement). This admittedly small sample implies a density on greenfield land of one asset per 5.6 km^2 but with the caveats that greenfield sites which have only been evaluated might yet prove to have an undetected early medieval presence and that historic settlement cores appear to be favoured locations (at least if not on clay).

Conclusion: the early medieval period makes a modest contribution to archaeological sensitivity in the Vale and Icknield Belt reflecting a moderate presence, lack of upstanding remains and only a single SM. The case studies imply a density range of ‘common’ (one or more asset per 1–10 km^2) in the Icknield Belt and Vale but avoiding the clay geologies. Proximity to routeways seems to be favoured and better mapping of the early medieval road system might help predictive modelling. Medieval settlement cores are identifiable as marking favoured locations.

The difference between the ANA and case study site densities implies poor visibility of about 25% (i.e. about 1 in 4 actual sites is sufficiently defined to be an ANA). This estimate appears generous given the well-attested difficulties of finding this period in field evaluation. The virtual absence of recorded early medieval evidence from the Buckinghamshire Chilterns merits further investigation alongside questions about the use of this area in the Roman period.

4.3.8 Late medieval

The late medieval period is the most commonly represented in both the schedule (Fig. 4.12) and the ANAs (Fig. 4.13; note that Aylesbury's historic core is omitted because it is multi-period). The key monuments are deserted and still-inhabited settlements, earthwork remains of open fields (ridge and furrow) and a few castles and mills (wind and water). The schedule is dominated by deserted medieval settlement and motte-and-bailey castle earthworks. It does not cover inhabited historic settlements whilst the Bucks ANA system is selective in this respect.

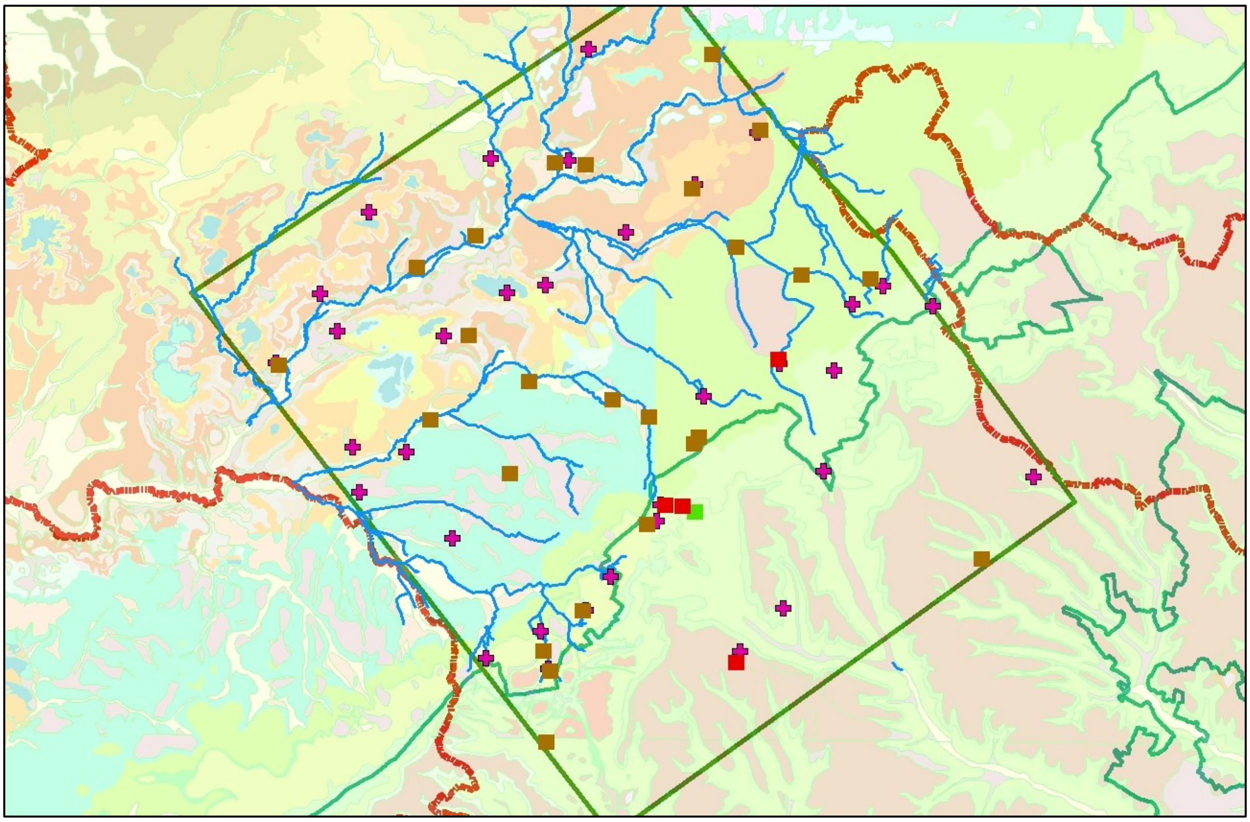


Figure 4.12: Late medieval churches and SMs (settlement in brown, castles in red, pillow mound in green) overlain on geology (see Fig. 4.2; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Roberts and Wrathmell (2003) drew a clear distinction between the predominantly nucleated settlement pattern of the South Midlands, part of their Central Province, and the lower-density dispersed pattern found in the Chilterns, part of the South East Province (although their use of 19th-century maps to study settlement pattern probably underestimates medieval dispersed settlement in the Vale). The Province boundary runs through the study area, slightly north-west of the modern Chilterns AONB boundary (Fig. 4.14). Aylesbury was the main market town with Haddenham, Princes Risborough and Wendover as secondary small market towns.

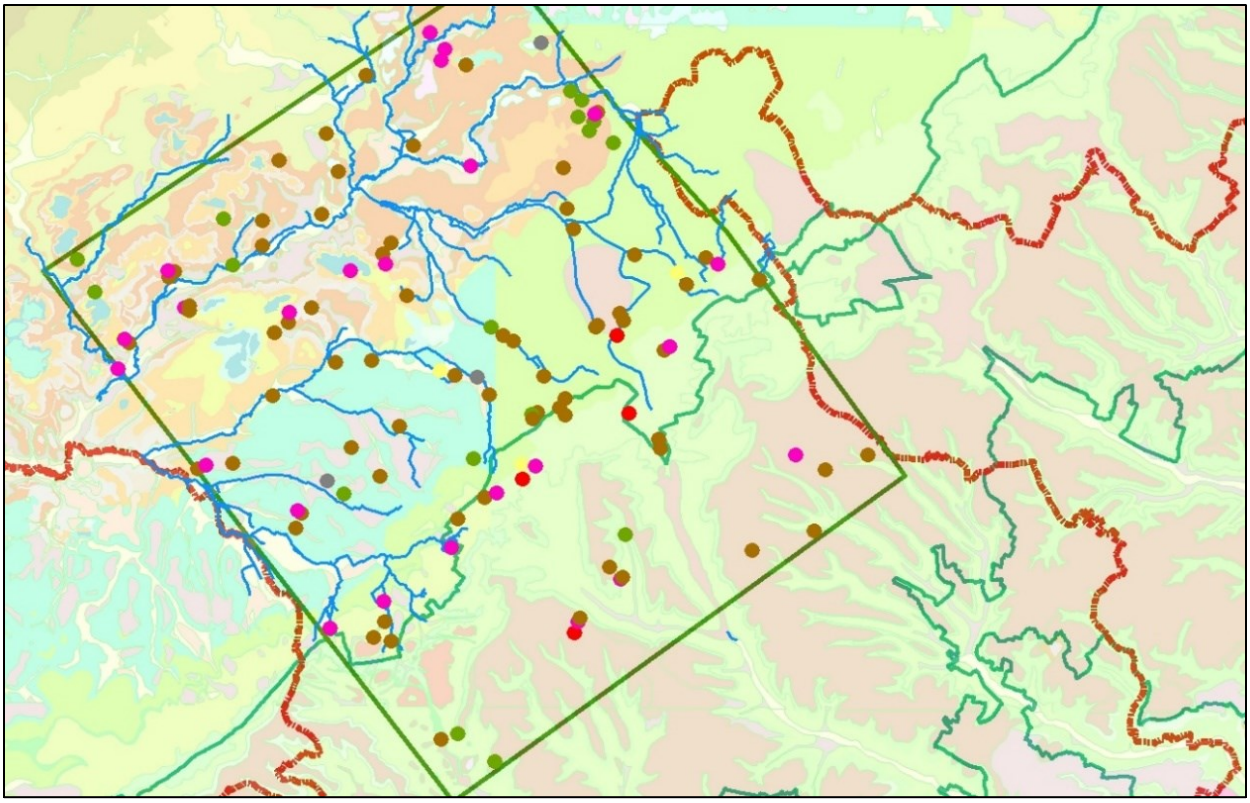


Figure 4.13: Late medieval ANAs (pink = religious and funerary; brown = settlement; green = agriculture; red = defensive; grey = industrial; yellow = unclassified), overlain on geology (see Fig. 4.2; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

This is the first period for which landscape patterns can be reconstructed from historic evidence. Following a simplified version of the approach taken in Northamptonshire (Partida *et al*. 2013), the Bucks HLC can be used to map approximate extents of open field, meadow, common and heath, woodland and settlement (Fig. 4.15), although the picture is incomplete and it is not possible to map medieval enclosed fields with confidence. Assarts have been mapped as woodland, while other pre-parliamentary enclosures not containing ridge and furrow might have been enclosed in the later middle ages, particularly in the Chilterns where open fields were less extensive and enclosure generally earlier. There are no mappable medieval deer parks in the study area.

Each medieval land use will have had its own distinctive signature from which significance and sensitivity will follow – scheduling has provided a framework for recognising the significance of castles, moats and deserted settlements whilst 'Turning the Plough' (Hall 2001) assessed ridge-and-furrow survival and significance. Other land uses lack equivalent frameworks. The distribution maps show the concentration of DMVs and historic settlement in the nucleated settlement/champion landscape of the Vale with lower densities in the dispersed settlement/woodland landscape of the Chilterns, and the Chiltern scarp dividing the two areas.

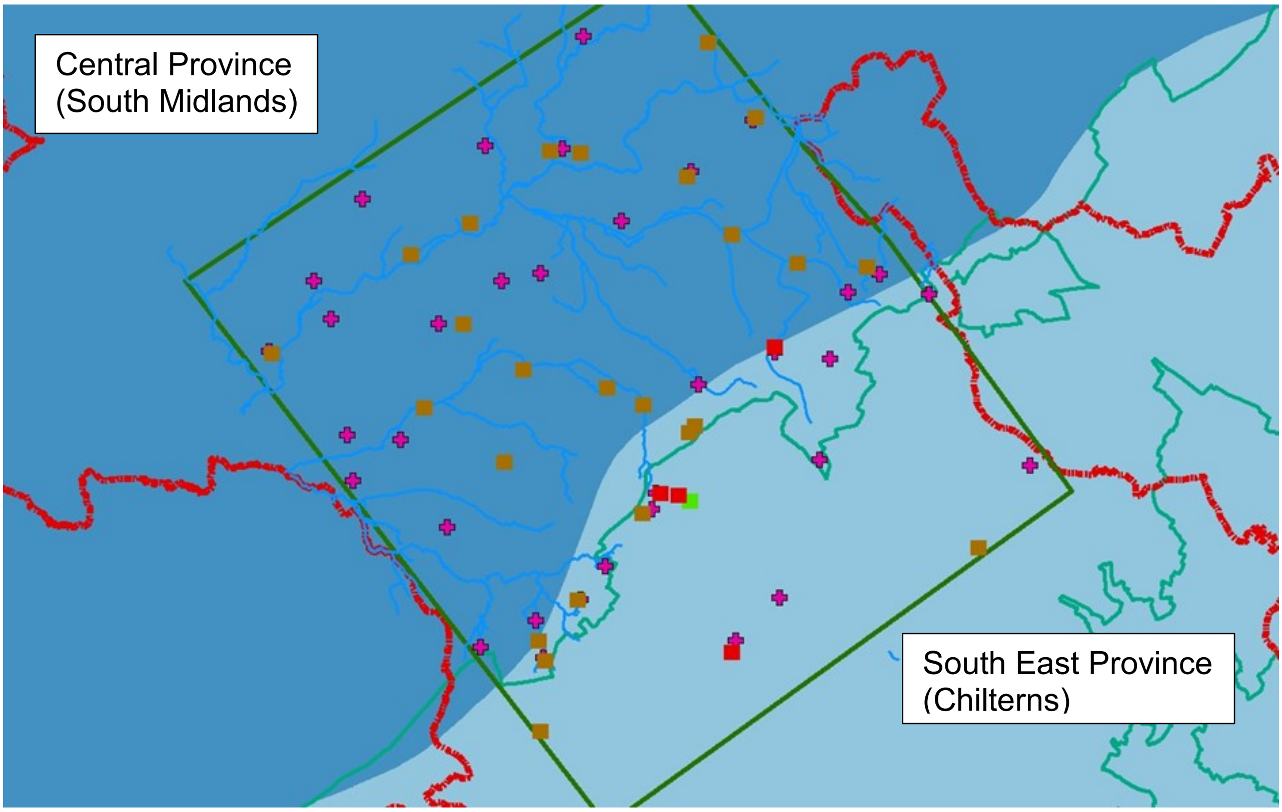


Figure 4.14: Late medieval churches and SMs (settlement in brown, castles in red, pillow mound in green) overlain on Roberts and Wrathmell's (2003) provinces

Ninety-nine ANAs covering 636.3 ha (2.2% of the study area) are primarily of later medieval date providing a baseline minimum of one asset per 3 km^2, although this does reflect more selective identification criteria. Unsurprisingly, proximity to medieval churches has shown a strong positive correlation with known assets (primarily medieval and post-medieval). Proximity in this case means within 400 m, with no effect being statistically noticeable beyond that (Figs 4.16 and 4.17).

Hardly surprisingly, all three historic cores case studies found some medieval archaeology, although in none of these was it the most significant period. The greenfield case studies picked up six substantive assets covering 28.9 ha in total (2.5% of the case study area) implying a density of one asset per 1.9 km^2. Almost all of the later medieval assets were found either within an ANA or within 200 m of a scheduled medieval monument or a medieval church. In all three cases shown in Fig. 4.18 substantial preservation in situ was negotiated.

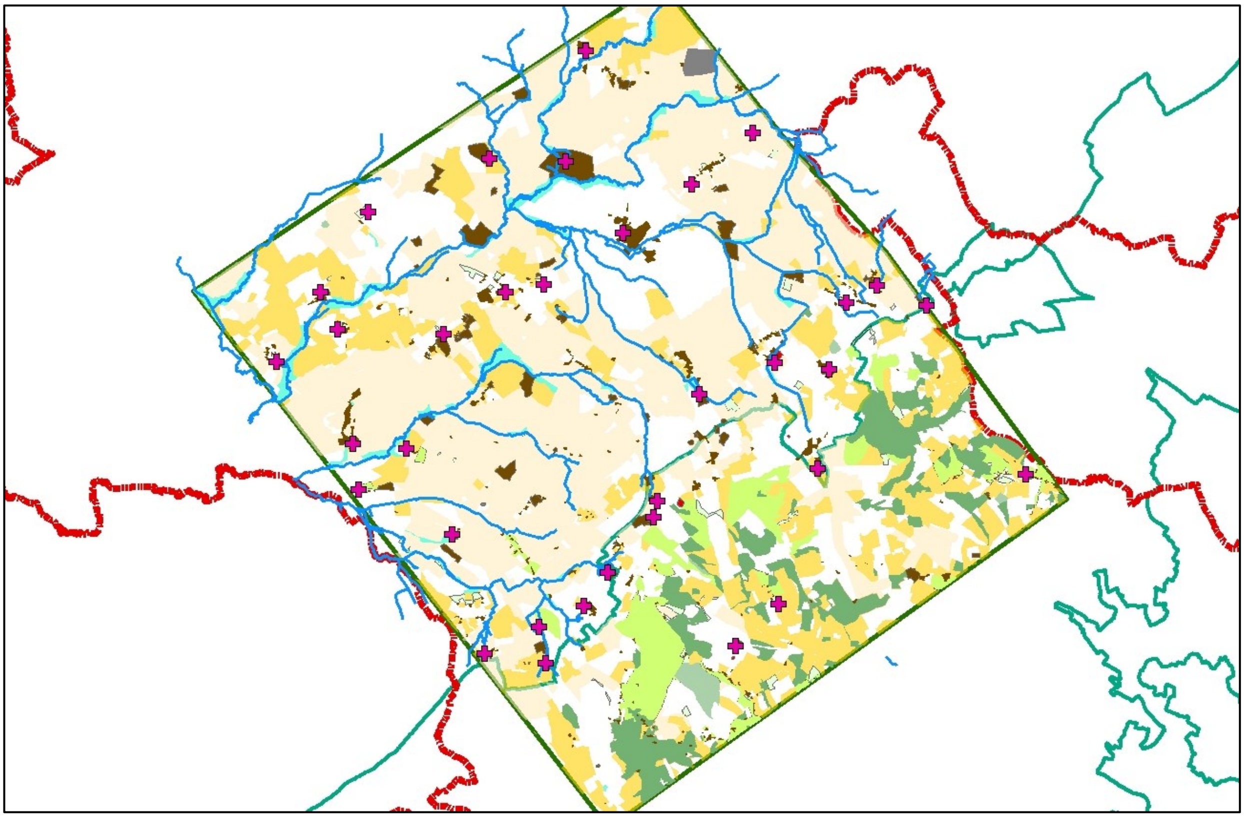


Figure 4.15: Later medieval settlement partly reconstructed from ANAs and HLC, showing settlement (brown), churches (purple), open fields (light yellow), ancient enclosed fields (dark yellow), uncultivated pasture (light green), meadow (blue) and woodland/assarts (dark green)

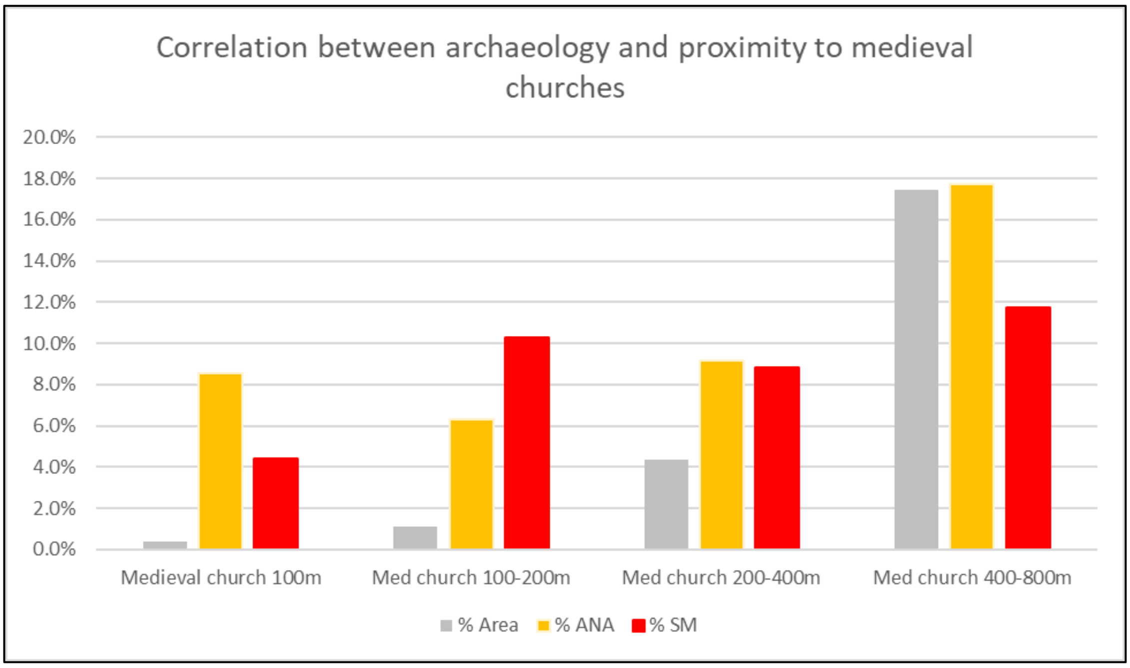


Figure 4.16: Graph showing the percentage of designated and non-designated assets within set distances from medieval churches

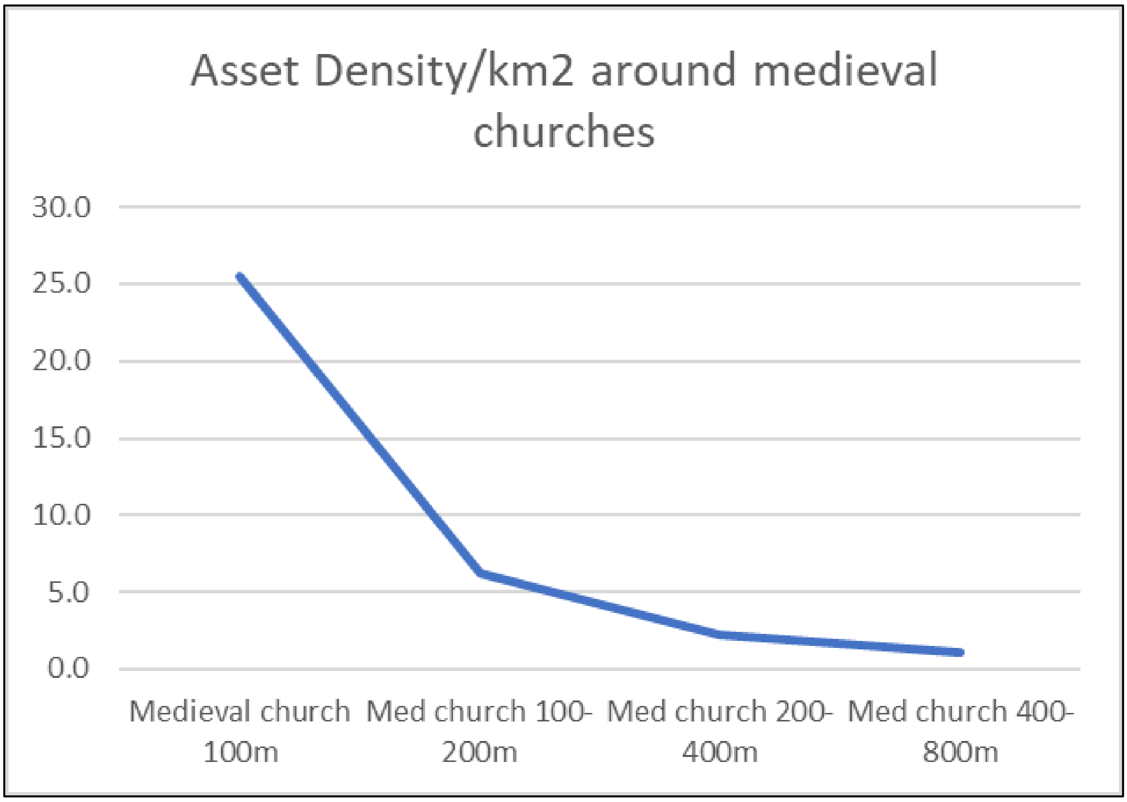


Figure 4.17: Graph illustrating how the density of non-designated assets drops off to the study area average of 0.98 per km^2 with increasing distance from churches

The medieval open fields pose something of a conundrum as they can be viewed both as assets and as negative indicators for other medieval and post-medieval archaeology. The view taken here is to follow the ANA system in recognising substantive survival of earthworks as an asset, but overall these areas do show a moderately negative correlation with ANAs and SMs, notably to the south-west, east and north of Aylesbury (Fig. 4.19). An approximation to the extent of open fields was derived by mapping HLC polygons classified as ‘land enclosed from open fields’ (ENOF; derived largely from an HER volunteer project, supplemented by the ‘Turning the Plough’ project and readily available aerial photography). This covers 41.3% of the study area, although the mapping is generalised and undoubtedly includes some land that was not part of the open fields.

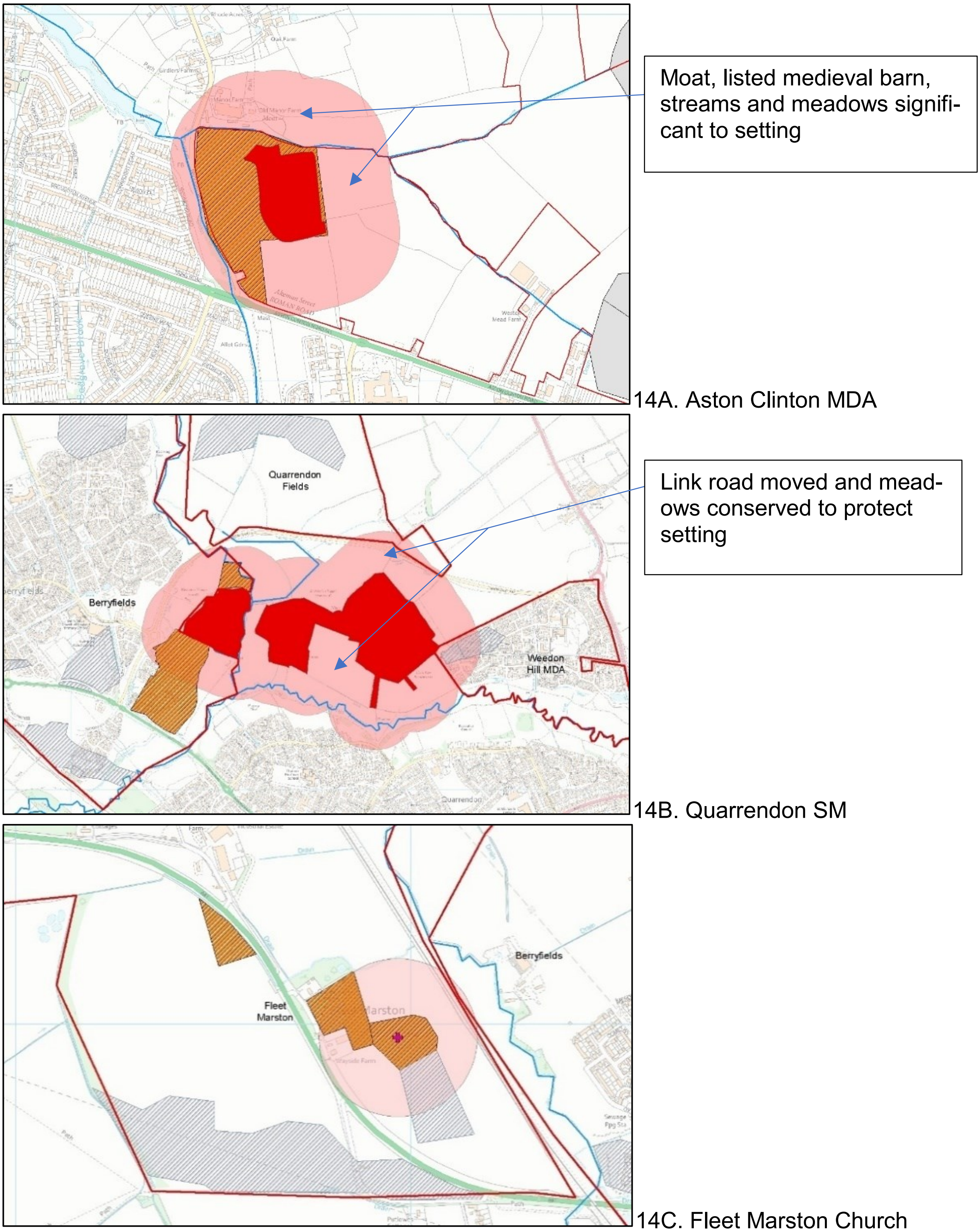


Figure 4.18: Three development case studies showing the relationship of a 200 m buffer around SMs and medieval churches to archaeological assets found during evaluation (SMs in red, medieval assets hatched brown, other assets hatched grey). Base map © Crown Copyright [and database rights] 2023. OS 100024900.

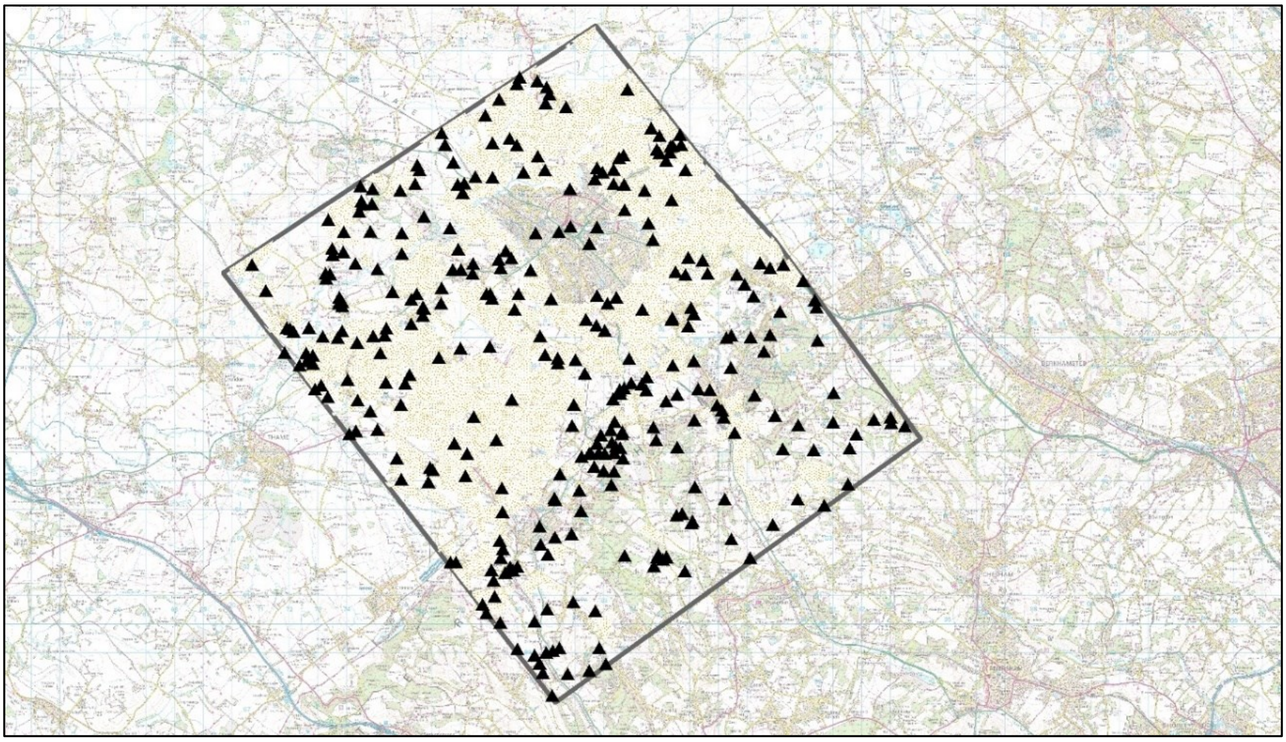


Figure 4.19: Archaeological Notification Areas overlain on HLC polygons enclosed from open fields (ENOF). Base map © Crown Copyright [and database rights] 2023. OS 100024900.

Conclusion: the later medieval period makes a high contribution to archaeological sensitivity being represented across the whole study area, including many assets in good and excellent condition and many SMs. Deserted settlement earthworks in the Vale are a locally characteristic feature. The AONB provides a well-defined boundary between the different medieval landscape characters of the Chilterns and Vale. A rough approximation to different medieval land uses can be inferred and mapped from existing HER sources (primarily HLC) and correlated with anticipated archaeological signatures. Medieval settlement evidence is found preferentially within existing historic settlements (mapped by HLC) or known deserted sites (mapped as ANAs and/or scheduled) or within 200–400 m of medieval SMs or churches. It is rarely encountered elsewhere although there will be a few 'lost' medieval dispersed settlements. The case studies imply a density range of one asset per 2–3 km^2 (towards the higher end of 'common') with a much higher level of visibility than earlier periods – perhaps as many as two thirds of medieval assets are already identified, at least in general terms (i.e. fair to good visibility).

4.3.9 Post-medieval and modern

For this study, assets of mid-16th to 18th century date which are identified as of archaeological interest were classified as post-medieval and those of 19th and 20th century date as modern. Many assets in these categories actually span both periods and/or have medieval origins. Assets identified as ANAs are primarily historic settlements and designed landscapes, along with several mills, a chalk-cut cross and a single installation of WW2 military supply infrastructure. Conservation areas and listed buildings may also have archaeological interest (Fig. 4.20).

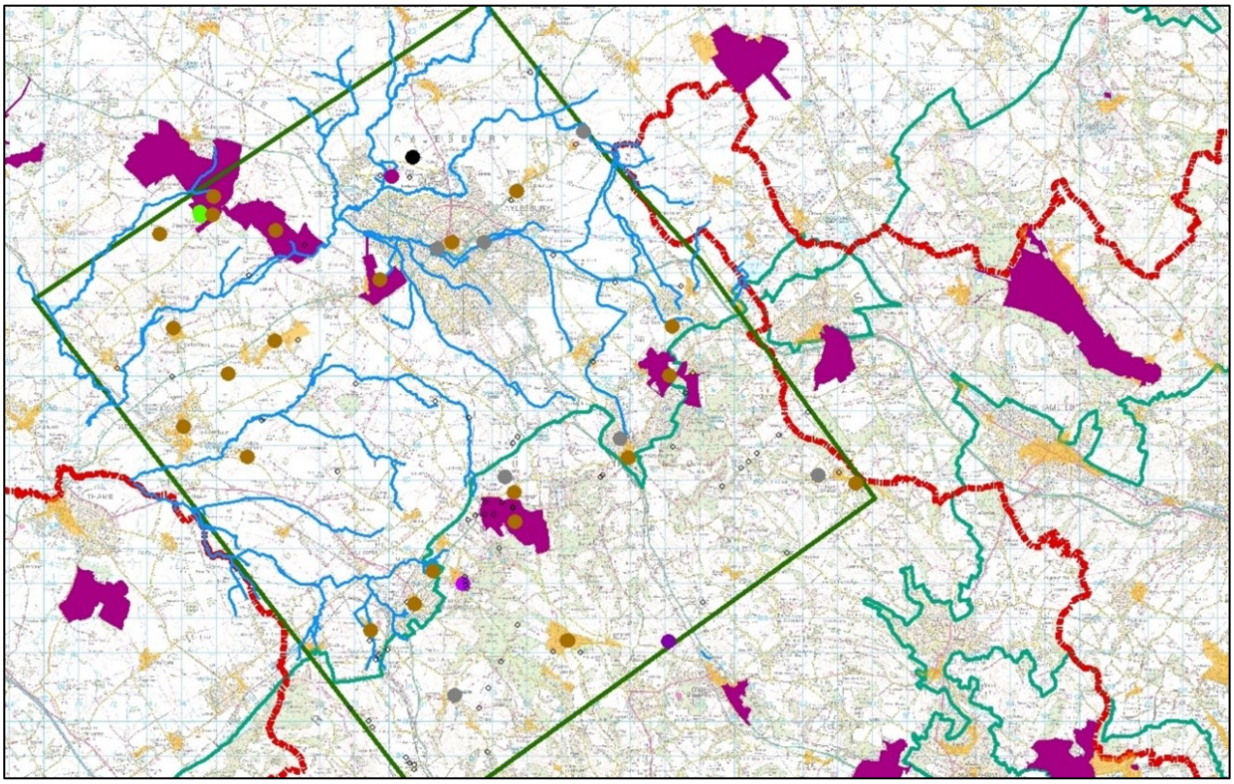


Figure 4.20: Post-medieval and modern assets of archaeological interest: purple = recreation (areas are RPGs); pink = religious; brown = settlement (conservation areas in yellow); green = agriculture; grey = industrial; black = infrastructure. Base map © Crown Copyright [and database rights] 2023. OS 100024900.

Historic maps are available from the late 18th/19th century, and 19th-century landscape character has been mapped for HLC. The Chiltern woodlands are known to contain extensive post-medieval earthworks related to woodland management and industry but this is not yet captured by the ANA system. The late 19th century extents of the principal HLC types identified as of post-medieval archaeological interest (historic settlement, historic parkland [designed landscapes] and ancient woodland) have been mapped from HLC (Fig. 4.21). There were no 19th-century industrial or military complexes in the study area but those of the 20th century potentially hold an archaeological interest (largely in relation to buildings and structures) and can also be mapped from HLC.

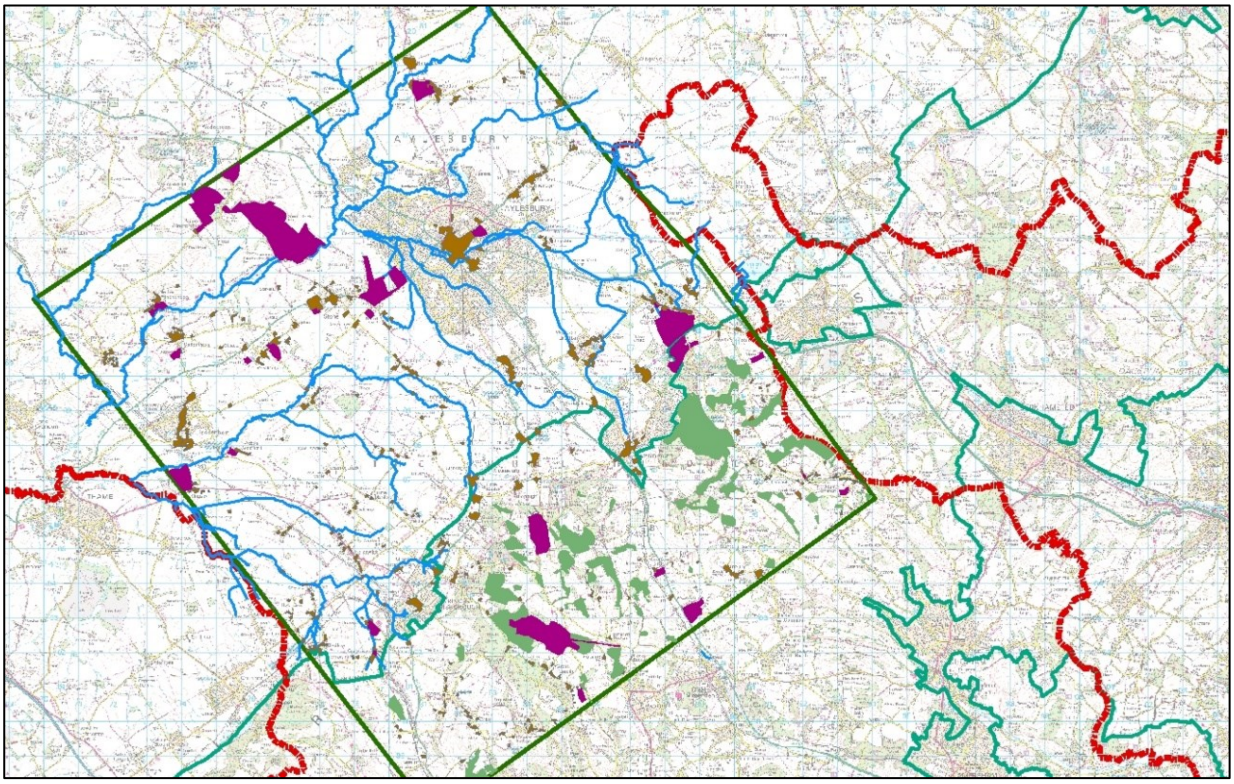


Figure 4.21: Post-medieval HLC types of archaeological interest: late 19th century extent of ancient woodland (green), designed parkland (purple) and settlement (brown). Base map © Crown Copyright [and database rights] 2023. OS 100024900.

Some surviving historic landscapes, such as ancient woodlands or commons, could reasonably be considered as non-designated heritage assets of historical as well as archaeological interest. No attempt has been made to extend the current scope of the Bucks ANA system in this respect and a separate national project is underway to explore how sensitivity might be assessed in relation to historic landscape character (Herring 2022). Linear features (canals, railways and turnpike roads) are mapped in the HER but not identified as notification areas. Again their significance is primarily historical rather than strictly archaeological. Only two SMs have a major post-medieval component: the Tudor garden earthworks at Quarrendon and Whiteleaf Hill chalk-cut cross.

4.4 Overview of presence

As noted above, this study has not attempted to digest the entire contents of the HER. Instead it focuses on assets of significance meriting consideration in strategic planning and land-use decisions. These are principally SMs, archaeological interest associated with other heritage assets, assets identified as ANAs by the Bucks HER (2012 dataset) and assets discovered on case-study development sites.

There are 67 SMs within the study area covering 176.8 ha (0.6% of the study area), while the Bucks HER identified 316 ANAs covering 3638 ha or 12.4% of the study area. As detailed above, the local archaeological record is dominated by later medieval archaeology with substantial Romano-British and later prehistoric contributions and numerically more modest but still significant Neolithic–Early Bronze Age, early medieval and post-medieval/modern elements. In contrast Palaeolithic and Mesolithic archaeology is rare and ephemeral (Fig. 4.22). The dominant asset types vary by period, with religious (burial) monuments dominant in early prehistory, defensive and boundary features in later prehistory, settlement in the Romano-British, religious (burials) in the early medieval and settlement in the later medieval and post-medieval periods, the latter alongside designed landscapes (Tables 4.3–5). This pattern is not unusual for non-coastal areas of southern and midland England.

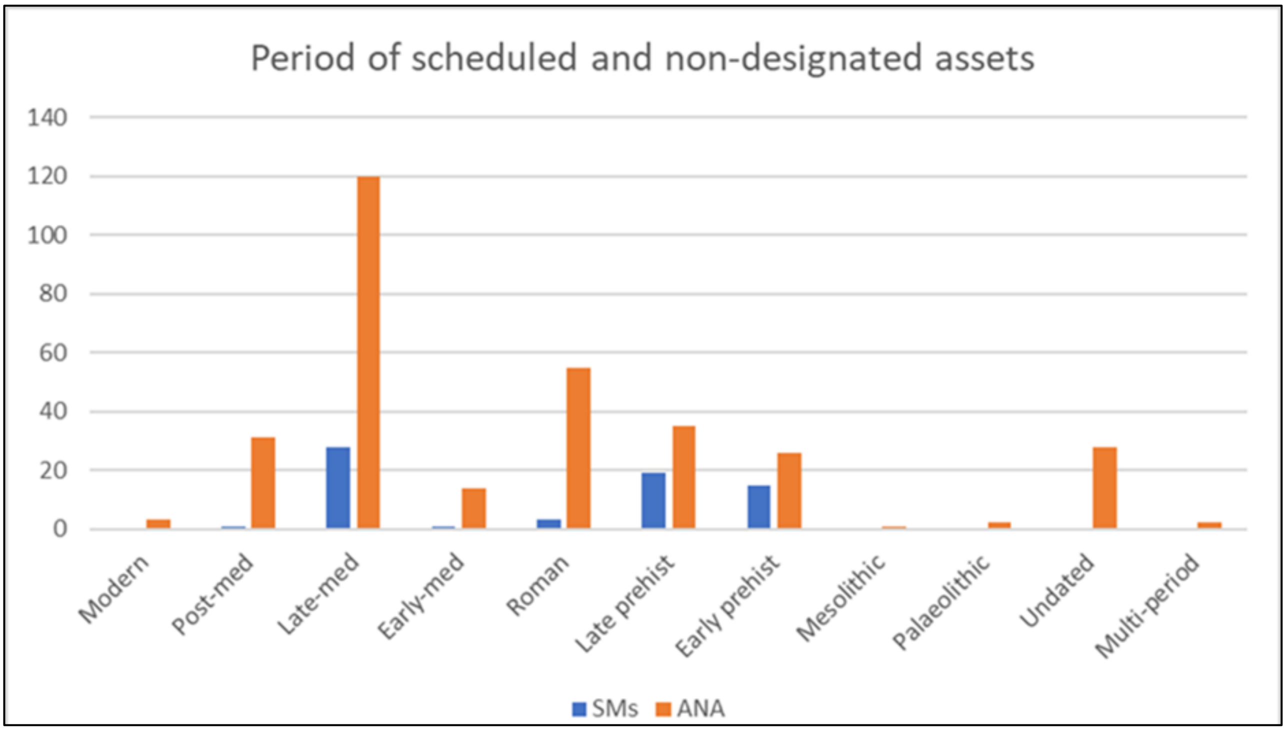


Figure 4.22: Designated and non-designated archaeological assets by period

The spatial patterning of these assets has also been assessed and the main distinction found (as expected) to be between the Chiltern Hills and the Vale of Aylesbury. However, more subtle variations are evident. A concentration of Neolithic–Early Bronze Age activity can be seen along the Chiltern scarp and Saunderton Gap, focussed on permeable chalk geology, with a lesser concentration on limestone and gravel along the Thame. In contrast the claylands seem to have been avoided until the later prehistoric and Roman periods. Later prehistory is the only period that sees substantial activity on the Chilterns clay-with-flints but as that mostly involves the construction of the major Grim's Ditch boundary it may in fact be consistent with this being a marginal location. Roman sites are common and show some preference for proximity to Akeman Street, particularly around the nucleated settlement at Fleet Marston, and the two Icknield Ways. The early medieval pattern is not clear although claylands again seem less favoured. Medieval assets are much better understood than earlier periods and hardly surprisingly show a close correlation with extant medieval churches and SMs. Conversely areas of ploughed-down ridge and furrow are unlikely to contain significant medieval remains. Favoured areas for post-medieval/modern archaeological interest can be identified from HLC and historic maps.

Today's archaeological landscape is of course a palimpsest generated by these shifting activity patterns and it might legitimately be wondered whether for land-management purposes any useful patterns can be deduced. An implication of this is that certain periods and types of archaeology will dominate overall presence calculations. For example, early prehistoric assets correlate positively with proximity to the Upper Icknield Way but its overall correlation with all periods is actually a weak negative because more common periods were focussed elsewhere.

The study has examined the correlation of known assets with geology, topographical and cultural indicators. Archaeological assets are found on all the common geologies and some patterns are evident, notably a strong positive correlation of undesignated assets with limestone and of SMs with chalk and clay-with-flints (Fig. 4.23). This latter association reflects the survival of prehistoric earthworks in the Chilterns. Alluvium has a moderate negative correlation with undesignated assets whilst the mudstones have a moderately negative correlation with both scheduled and undesignated archaeology. The case studies were mainly on mudstone (58.7%) and gravel (23.0%) and cannot be directly compared to this data but it seems plausible to suggest that overall asset densities may not vary tremendously by geology, except perhaps on the limestone where they might be about 50% higher and the alluvium where conversely they could be 50% lower.

Only a limited range of topographical indicators were explored and the results were not encouraging (Fig. 4.24). Historic watercourses were reconstructed from 19th-century maps, local high points located by eye from contours, and steep slopes mapped from a digital terrain model which was then interpreted to remove modern features. There was a strong positive correlation between SMs and watercourses outside the AONB, where many of these assets are medieval moated sites or villages (and a Tudor water garden), and a moderate positive correlation between SMs and steep slopes in the Chilterns. The case studies identified many local topographical nuances relevant to their interpretation but (somewhat surprisingly to the writer) this initial study suggests that topography has not had a great influence on overall asset distribution, although further systematic analysis using lidar and digital terrain models would allow a greater range of factors to be considered (and note that the case studies did detect some correlations: see Appendix 1).

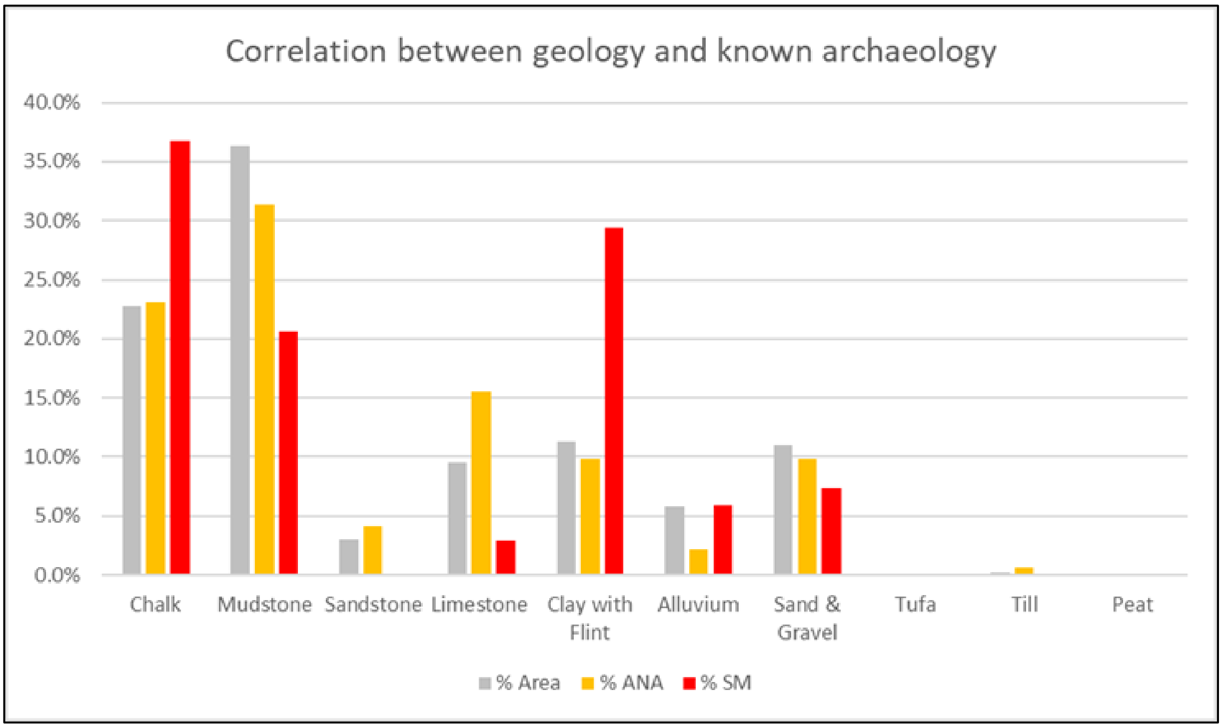


Figure 4.23: Graph showing percentage of asset centroids within each surface geology in comparison with the overall proportion of the study area covered by that geology

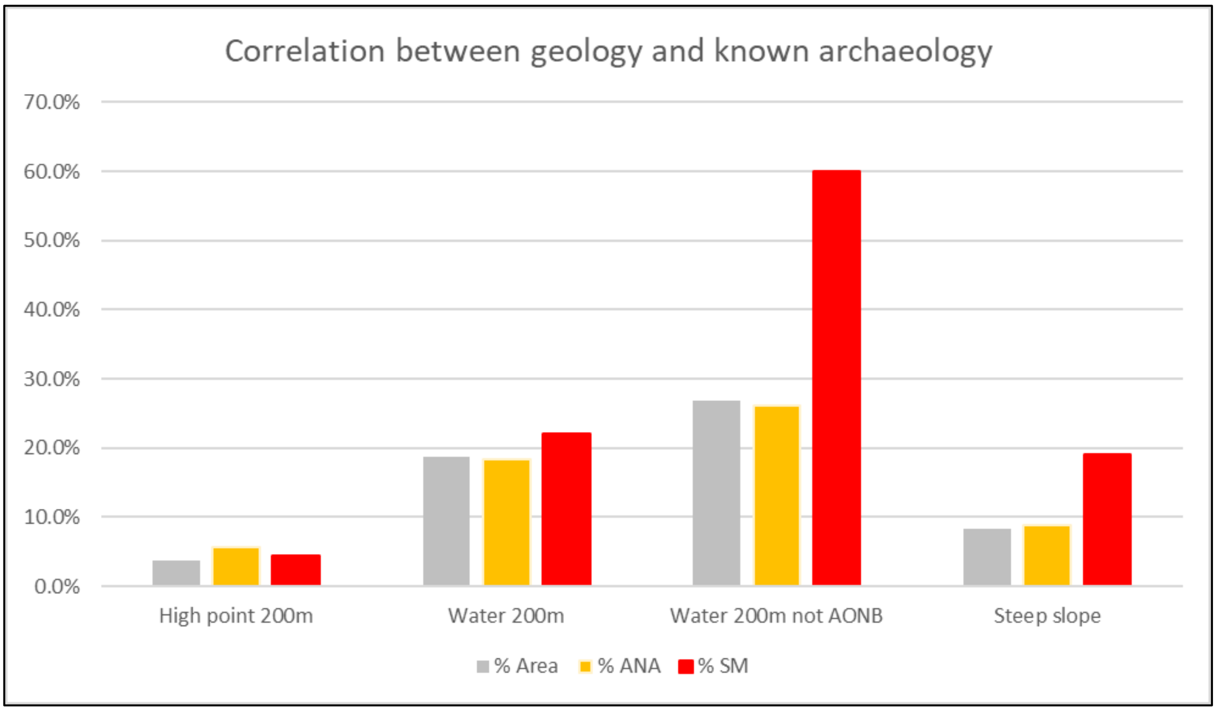


Figure 4.24: Graph showing percentage of asset centroids within each topographical category compared to the overall proportion of the study area covered by that category

A slightly wider range of cultural indicators were investigated, with mixed results (Fig. 4.25). Like topography, routeways proved disappointing as some localised or period-specific associations failed to translate into an overall correlation. An important point here is that proximity to Roman roads probably does correlate positively with Roman assets and the Upper Icknield Way with barrows but these effects are not strong enough to have an overall impact, and may even be negated by other factors, such as a propensity of medieval settlements to avoid highways and the unwatered high ground of the Chiltern scarp deterring settlement.

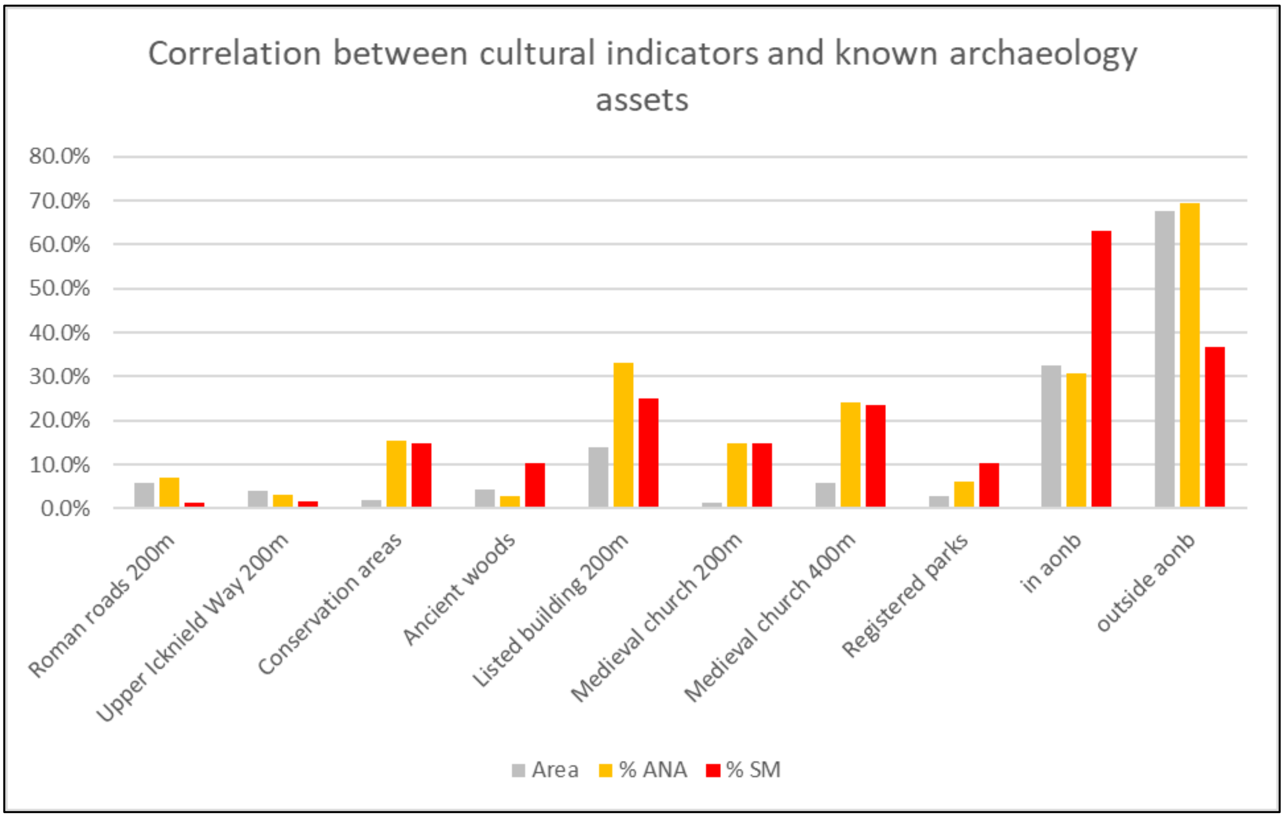


Figure 4.25: Graph showing percentage of asset centroids within each cultural category compared to the overall proportion of the area covered by that category

Other correlations are more nuanced: ancient woodlands show a moderate negative correlation with ANAs but a weak positive one with SMs. This probably reflects a lack of survey to identify less substantial earthworks and a general lack of opportunities for investigation (a pattern which may change as a result of the ‘Beacons of the Past’ project). The Chilterns AONB part of the study area has a similar density of ANAs as the rest of the study area but roughly 3.5 times its density of SMs – note that this reflects a concentration of SMs within this part of the AONB rather than a generally higher density across the whole of the Chilterns.

On a more encouraging note, correlations of archaeological assets with conservation areas, registered parks and proximity to listed buildings and (particularly) medieval churches were all strongly positive. Further research could usefully be undertaken into these associations – for example the correlations may be stronger for some types or dates of buildings than others – and the associations are unsurprisingly mainly with medieval and post-medieval archaeological interests.

The case studies enabled some of these indicators to be tested against investigation outcomes (Fig. 4.26). Alluvium and chalk geologies proved negative (i.e. there was less archaeology within them than the overall average of 13.6%). Neutral indicators include proximity to water and location on mudstone or sand and gravel. Proximity to Roman roads, medieval churches (within 400 m) and listed buildings were weakly positive. The best positive predictor was proximity to a local high point, followed by inclusion in an ANA and 200 m proximity to a medieval church or SM. Generally, and encouragingly, these independent case-study results are consistent with previous analyses of the whole study area. The one notable discrepancy is that local high points changed from a weak to a strong positive indicator.

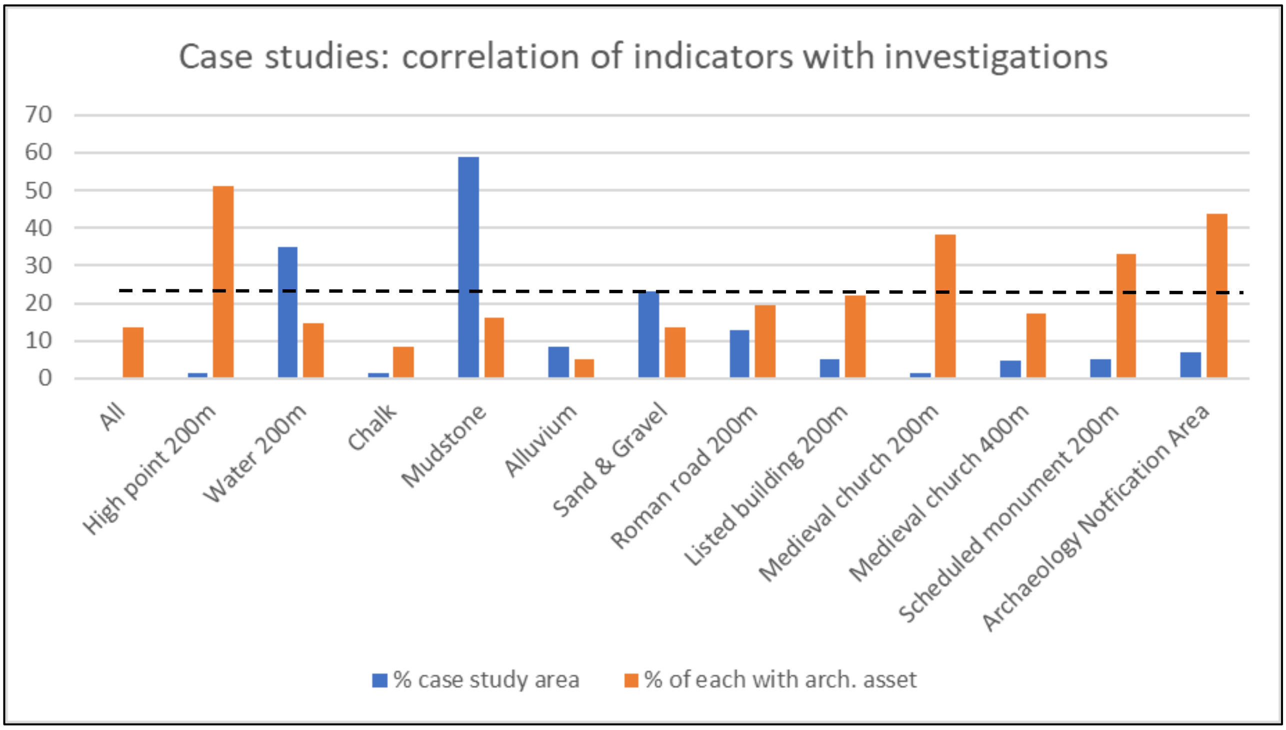


Figure 4.26 Graph showing correlations between archaeological assets found by investigations and indicators represented in the case studies, which overall found assets across 13.6% of their combined areas. Where the percentage with assets (orange bar) is above the dashed line, assets occurred more frequently than average.

In overview, the factors that emerge as significant indicators of presence can be summarised as follows in Table 4.6. The table also attempts where possible to give some indication how much each indicator increases (or decreases) the probability of encountering significant archaeology in relation to the norm for the study area. Surprisingly absent from this list is chalk geology.

Table 4.6: Indicators of presence

Indicators of presence			
Topographical		***Cultural***	
Favourable	***Less favoured***	***Favourable***	***Less favoured***
Limestone (x1.5)	Alluvium (x0.4)	Proximity to medieval church (mainly LM/PM) 200m (x2.8–x10.2) 400m (x1.3–x4.1)	Land enclosed from open fields (mapped by HLC - absence of LM/PM) (x 0.9)
Local high point 200m (x1.5–x3.8)		Proximity to SM 200m (x2.4)	
		Proximity to listed building 200m (x1.6–x2.4)	
		Within historic settlement (mapped by HLC) (x?)	
		Within registered park (x2.5)	
		Within conservation area (x8)	
		Within ANA (x3.2)	

The figures below illustrate how favourable and unfavourable or less favoured indicators are combined and layered, for the study area as a whole (Fig. 4.27) and for two smaller areas in more detail (Figs. 4.28 and 4.29). As can be seen on these maps, there are many overlapping indicators which might together give more weight than a single indicator. However, as many are not properly independent (e.g. medieval churches are also listed buildings) further thought would be needed as to how to combine these layers into a single presence map if indicators were to be weighted or multiple factors taken into account.

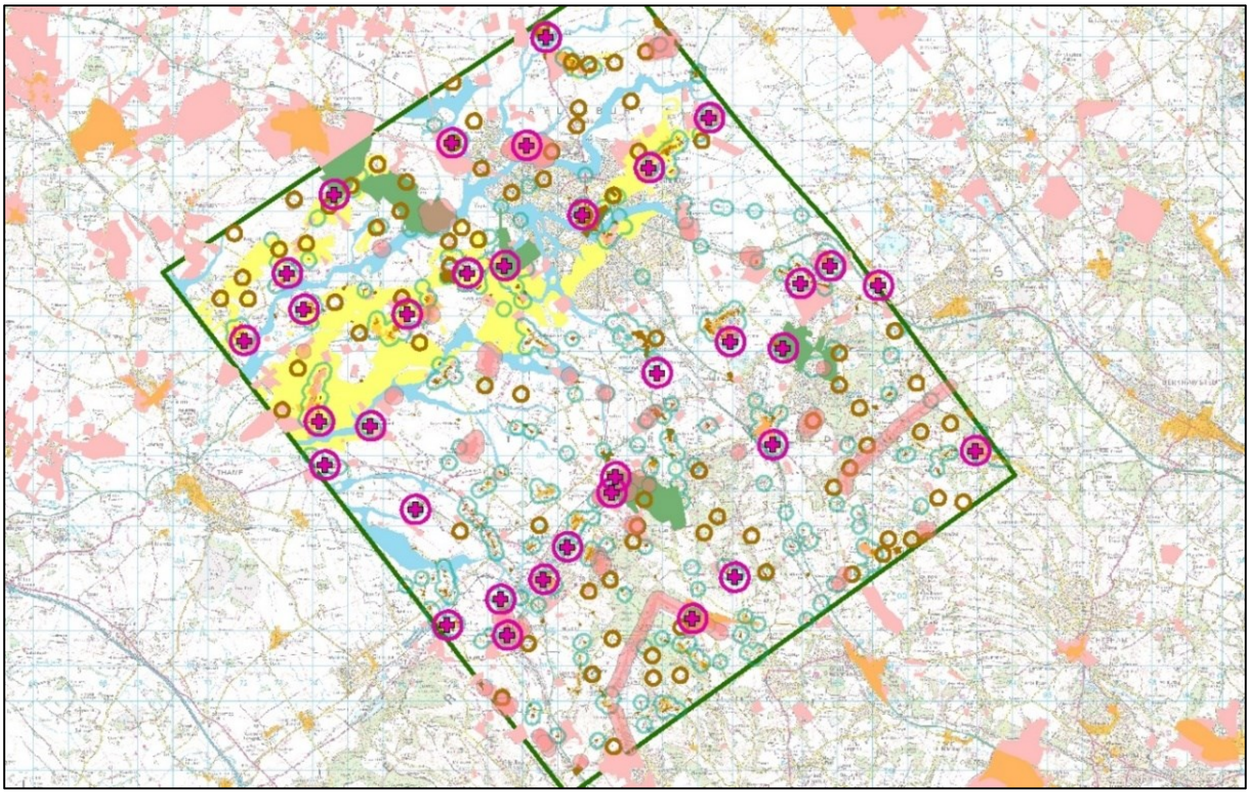


Figure 4.27: Positive presence indicators: limestone (yellow), SMs 200m (dark pink), high points 200m (brown circles), medieval churches 400m (crosses in circles), listed buildings 200m (turquoise), ANAs (light pink), historic cores (brown), conservation areas (orange), registered parks (green), and negative indicator alluvium (blue). Base map © Crown Copyright [and database rights] 2023. OS 100024900.

Excluding the ANAs, which are considered known assets for this purpose, the favourable indicators cover 9054.3 ha and the less favourable indicator (alluvium) covers only 1708.1 ha. The two indicators overlap across 309.9 ha but once ANAs are overlain the residual overlap areas are minor and can be discounted for this purpose. Land enclosed from open fields has not been mapped for this overall analysis because its influence is only a moderate negative effect, or about a 10% reduction in asset density. The identified assets and presence potential can then be assigned to levels as outlined above (3.2.1) and mapped in Fig. 4.30. In combining the various factors known assets 'trump' indicators, and favourable indicators trump less favourable ones. Level 0 has not been mapped for this study.

It is notable that the HER known asset density for all periods (including undated) is 1 per 1 km^2, whereas the case studies generated a much higher figure of 1 per 0.1 km^2. These figures imply an overall visibility of only around 10%, i.e. the Buckinghamshire HER contains sufficient information to identify around a tenth of extant heritage assets.

Figure 4.28: West of Aylesbury detail (see Fig. 4.27 for key). Base map © Crown Copyright [and database rights] 2023. OS 100024900.

Figure 4.29: Princes Risborough detail (see Fig. 4.27 for key). Base map © Crown Copyright [and database rights] 2023. OS 100024900.

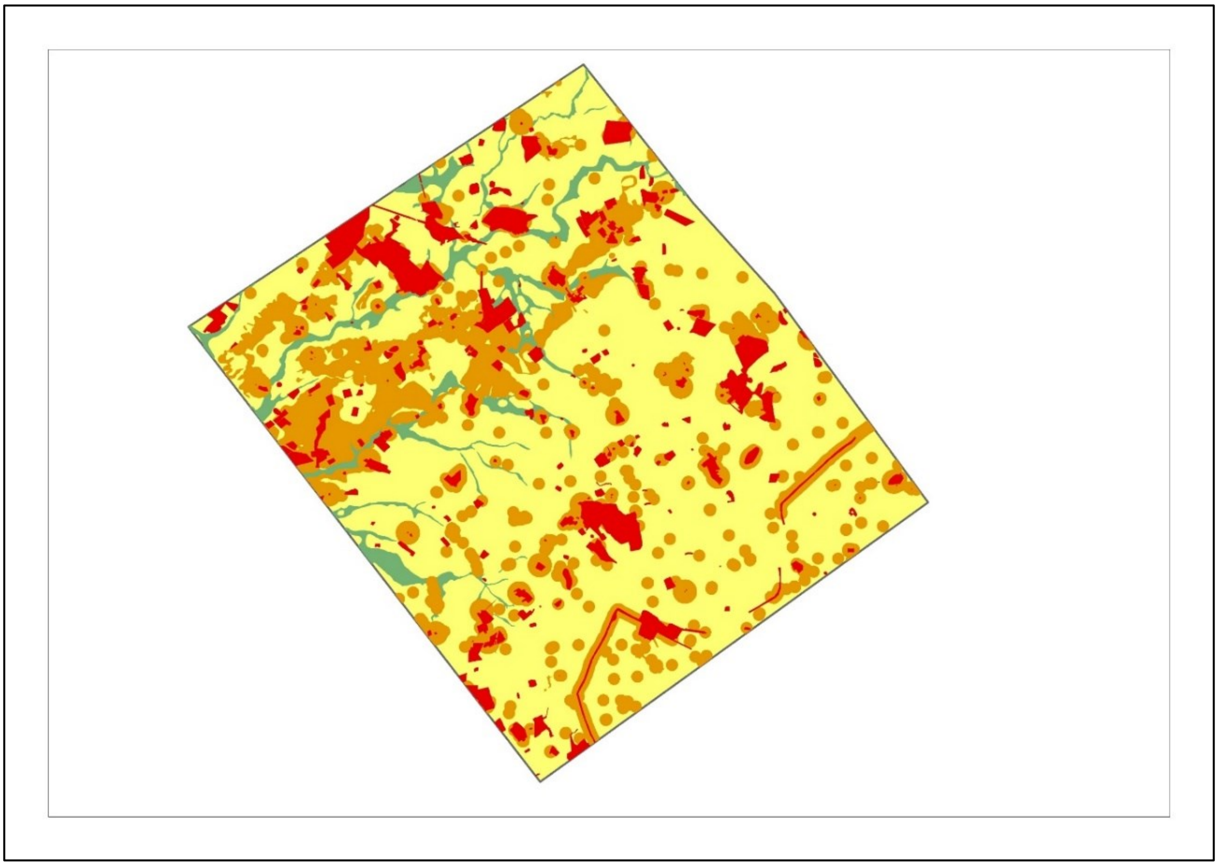


Figure 4.30: Presence model for Vale of Aylesbury: red = Level 4 (known assets); orange = Level 3 (favourable locations); yellow = Level 2 (neutral [average] locations); green = Level 1 (less favourable locations). Level 0 was not mappable due to limited coverage of event polygons.

4.5 Condition mapping

Mapping condition used HLC as the basis for assessment, supported by land cover maps (for the physical impact of modern land use), geological mapping (for soil chemistry), ANA alert maps and 'Turning the Plough' ridge and furrow (for known condition), and HER Events (for evaluation etc). GIS data was extracted following the rules outlined in Appendix 2 in order to allocate each land parcel one of the condition codes shown in Table 3.3. In practice this left out a few mostly small polygons where land cover and HLC are inconsistent, either due to changes in land use between the surveys, scale of mapping or other factors (e.g. HLC enclosed land mapped as neither arable or pasture land cover). For the purposes of this pilot study such minor inconsistencies are considered immaterial and could be tidied up manually if necessary in real-world usage.

In the study area coding condition proceeded in three steps:

Step 1 involved classifying the known condition of known assets using the Bucks ANA system (which contains all SMs within the study area). Some data of this nature was already included in the ANA shapefile but it was augmented for this study by personal local knowledge. In practice this simply involved identifying earthwork monuments and historic places with a built-heritage component (mainly villages and designed landscapes here but could include historic industrial or military areas elsewhere). For the northern part of the study area (outside the Chilterns AONB) ridge-and-furrow earthworks mapped from vertical aerial photography for 'Turning the Plough' (in 1997) was given code UF (this dataset used earlier vertical photography so some fields have doubtless been lost since then). There was insufficient information to code 'flat' sites and findspots, nor were site-specific COSMIC assessments available, so these assets were removed from step 1 and the land assessed under the step 2 criteria.

<u>Step 2</u> addressed the land not classified by step 1 (the vast majority) using information on historic and recent land use from Bucks HLC and a range of supporting GIS datasets (Land cover 2019, BGS alluvium and 'Turning the Plough' aerial mapping of ridge and furrow) to code the likely condition of archaeological assets. It is important to emphasise that this approach does not depend on an asset being known or expected to be present – it considers what the likely physical condition of an asset would be *if* one were present.

The HLC Broad Category (e.g. CIVIC, WOODLAND etc.) was used to structure this analysis. In the study area some HLC broad categories could be allocated directly to a condition code (e.g. CIVIC was mapped directly to code SF) whilst others required further processing. For example, WOODLAND was divided between Ancient Woodland (Code V), Secondary or Replanted Woodland (Code S) and Conifer Plantations (Code DF), reflecting the very wide range of archaeological survival found in modern wooded areas. The most complex (and extensive) HLC Broad Category was ENCLOSED land, which in the study area is almost entirely land that has remained in agricultural use for at least several hundred years, and in many cases at least a thousand years. Factors acting in favour of better preservation would be modern grassland land cover, protective alluvial cover and survival of ridge-and-furrow earthworks; the latter are of intrinsic heritage interest but also an indicator of no or minimal post-enclosure cultivation, though conversely they imply disturbance to pre-medieval archaeology.

Factors indicating lesser preservation would be HLC prairie fields, modern arable land cover and former inclusion within medieval open fields. Fortunately the HLC recorded the likely origin of enclosed land including, as mentioned above, a code (ENOF) for enclosures from former open fields. This indicates the generalised extent of documented medieval cultivation at a strategic scale that could be refined by local area or site-based studies. While upstanding ridge-and-furrow earthworks have positive aspects, ploughed-down ridge and furrow is considered a negative factor. Condition on ENCLOSED land can therefore range from code D (prairie fields) through S or SF (arable fields) to V (under alluvium or pasture).

<u>Step 3</u> involved coding the soil's chemical survival conditions in the simple three-fold schema of A (Anoxic), B (Basic) and C (Acidic). This categorisation aims to identify wetlands where widespread waterlogged structural and environmental remains are expected (code A). The Peat layer of the UK Soil Observatory identifies only a very small area of peat in the study area (Fig. 4.31) and no others are known from archaeological investigation. Anoxic remains are not widely represented in the study area but could be anticipated along watercourses, under alluvial spreads or associated with 'wet' monuments such as bridges, moats and mills. For this study only BGS alluvium and peat mapping has been classified A but this could be refined by identifying known waterlogged monuments, or other topographical features having anoxic potential in addition to mapped wetlands.

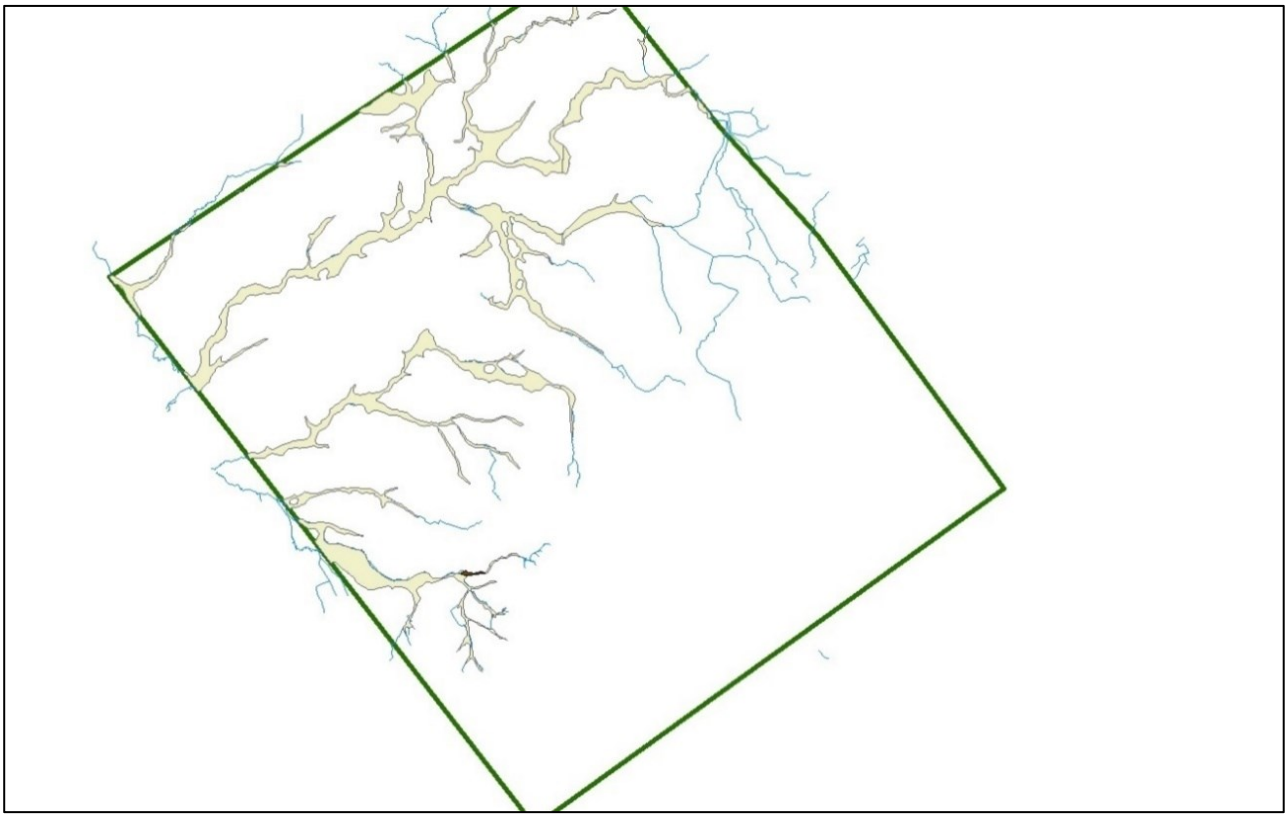


Figure 4.31: Anoxic potential map showing alluvium and peat plus historic streams extending beyond the alluvium for reference (derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Dryland was then divided into those soils which have fair to good preservation of bone, metalwork, etc and those where such remains are vulnerable to destruction. Across the Vale of Aylesbury soils are predominantly basic or neutral or mildly acidic with high carbonate content on the chalk and limestone and low-variable carbonate on the clay (Fig.

4.32). Only on head deposits, alluvium/colluvium and river gravels is there no carbonate content. If bone survival is used as a proxy (since it is the most commonly found material other than chemically robust ceramics and lithics) then most of the study area can be coded B. Only in three areas is soil sufficiently acidic (pH<6) to destroy or substantially harm these vulnerable classes of evidence (Fig. 4.33); two of these areas lie on clay-with-flints but there is little excavated evidence to assess actual material survival in these parts of the study area. The intention was to assign these areas to code C but this aspect of the methodology proved problematic to ground-truth and was not supported by Historic England's science advisors.

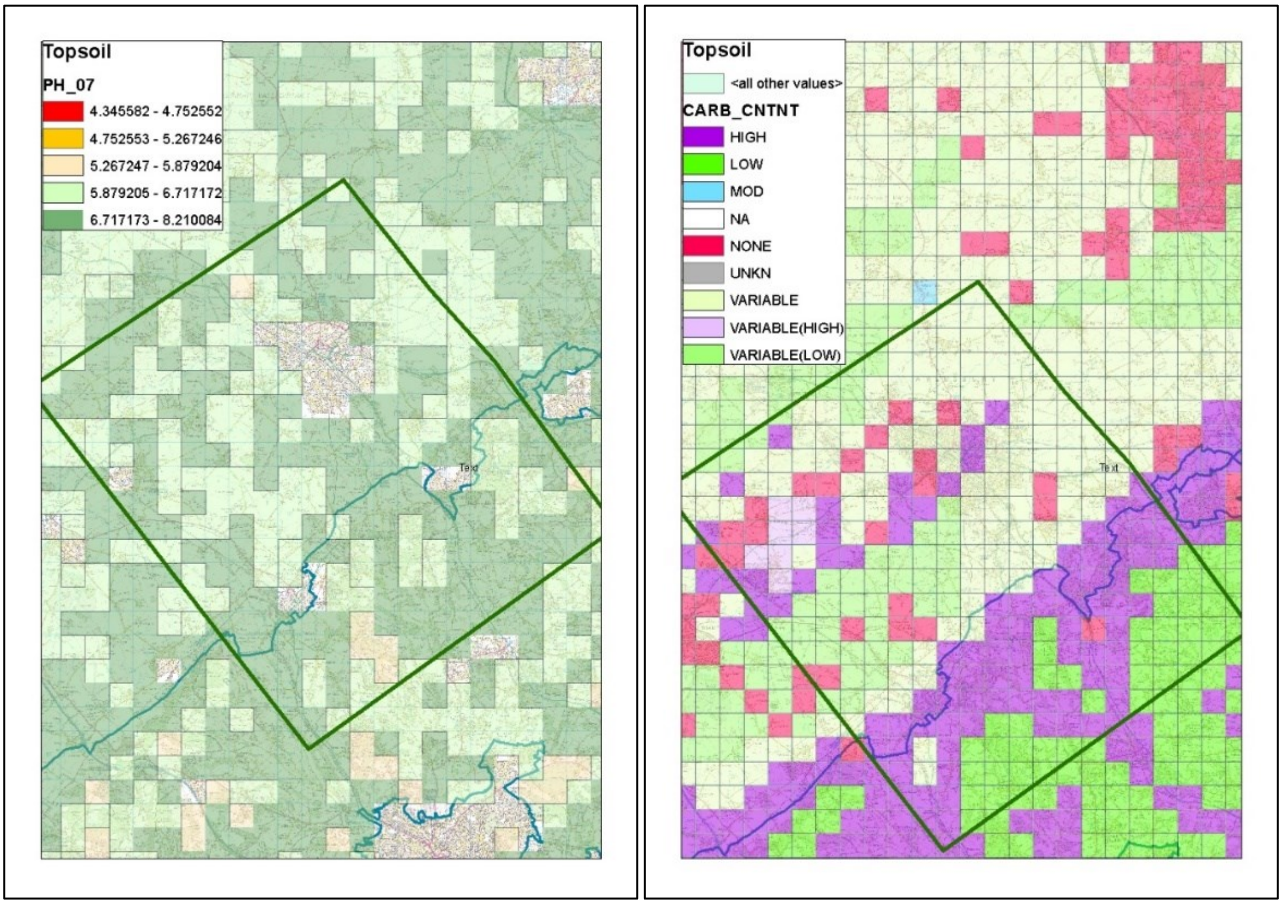


Figure 4.32: Topsoil pH and carbonate content across the study area mapped by the UK Soil Observatory. Model estimates of topsoil properties [Countryside Survey] © Database Right/Copyright NERC Centre for Ecology & Hydrology. All rights reserved.

Applying the coding methodology involved creating a suite of shapefiles and assembling them to create the condition model map (Fig. 4.34), which shows quite locally varied patterns but with the Chilterns having more level 2 condition areas and the Vale more level 1 (cf. Figs 4.35 and 4.36).

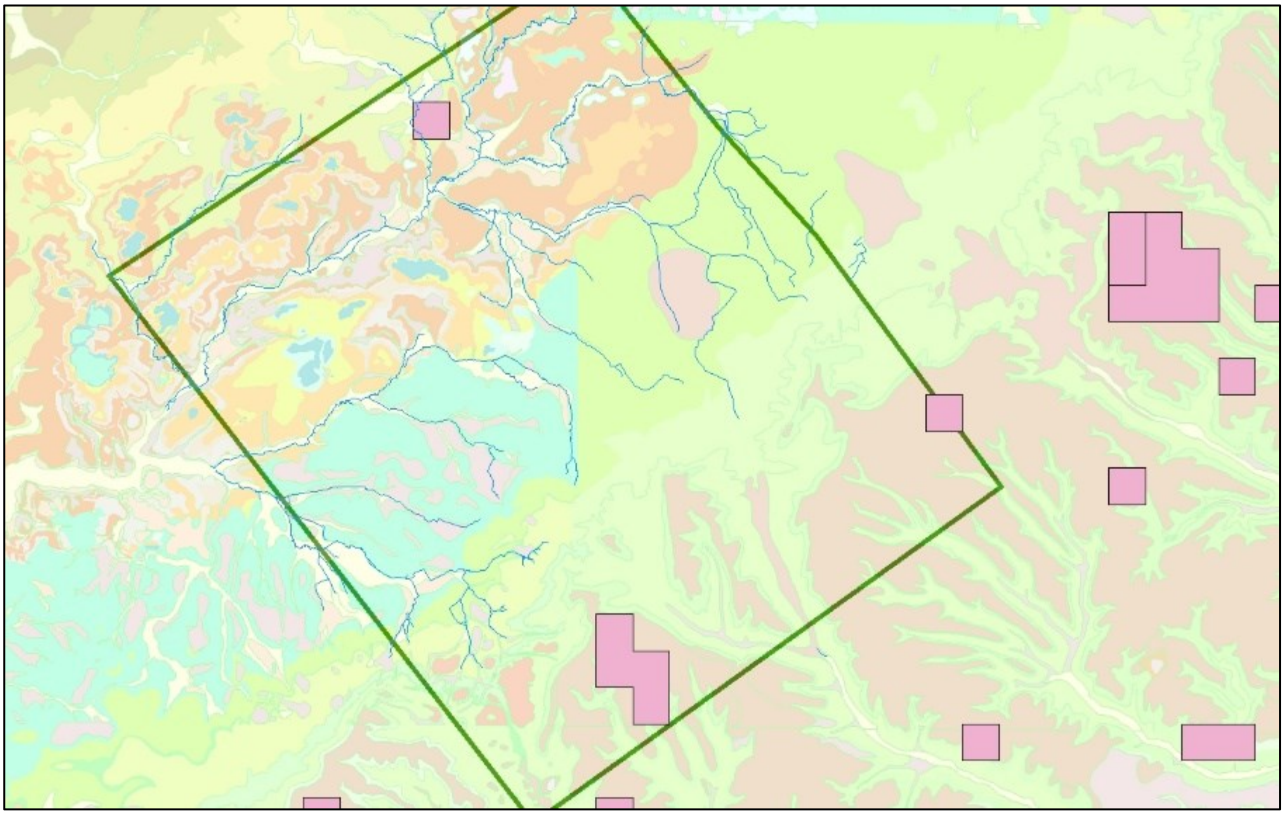


Figure 4.33: Strongly acidic soils (red) overlain on geology (see Fig. 4.2; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

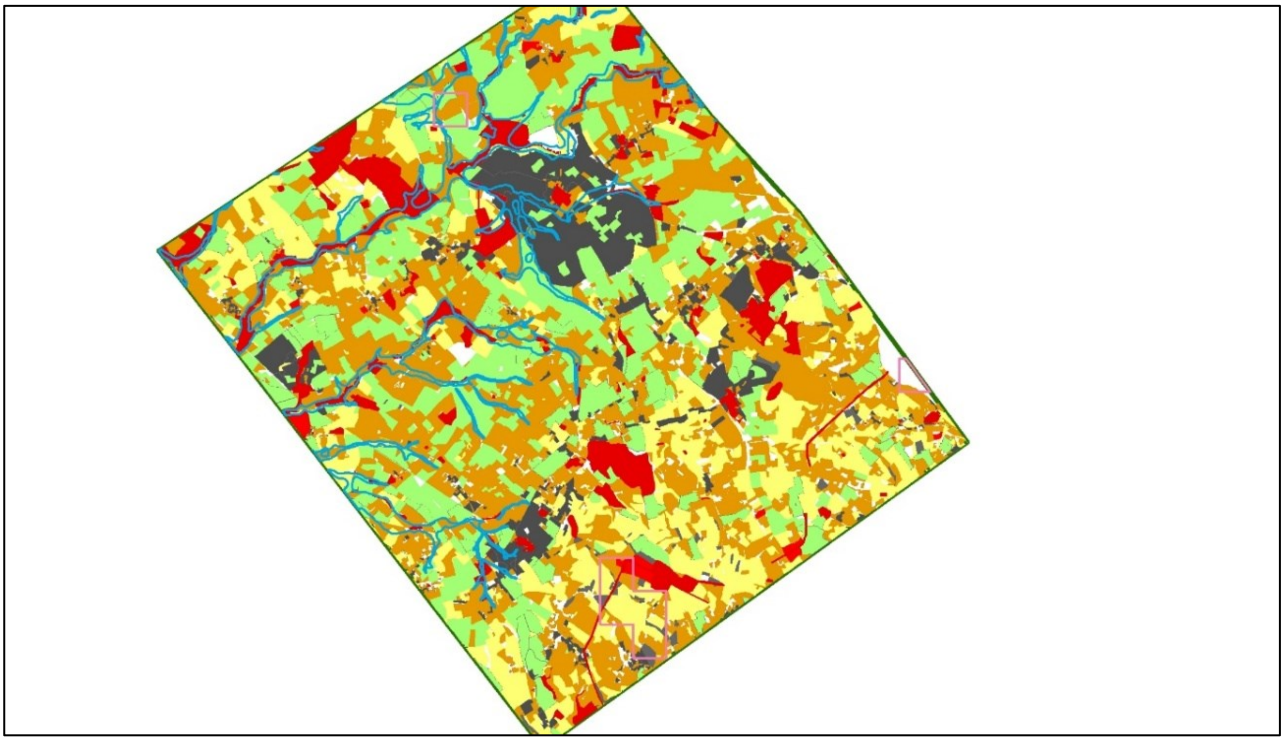


Figure 4.34 (previous page): Overall condition model showing level 4 physical condition (red), level 3 (orange), level 2 (yellow), level 1 (green) and level 0 (grey) with soil chemistry outlined blue for anoxic potential and white for acidic – other soils are basic/neutral

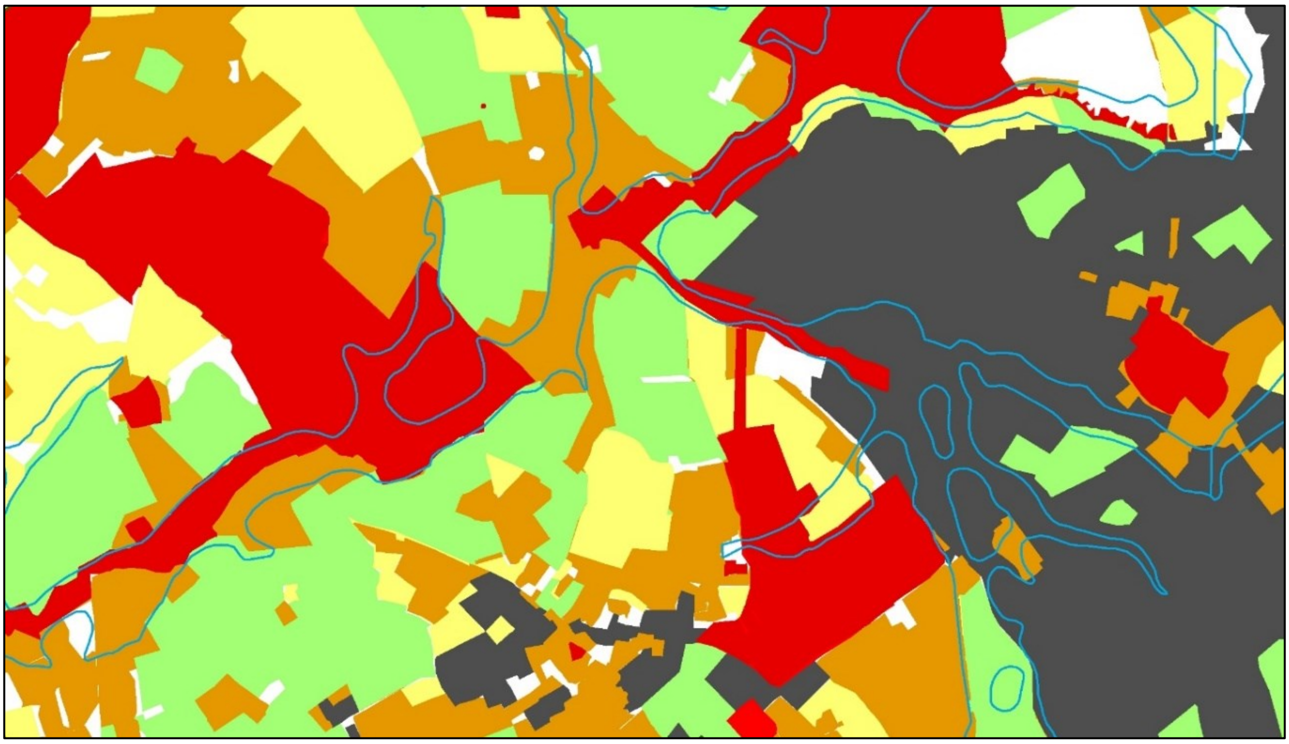


Figure 4.35: Detail of condition model in the area to the west of Aylesbury (see Fig. 4.34 for key)

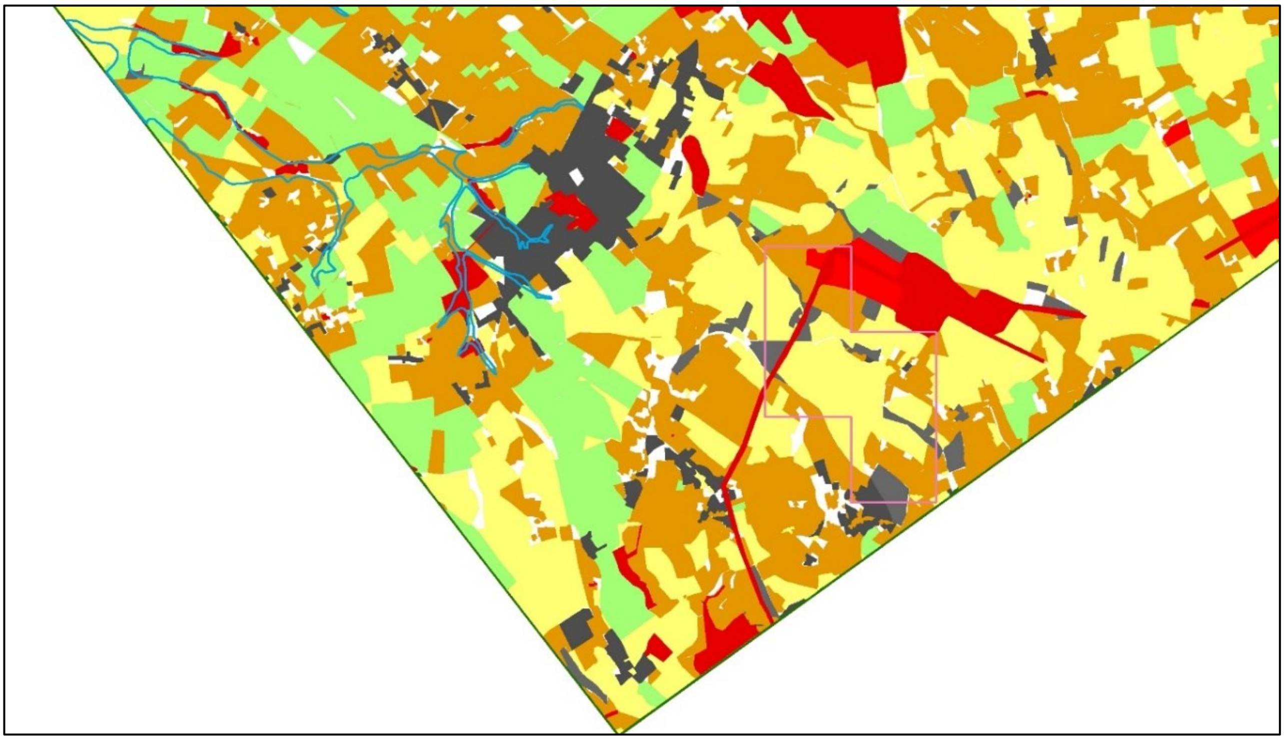


Figure 4.36: Detail of condition model around Princes Risborough (see Fig. 4.34 for key)

4.6 Significance

4.6.1 Scheduled monuments

There are 67 SMs within the study area covering 176.8 ha (Fig. 4.37), which comprise:

- 15 x Neolithic/Early Bronze Age barrows (though one is actually a natural tump and another a post-medieval windmill mound)
- 16 x later Bronze Age/Iron Age linear boundary earthworks: three are cross dykes and the rest are segments of Grim's Ditch
- 3 x later Bronze Age/Iron Age hillforts
- 1 x Romano-British barrow
- 2 x Romano-British settlements (one villa and one old scheduling described as a 'village')
- 1 x early medieval cemetery
- 1 x later medieval pillow mound
- 3 x later medieval motte and bailey castles
- 24 x later medieval deserted settlements and moats (one is also a post-medieval garden)
- 1 x post-medieval religious hill figure

As can be seen from the graph (Fig. 4.38) the schedule has reasonable representation of prehistoric and medieval monuments but for other periods coverage is sparse compared to known assets. The form of assets was also classified using the broad categories outlined in Table 3.4 (Fig. 4.39). There are no scheduled buildings or structures within the study area – recent designation of redundant structures, such as the Cold War rocket testing facilities at Westcott just north of the study area, has favoured listing. The vast majority of SMs in the study area are earthworks. Only eight (12.7%) are 'flat' with no or negligible visible components – these are the one early medieval cemetery, the two Romano-British settlements and five ploughed-down barrows, part of a barrow cemetery at Saunderton. If equivalent significance to a SM for non-designated assets were to be judged simply by reference to previous precedent then prehistoric and medieval earthworks would be the prime candidates in the study area.

National importance has been recognised afresh throughout the last century and there seems no reason to believe that the process of discovery and recognition is finished. The average rate of scheduling over the last century is about 7.5 monuments per decade but it fluctuates and the 'normal' rate is actually 4–5 per decade if the effect of the Monuments

Protection Programme (MPP) in the 1990s is discounted (Fig. 4.40). The cumulative extension of scheduling up to its present 0.6% of the study area shows a rather different pattern, dominated by larger areas in the 1950s to 1970s with a more gradual rise thereafter. The rate of increase averages slightly under 20 ha per decade (Fig. 4.41).

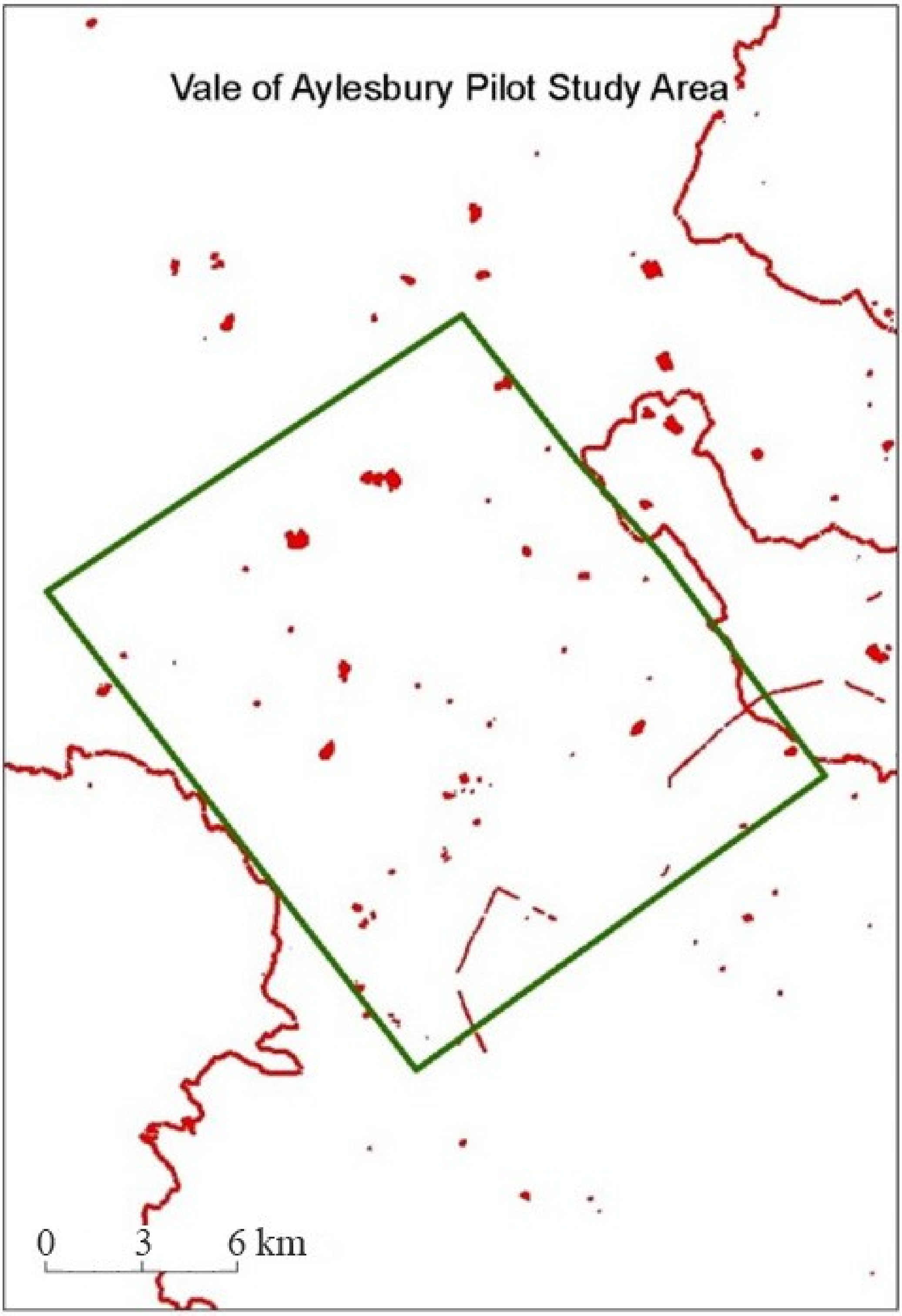


Figure 4.37: SMs in the study area

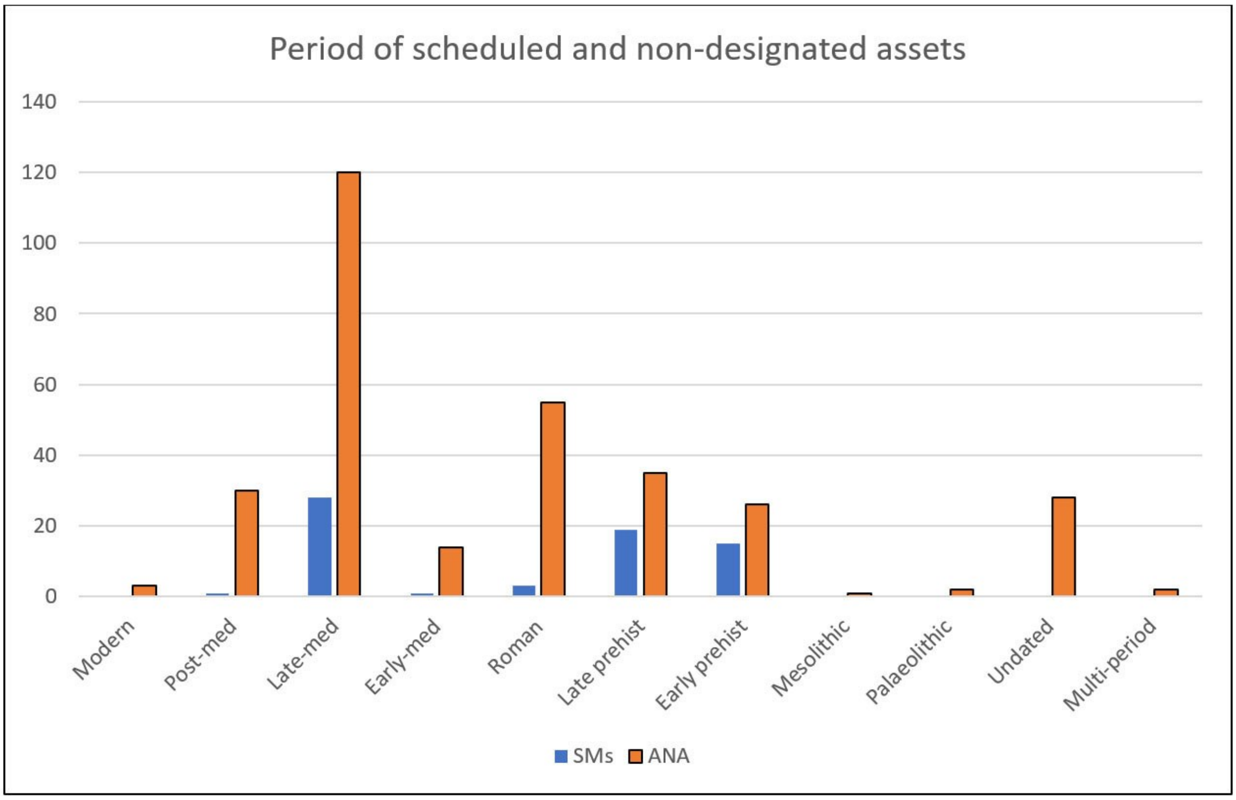


Figure 4.38: The principal periods of each SM and ANA

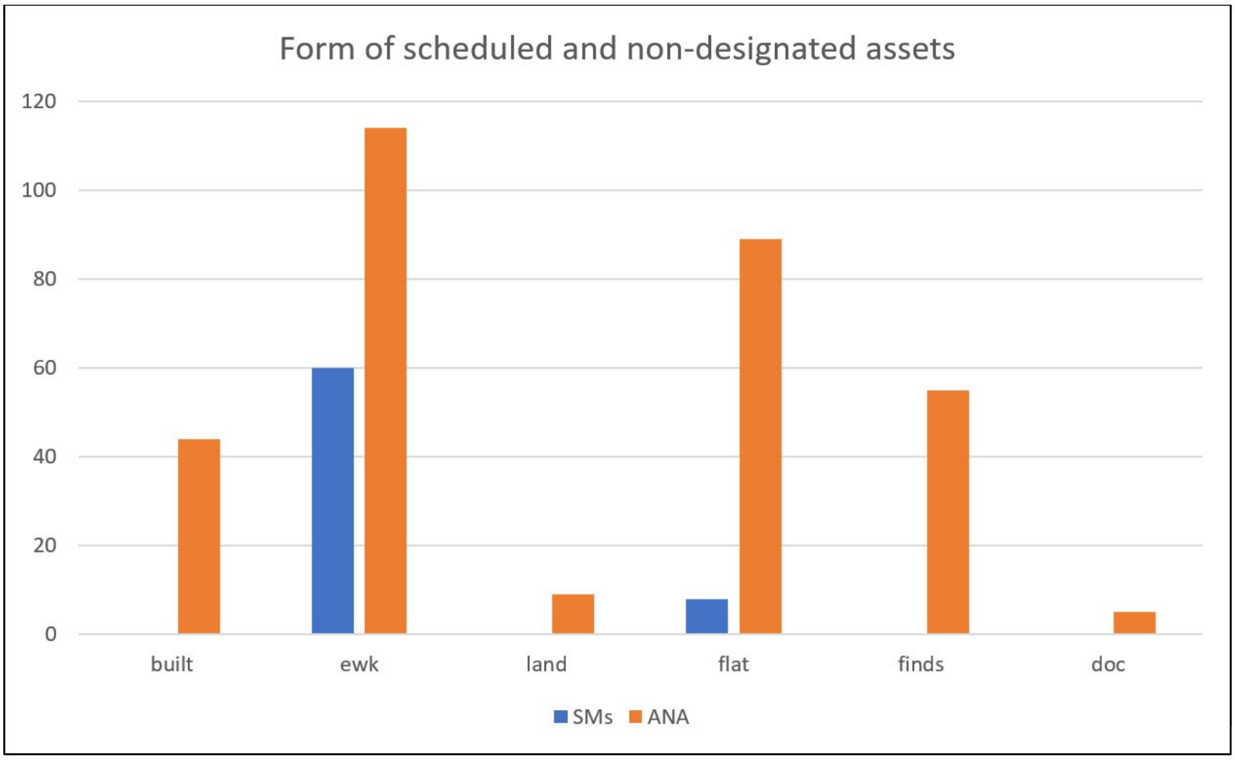


Figure 4.39: Form of heritage assets (note that five of the nine 'landscape' ANAs are registered historic parks and gardens)

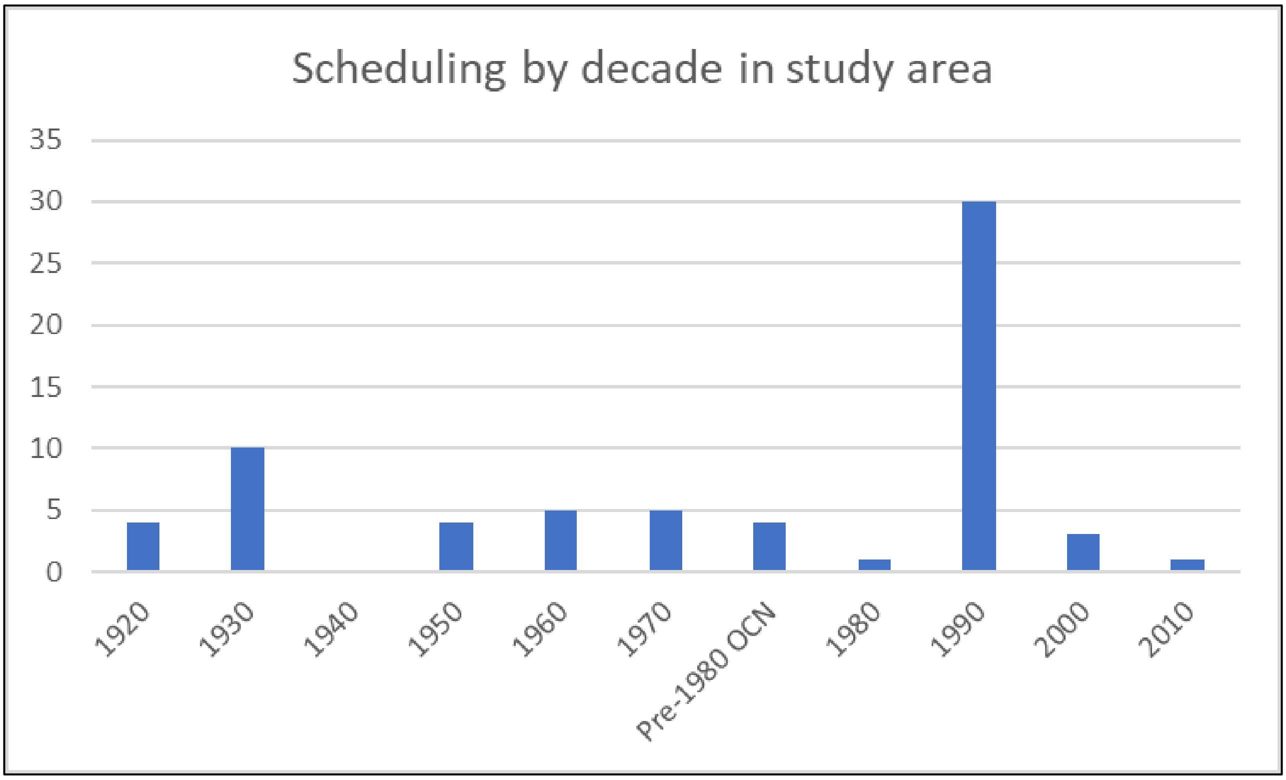


Figure 4.40: Date of scheduling for SMs

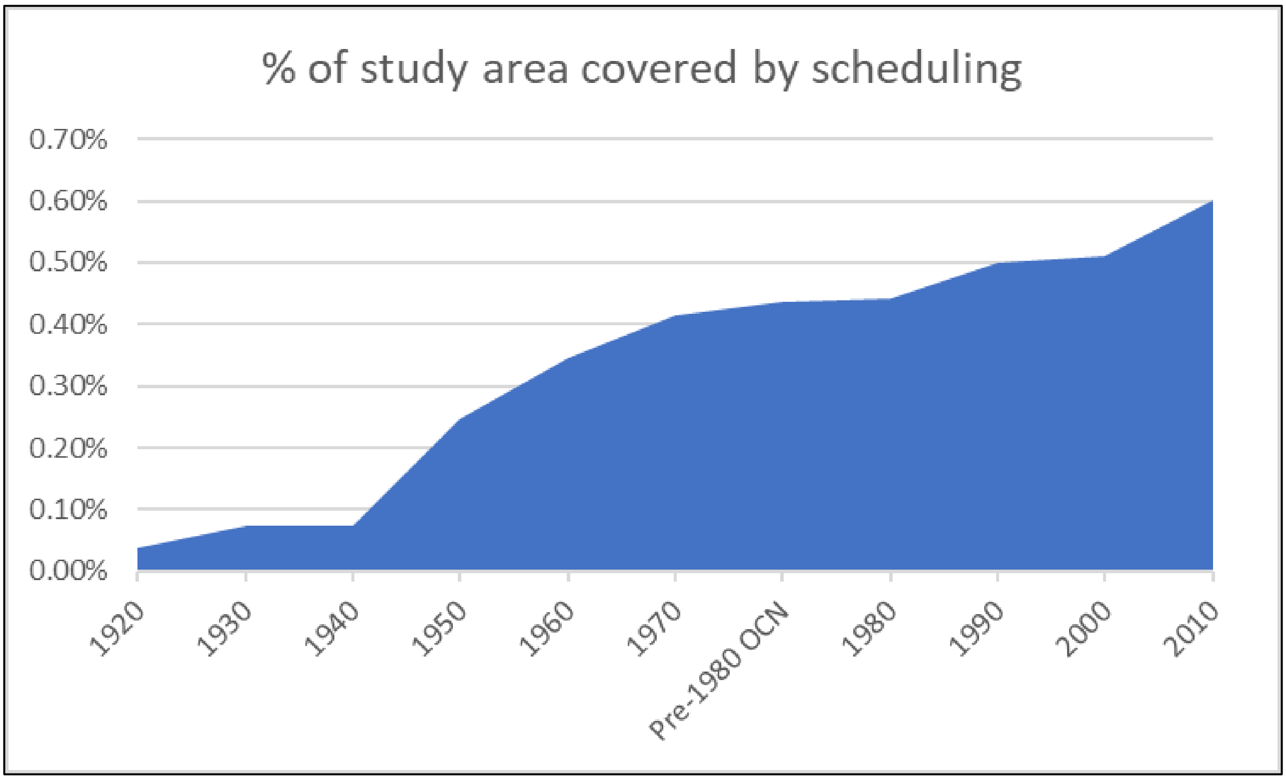


Figure 4.41: Area covered by scheduling over time

A request to schedule Fleet Marston Roman settlement in the late 1990s was declined on the basis of insufficient information. As far as is known, no monuments in the study area have been formally identified as of national importance but declined for scheduling using the Secretary of State's discretion.

The point of this analysis is to establish what precedents and trends there are for formally recognising national importance in the study area. Only 0.6% of the area is currently recognised as containing archaeological remains of national importance. What then is the risk of encountering more of these types of monument, and are there other types that might reasonably be anticipated or ought to be better recognised despite not currently being represented in the local schedule?

4.6.2 National importance

The Buckinghamshire ANA system includes a 'flag' indicating assets which the HER identifies as engaging with national importance (NI). Originally this identification was based on MPP assessments. Of the 316 ANAs in the study area 105 are flagged as NI sites. These comprise ANAs which include SMs, which are associated with other designated assets of evident archaeological interest (such as historic designed landscapes or medieval churches) or which in the archaeology team's view have revealed evidence indicative of NI. This study has not sought to interrogate the assumptions behind these judgements. Assets of potential national significance have also been encountered in the case studies, including:

- medieval settlement and earthwork ridge and furrow close to scheduled medieval settlements at Aston Clinton MDA and Berryfields and the listed medieval church at Fleet Marston
- Iron Age ritual activity associated with a hillfort underneath the Old Town of Aylesbury
- Romanised farmsteads (possible villas) found during evaluations at Aylesbury Woodlands, Bierton village and Hampden Fields
- the Roman nucleated roadside settlement at Berryfields/Fleet Marston
- well-preserved Roman maltings at Berryfields and Weedon Hill.

4.6.3 The Chilterns AONB and other designations

The NPPF provides additional policy recognition to cultural heritage within protected landscapes and the part of the AONB within the study area has a density of 0.45 SMs per km^2 compared to only 0.13 per km^2 in the part outside the AONB. This is reflected in a strong positive correlation between clay-with-flints and SMs and a moderately positive correlation with chalk geology. However, although this higher density of SMs is a feature of this part of the Chilterns it is not true of the Chiltern Hills as a whole (as defined by the Chilterns NCA) where the density is fairly typical for this part of England, and lower than the national average of 0.36 SMs per km^2 (Fig. 4.42). Conservation areas, registered parks, and proximity to medieval churches also show strong positive correlations with SMs and of course all are designated assets with a likely archaeological interest.

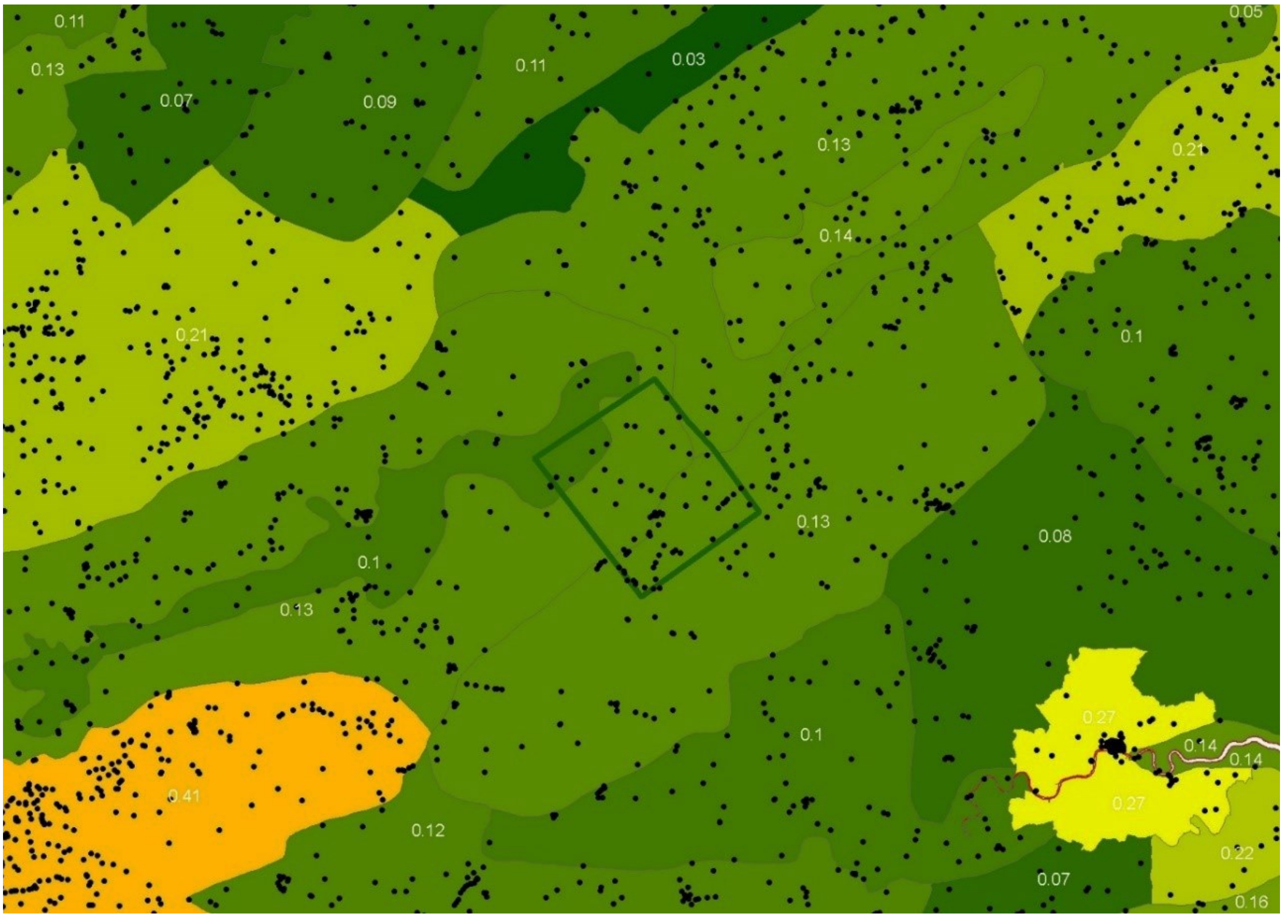


Figure 4.42: Density of SMs per km^2 for each NCA, with actual SMs to show distribution and a cluster in the southern part of the study area

4.6.4 Research frameworks

Archaeological significance rests ultimately on an ability to articulate how investigation might advance understanding of matters of research interest. The relevant regional research framework for the study area is Solent-Thames (Hey and Hind 2014). Like most such documents it does not map research priorities, and indeed for many topics it is hard to see how that could be done. However, as a spin-off from the Solent-Thames research framework, an attempt has been made to formulate a spatial research framework for the study area from the later Bronze Age to the Norman conquest (Alqassar and Kidd 2018; Table 4.7). This paper drew a distinction between a core settlement zone between the

Chilterns and the Thame (the 'Icknield Belt') and episodically settled land in the Chilterns and on the claylands north of the Thame. A framework of coaxial trackways was seen to link these three landscape zones, thus highlighting an aspect of landscape character and significance which is hard to capture in a purely asset-based approach. It may therefore be useful to consider where the clustering of related assets (particularly those of high significance) and other features define a landscape with high research potential.

Table 4.7: Summary of Vale of Aylesbury landscape model (Alqassar and Kidd 2018, table 2)

Period	***Chiltern Hilltops***	***Icknield Belt***	***Claylands north of the Thame***
Medieval (C12 to mid-C14)	Colonisation by piecemeal assarting to form dispersed pattern of linear rows and common-edge settlement with isolated manors and daughter chapels	Aylesbury and Wendover become towns set within a stable, fully exploited village and open-field landscape. Parish structure fossilises historic links to Chilterns.	Creation of Bernwood Forest. Piecemeal encroachment into remaining waste and woodland creating isolated manors and daughter hamlets.
Saxo-Norman	Generally still sparsely occupied with much woodland mainly on clay-with-flints used for swine. Landscape managed from Icknield Belt villages.	Medieval settlement pattern, parish boundaries and open field landscape in place. Royal estate centred on Aylesbury heading the 3 (or 8) 'Hundreds of Aylesbury'. Radial road network also centred on Aylesbury.	Colonisation to form nucleated villages with open fields
Middle Saxon	Sparsely occupied (extensive woodland or waste?)	Minster at Aylesbury (late C7?). Origins of radial road network centred on Aylesbury? Creation of open fields?	Sparsely occupied (extensive woodland or waste?)
Early Saxon	Sparsely occupied (woodland regeneration?)	Settlement continues on a minority of RB sites and begins on some sites that become medieval villages. The former are abandoned in/by the Middle Saxon period. Aylesbury mentioned as British 'town'. 'Aylesbury cluster' of pagan cemeteries references coaxial trackways and Roman roads.	Sparsely occupied. (chronology of RB settlement abandonment uncertain) (woodland regeneration?)
Roman	Sparsely occupied (farmed from villas in Chiltern valleys and along Icknield Belt?)	Villas and non-villa agricultural settlements alongside coaxial trackways and linked laterally by Lower Icknield Way Roman Road. Diversification of rural economy.	Fleet Marston small town nexus for road network. Non-villa settlement, largely unbounded landscape away from settlement 'closes'.

Iron Age	Hillforts, Grim's Ditch major land boundary divides the hills north from south and implies open contested countryside? Upper Icknield Way functional?	Hillforts, unenclosed settlement, coaxial trackways developing	Unenclosed settlement, largely unbounded landscape
Later Bronze Age	Ringforts and cross-ridge dykes? Upper Icknield Way functional?	Ringforts, unenclosed settlements, origins of coaxial trackways?	Sparsely occupied (open rough grazing?)

4.6.5 Identifying and mapping significance

Significance of known assets on the basis of existing information is identified by scheduling and the local ANA system, albeit the latter could be enhanced by more up-to-date criteria and a more rigorous assessment process. The ANA system 'flags' areas considered by the Bucks HER to have high potential for archaeological assets of national importance; these are professional judgements supported originally by assessments made for the Monuments Protection Programme in the 1980s and early 1990s. Another factor was consideration of archaeological interest associated with listed or registered assets or protected landscapes (in this case the Chilterns AONB), on the grounds that such an association could add weight to consideration under current planning policy.

For the purpose of this study, significance was addressed spatially by dividing the area into levels, as described above (3.2.3): Level 4 (known exceptional/nationally important); Level 3 (high potential for discoveries of national importance); Level 2 (some potential for such discoveries); Level 1 (low potential/'background' only). The results are shown on Fig. 4.43, while examination of the mapping also highlighted the concentration of scheduled prehistoric monuments in this part of the Chilterns (Fig. 4.44). From this it was inferred that new discoveries of nationally significant prehistoric monuments are more likely to occur on the Chilterns chalk (and perhaps clay-with-flint) geologies than further north in the clay vale. This is not to say that prehistoric archaeology is absent further north – far from it – but rather that current and past designation criteria strongly emphasise designation of the types of monument (especially visible earthworks) found in the Chilterns, and that this cluster could be held to have 'group value'.

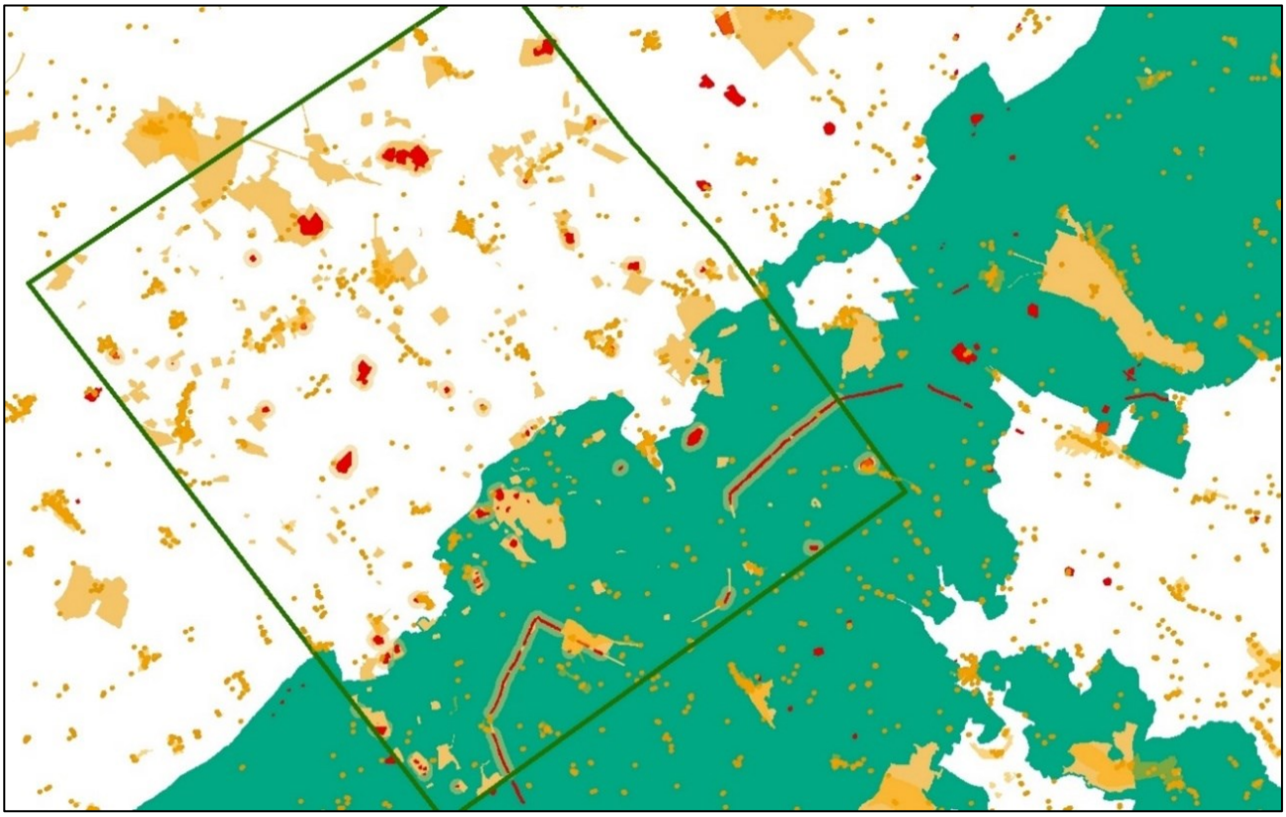


Figure 4.43: Mapping above-baseline significance levels: level 4 NI (red), level 3 potential for/association with NI (orange), and Chilterns AONB (green)

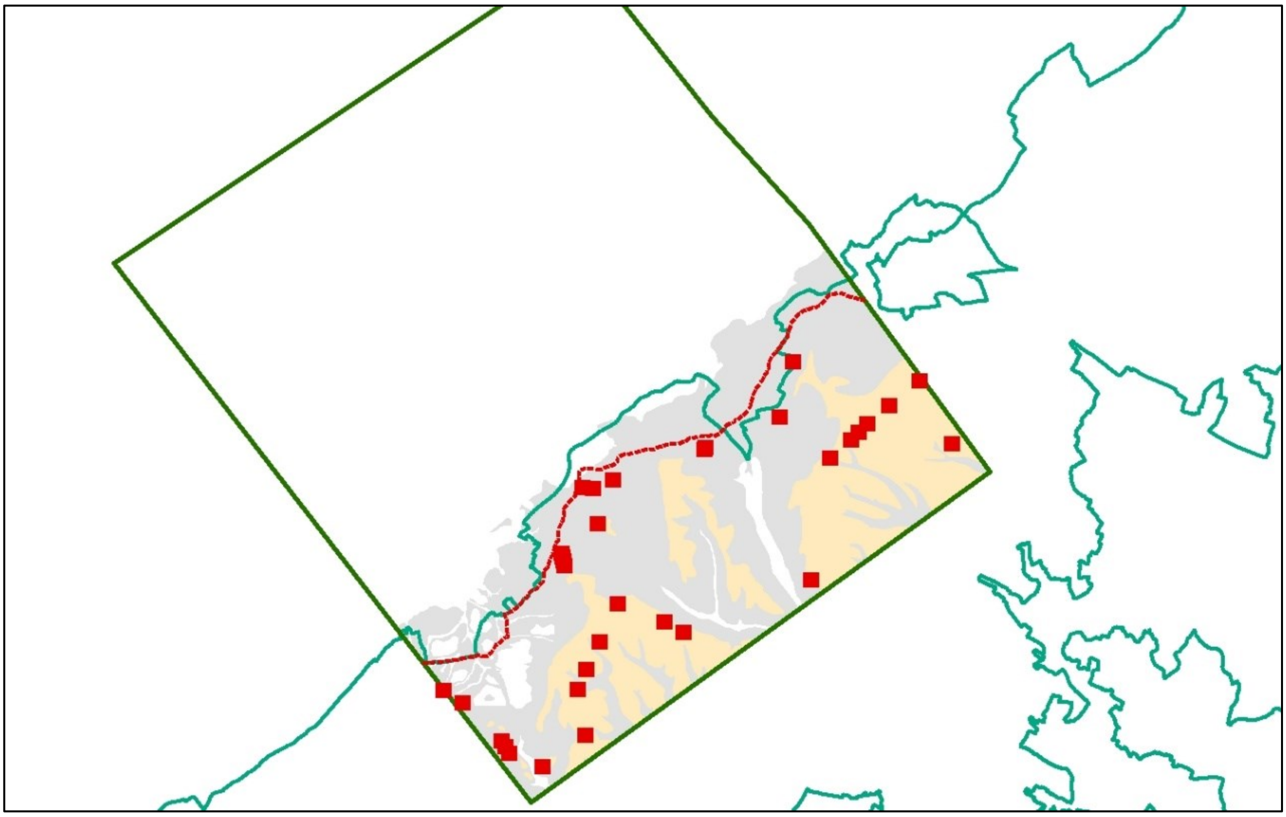


Figure 4.44 (previous page): The Chilterns AONB contains all the scheduled prehistoric monuments in the study area with the NW limit defined by the Upper Icknield Way and chalk geology. The concentration of these nationally important assets within a protected landscape justifies level 3 significance rating.

4.7 Summary

The main propositions emerging from the study are:

1. The Bucks HER identifies 316 ANAs covering 3638 ha or 12.4% of the study area as having known archaeological interest.
2. Case studies show that a high proportion (75–90%) of pre-medieval heritage assets are not currently known and recognised as such, and that typically large greenfield development sites have substantive archaeological interest covering 5–20% of their area.
3. Lower Palaeolithic and Mesolithic archaeology is locally very rare and currently makes little contribution to sensitivity. Neolithic and Early Bronze Age archaeology is predominantly found on chalk and limestone geology and hardly at all on mudstone. Later prehistoric, Roman and medieval archaeology is found across all geologies and topographical locations.
4. Medieval and post-medieval assets and landscapes can be mapped with tolerable accuracy for strategic decision-making to provide a spatial predictive model of archaeological character. Proximity to known heritage assets (such as medieval churches and SMs) is a good predictor of new discoveries.
5. The Chilterns AONB has a strong association with prehistoric SMs and has a distinctive character providing an appropriate zonal boundary for archaeological management purposes.
6. Combining all periods, favoured locational factors for the presence of known and newly discovered assets were found to be limestone geology, local high points, medieval churches, ANAs and nationally designated heritage assets (or proximity to them). Less favoured locations proved more difficult to detect with alluvial geology being the only mappable factor. Some factors, such as proximity to Roman roads, proved inconclusive or have ambivalent results.
7. The potential condition of archaeological remains can be mapped with tolerable accuracy for strategic decision-making regardless of whether the presence of an asset has been confirmed in that location.

8 There are 67 SMs within the study area covering 176.8 ha (0.6% of the study area) but the schedule is highly selective and biased. There are many NDHAs (both known and as yet undiscovered) that could be considered of national importance and many other situations where archaeological interest contributes to the significance of designated heritage assets, as an aspect of the asset itself or as part of its setting.

9 While some of the study's conclusions may appear 'obvious' to experienced practitioners, in defence of the methodology it is suggested that others are not, and that statistical analysis can confirm, refute or refine personal impressions which may be coloured by psychological factors such as confirmation bias. This approach also has the merit of providing a basis for structured 'expert system' approaches which will help less experienced practitioners appreciate local patterning without the need to study every detail of the increasingly voluminous literature.

4.8 HS2 Predictions Testing

The Vale of Aylesbury sensitivity study was subsequently used to model the expected occurrence of archaeological assets along the HS2 route as it passes through the study area. Predictions were made of the extent, period, location and condition of assets that would be encountered based on numerical analyses of selected HER and other datasets. This is a different approach to the professional judgement normally employed on major developments.

As detailed below, the model accurately predicted the overall coverage of archaeological assets, which at 11.3% of the development area was in the lower-middle part of the expected range. The model successfully predicted the relative frequency of assets of different periods with their absolute occurrence being consistently at the high end of the predicted range. This may indicate that for pre-Norman archaeology the Bucks HER records about 10% of actual assets.

The model successfully predicted where assets would be more likely to occur, identifying less than a quarter of the HS2 corridor which contained half the assets. The value of the Bucks HER's ANAs has been demonstrated, as have a number of indicators which might be used to further enhance them.

The model used historic and modern land use to predict where preservation would be better or worse. Whilst only one third of predictions were precise, the four levels did broadly correlate with the typical condition of assets found. With caution, the model can be used to map areas of likely better or worse preservation.

Some additional caution must be expressed, however. The study is limited by incomplete information from ongoing HS2 fieldwork, depends on the reliability of industry-standard evaluation strategies and inevitably involves a degree of professional judgement by the author. Probably the figures provided here slightly understate the archaeology actually affected by this section of HS2.

The prediction assumed (simplistically) that the entire ‘red line’ consented development land within the study area (721 ha) would be subject to evaluation. In practice evaluation data is available for 473.1 ha (almost 66%) with the remainder assumed to have been descoped at desk-based assessment stage, either due to modern land use (e.g. roads) or minimal planned disturbance. This reduction in evaluation area implies predictions for the quantity of archaeology encountered should be reduced by about a third.

The evaluated area was divided into land covered by trial trenching (17 areas covering 304.7 ha) and ‘blank areas’ descoped after geophysical survey (12 areas covering 168.5 ha). Within the trial-trenched land assets were identified at 34 locations covering an area of 53.6 ha in total. Identifying and mapping the extent of ‘assets’ has required some professional judgement. All areas identified for mitigation were included as were some areas with obvious concentrations of features but where mitigation was not specified. The extent of assets is probably a modest under-estimate as investigations in certain locations do not yet have complete reports, while other areas may be subject to Construction Integrated Recording (CIR) in due course. Some mitigation areas clearly had features extending beyond the limits of investigation – albeit some allowance could be made for this. Furthermore, some assets could have been missed entirely but this is a rather different issue related to the reliability of industry-standard evaluation strategies – in practice what this study seeks to achieve is to predict what will be found by industry-standard evaluation and mitigation measures, accepting that these have limitations.

As archaeological management seeks to manage ‘significance’ rather than treating all physical remains equally, the identified asset sites were classified by the author (having regard to HS2’s assessments) as follows (Fig. 4.45):

- High significance (5 sites, 15.8 ha): assets of evidently high research potential and arguably national significance
- Medium significance (22 sites, 24.4 ha): well-defined assets broadly equivalent to Bucks ANA sites and with clear research potential

- Low significance (7 sites, 13.5 ha): other local concentrations of remains, likely of modest research potential

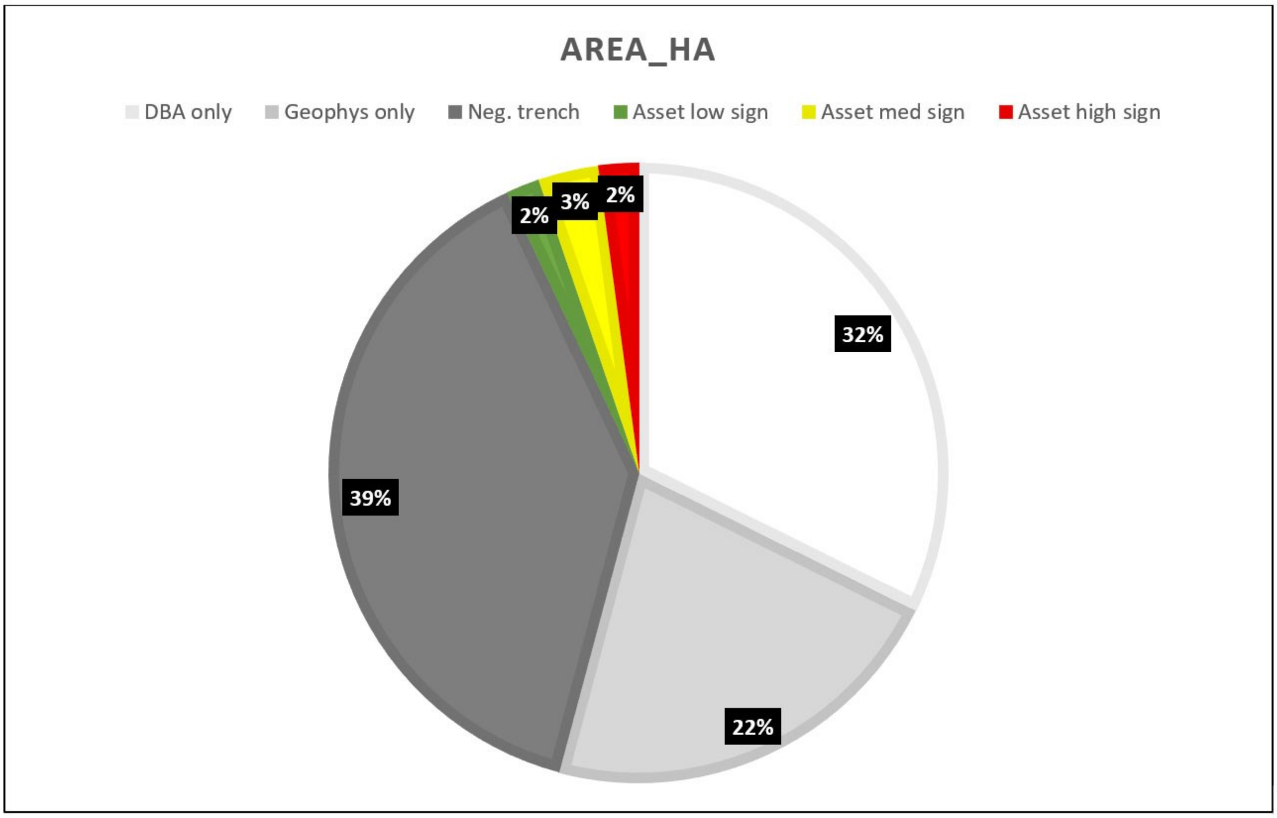


Figure 4.45: Extents of field evaluation and assets in the HS2 test area

4.8.1 Prediction 1: Overall coverage of archaeological assets

The presence of 53.6 ha of assets means that 7.4% of the consented area (721 ha) or, more meaningfully (since the unevaluated portion will presumably contain some as yet unidentified assets), 11.3% of the land evaluated contained assets of archaeological interest. The Vale of Aylesbury case studies indicated that for large greenfield developments between 5% and 20% (average 13.6%) of the development area would normally be expected to show substantive archaeological interest. The model therefore predicted the area of heritage assets requiring mitigation after evaluation as follows (Table 4.8):

Table 4.8: Estimated coverage of archaeological assets

Low estimate (5%)	***Average estimate (13.6%)***	***High estimate (20%)***
36 ha	98 ha	144 ha
Actual result: 11.3% of land evaluated contained an asset		

The actual result is towards the upper end of the low-to-average predicted range, but with the caveat that once ‘missing data’ is factored in the figure will likely increase slightly i.e. the model is successful, albeit it slightly overestimated the extent of archaeology. One explanation for why the HS2 result might be a little lower than predicted could be that there were more high-potential areas in the greenfield development sites used to build the model, but this does not actually seem to be the case as ANAs covered only 6.9% of the greenfield sites but 16.9% of the HS2 corridor.

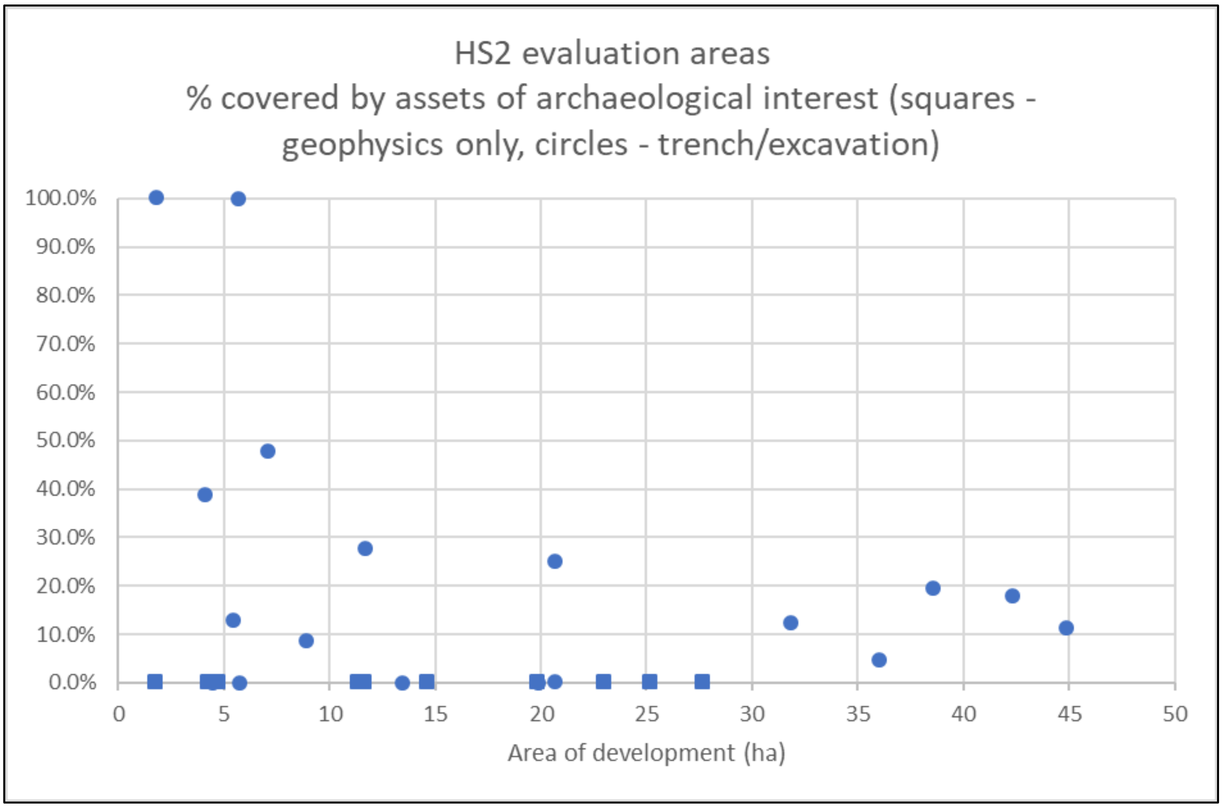
Individual evaluation areas show a pattern consistent with that observed in the greenfield case studies (Fig. 4.46). Larger sites (30+ ha) consistently return 5–20% archaeology. Smaller sites (particularly <10 ha) are much more variable with tendencies towards extremes, i.e. ‘hit’ or ‘miss’. This scale effect means prediction of overall archaeological coverage is possible in broad terms with larger sites but problematic with smaller ones.

4.8.2 Prediction 2: Condition of archaeological assets

Comparison of the predicted and actual observed condition of assets shows a broad correlation (Table 4.9). Thirteen of 34 predictions were on target with nine under-estimates and 12 over-estimates. The most common actual level was 2 (see Table 3.3) except where the predicted level was 1, in which case the most common actual level was also 1. However, although only just over one third of predictions were correct the mean actual condition does generally improve in relation to the prediction (except between predicted levels 2 and 3).

The model has performed best at identifying areas of exceptional or poor (below average) survival but less well at distinguishing the middle ground. Interestingly level 2 (fair condition) is found fairly evenly across all predicted categories.

The result lends support to the idea that systematic mapping of historic and modern land use can help predict general patterns and trends of asset condition but field investigation is essential to ground-truth the predictions due to local variations and limitations of inference from strategic datasets. Distinctions between levels 2 and 3 appear problematic and the two categories might simply be merged. However, future projects might seek to gain more local information on recent land use, for example using aerial photography and lidar to provide more accurate prediction. Better polygonised mapping of former ridge and furrow in the Central Province would be a good start; in the case study this simple expedient would probably have moved the two predicted level 3/actual level 1 cases into predicted level 2, improving the median performance of the model.



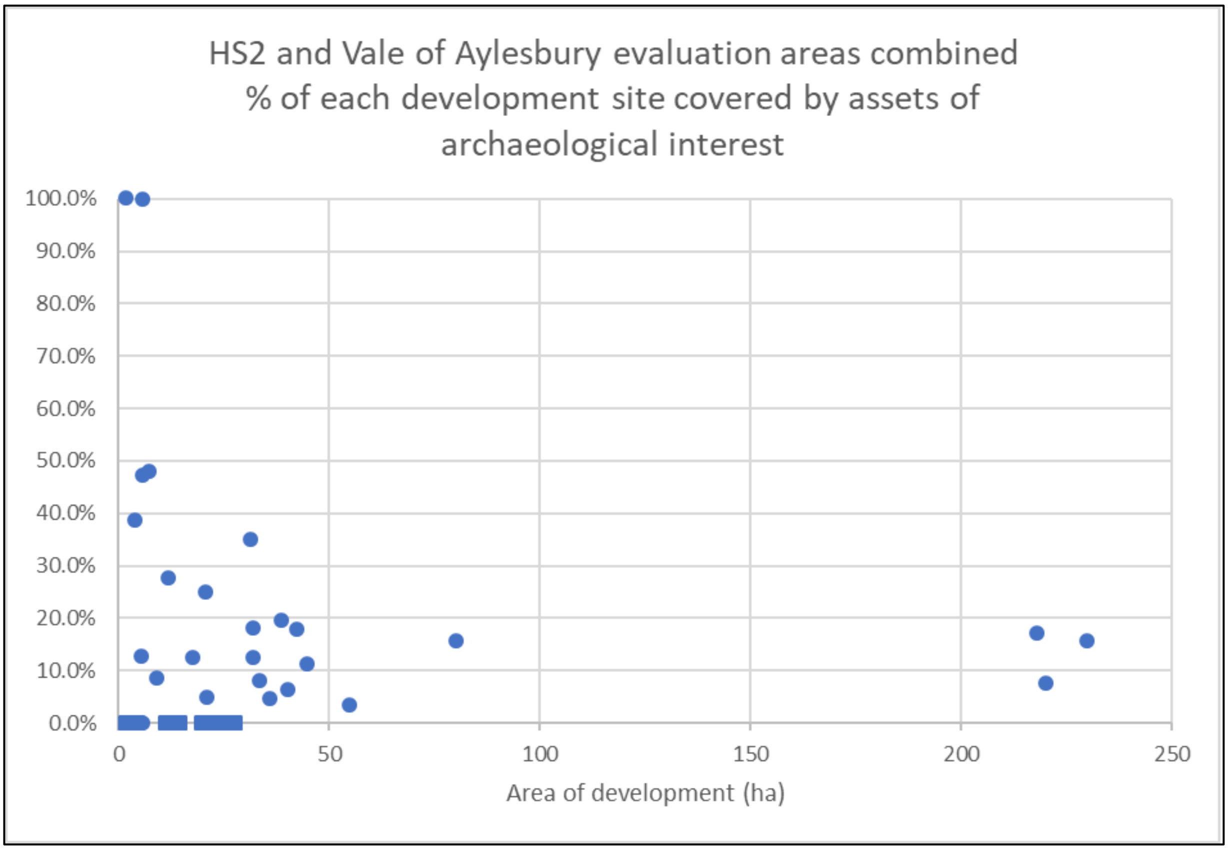


Figure 4.46: (a) proportion of HS2 evaluation areas covered by archaeological assets, and (b) combined with Vale of Aylesbury

Table 4.9: Comparison of the predicted and observed condition of assets

Actual Level	***Predicted - 4***	***3***	***2***	***1***
4	xx		x	
3	xx	x	xx	x
2	xxxx	xxxx	xxx	xxxxx
1		xx		xxxxxxx
Mean level	2.75	1.86	2.67	1.54
Modal level	2	2	2	1

4.8.3 Prediction 3: Periods represented

The model predicted the total numbers of assets expected with some indication of types (Table 4.10). As the model assumed the whole consented area would be evaluated its predictions ought to be adjusted pro-rata (i.e. reduced by one third) to allow for the actual evaluated area. Identification of discrete assets within excavated areas involves some professional judgement.

The actual results are consistently clearly at or above the upper end of the predicted ranges. This is not entirely unexpected as the lower predictions assumed asset densities based only on known assets. The high prediction assumed asset visibility of 10% for pre-conquest periods – an estimate that appears to be supported by the results, albeit hinting the real figure is perhaps slightly below 10%.

Table 4.10: Assets by period

Period	***Known archaeological assets (ANA) in 2013***	***Predicted range and location (without adjustment)***	***Actual***
Modern	None	None attempted as few identified in study area and none in HS2 corridor	Two sites reported significant modern archaeology associated with earlier assets
Post-medieval	2 comprising: 1 – Settlement 1 – Recreation + 1 LB	2–8 Substantive assets towards the lower end of this range Favourable predictors: conservation area, registered historic park, proximity to medieval church (400m), proximity to listed building (200m), post-medieval ANA and historic woodland (extant or former). Less favourable: land enclosed from open fields.	Nine sites reported significant post-medieval archaeology comprising 13 assets They were entirely located in the Stoke Mandeville and Wendover areas Half were agricultural and with the exception of St. Mary’s Church are mostly of low significance

Late medieval	4 comprising: 3 – Settlement 1 – Agricultural	1–15 Substantive assets at low end of range (1–4) Preferred at Hartwell, Stoke Mandeville, Putlowes and Wendover. Less favoured in former open fields.	Nine sites reported significant late medieval archaeology comprising 15 assets They were mainly located in the Stoke Mandeville and Wendover areas
Early medieval	None	1–4 Expected lower end of range as the HS2 route largely avoids known medieval cores	Two sites reported significant early medieval archaeology comprising 3 assets
Roman	5 comprising.. 1 – Settlement 1 – Transport 3 – Unclassified	5–36 Substantive assets towards mid-range (12–14) possibly including one 'special' monument type Preferred along road corridors. Less favoured south of Icknield Way and on clay-with flints.	Twenty-one sites reported significant Romano-British archaeology comprising 31 assets. The main concentration was around Fleet Marston ANA and within its road corridors. South of the Upper Icknield Way proved sparse.
Later prehistoric (MBA–IA)	1 – Defensive (Grims Ditch)	3–24 Substantive assets towards lower end of range (3–11) possibly including one 'special' monument type. No locational preference identified.	Eighteen sites reported significant LBA/IA archaeology comprising 29 assets scattered fairly evenly along the route
Neolithic/ Early Bronze Age	None	3–7 On limestone or chalk especially along Upper Icknield corridor. Not on mudstone.	Five sites reported significant Neolithic/EBA archaeology comprising 8 assets All bar one doubtful site is on chalk within c 1km of the Upper Icknield Way
Mesolithic	None	0–1 Probably no substantive assets but possibly some lithics Favoured locations on limestone or sand SE of Hartwell	Two sites reported small Late Mesolithic/Early Neolithic lithic assemblages, counted as 2 assets but not substantive remains Both sites in the Chilterns
Palaeolithic	2 Pleistocene faunal sites	Not applicable as period not assessed	No Palaeolithic artefacts reported but Pleistocene fauna from ANA south of Hartwell
Undated	None	No prediction made	Ten sites reported potentially significant undated archaeology comprising 10 assets. Only concentrations of undated assets were counted. There was no obvious pattern.

For all periods the model has done better at predicting the number of sites containing assets than the number of assets found (i.e. many of the sites contain more than one asset). It is not entirely clear why this is. The model has also successfully predicted the overall pattern of periods represented (Fig. 4.47), except that the undated assets were not predicted because they were rare in the Aylesbury case study dataset (in retrospect two or three could have been predicted, still well below the ten actually encountered). Typically undated assets might be considered of low significance but if only characterised by evaluation they might prove dateable and of higher significance on further investigation.

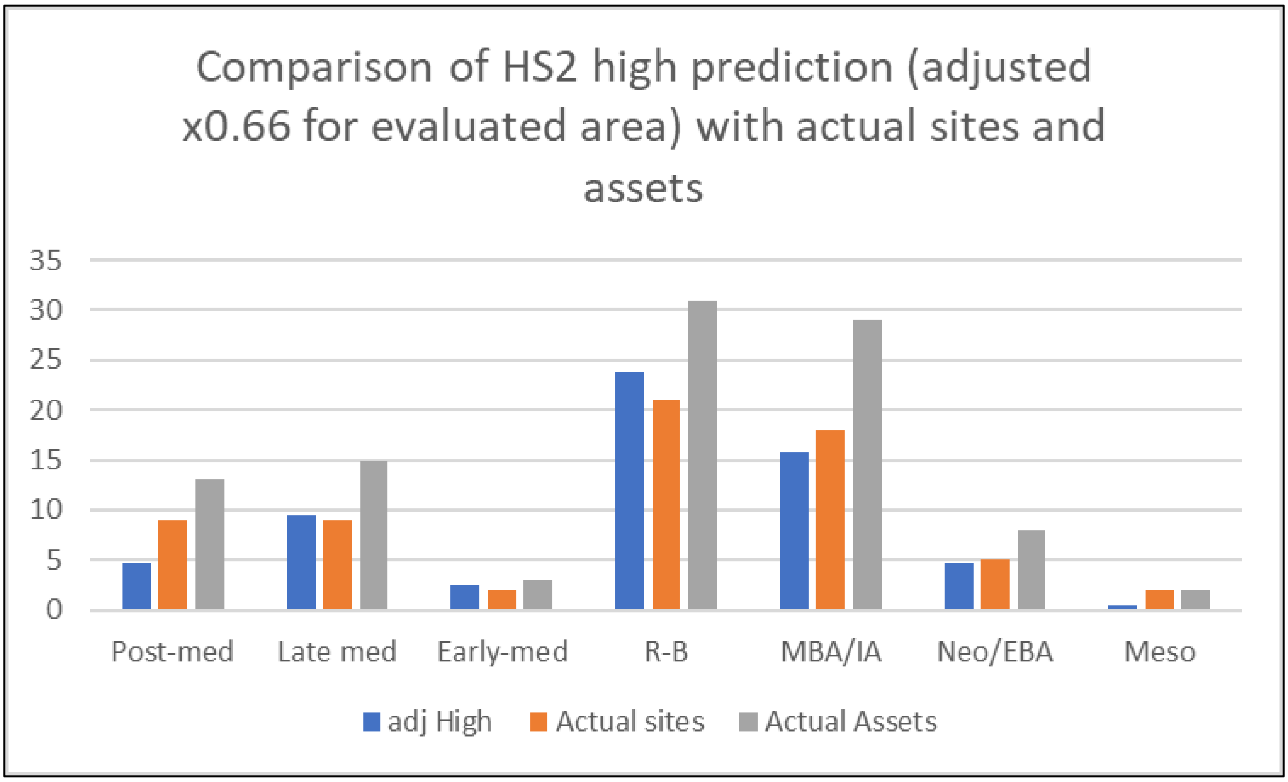


Figure 4.47: Comparison of HS2 high prediction with actual sites by period

Perhaps surprisingly the greatest discrepancy is in the post-medieval period where larger than expected numbers of low-significance assets were found. The two sites producing small numbers of possible Mesolithic lithics can be discounted as a meaningful discrepancy.

4.8.4 Prediction 4: Location of archaeological assets

The predictive model divided the HS2 corridor into four categories which can now be tested against where assets were found (Table 4.11). Archaeological Notification Areas proved successful as they contained more than a third of the assets (by area) but only covered one sixth of the corridor. Favoured areas outside ANAs showed a similar degree of enhancement. Taken together this means less than a quarter (23.8%) of the corridor could be identified as containing half (50.7%) the assets.

Table 4.11: Assets by land category

Presence level	***% HS2 corridor***	***% assets***
1. Archaeological Notification Areas	16.2%	34.6%
2. Favoured areas (outside ANAs)	7.6%	16.1%
3. Neutral/average areas	65.7%	43.3%
4. Less favoured areas	10.5%	6.0%

Factoring significance into the equation (Table 4.12) shows that assets of lower significance form a much higher proportion of assets found in neutral or lesser potential areas but on a cautionary note almost half the high-significance assets were found in areas of neutral (average) potential. The high-significance assets were either known or within the Chilterns AONB, which was highlighted for this potential. The analysis does not therefore provide support for early (premature) descoping prior to field evaluation because of these highly significant new discoveries.

Table 4.12: Proportions of assets of different significance in each land category

Significance	**High**	**Medium**	**Low**	**Total**	**%**
ANA	7.70	8.98	1.86	18.54	34.6
Favoured	2.12	5.70	0.81	8.63	16.1
Neutral	8.65	6.85	7.65	23.15	43.3
Less	0	0	3.20	3.20	6.0
	18.47	21.53	13.52	53.52	

Turning to specific locational indicators (Fig. 4.48), geology is confirmed to have little predictive power for overall asset distribution, although as noted above there do seem to be a few periods when it does – the Neolithic/Early Bronze Age avoidance of clay being the most obvious.

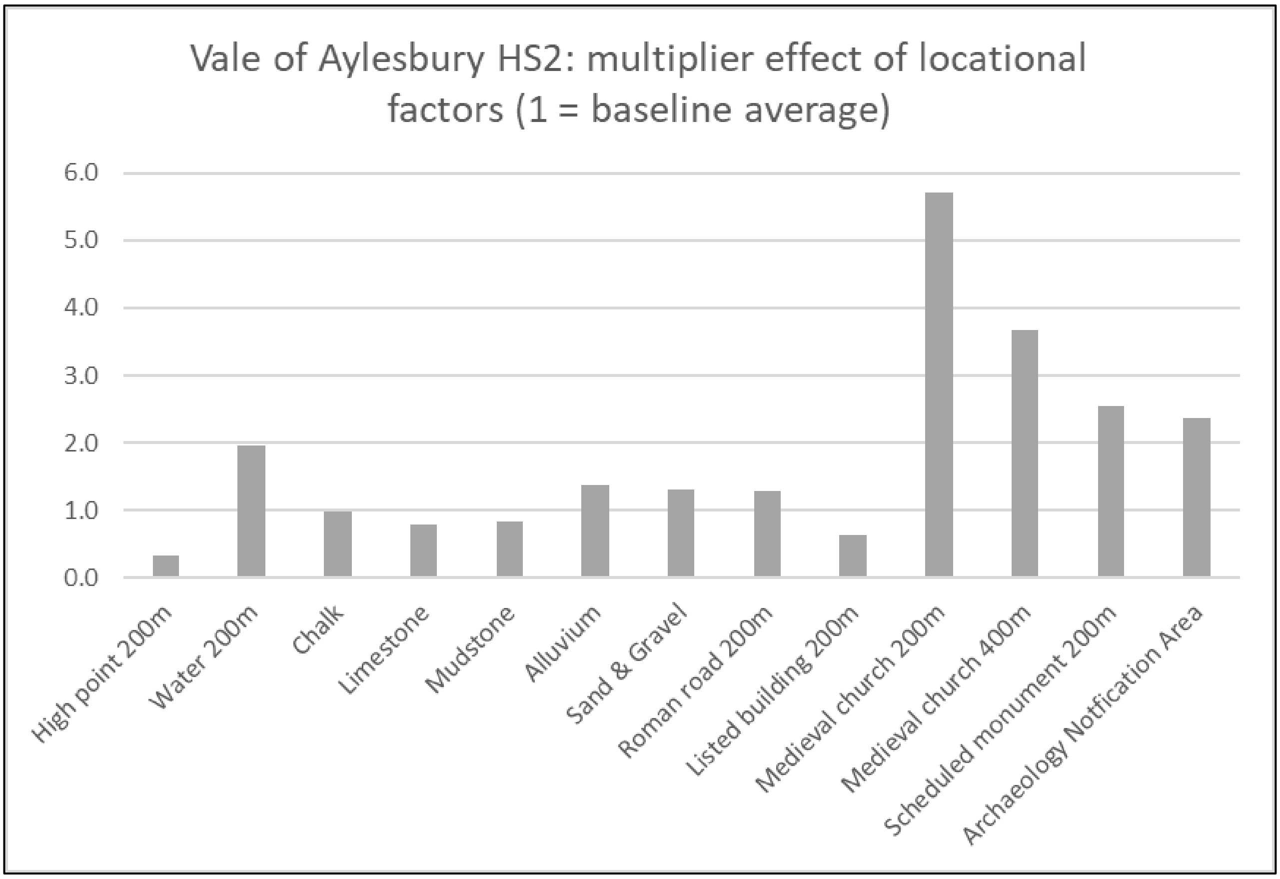


Figure 4.48: Multiplier effect of different locational factors

5 London Gateway results

5.1 The study area

London Gateway was chosen for the second pilot study mainly because it offered useful contrasts with the first pilot study, in the Vale of Aylesbury (section 4), and because the local authority archaeologists supported the study. The most notable contrasts between the two pilot study areas are:

- London Gateway is coastal whereas the Vale of Aylesbury is inland.
- London Gateway lies firmly within the South-Eastern historic landscape, sometimes characterised as ‘ancient’ or ‘woodland’ in contrast to the ‘planned’ or ‘champion’ landscapes of the Midlands.
- London Gateway has extensive alluvial areas whereas the Vale of Aylesbury includes a substantial block of chalk ‘hill country’.
- London Gateway has extensive pre-medieval cropmark landscapes recorded by the National Mapping Programme.
- The Vale of Aylesbury has a protected landscape (the Chilterns AONB) and was relatively little impacted by 20th-century development away from the main towns, whereas London Gateway has been affected by major industrial, military, mineral extraction and landfill works.
- Buckinghamshire operates a ‘notification map’ system for archaeological assets whereas Essex has area-based archaeological assessments.

Away from the existing settlements the study area is largely designated as greenbelt but it is also an area of intense development pressure for port facilities and the route for a new Lower Thames river crossing runs through the area. Along with the rest of the Thames Estuary it is an area of flood risk, particularly relating to sea-level rise and flood surges. The north-western part of the study area lies within the Thames Chase Community Forest, established in 1990, which covers c 100 km^2. Its aim over 40 years is to plant 5.5 million trees and turn 30% of the area into woodland.

The study area is roughly rectangular (31.5 x 14.2 km) and covers 16,406 ha (Fig. 5.1). It lies entirely within the modern and historic county of Essex, mainly in Thurrock but taking in small parts of the neighbouring districts of Brentwood, Basildon and Castle Point. Its boundaries are defined by the Thames Estuary to the south, Greater London and the built-up area of Grays to the west, and the A127 and the southern edge of Basildon built-up area to the north. The eastern boundary stops short of Benfleet Creek and cuts across Canvey Island but includes Holehaven Creek. The area straddles two National Character Areas: the Greater Thames Estuary and Northern Thames Basin (Fig. 5.2).

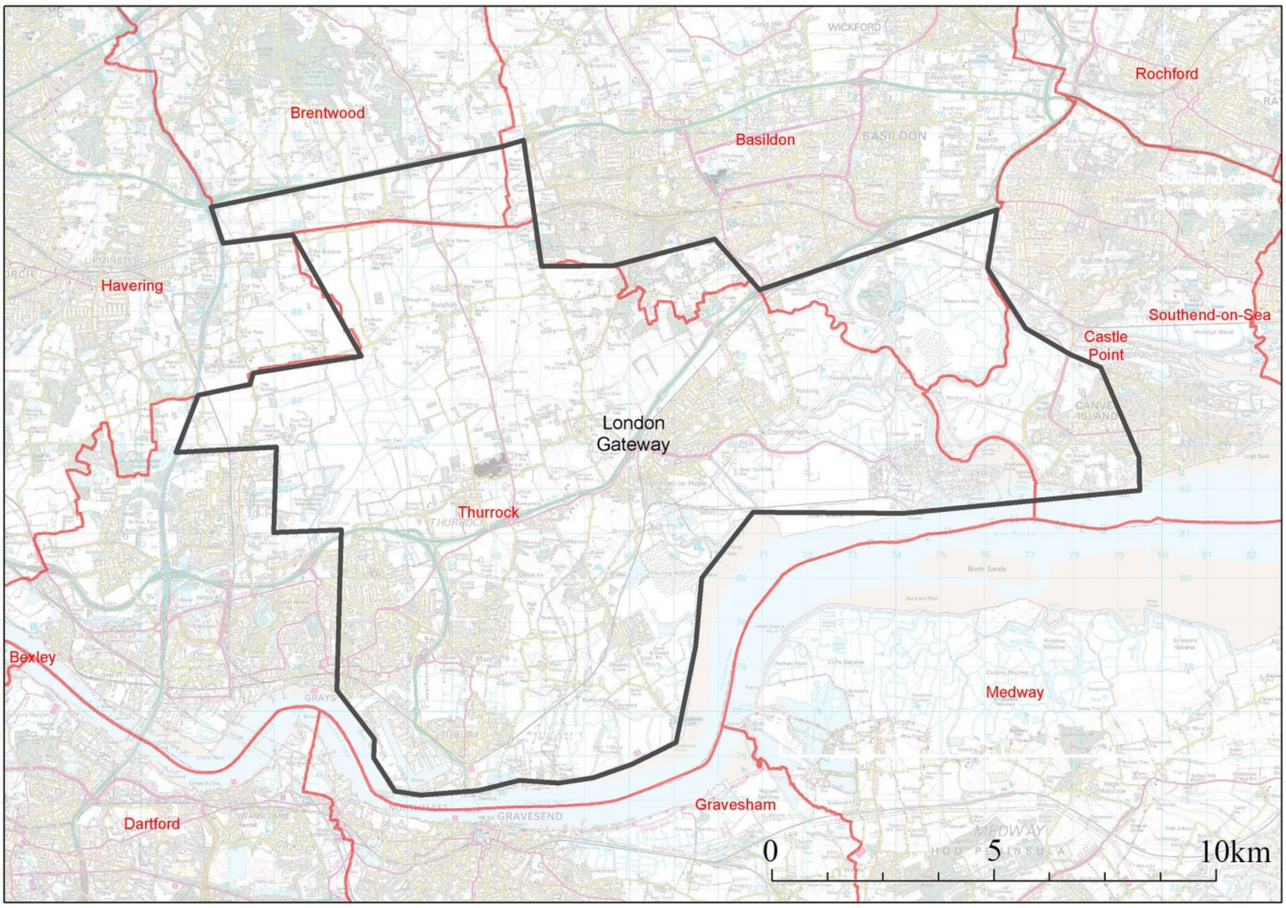


Figure 5.1: London Gateway study area. Base map © Crown Copyright [and database rights] 2023. OS 100024900.

The geology of the study area is summarised in Table 5.1 and Fig. 5.3. Note that in places the surface geology has been altered by modern quarrying and landfill but these changes have not been adjusted for in the model.

The study area lies within the much wider area of the Lower Thames Estuary covered by the Thames Gateway Historic Environment Characterisation (Chris Blandford Associates 2004) which defined Historic Environment Character Areas (HECAs). This study led on to the Greater Thames Estuary Historic Environment Research Framework (Heppell 2010). Regional synthetic studies are also available for all periods prepared for the East of England Regional Research Framework[23] and for the Iron Age to medieval periods (Rippon 2018). National studies, notably the Atlas of Rural Settlement in England (Roberts

[23] https://researchframeworks.org/eoe/

and Wrathmell 2003), the Roman Rural Settlement Project (Smith *et al.* 2016) and EngLaId (Gosden *et al.* 2021), provide invaluable context. Essex is also well served by archaeological resource management studies: it has full HLC coverage (Bennett 2011a) and was covered by National Mapping Programme aerial survey (Ingle and Saunders 2011). Other relevant resources include a survey of Historic Coastal Grazing Marshes (Gascoyne and Medlycott 2014) and a study of the county's potential for Palaeolithic archaeology (O'Connor 2015).

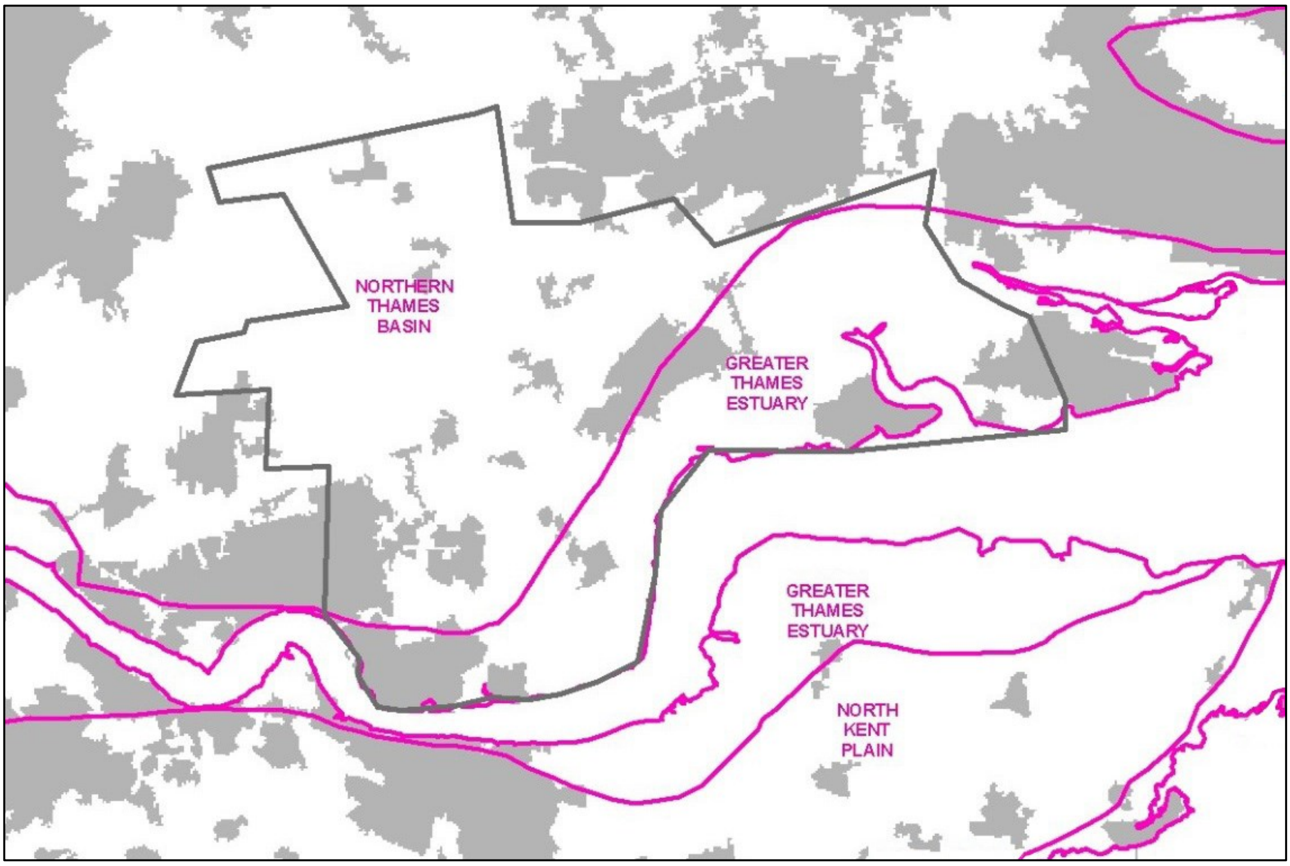


Figure 5.2: London Gateway study area and National Character Areas

Table 5.1: Simplified surface geology classification

	Type	***Comprises Codes BGS_LEX***	***Notes***	***Area (ha)***
Superficial geology	Sand & Gravel	BPGR, BHT, GFDMP, LHGR, KPRG, RTDU, RTD3, RTD4, STGR, TPGR	Black Park, Boyn Hill, Lynch Hill, Kempton Park and Taplow river terrace gravels	2174.8
	Head	HEAD		4650.3
	Alluvium	ALV		2693.7
	Coastal	TFD, TRD, BTFU	Mixed Beach, Tidal Flat and River Deposits	3640.9

	Silt	ILSI	Ilford Silt	17.5
Bedrock geology	Chalk	LSNCK		69.7
	Mudstone (clay)	CLGB, LC, LMBE	London Clay and Lambeth Group	2818.1
	Sand	TAB, BGS, HWH	Bagshot and Thanet Formations	340.9

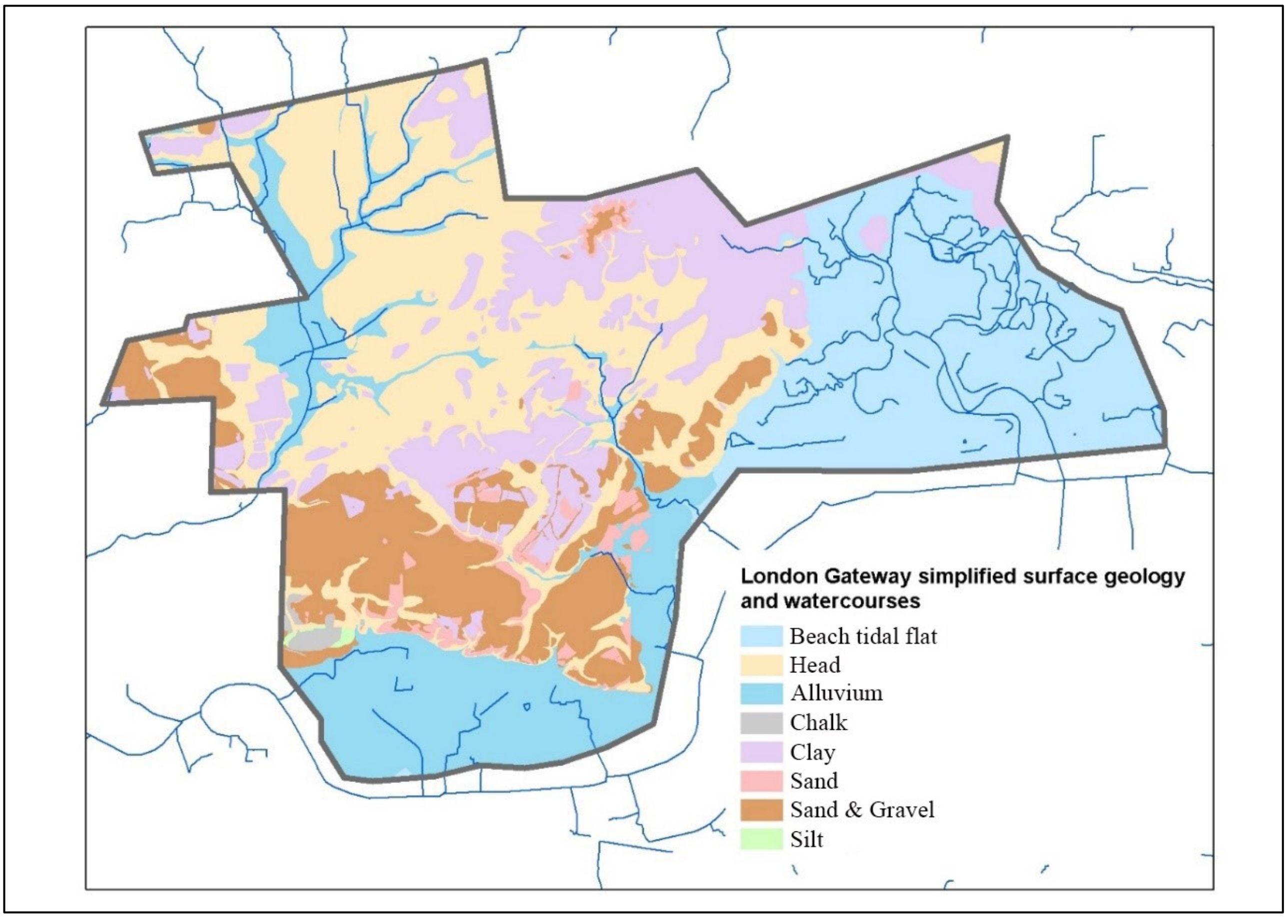


Figure 5.3: London Gateway surface geology (derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.) and watercourses

Essex County Council Archaeology Service completed a Historic Environment Characterisation Assessment for Thurrock (Essex County Council 2009) and have also done one for Basildon. These assessments subdivide the HECAs defined by Chris Blandford Associates (2004) into Historic Environment Character Zones (HECZs; Fig. 5.4) for which historic urban/landscape and archaeological character are described and scored by professional judgement against seven criteria derived from the Secretary of State's non-statutory criteria for assessing monuments for scheduling:

- Diversity of historic environment assets

- Survival
- Documentation
- Group value association
- Potential
- Sensitivity to change
- Amenity value.

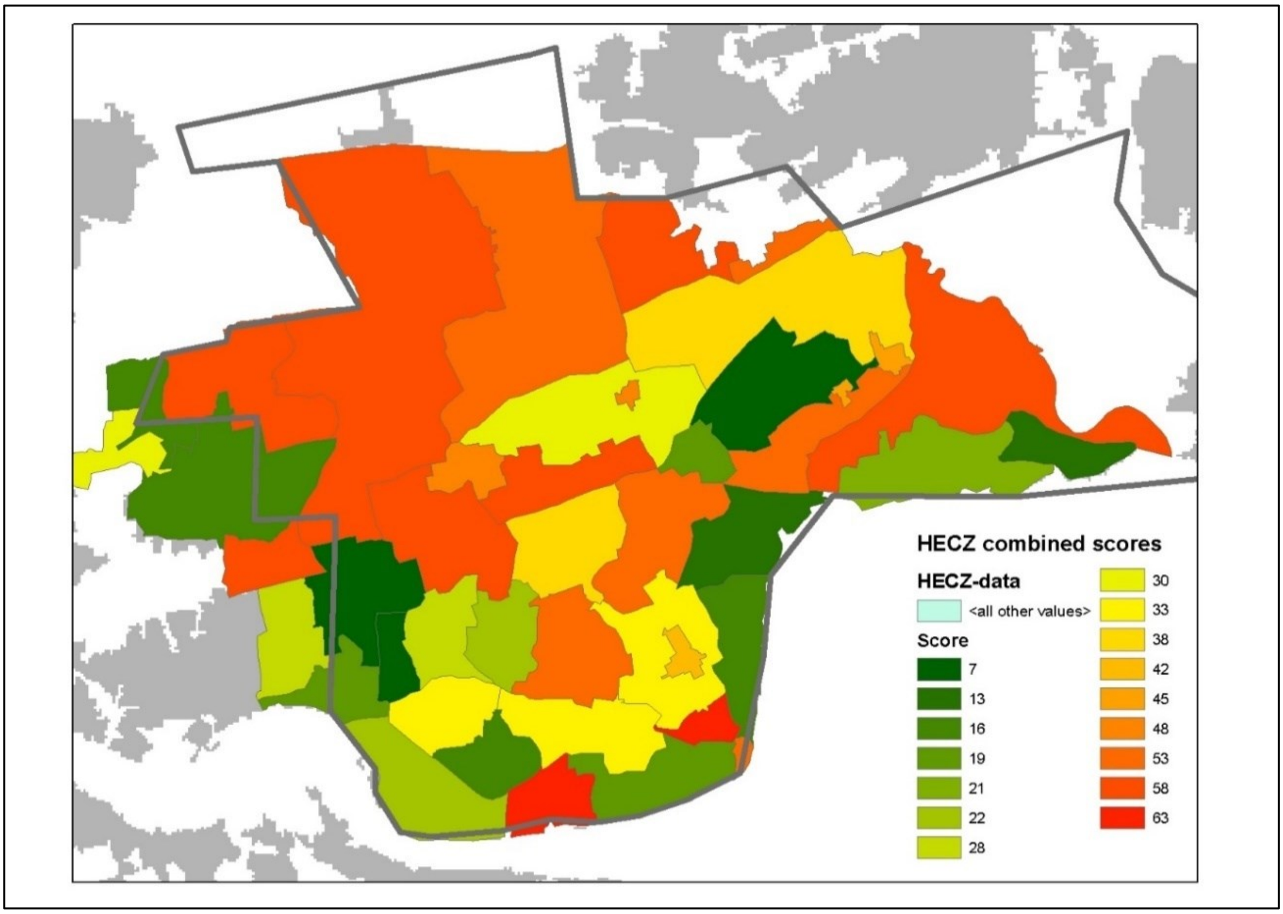


Figure 5.4: Thurrock Historic Environment Character Zones (HECZ) combined scores

Each of the seven criteria was scored on a scale of 1–3 but combined scores were not calculated in the Essex CC report. The methodology used here follows the MPP in squaring each criteria score, then adding them together to give a total between 7 and 63, as shown on Fig. 5.4. In the context of sensitivity mapping, diversity of assets and group value loosely equate to presence, documentation relates to the visibility of assets, survival to condition, and amenity value and sensitivity to opportunity and vulnerability respectively. One important difference is that the HECA method encompasses the whole historic environment whereas this study is focussed on archaeology.

To test the methodology, the pilot study has deliberately not incorporated the latest results from the Lower Thames Crossing and ongoing development-led investigations, which will be used in a similar way to the HS2 results in the Vale of Aylesbury (4.8). Thus the ‘current’ situation referred to in this paper can be thought of as broadly the late 2010s.

5.2 History of archaeological investigation and state of knowledge

Modern archaeological investigations in the Lower Thames began as rescue excavations carried out the 1960s to 1980s, mainly prompted by mineral extraction or infrastructure development (Williams and Brown 1999, 3). By far the largest and most important of these investigations within the study area was that at Mucking, carried out between 1965 and 1978. Interest in the intertidal zone prompted coastal surveys from the late 1980s whilst the Essex Mapping Project (1993–2003) documented the county’s rich cropmark resource recorded by aerial photography. From the 1990s developer-funded investigations have become the norm, although as yet only one large-scale investigation, at Stanford Wharf Nature Reserve for the London Gateway Port, has been published (Biddulph *et al.* 2012).

For the present study, the Essex HER provided GIS ‘Event’ datasets in a combination of point and polygon format. Recent investigations are mapped as polygons (except for very small projects) but older events were recorded as points (Maria Medlycott, pers. comm.). In practice the study area event data was dominated by points (227), with only 38 polygons. Therefore, unlike the Vale of Aylesbury study (4.2), it was not possible to reliably estimate the proportion of the study area investigated by different methods. This data was manipulated to remove desk-based research and non-archaeological events and to classify fieldwork using the simplified investigation types defined by the EngLaId project (Table 5.2; Gosden *et al*. 2021, table 2.3). As most of the case studies did not have polygonised events these were added as well. Unfortunately the limited data available for some events caused some uncertainty, particularly between open-area and keyhole investigations recorded as point data. As a consequence some open-area excavations will have been classified as keyholes on a precautionary basis.

This analysis suggests that over 8% of the study area has been subject to some form of archaeological ground-based investigation recorded on the Essex HER, assuming a nominal 50 m radius for point events outside polygons. This is just over half the level of investigation recorded for the Vale of Aylesbury pilot study (14%); both exclude aerial survey. From these events, six case studies were identified covering 829.6 ha (5.1% of the study area; Appendix 3). Investigation is spread unevenly across the study area with most focussed in the south (Fig. 5.5).

Table 5.2: Categorisation and quantification of investigations (source: adjusted Essex HER data)

Code	***Simplified EngLald investigation type***	***Number***	***Est. area (ha)***
1	Intrusive: open area excavation (inc. strip, map and sample)	12	
2	Intrusive: keyhole (evaluation trenches, test pits etc.)	171	
3	Non-intrusive survey (geophysics, aerial, earthwork)	21	
4	Fieldwalking/metal detecting	3	
5	Other (includes historic building recording)	49	
6*	Preservation in-situ (decision to preserve identified archaeology within development)	Not identified	
Deleted	Desk-based research, syntheses	8	
Total	Land in the study area subject to any form of investigation	264	>1292 (>7.9%)

Note: investigations sometimes overlap giving a higher figure for total coverage of investigations than for all land covered by any investigation

**not recorded in Essex HER or EngLaId but added for this study*

Figure 5.5: Archaeological investigations recorded as points and polygons

5.3 Character of the archaeological resource

The intention of this section is not to reiterate published syntheses; rather it is to attempt to quantify what we know about that subset of the archaeological resource which has (or potentially has) some strategic significance. As Thurrock does not have archaeological planning alert maps this posed a greater challenge than it did for the Vale of Aylesbury because the totality of the HER had to be considered to identify prospective known heritage assets of archaeological interest (see 5.6 below). It is then necessary to consider what we might infer from this data about as yet undiscovered assets, a process that relies on the assumption that the known dataset is a useful, albeit imperfect, indicator of the undocumented dataset.

5.3.1 Categories

In order to analyse known assets they have been allocated to ten broad periods (including ‘undated’) and eight types (including ‘unclassified’), enabling data to be expressed as a grid (Table 5.3).

Table 5.3: Categorisation and quantification of assets

Period	Settlement	Agriculture	Industry	Transport	Religious/ Funerary	Defensive/ Military	Recreation	Unclassified	**Total**
Modern	0	0	4	0	0	18	0	0	**22**
Post-medieval	11	2	11	1	14	9	1	5	**54**
Late medieval	37	4	4	1	17	1	1	2	**67**
Early medieval	9	1	0	0	0	0	0	1	**11**
Roman	8	0	12	0	3	0	0	0	**23**
Later Prehistoric	12	3	0	0	3	7	0	0	**25**
Neolithic/Early Bronze Age	2	0	0	0	27	0	0	2	**31**
Mesolithic	0	0	0	0	1	0	0	1	**2**
Palaeolithic	0	0	0	0	0	0	0	1	**1**
Undated	3	3	6	1	0	2	0	79	**94**
Total	**82**	**13**	**37**	**3**	**65**	**37**	**2**	**91**	**330**

The overall known asset density is 2 per km^2 and some patterns emerge (Fig. 5.6). Palaeolithic and Mesolithic archaeology makes a numerically minor contribution to the known assets but all other periods are fairly well represented and undated sites noticeably make up about 30% of the resource. The prevalence of undated assets is a product of aerial survey. Most types of asset are well represented, with the exceptions of agriculture, transport and recreation. However, agriculture and transport are surely greatly under-represented as field systems and trackways have been 'hidden' under other categories, including unclassified cropmarks.

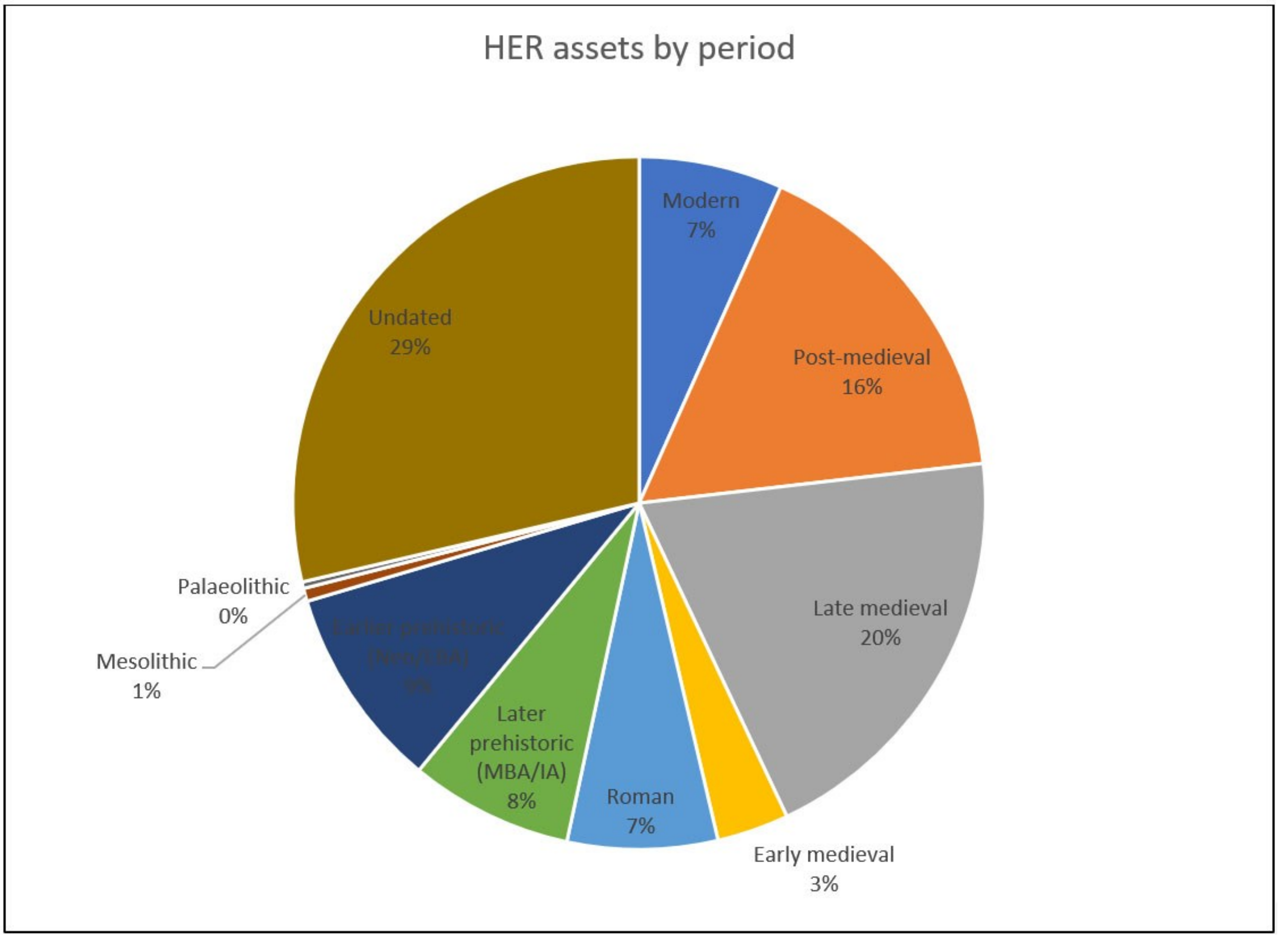


Figure 5.6: HER assets by period

Interestingly the overall HER pattern is different from that seen in the case studies (Fig. 5.7), where the undated category is absent and pre-11th century AD periods dominate, reflecting the location of these sites mostly away from historic settlements. The asset density observed in the case studies is much higher at 13.75 per km^2 . Taken at face value this might suggest that only about 15% of the actual resource is known but in part the discrepancy can probably be put down to the finer distinctions that can be made from published excavation reports compared to HER entries, so this is a minimum estimate.

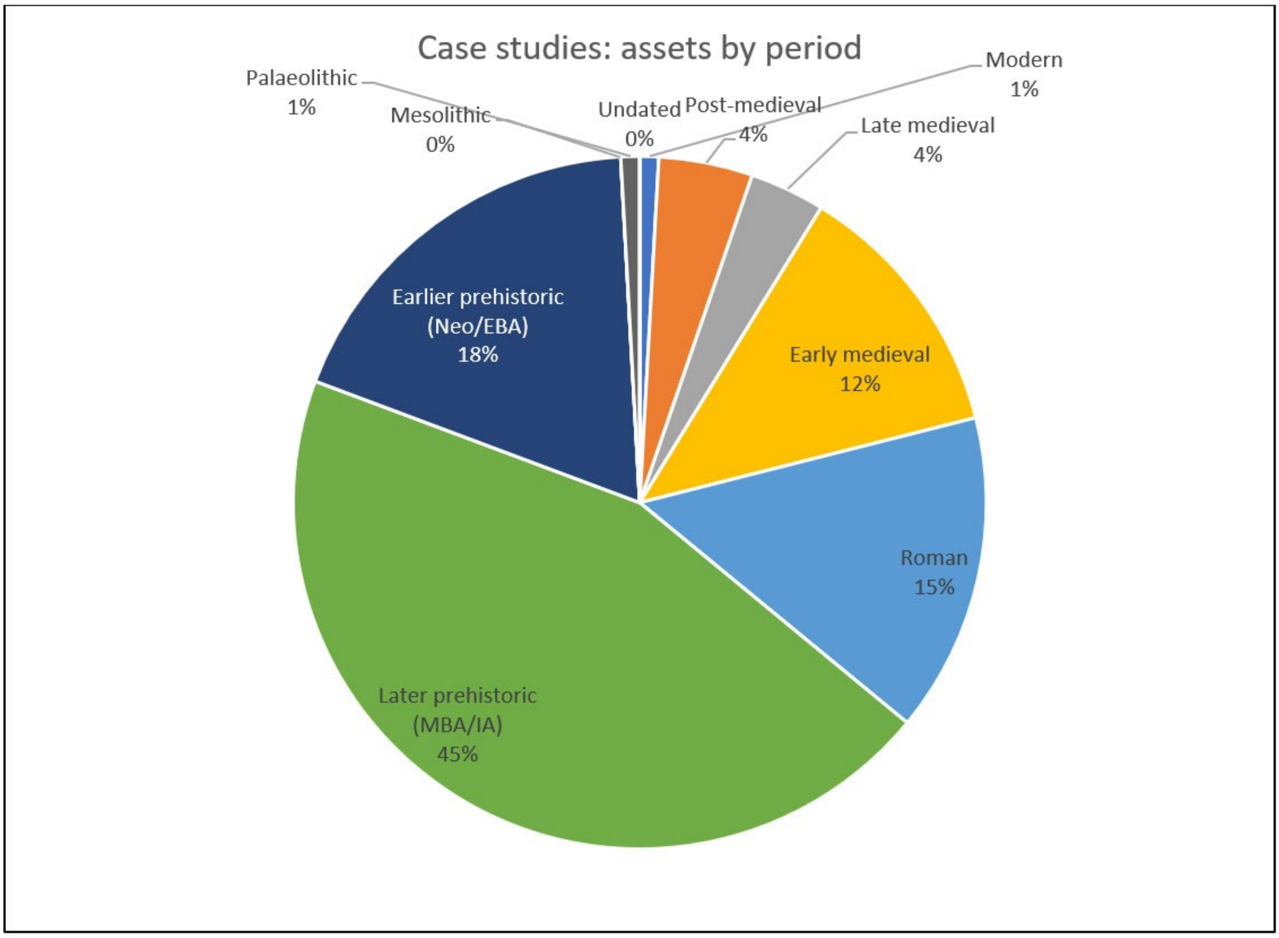


Figure 5.7: Case study assets by period

When considering strategic issues it is helpful to identify key monument types which are particularly relevant whether because of their frequency within the study area, their good condition or high significance. This scoping exercise for the London Gateway, largely based on the Thurrock Historic Environment Characterisation Project report (Essex County Council 2009) runs as follows:

5.3.2 Palaeolithic

London Gateway has benefited from a recent comprehensive assessment by the ‘Managing the Essex Pleistocene’ project. In overview that project concluded that:

> The county of Essex contains some of the most significant sites of national importance for the correlation of Pleistocene history across Europe. The Pleistocene deposits of the lower reaches of the River Thames and its tributaries are of international significance; they form a framework for this part of the geological record in Britain, and they have important links with the glacial stratigraphy of East Anglia, the fluvial stratigraphy of the Rhine

> and Seine and the terrace sequence can be correlated with the global climatic stratigraphy. (O'Connor, 2015, 4)

The project defined Lithological Units (LUs) and categorised the potential of each area as Very High, High, Medium, Low, Zero or Uncertain using defined criteria. There are no areas of very high potential within the study area but large areas of medium and high potential in a central-southern zone broadly correlating with, although not limited to, the Lower Thames gravel terraces (Fig. 5.8).

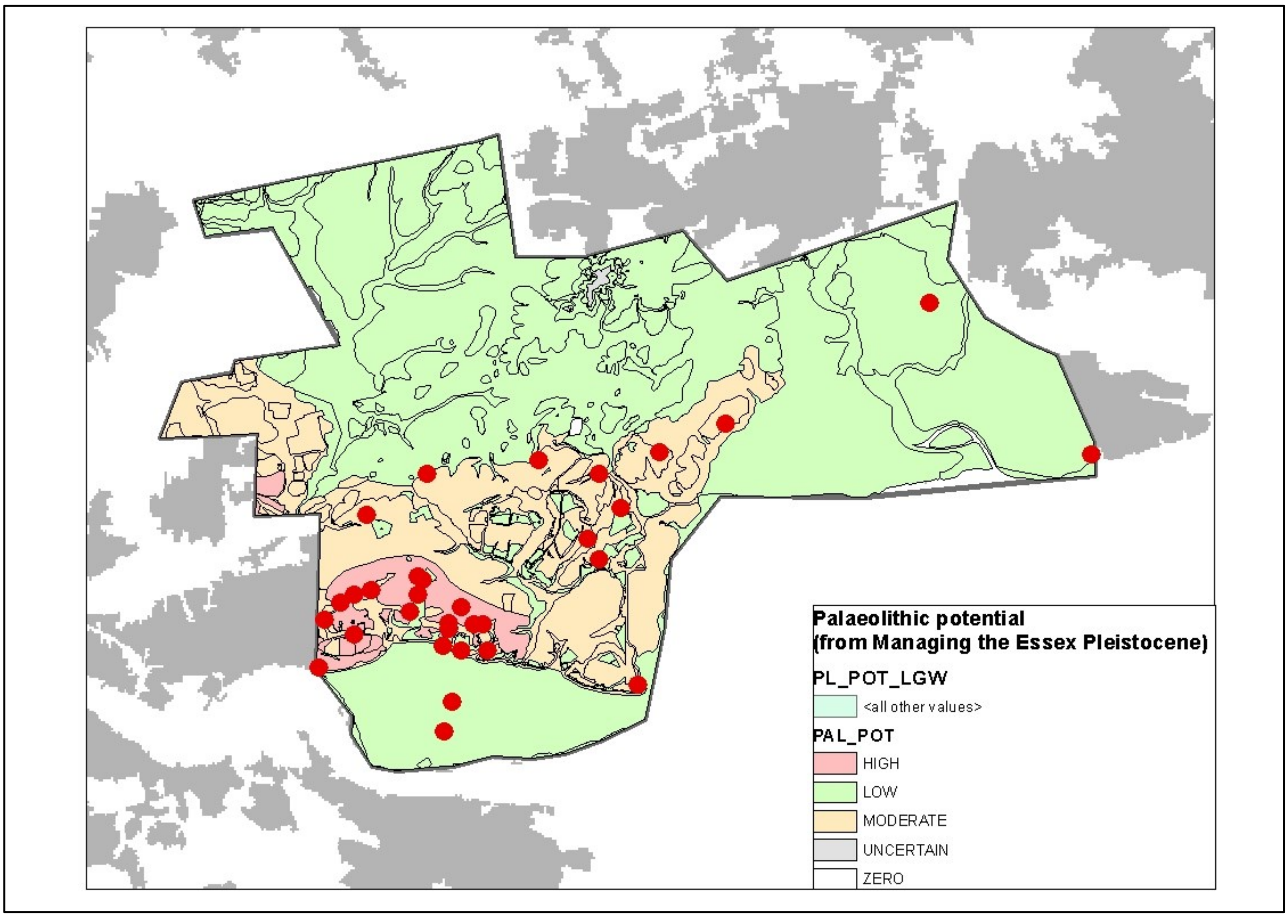


Figure 5.8: Palaeolithic findspots and potential

5.3.3 Mesolithic

The Thurrock HEC report notes 'sporadic finds' of Mesolithic material across the area and goes on to explain the context of sea level rise creating a complex Holocene stratigraphy under the marshes of the Thames foreshore. The potential for new discoveries of Mesolithic sites was illustrated at Tank Hill Road on the CTRL route, just west of the study area, where a well-preserved Late Mesolithic–Early Neolithic transitional campsite was found.

Within the study area the Essex HER records 20 Mesolithic findspots (Fig. 5.9). Their main focus is along the gravel ridge between Grays and Stanford-le-Hope. Five were considered sufficiently well-defined and significant to merit recording as HER polygons; this includes one nationally very rare findspot of Mesolithic human remains (from alluvial deposits at Tilbury). However, the study area planning case studies have hardly any Mesolithic archaeology, only a few ‘stray finds’.

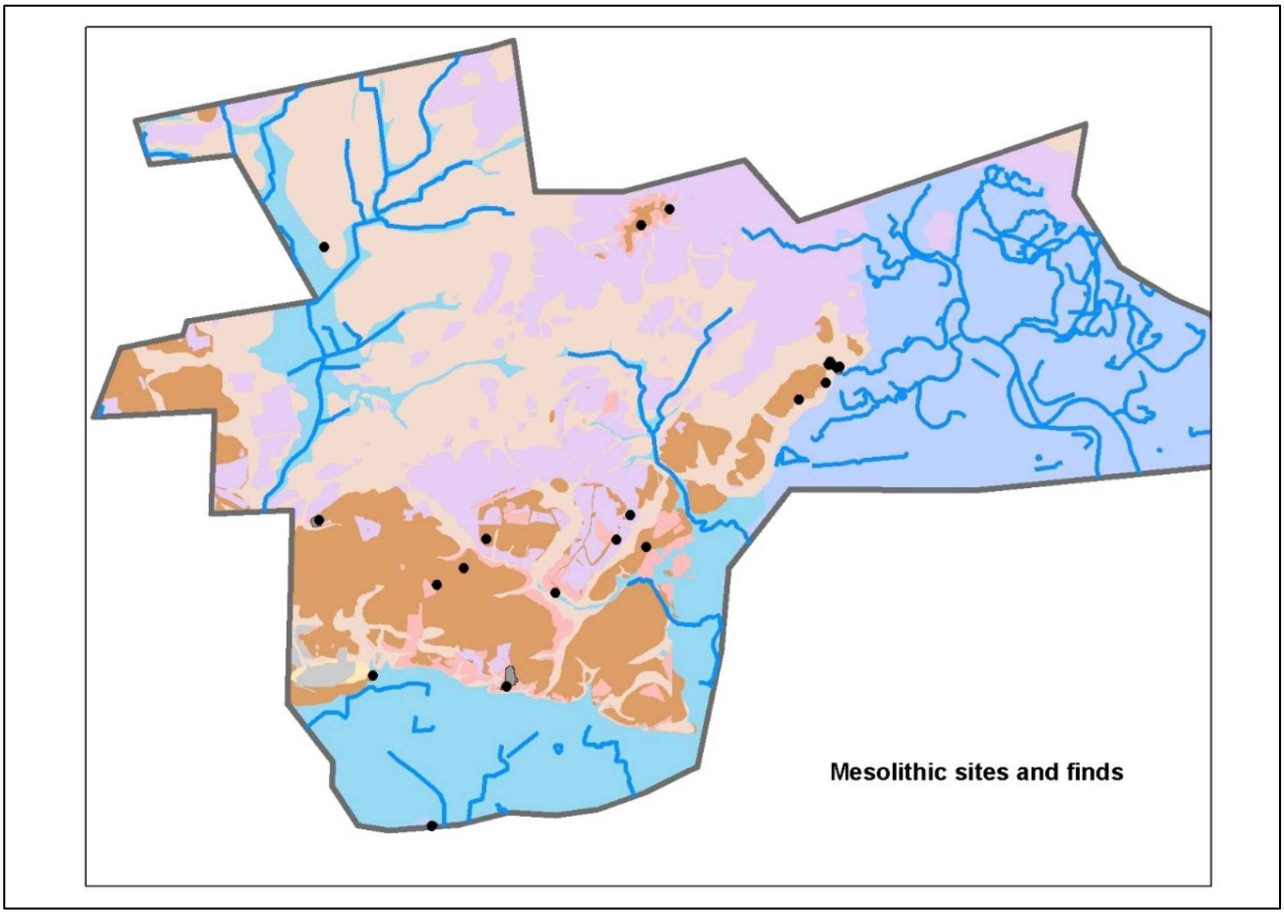


Figure 5.9: Mesolithic findspots on a background of geology (see Fig. 5.3; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved) and watercourses

The East of England Research Framework observes that ‘although excavations continue to routinely recover small quantities of Mesolithic lithics, major discoveries remain rare.’ It highlights the role of predictive modelling, and the Holocene sequences of river valleys, coastal and offshore areas as having potential for such deposit modelling studies (Billington 2020).

It therefore appears that a ‘background signature’ of occasional Mesolithic flints can be expected across the landscape but substantive Mesolithic occupation sites (normally lacking deep cut features) within arable land will long ago have been reduced to ploughzone artefact scatters, unless they are sealed beneath alluvium. In-situ Mesolithic sites (i.e. sites with surviving features and/or artefacts in or close to their original positions of deposition) are most likely to be found in locations that have avoided or been protected from cultivation, such as the alluvial riversides or the coastal zone – such sites are potentially of national significance.

The density of known substantive Mesolithic occupation sites in the London Gateway is therefore rated as 'rare' (1–10 per 100 km^2) but taking account of the very poor visibility of this period and the obscuring effect of the alluvial/coastal deposits the actual density of in-situ sites could be higher. On this evidence it is suggested that the gravel ridge and the alluvial/coastal deposits present the best opportunity for new discoveries, with the latter least well understood but having the greatest potential.

Conclusion: at present the known Mesolithic of London Gateway makes a minimal contribution to archaeological sensitivity in relation to strategic planning decisions. However, as noted in the East of England Research Framework (and illustrated by the Stanford Wharf case study) deposit modelling is necessary to understand the potential of the alluvial/coastal deposits where Mesolithic sites of national importance could survive.

5.3.4 Neolithic and Early Bronze Age

For the Neolithic the main monument is the scheduled causewayed enclosure at Orsett Cock (Hedges *et al*. 1978). For the earlier Bronze Age round barrows are the main monument type, mainly recognised from aerial photography, although eight were encountered in the 18 ha excavated at Mucking. Lithic scatters and pit clusters indicative of settlement were also recorded at Mucking (Evans *et al*. 2016). Sites of these periods are shown on Fig. 5.10.

Saunders (in Ingle and Saunders 2011, 18) notes that four causewayed enclosures are known in Essex and that there are 34 mapped prehistoric sites within a 1 km radius of Orsett Cock, most of which are ring-ditches; other sites include enclosures and trackways (Fig. 5.11). Although none of the round barrows and trackways are identified as Neolithic it may be specifically due to the existence of the Neolithic site that the round barrows were built. Saunders (in Ingle and Saunders 2011, 23) also reports 21 mortuary or long enclosures in Essex (plus a further 18 possible examples). One of these is recorded within the study area and should be flagged as potentially of national significance. Cursus (two) and henge monuments are also recorded in Essex; none are known from the study area but new discoveries should not be ruled out, especially of Neolithic circular monuments (so-called 'hengiforms') which can easily be confused with barrow ring-ditches.

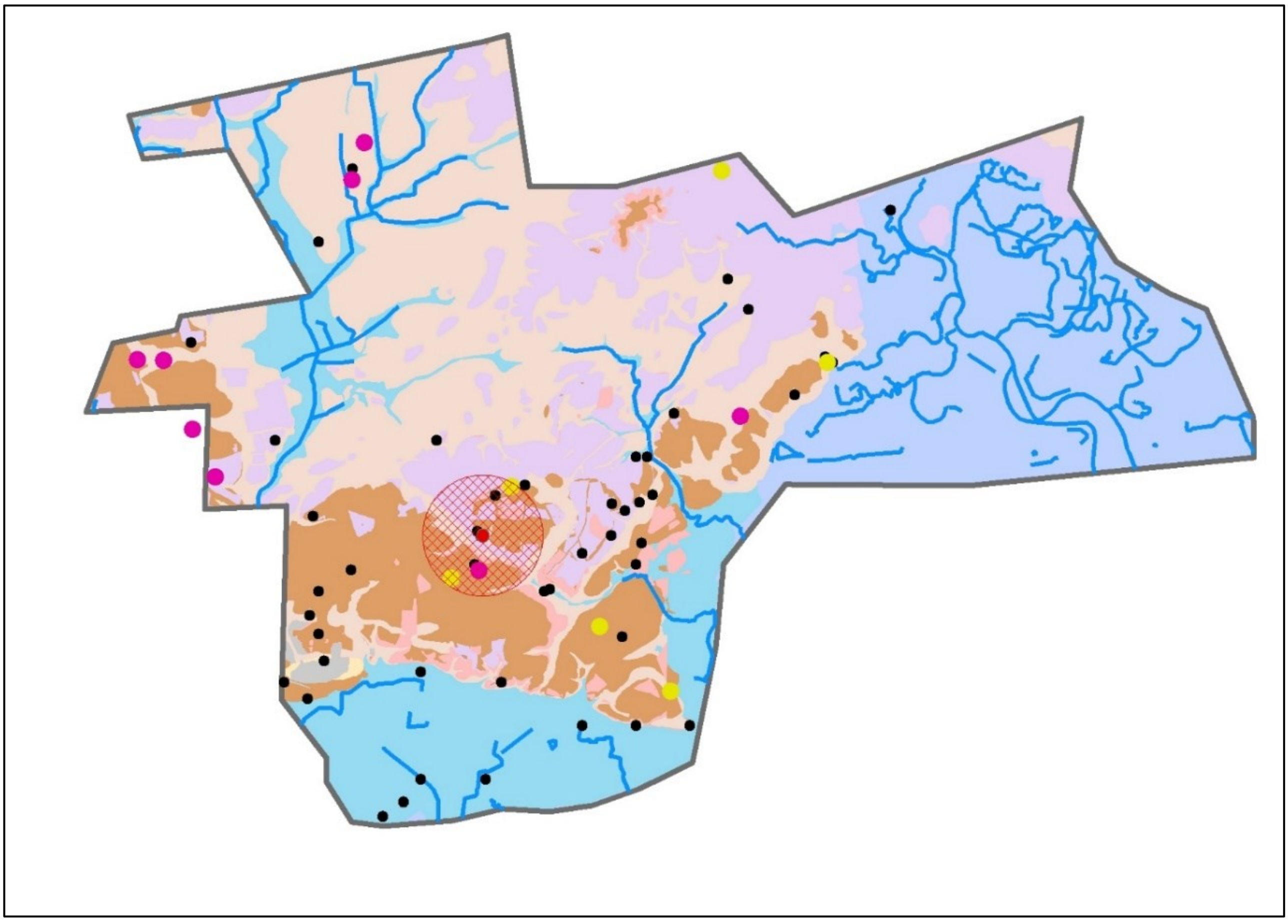


Figure 5.10: Neolithic–Early Bronze Age monuments overlain on geology (see Fig. 5.3; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved): purple = religious (burial/ceremonial monuments); yellow = unclassified (mainly lithic scatters); black = other point records

There are only 24 round barrows still upstanding in Essex but ring-ditches are much more common. 684 round barrow or ring-ditch groups were recorded in the Essex HER in 2012 and 1605 ‘circular or sub-circular enclosures’ were recorded in the NMP project (these will not all be early prehistoric but the majority probably are ploughed-down round barrows). Subregional variation is noted across Essex, with larger clusters of round barrows in the east of the county mainly concentrated in the river valleys, only a few of which are more than 500 m from a watercourse. However, only three of the nine smaller clusters in north-west Essex are within river valleys. The others appear to be on higher ground overlooking rivers and in some cases just below the brows of hills (Ingle and Saunders 2011).

The Essex HER polygon dataset of potentially Neolithic–Early Bronze Age monuments was cleaned of records which appeared not to have a significant prehistoric component, as well as destroyed sites (e.g. Mucking). This left 31 polygons covering burial/ceremonial monuments (27), settlements (2) and lithic scatters (2) with a combined area of 438.3 ha

(2.7% of the study area). Six of these ‘assets’ overlap with SHINE polygons (see 2.2 and 5.6.2) and from a rapid review it appears perhaps three might be considered potentially of national significance. In the time available it was only possible to peruse the monument point data, which appears to be dominated by findspots, although there may be additional definable assets within this dataset. Thus there are 31 identifiable early prehistoric assets with a known asset density of 1 per 5.3 km^2. The Neolithic and Early Bronze Age were well represented on the gravel at Mucking but less so in the other case studies.

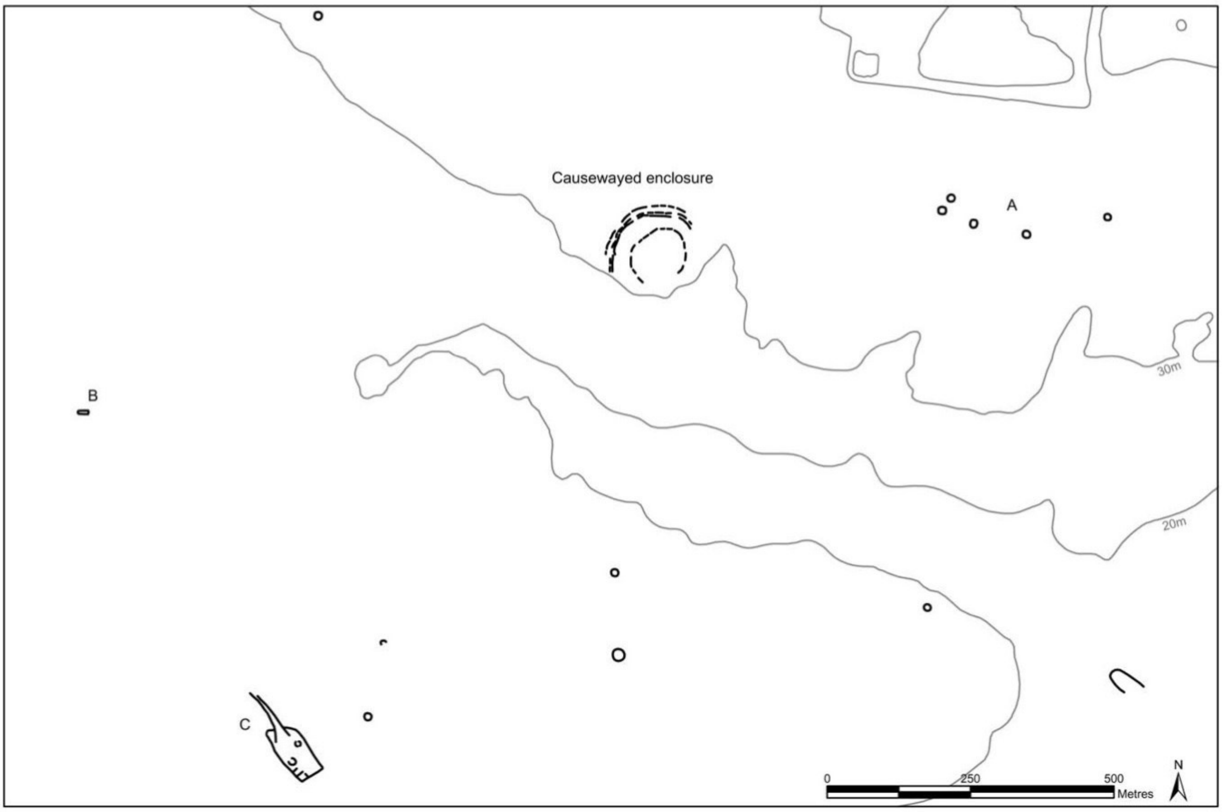


Figure 5.11: Cluster of Neolithic–Early Bronze Age monuments around Orsett Cock causewayed enclosure (from Ingle and Saunders 2011, fig. 2.5)

The distribution of known assets is skewed towards the sand and gravel ridges with few records on coastal, head and mudstone geologies. A strong preference of early prehistoric sites for permeable geologies is a commonplace observation elsewhere. The scatter of finds on the alluvium under and east of Tilbury hints at the potential for new discoveries within or beneath these deposits.

Conclusion: the Neolithic and Early Bronze Age make a modest contribution to archaeological sensitivity. Known assets favour the permeable sand and gravel geologies, whilst clay and head geologies appear unfavoured. However, this hypothesis would need to be tested by case studies on the claylands and head.

Several cropmarks indicate potential for further nationally important discoveries, to which should be added the potential for well-preserved remains under alluvium.

The overall average density of known assets is around 1 per 5 km^2 but may be very low on the clayland and correspondingly higher on the sand and gravel. The case study data identified one asset per 0.4 km^2, dominated by records from Mucking on the sand and gravels where there was an extraordinarily high density of almost one asset per ha. Taken at face value these figures indicate a visibility of slightly under 10% but that may be a bit too pessimistic, for reasons given previously.

The density of major ceremonial monuments (causewayed enclosures, henges, cursuses etc) is impossible to estimate on evidence from the study area alone but to judge by evidence from across Essex their known density is about 1 per 700 km^2; clearly new discoveries are likely.

5.3.5 Later prehistoric (Middle Bronze Age to Iron Age)

The Thurrock HEC report notes that settlements of the Late Bronze Age formed part of an intricate network of national and international exchange. It saw large-scale field systems and a highly characteristic series of circular enclosures, of which the excavated Mucking North and South Rings are the best known.

Field systems developed further throughout the Iron Age. A large Middle Iron Age settlement excavated at Mucking comprised numerous roundhouses set within a system of fields, tracks and enclosures. In the Late Iron Age settlements comprising multiple ditched defensive enclosures developed, one of the best examples of which was excavated at Orsett Cock. The area was also at the forefront of early coin usage, with one of the largest early 'potin' hoards found at Corringham.

Cropmark sites are an important resource for this period, although many cannot be dated and complexes will often comprise a multi-period palimpsest (Fig. 5.12). Apart from generic 'ditches', enclosures are the most common type recognised across Essex during the NMP project, where an association with watercourses was noted: 38% are within 500 m of a watercourse and 64% within 1 km of a river (Ingle and Saunders 2011, 58).

The key monuments identified are settlements, defended enclosures and field systems (Fig. 5.13). The latter are problematic to date from aerial photography alone and some undated cropmarks are almost certainly later prehistoric/Roman field systems. The distribution is distinctive, with almost all the identified later prehistoric assets on or around the sand and gravel deposits between Grays and Stanford-le-Hope, their recognition linked to aerial photography and mineral extraction.

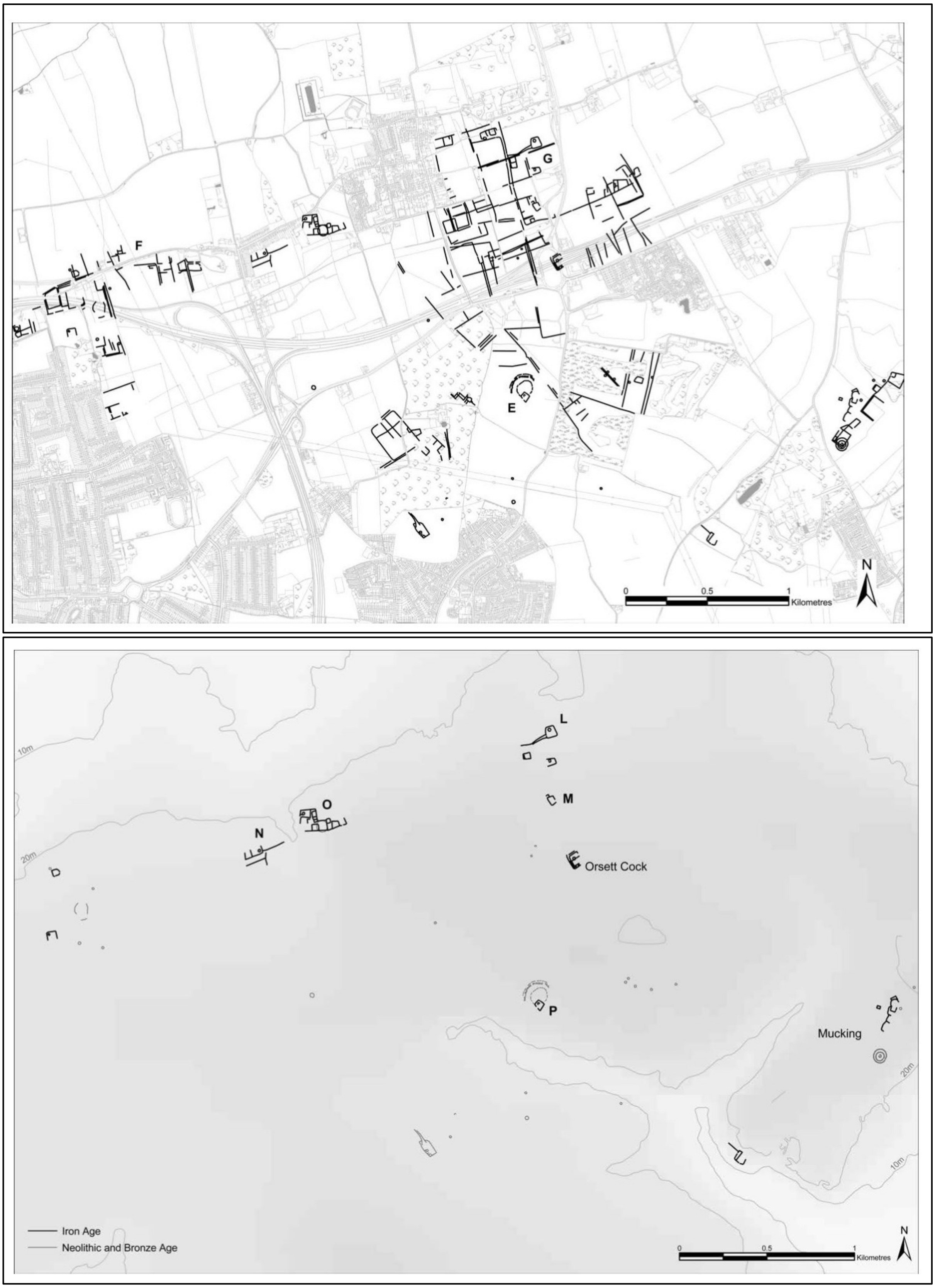


Figure 5.12: Multi-period cropmarks around Orsett (above) and likely Iron Age elements (below) (from Ingle and Saunders 2011, figs 3.19 and 3.21)

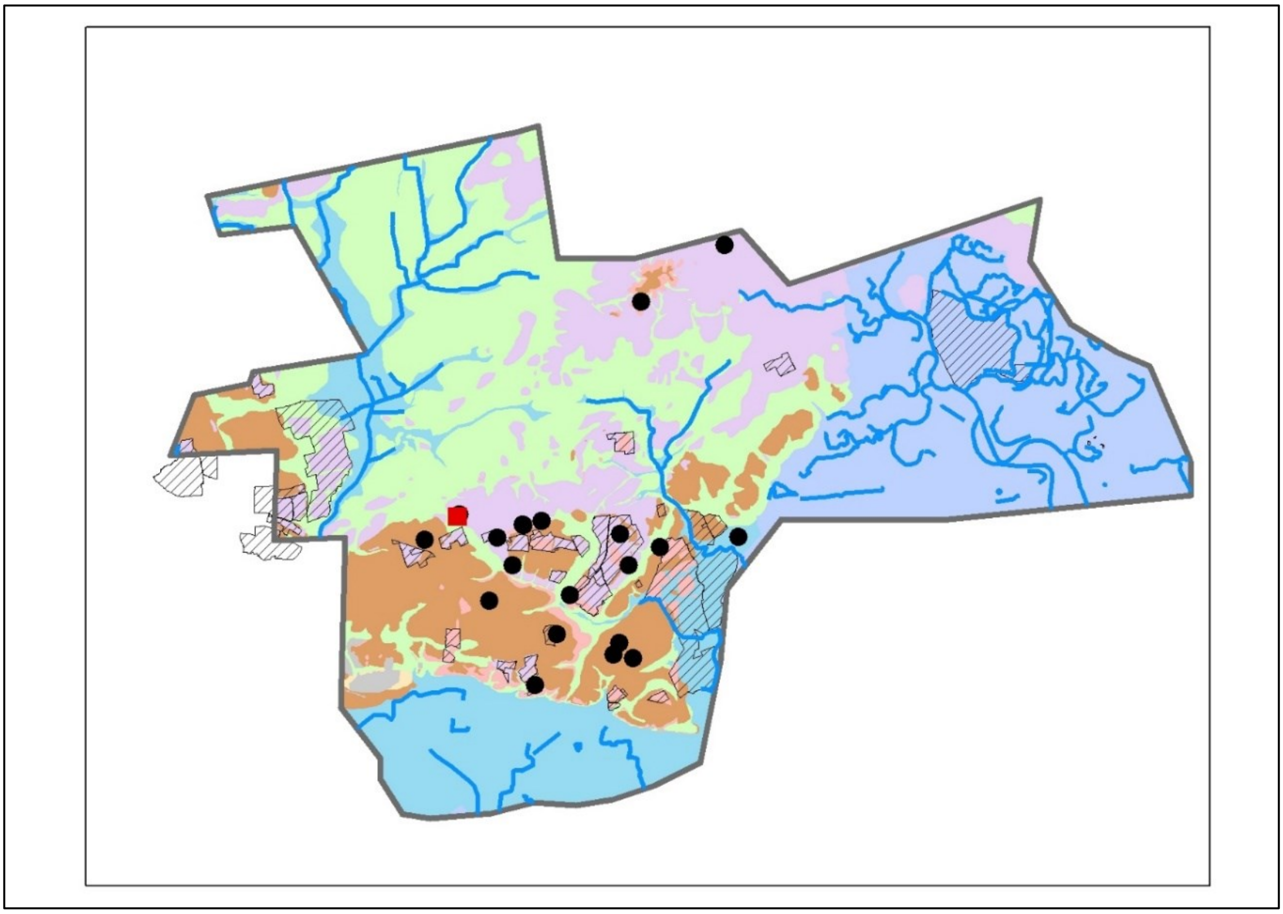


Figure 5.13: Later prehistoric asset distribution overlain on geology (see Fig. 5.3; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved): the red square is a scheduled Springfield-style defended settlement

The 25 assets covered 470.1 ha (2.87% of the study area) and provide a baseline minimum of 1 asset per 6.6 km^2. There is only one SM, a Springfield-style enclosure. However, we can be sure that many later prehistoric assets are as yet undiscovered. All of the case studies encountered later prehistoric assets, which were more common than any other period at a density of 1 per 0.16 km^2 and with an emphasis on the later Bronze Age, which appears particularly well represented. Visibility appears very low (only c 2.5%) but this may well be because a lot of cropmark sites which belong to this period have been classified as undated.

Conclusion: the later Bronze Age and Iron Age period makes a moderate contribution to archaeological sensitivity in the London Gateway as it has the second most extensive coverage of known assets. These assets imply an overall density in the range of 'common' (1 asset per 1–10 km^2), strongly favouring the sand and gravel geology. Case studies suggest a considerably higher density, with the period represented on all sites. Evidence for nationally significant assets comprises

the scheduled 'ringfort', the now destroyed Mucking North and South Rings, and Iron Age salterns found in the Stanford Wharf case study. The alluvial/coastal zone has potential for well-preserved but as yet undiscovered assets.

5.3.6 Roman

The study area lies towards the north-eastern end of the Roman Rural Settlement Project's South region. Excavated rural settlement sites in the large London Basin NCA are 80% 'farmsteads' with the remainder made up mainly of roadside settlements while villas are rarer than in any other part of the region. The Greater Thames Estuary NCA has only 13 recorded rural settlements, presumably reflecting its historically marginal marshland environment (Smith *et al*. 2016, fig 4.5, table 4.1).

The Roman period is not particularly well represented within the study area itself, with only 23 identified assets (covering 182.7 ha, 1.11% of the study area or one asset per 7.1 km^2) and two SMs – a barrow and a saltern (Fig. 5.14). The main asset types are rural non-villa settlements (8) and industrial sites (pottery kilns and salterns). Sites appear mainly on the alluvial and coastal deposits and around the edges of the sand and gravel deposits but rarely on the other geologies.

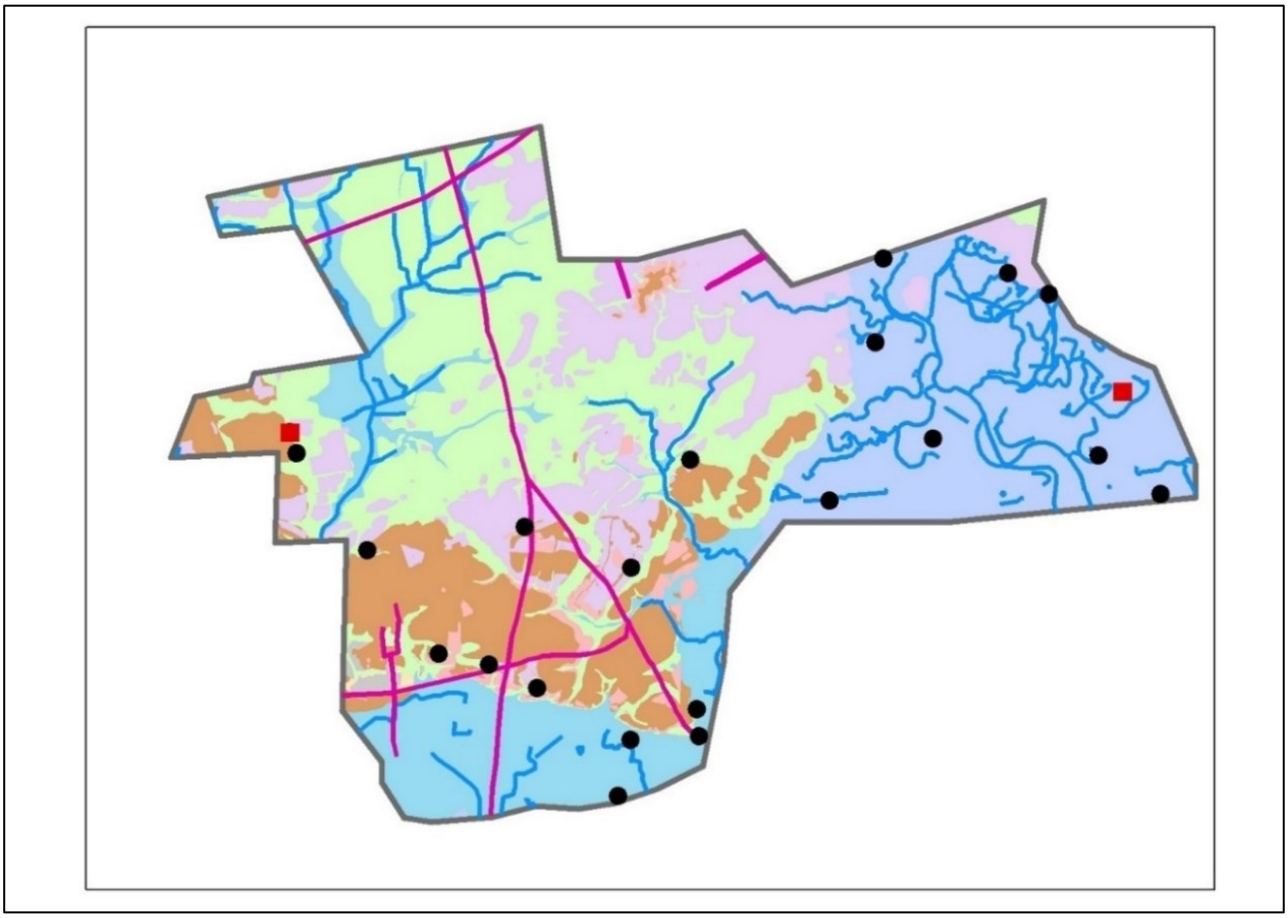


Figure 5.14 (previous page): Roman assets and SMs (red squares) with putative 'Roman roads', overlain on geology (see Fig. 5.3; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

These observations are broadly supported by the case studies which identified 17 assets at a density of 1 per 0.5 km^2. This is roughly one third of the density of later prehistoric assets (albeit covering a much longer time frame). Again the figures suggest that less than 10% of the actual resource is known, although some Roman sites surely lie within the undated cropmarks (Fig. 5.15).

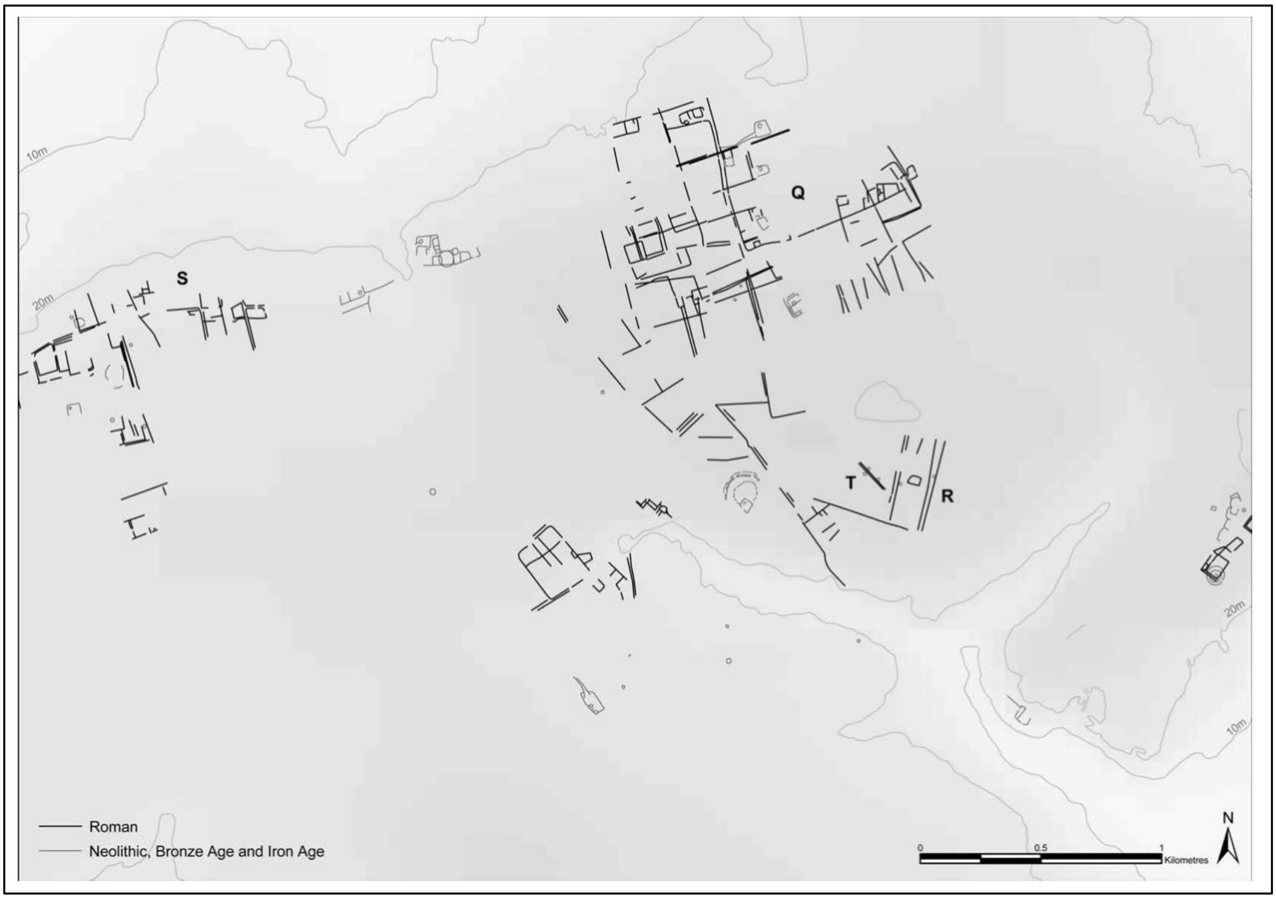


Figure 5.15: Extensive 'Roman' cropmarks like these in Thurrock are likely under-recognised in the study (from Ingle and Saunders 2011, fig. 3.22)

A network of secondary Roman roads is derived from the Historic England National Record of the Historic Environment but should be viewed with caution. Some of these conjectural routes are historic lanes which may indeed have ancient origins without necessarily being Roman roads in the sense of specially planned and engineered highways. Surprisingly, spatial analysis indicates a *strong negative* correlation between assets and these roads (Fig. 5.16), suggesting either that they were deliberately avoided or that they run through areas which were less intensively used or where few assets have been recognised.

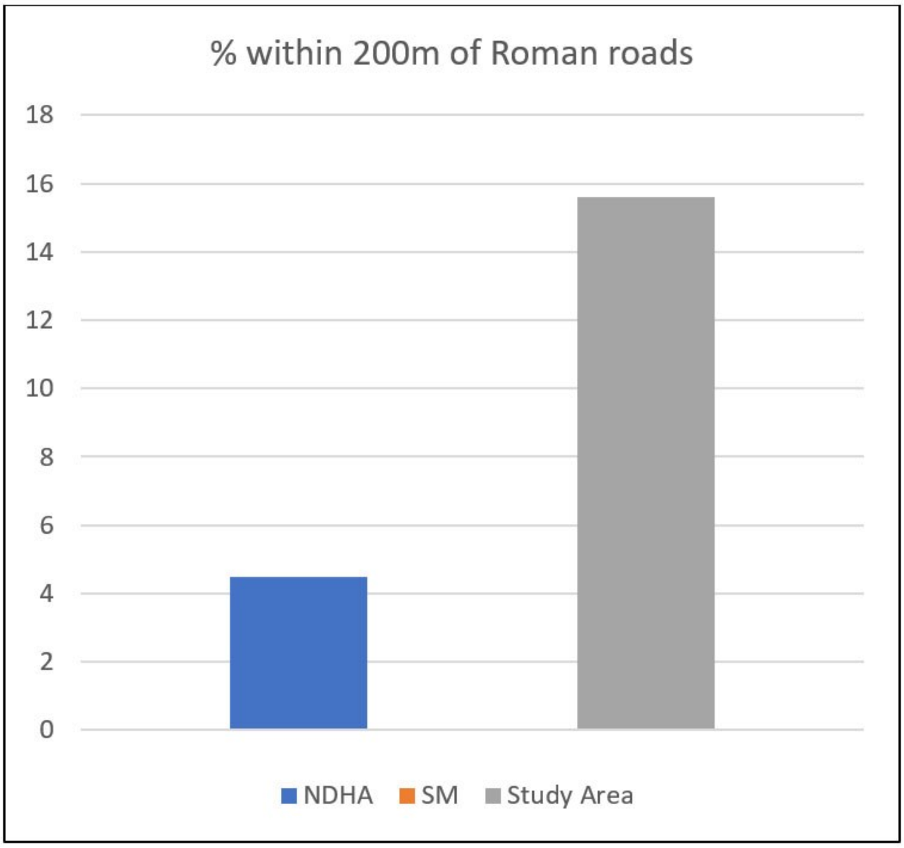


Figure 5.16: Proximity of all assets to 'Roman roads' indicates a strong negative correlation in the study area for which there is no immediately obvious explanation

Conclusion: the Roman period makes a surprisingly modest contribution to archaeological sensitivity in the London Gateway because, except for the Palaeolithic and Mesolithic, it is the least well represented period by area and the second least by number of known assets. Known asset density is lower than for later prehistory but still within the range of 'common' (1 asset per 1–10 km^2), although it is likely many undated cropmarks are or include Roman assets. Case studies suggest that the actual asset density is higher (around 1 per 0.5 km^2) and asset distribution is more even across the alluvial, coastal and sand and gravel geologies but much rarer elsewhere. Evidence for nationally significant assets is limited to the two SMs and, uniquely in Britain, a boathouse found at Stanford Wharf. The alluvial/coastal zone has potential for well-preserved but as yet undiscovered assets.

5.3.7 Early medieval

The key monuments identified are settlements. Pagan Saxon burial grounds have been excavated at Mucking but are not known elsewhere in the study area. Horndon-on-the-Hill was the site of a pre-Conquest mint. The south Essex marshes in the early medieval period have been reconstructed as a 'mixture of intertidal environments ranging from relatively high vegetated saltmarshes through to unvegetated mudflats' with their extent inferred from the local alluvial and coastal deposits (Fig. 5.17). By the eleventh century these marshes provided valuable sheep pasture (Rippon in Evans *et al.* 2016).

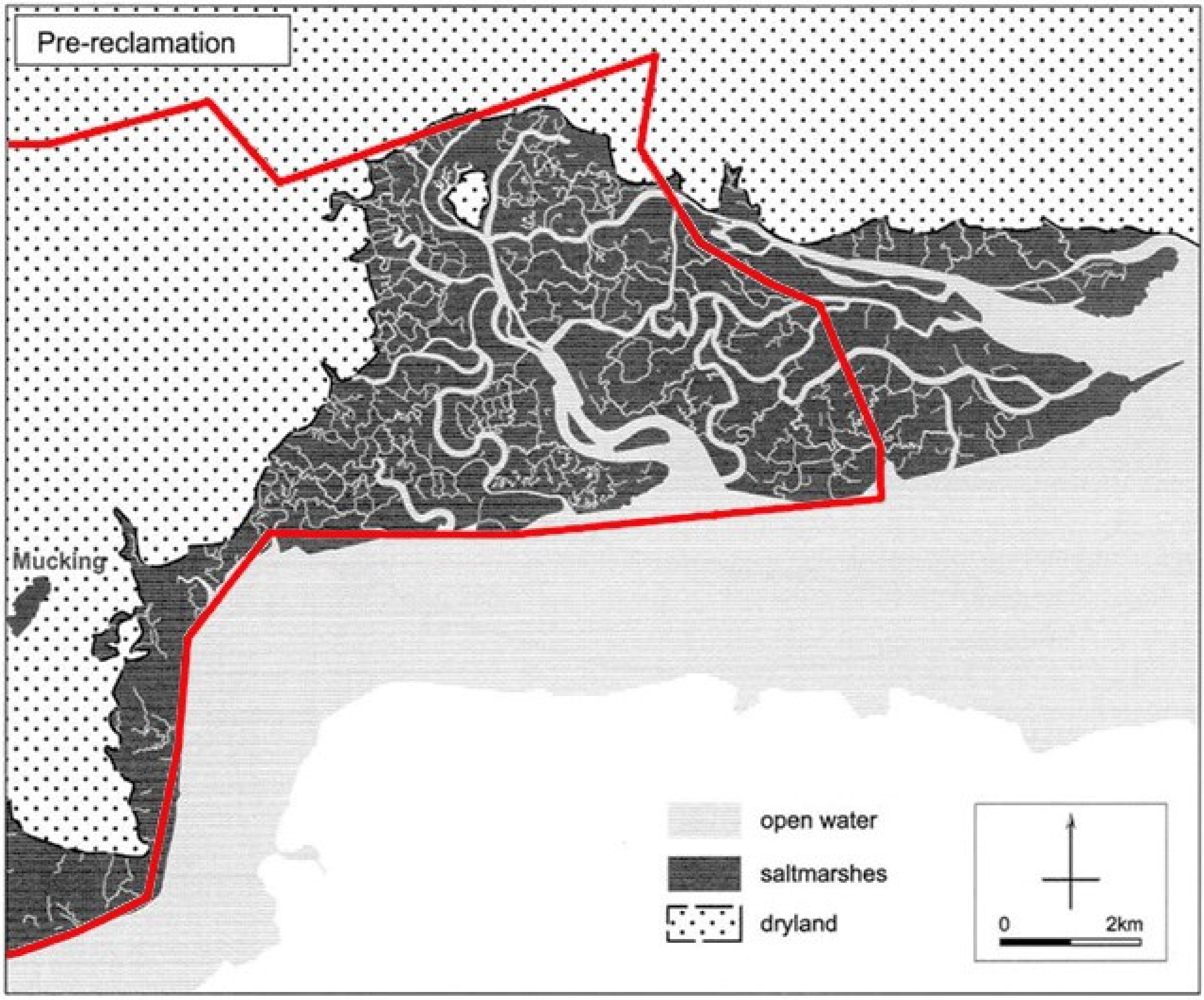


Figure 5.17: The south Essex marshes in the early medieval period (from Evans et al. 2016, fig. 6.11) in relation to the pilot study area

Only 11 assets were identified covering 275.6 ha (1.68% of the study area), providing a baseline minimum of one asset per 14.9 km^2, again focussed on and around the sand and gravel deposits (Fig. 5.18). There are no SMs but the Mucking case study illustrates the area's potential for extensive nationally significant discoveries. It is not clear to what extent Roman or later medieval settlement might act as an indicator of a less easily detected early medieval presence.

Three of the six case studies encountered early medieval assets at an overall density of 1 per 0.6 km^2. This is a surprisingly high density, not much less than that for the Roman period. It also implies very poor visibility of around 4%.

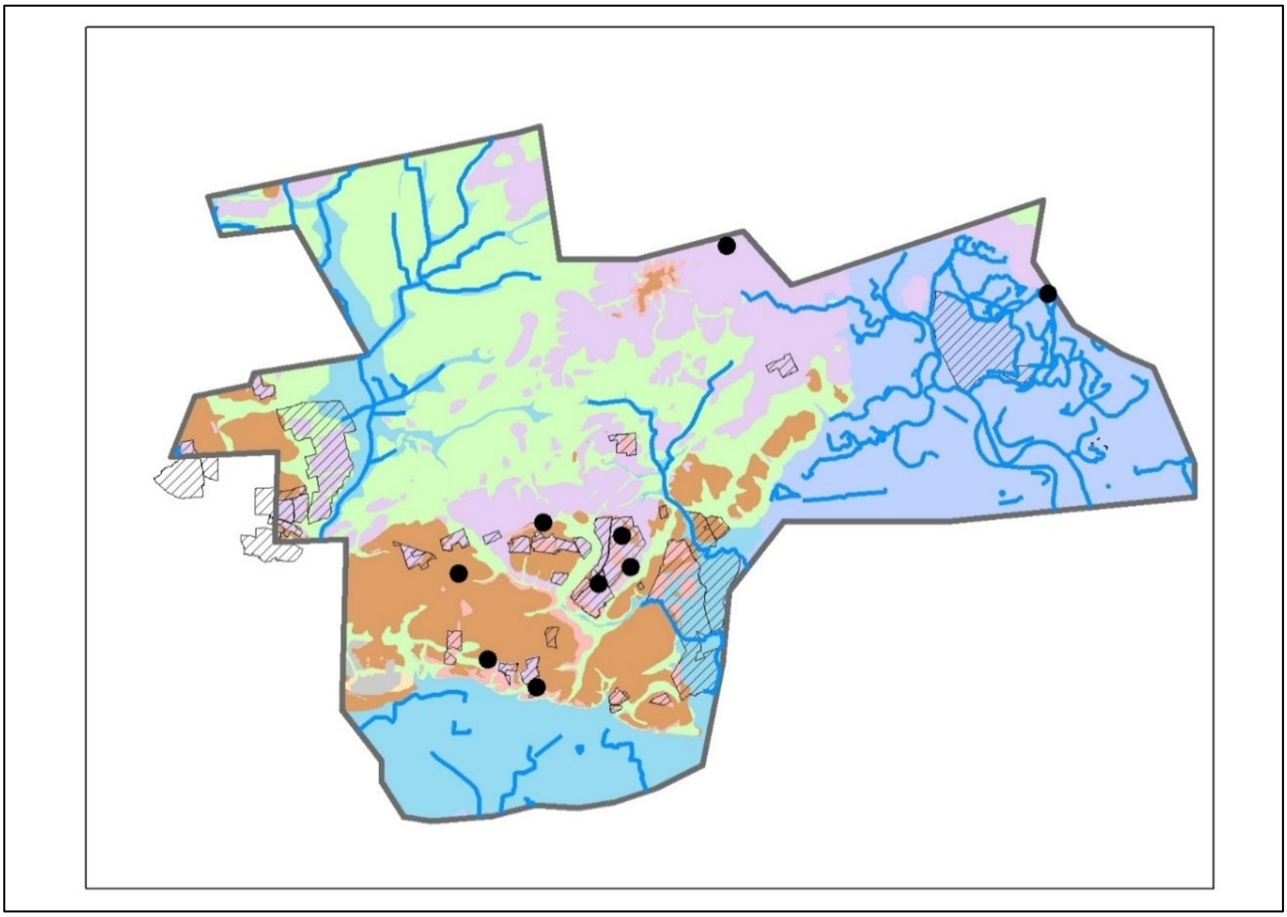


Figure 5.18: Early medieval assets overlain on geology (see Fig. 5.3; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved) showing correlation with sand and gravel (brown) and discoveries on mineral extraction sites (hatched)

Conclusion: The early medieval period makes a moderate contribution to archaeological sensitivity in London Gateway, and Mucking illustrates the potential for nationally significant discoveries. The known assets imply a minimum density range of 'rare' (one or more assets per 10–100 km^2), concentrated on sand and gravel geologies. However, the case studies indicate that visibility is poor and asset density could be very much higher. No other attractors are apparent and it is unclear how much settlement or other assets might be found on the clay and head deposits. The coastal marshes were presumably not suited for settlement, although occasional structures relating to fishing, sheep management or water transport might be present.

5.3.8 Late medieval

The late medieval period is the most commonly represented in terms of the number of assets (except for undated assets), although not in area. The key monuments are settlements and churches (20); there are only three SMs. Roberts and Wrathmell's (2003) study of rural settlement patterns placed the study area within the Thames sub-province, part of the South East Province, and characterised by a dispersed settlement pattern. The local market town was at Horndon-on-the-Hill. Unfortunately mapping of historic settlement cores in both the HER monument and HLC layers is problematic – the former concentrates on 'monuments' without identifying the likely full historic settlement areas, whilst the latter absorbs the core within a much larger area of modern settlement (Fig. 5.19).

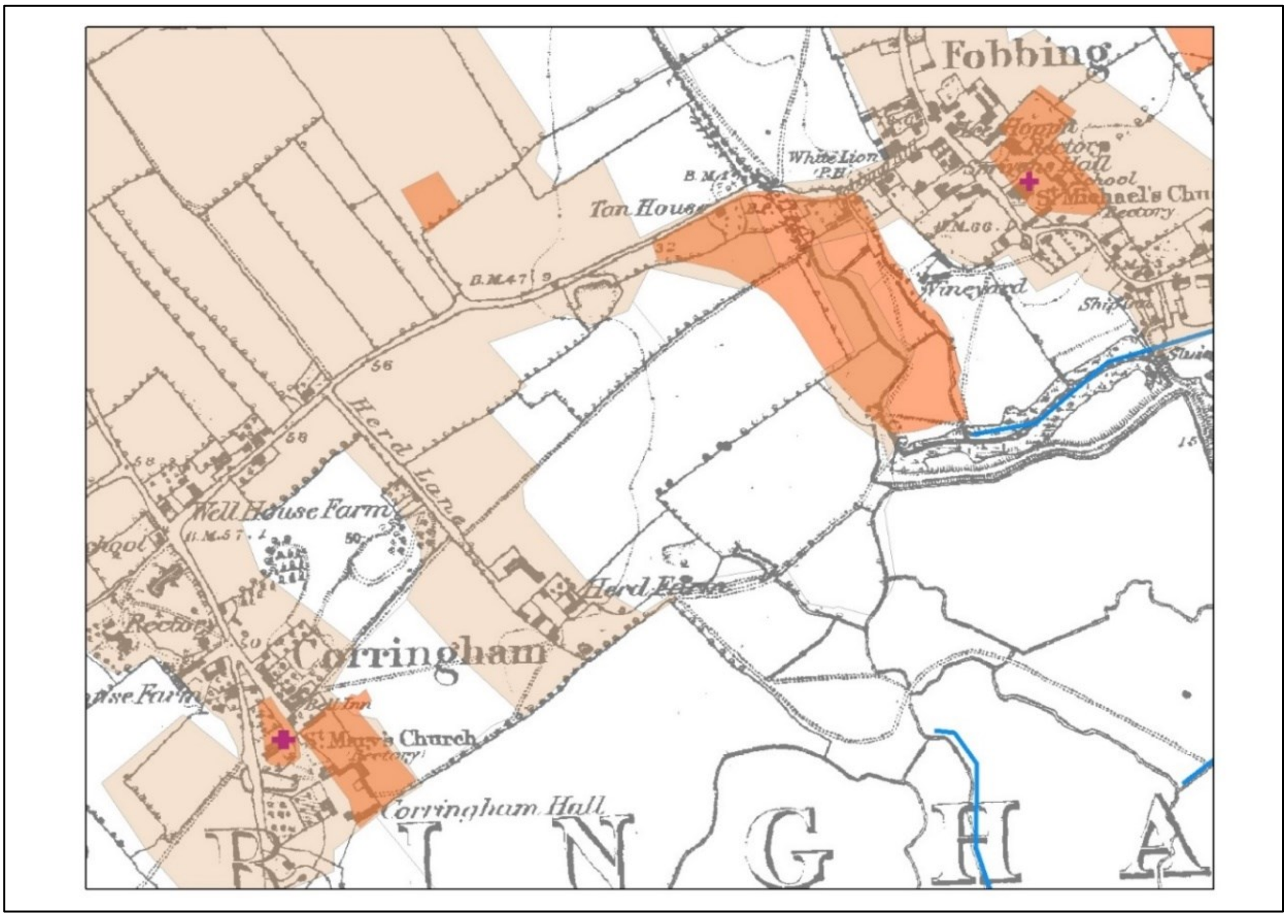


Figure 5.19: The case of Corringham and Fobbing illustrates the problem of mapping historic cores from existing Essex HER data. Monuments (orange) are selective and do not encompass the whole core whilst HLC (beige) includes large areas of former fields now built over.

Proximity to medieval churches shows a much weaker correlation with known assets than seen in the Vale of Aylesbury, with only a 100 m buffer appearing significant (Fig. 5.20). Reasons for this may include the dispersed settlement pattern and less emphasis on medieval settlement archaeology in the HER.

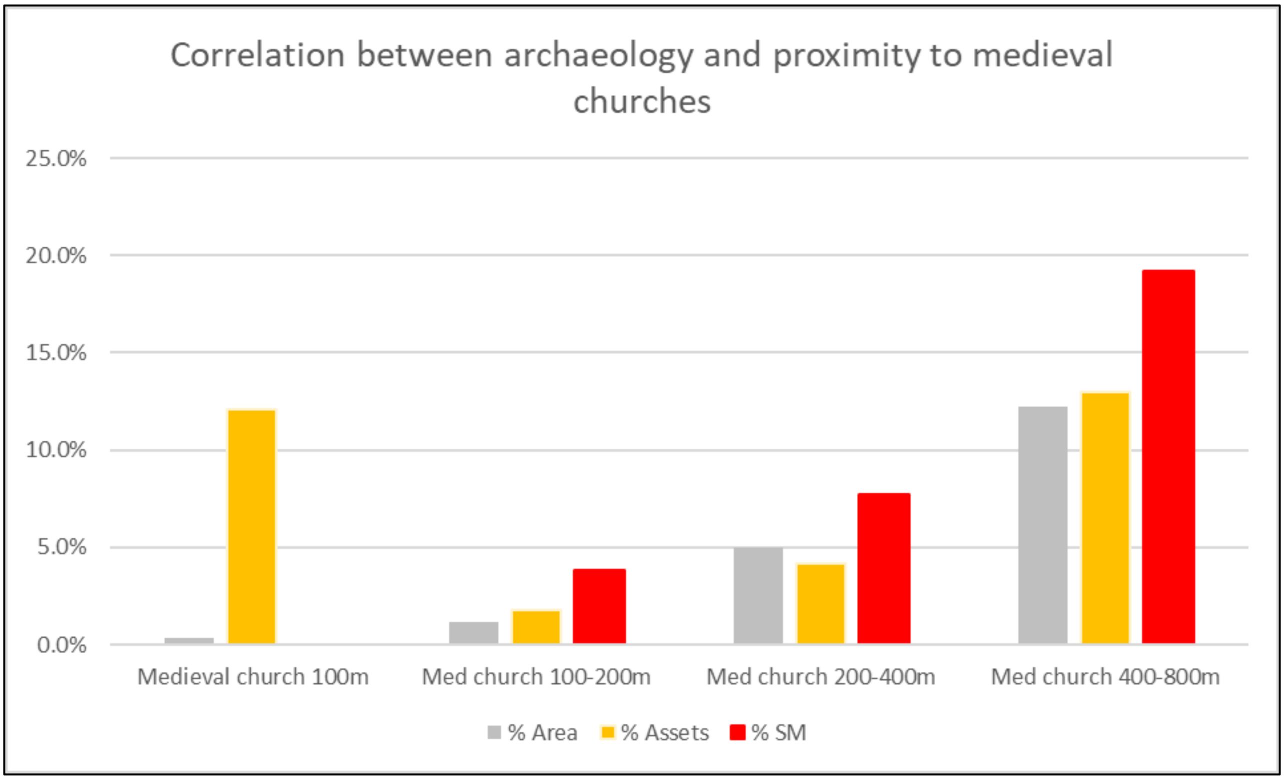


Figure 5.20: Correlation between archaeology and medieval churches

The Essex HLC is not sufficiently refined to allow reconstruction of the medieval landscape in any detail but the early modern (pre-18th century) pattern could be recovered. The pattern of fields on the dryland with only residual areas of woodland, commons and meadows presumably reflects medieval land use patterns.

Reclamation of the south Essex marshes started in the 12th and 13th centuries AD with the embankment of some marshes for arable cultivation (Rippon in Evans *et al.* 2016; Fig. 5.21), although HLC only captures the later phase of this development.

A total of 67 assets were identified, covering 3265.7 ha (1.62% of the study area) providing a baseline minimum of one asset per 2.4 km^2. The main types are settlement and religious (Fig. 5.22). The distribution pattern is different from earlier periods, with sites no longer concentrated on the sand and gravel but more evenly spread across the dryland and starting to appear on the reclaimed coastal marshes (Fig. 5.23). Also, for the first time a concentration of settlements can be seen in the north-west around Mar Dyke Basin, an area also thought to be reclaimed fenland.

The case studies found few later medieval assets, at a density of 1 per 2.1 km^2 which could imply that 85–90% of the actual resource is recorded on the HER in recognisable form. This is quite a contrast to the low visibility estimates made for earlier periods and seems somewhat optimistic.

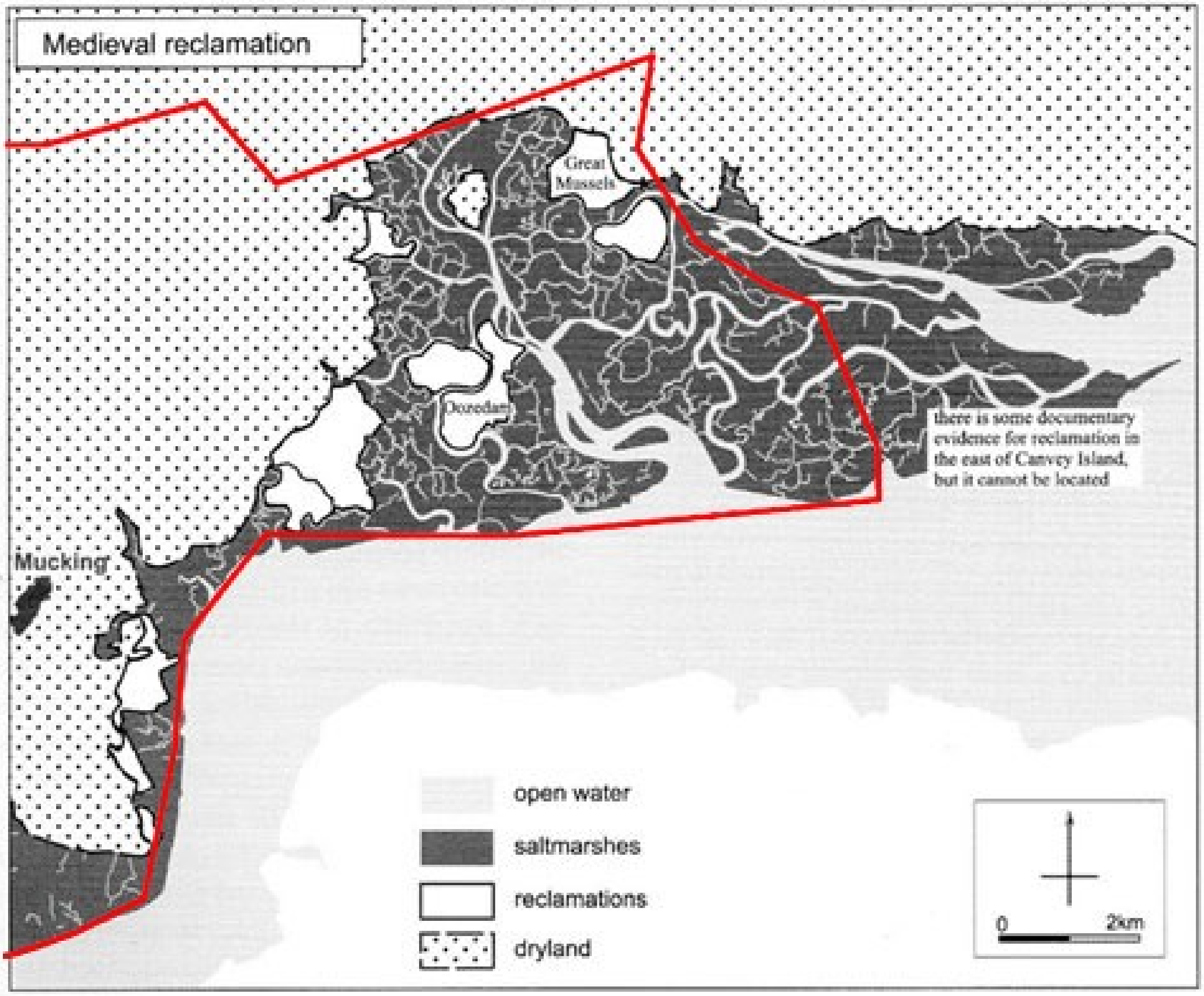


Figure 5.21: Medieval reclamation of marshland (from Evans et al. 2016, fig. 6.12)

Conclusion: the later medieval period makes a moderate contribution to archaeological sensitivity, being more evenly represented across the whole study area but there are few SMs. Known asset densities are at the higher end of the range of ‘common’ (one asset per 1–10 km^2) and the case studies support this. The Essex HLC lacks the detailed information needed to reconstruct late medieval landscapes but the areas of wetland, reclaimed wetland, commons, fields and woodland can be deduced in broad terms. However, medieval settlements are poorly mapped and characterised while medieval churches seem to only be preferentially associated with known assets over a short distance of 100 m.

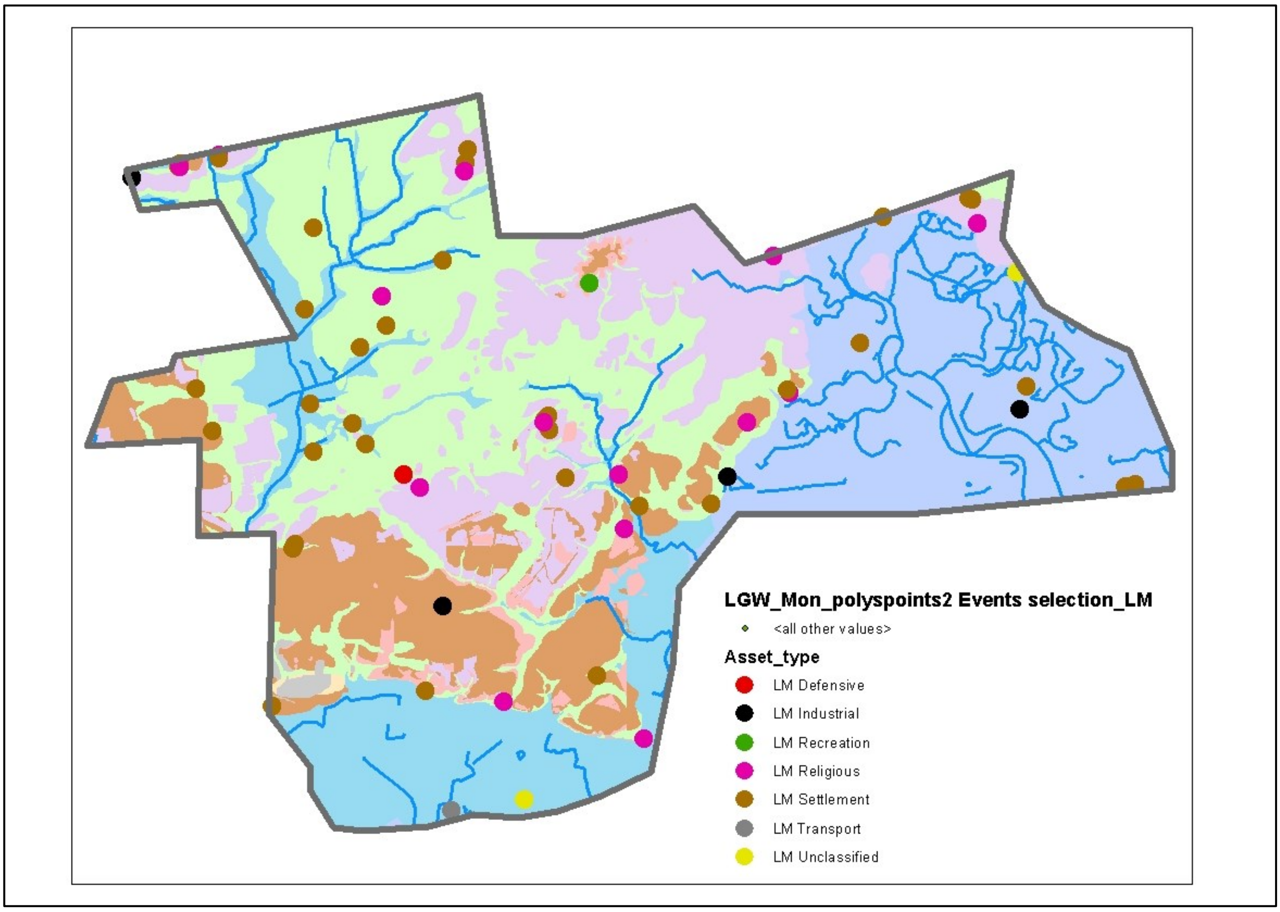


Figure 5.22: Later medieval assets subdivided by type, overlain on geology (see Fig. 5.3; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

5.3.9 Post-medieval and modern

The Essex HER classifies 16th- to 19th-century records as post-medieval and those of 20th-century date as modern (a slightly different definition to Bucks: see 4.3.9). There are 323 monument polygons attributed to the post-medieval and/or modern periods, some of which span both and some of which have medieval origins. Conservation areas and listed buildings may also have archaeological interest. Selection of which monument records might merit description as heritage assets was necessarily somewhat subjective and imperfect given the limited dataset available (Table 5.4).

Overall, 54 post-medieval and 22 modern assets were identified, with each period covering just over 2% of the study area. Assets of both periods would be judged as ‘common’ with one every 3.0 and 7.5 km^2 respectively. Post-medieval assets lack obvious patterning in relation to topography and geology, being fairly evenly distributed and heterogeneous in type (Fig. 5.24), while modern assets are mainly defensive/military, located in or on the edges of reclaimed coastal marshland (Fig. 5.25). Unsurprisingly there is a strong positive correlation between post-medieval assets and conservation areas or 200 m buffers around listed buildings (Fig. 5.26).

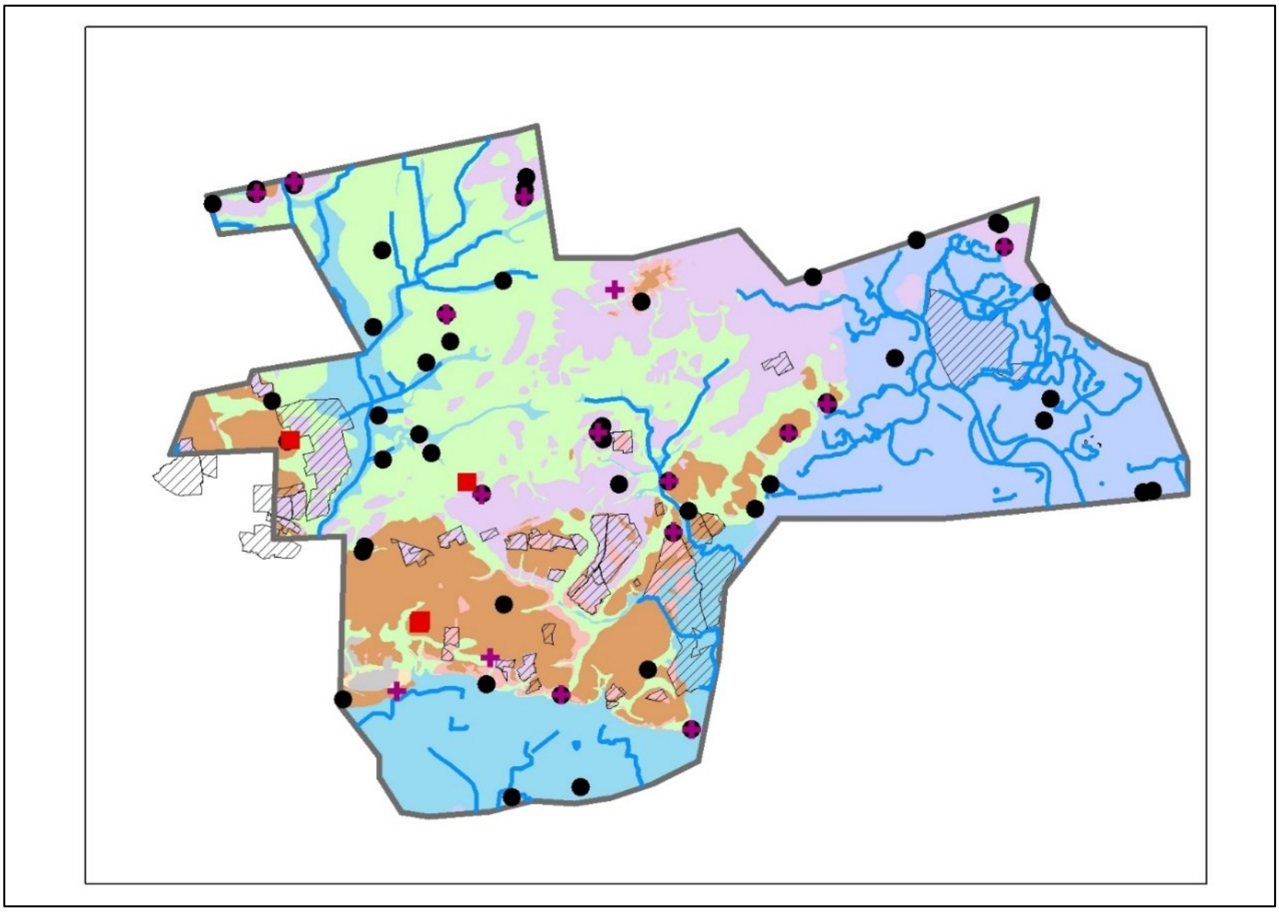


Figure 5.23: Later medieval assets plus SMs (red squares) and medieval churches (crosses), overlain on geology (see Fig. 5.3; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Table 5.4: Post-medieval and modern assets

Essex HER Period	***Monument polygons***	***Prospective assets***	***Comments***
Roman to post-medieval	1	0	A destroyed mill mound
Medieval to post-medieval	26	3 1 Industrial 1 Settlement 1 Religious	Marshes excluded because they are 'historic landscape' like ancient woodlands but likely to contain assets such as sea defences, sheep-cotes and environmental evidence
Late medieval to modern	7	5 Settlement	All prospective assets are long-lived historic settlements

Post-medieval	149	46 2 Agricultural 7 Defensive 9 Industrial 1 Recreation 11 Religious 10 Settlement 1 Transport 5 Unclassified	A large and diverse group Poor information on current condition is a problem and many sites excluded because they just seem to be recorded on historic maps (e.g. ‘Farm shown on 1777 map’) Many identifiable assets of built form although it is not always clear that a building is still standing, and particularly with churches the record can cover rebuilding or addition of a feature to an earlier building
Post-medieval to modern	33	5 1 Industrial 2 Religious 2 Defensive	A mixed group with similar issues to the previous one
Modern	107	19 16 Defensive 3 Industrial	Mainly WW2 military sites. The main issue is poor information on condition: in principle ‘extant’ sites surviving as built structures or earthworks could be considered assets but for sites which have been levelled or built over it is not clear which (if any) retain sufficient interest.

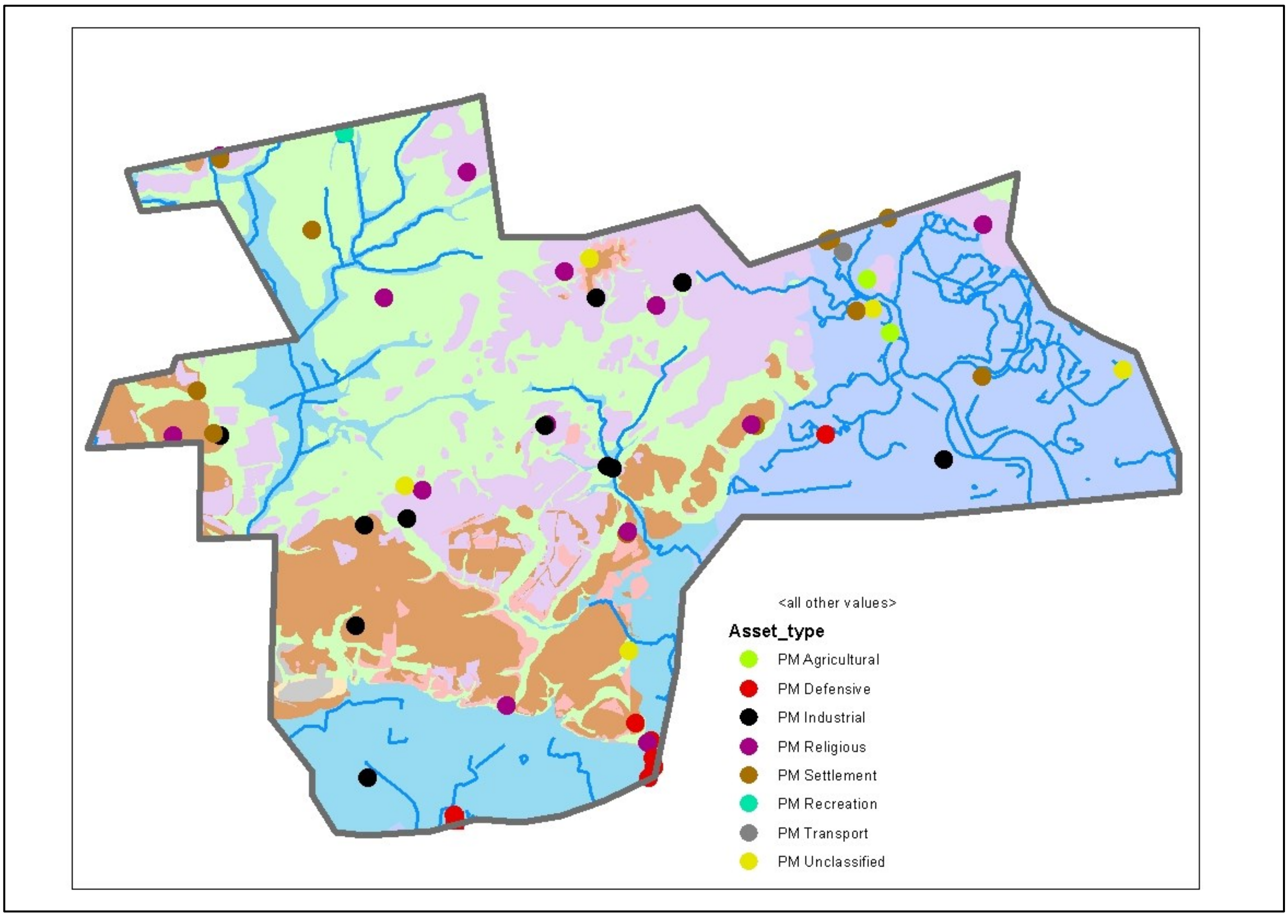


Figure 5.24 (previous page): Post-medieval assets subdivided by type, overlain on geology (see Fig. 5.3; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Post-medieval and modern assets were rare in the case studies, with only five and one respectively, giving asset densities of 1 per 1.66 km^2 and 8.30 km^2. These relatively low densities suggest the case studies largely avoided post-medieval and modern archaeology. Apart from a small settlement and wharf on the DP World site they were incidental records of field systems on sites of earlier interest. It seems likely most post-medieval/modern assets are already identifiable in general terms from the HER.

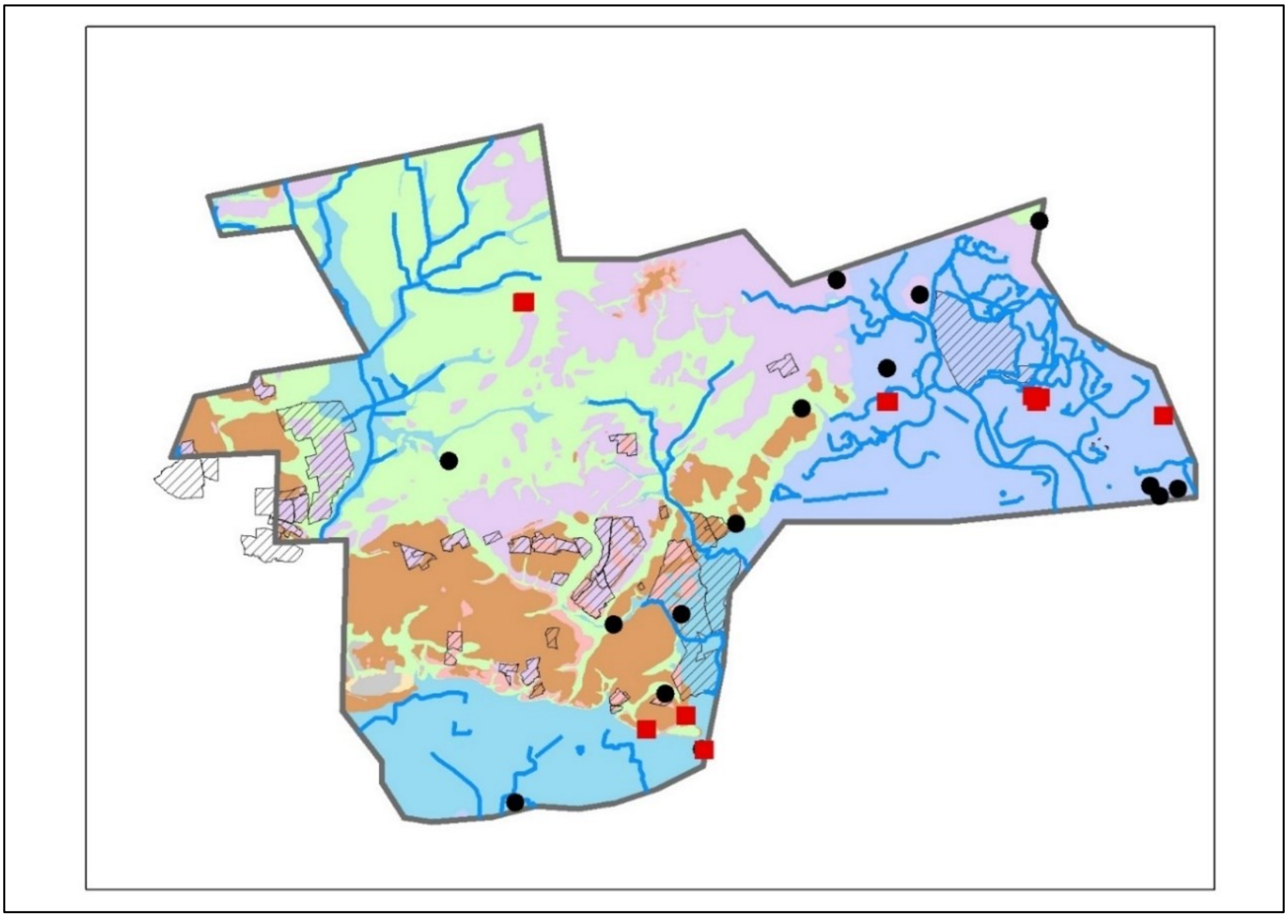


Figure 5.25: Distribution of modern assets (SMs shown as red squares), overlain on geology (see Fig. 5.3; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

The modern landscape is much altered by 20th century impacts, particularly the expansion of settlements, industry, mineral extraction and landfill and mechanised agriculture. Essex HLC recorded previous historic landscape types which were still considered to be visible and so with some manipulation it has been possible to present a simplified pre-18th century landscape character map (Fig. 5.27) covering ‘ancient’ enclosed fields (AEF), medieval and post-medieval reclaimed land (CDF-dc and dc), coastal managed wetland (CMW), inland managed wetland (IMW), commons wastes and heaths (CWH) and ancient woodland (aw). Unfortunately, as noted above (5.3.8), historic settlement cores have not been mapped by Essex HLC in a useable way. A similar picture to that from HLC is provided by Rippon's reconstruction of 17th century reclamation of the saltmarshes (Fig. 5.28).

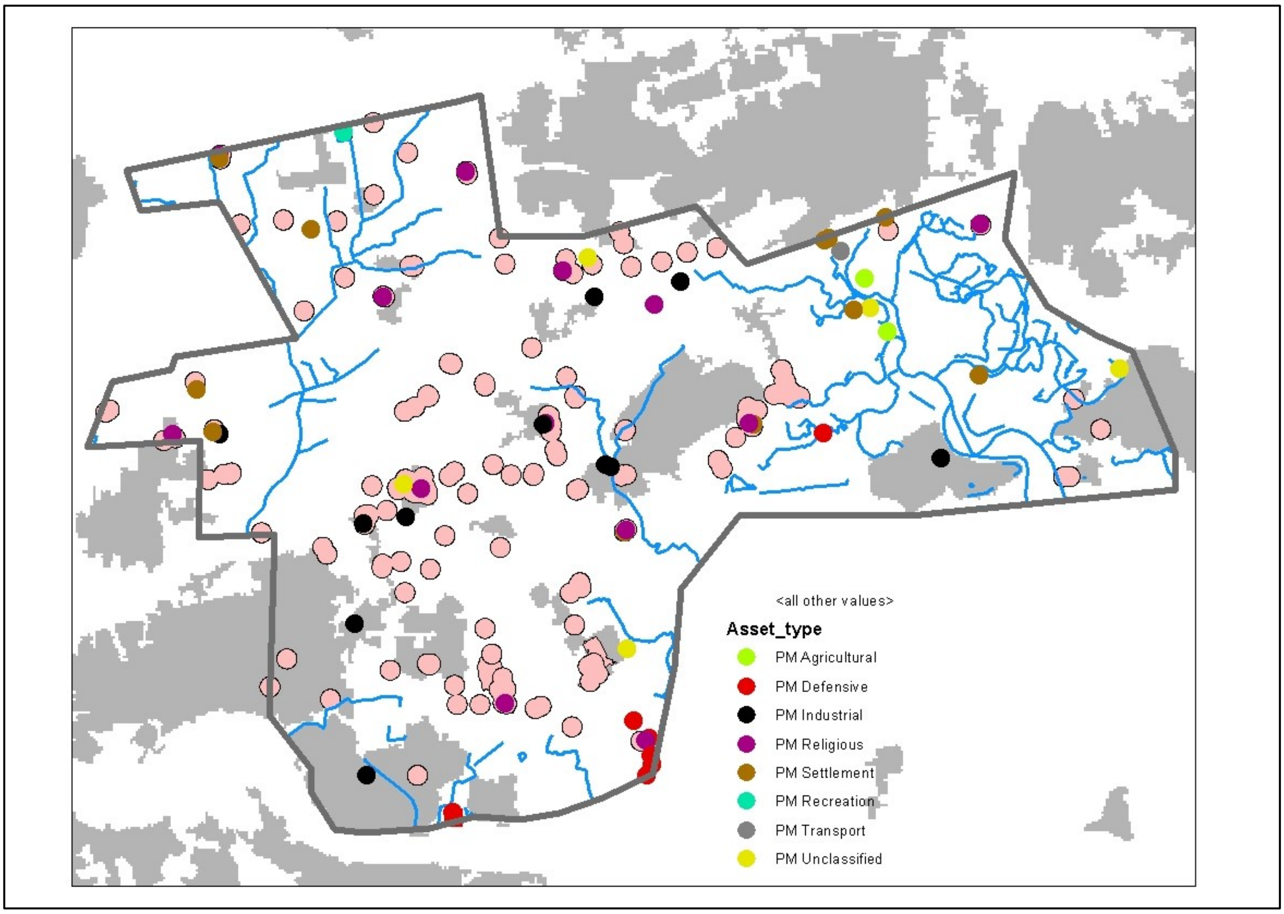


Figure 5.26: Post-medieval assets in relation to 200 m buffers around listed buildings (pink)

Military and defensive structures were a feature of the area from the 16th century, becoming increasingly important up to WW2 (Fig. 5.25). Tilbury Fort and eleven WW2 structures are scheduled, illustrating the significance of this period and asset type locally.

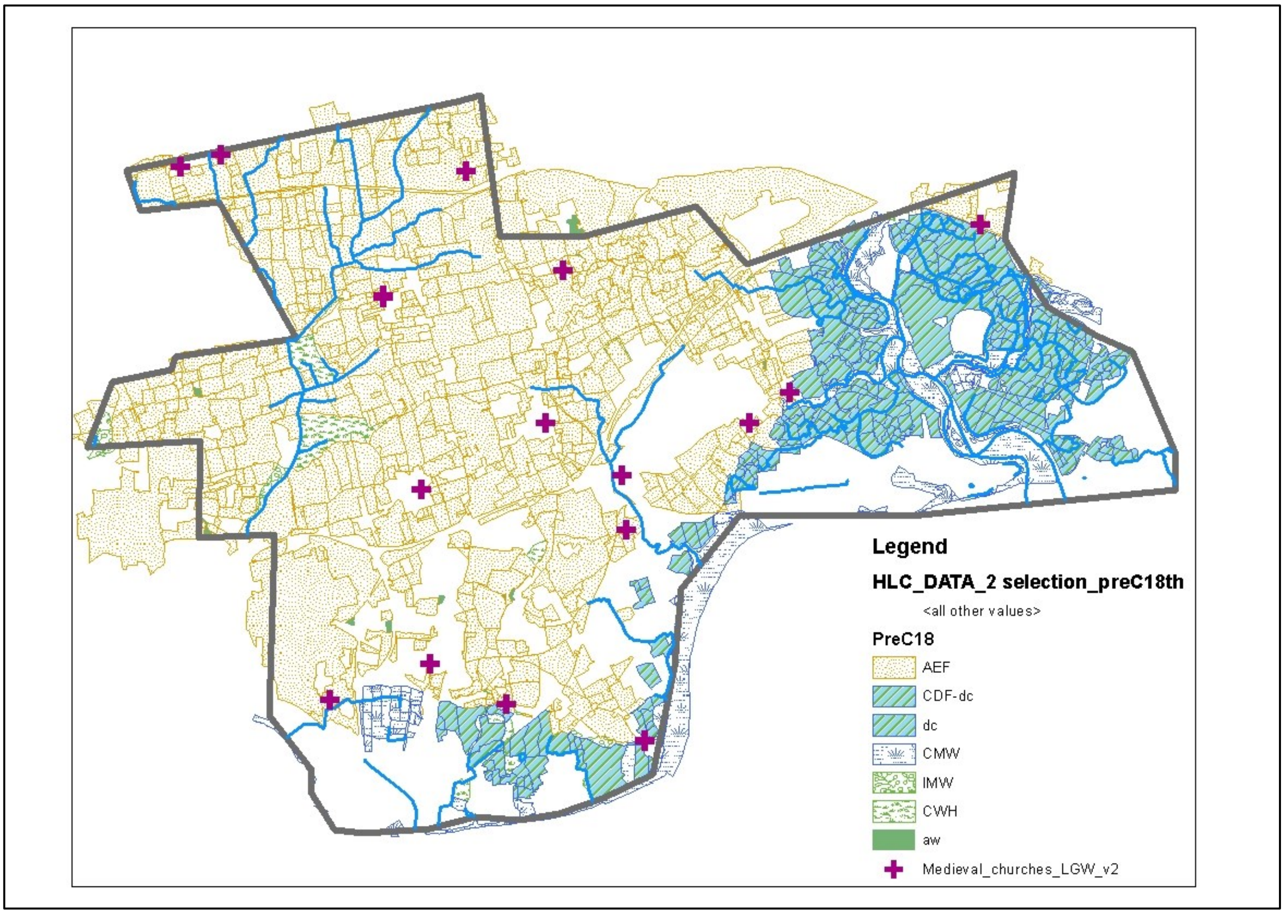


Figure 5.27: Pre-18th century landscape interpreted from Essex HLC (blank areas have no surviving pre-18th century landscape component recognised in the HLC)

Conclusion: convincing patterning of post-medieval and modern assets is difficult to discern as they are quite broadly distributed. There is some association with listed buildings and conservation areas and away from these there are military structures and earthworks on the reclaimed marshes. The process of land reclamation, drainage and sea defence is also of interest but more difficult to articulate in terms of assets.

The recognition of assets of archaeological interest is more problematic in these periods than earlier ones, not so much because they are hard to find but because of the judgements needed to identify significance, and the potentially overlapping roles of archaeologists and conservation officers.

The known post-medieval asset densities are similar to the medieval period but modern asset densities are fairly low, reflecting the very selective criteria for asset recognition.

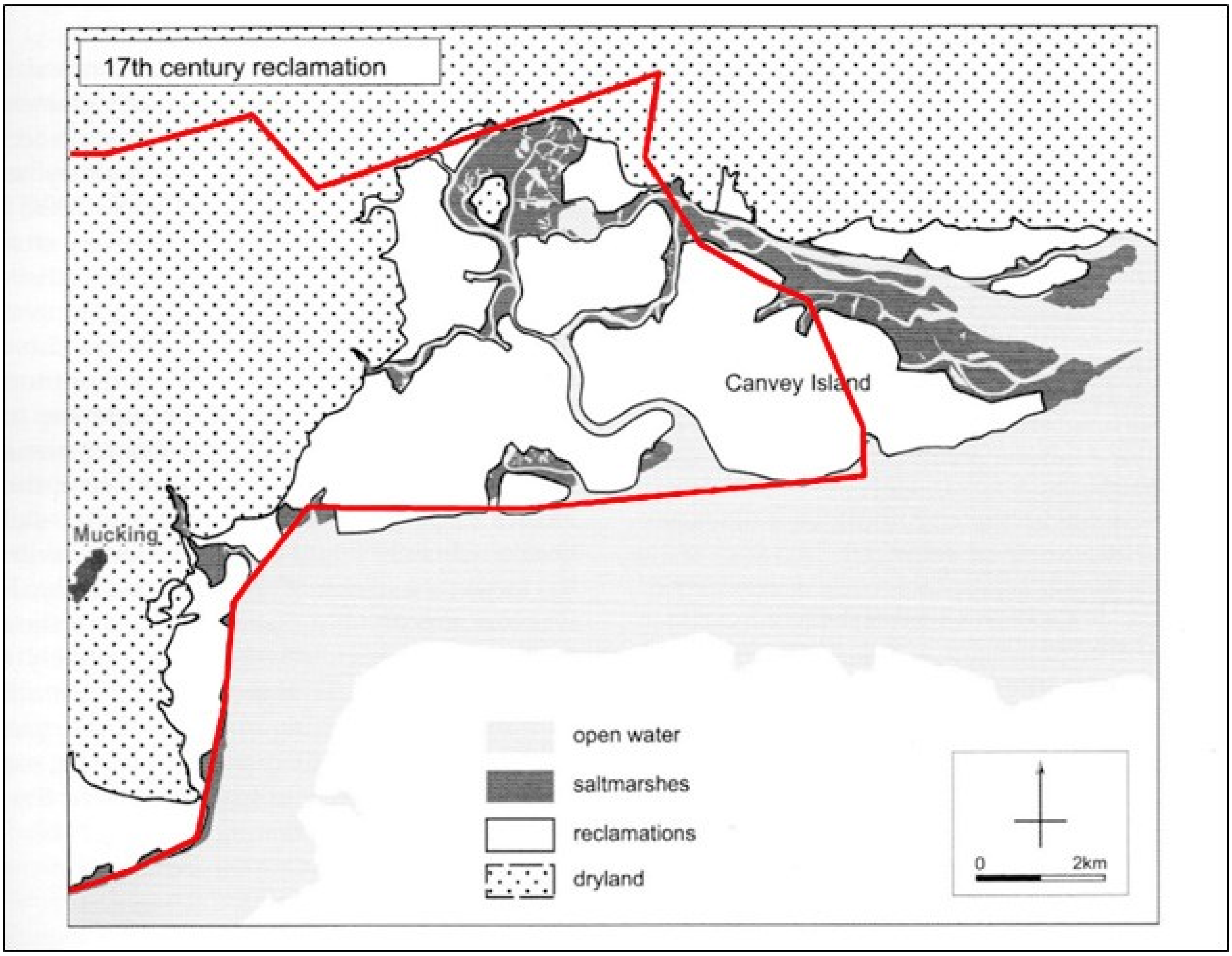


Figure 5.28: Post-medieval reclamation of marshland (from Evans et al. 2016, fig. 6.12)

5.3.10 Assets of unknown date

There are also 94 assets of unknown date in the study area, occurring at a high density of 1 per 1.7 km^2 (Fig. 5.29). This is a remarkably high proportion (28.5%) of all known assets, primarily reflecting the success of aerial photography in identifying archaeological interest but the difficulty in attributing reliable dating to many of these features. The distribution of undated assets shows concentrations on the sand and gravel, as expected for cropmarks, and lesser concentrations on parts of the alluvial and coastal deposits, reflecting undated earthworks. Undated assets are rare on head deposits, conforming to the patterns of pre-medieval assets. The case studies did not encounter any undateable assets.

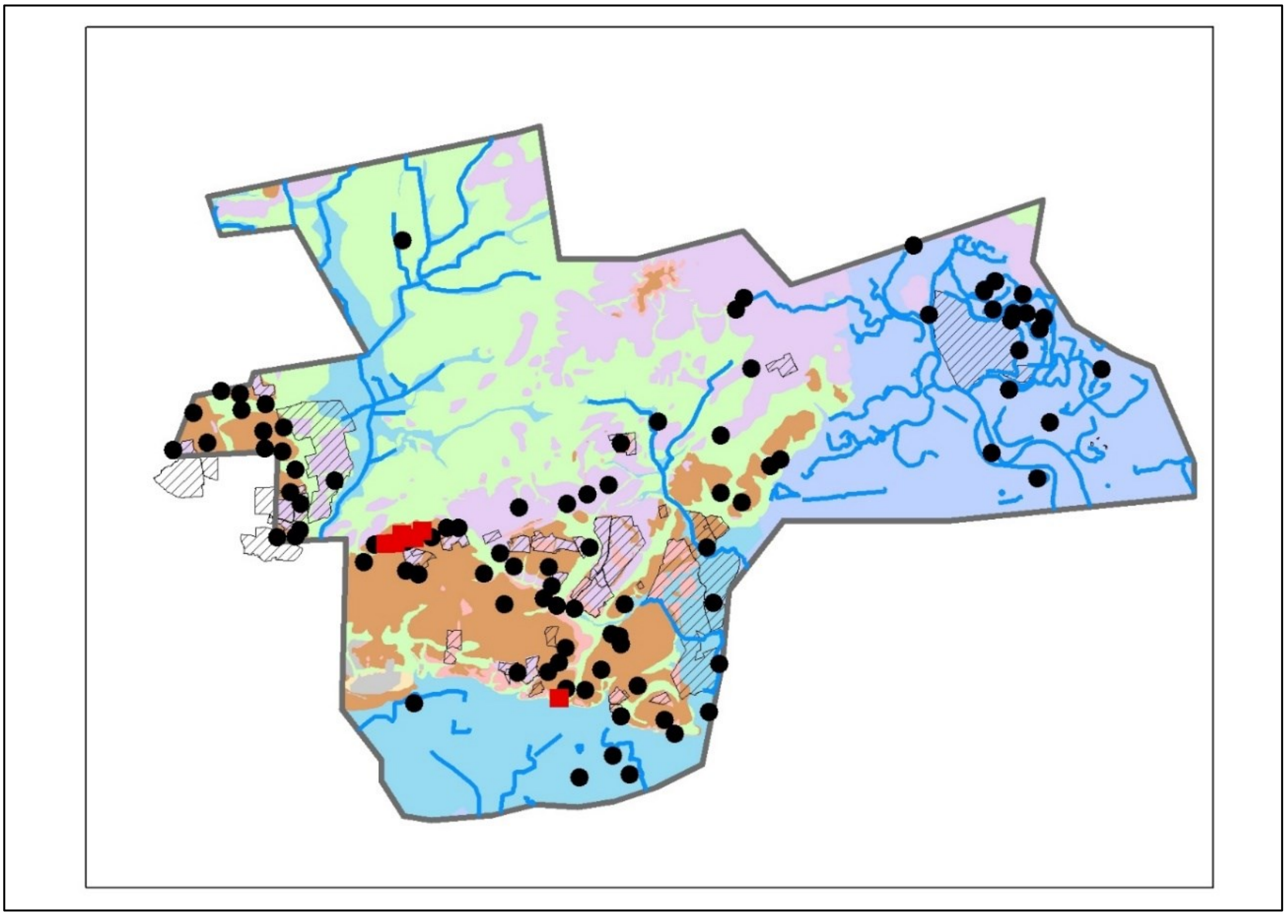


Figure 5.29: The distribution of undated assets, overlain on geology (see Fig. 5.3; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Conclusion: the high number of undated assets is problematic for the period-based analysis as most periods are probably under-represented and the visibility estimates depressed in the sense that assets are known but just cannot be assigned to a period. Further examination of the NMP data would probably enable some undated records to be assigned to a period on balance of probability, although some cropmark complexes will doubtless be multi-period.

5.4 Overview of presence

This study did not attempt to digest the entire contents of the Essex HER. Instead it sought to focus on assets of significance meriting consideration in planning and land use decisions but in Essex, apart from SMs, this is not straightforward.

There are 19 SMs within the study area covering 110.4 ha (0.67% of the study area). Whereas the Vale of Aylesbury case study used Buckinghamshire's Archaeological Notification Areas to distinguish known non-designated 'assets' from background information, the Essex HER does not, as noted previously, maintain an equivalent dataset so for this case study HER monument polygon data was scanned to identify potential assets (it must be stressed that this selection has been done for methodological research and is NOT rigorous enough to be used for planning purposes). Records selected as assets were sufficiently well defined to be indicative of substantive archaeological remains likely to be a material consideration in planning decisions. In all, 330 assets were identified covering 26.2% of the study area at a density of 2 per km^2, as discussed above (5.3.1 and Table 5.3). Roman assets were surprisingly less evident compared to other periods than would normally be expected in southern or eastern England (Figs 5.6 and 5.30).

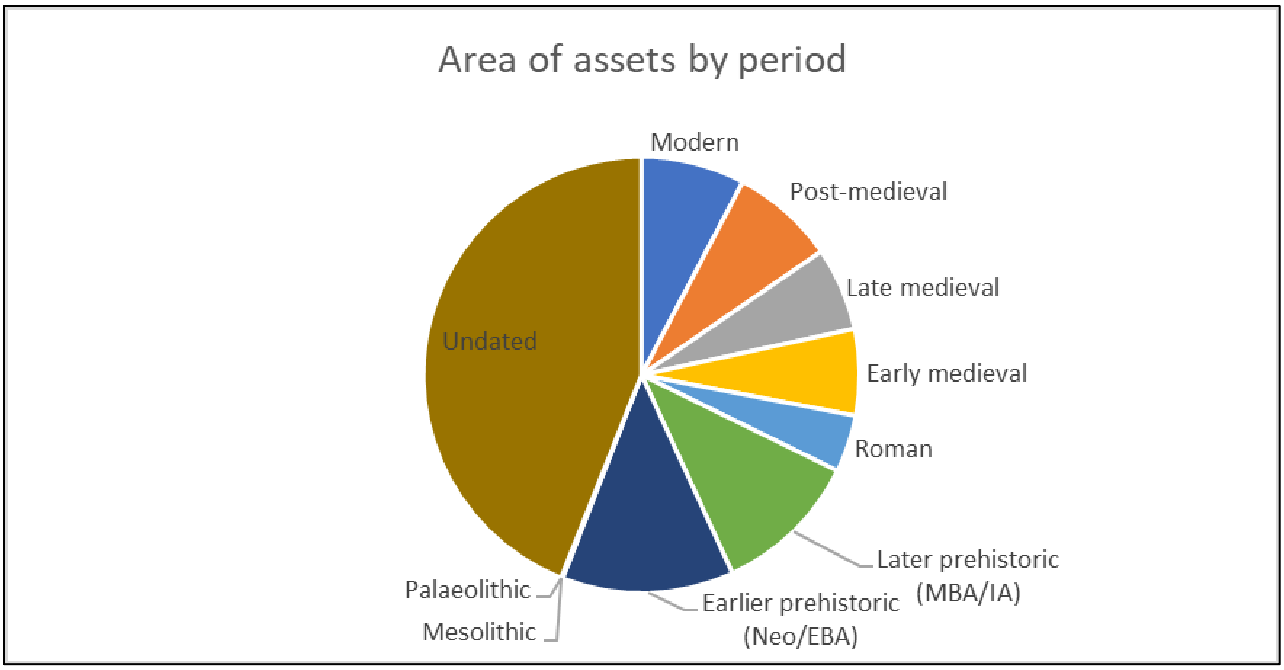


Figure 5.30: Area of assets by period

Functionally identifiable assets (Fig. 5.31) are dominated by settlement from later prehistory onwards and by religious/funerary assets in the Neolithic/Early Bronze Age and medieval/post-medieval periods. Defence and industrial assets are also present in significant numbers. The rarity of agricultural assets such as field systems is probably due to them actually occurring within the undated unclassified category of cropmarks, but field systems are also recorded by HLC.

The study has examined the correlation of known assets with geology, topographical and cultural indicators. Archaeological assets are found on all the common geologies and clear patterns are evident (Fig. 5.32), with strong positive correlations of undesignated assets with sand and gravel and (more surprisingly) with mudstone (London Clay), and a strong negative correlation with head deposits. The density of assets on the sand and gravel is notably high at 4.83 per km^2, almost 2.5 times the average, whilst on the head deposits it is only 1.1 per km^2, just over half the average. Alluvial and coastal geologies show a moderate negative correlation and a density around 1.4 assets per km^2, although this is likely an underestimate given the obscuring effect of these geologies. On this basis sand and gravel can be identified as a 'favoured' geology and head as 'less favoured'. The other geologies show some but less pronounced variation within the range of 1.4 to 2.8 assets per km^2.

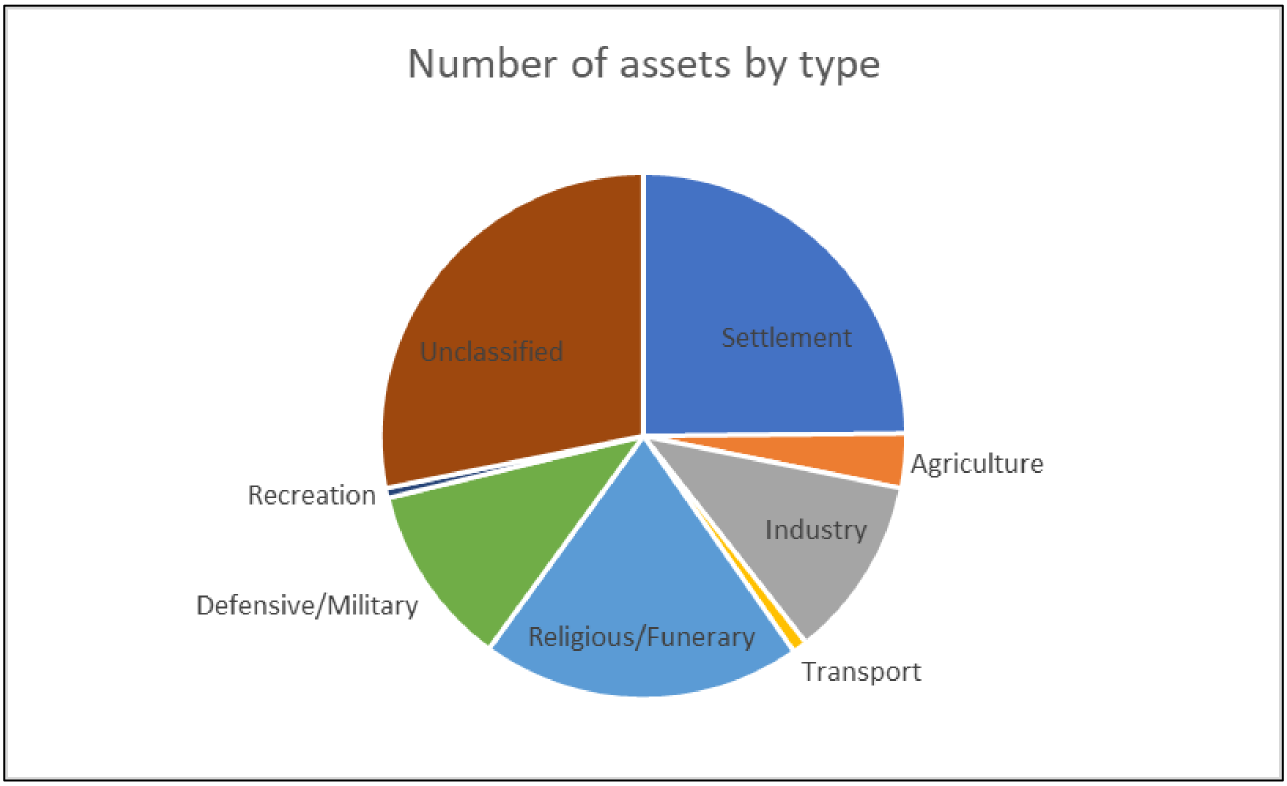


Figure 5.31: Number of assets by type

The case studies supported the high incidence of archaeology on the gravels which had four times the density of head deposits. There was an even lower occurrence on alluvial and coastal deposits, although this effect is exaggerated by the likely deep burial of some prehistoric remains and limited attention given to historic features such as sea defences in mitigation strategies. There was insufficient data from the case studies to assess correlations with other cultural or topographical indicators. The small number and diverse character of the SMs generate few patterns although the sand and gravel again shows a strong positive correlation, partly because of the scheduled Orsett cropmarks comprising four areas.

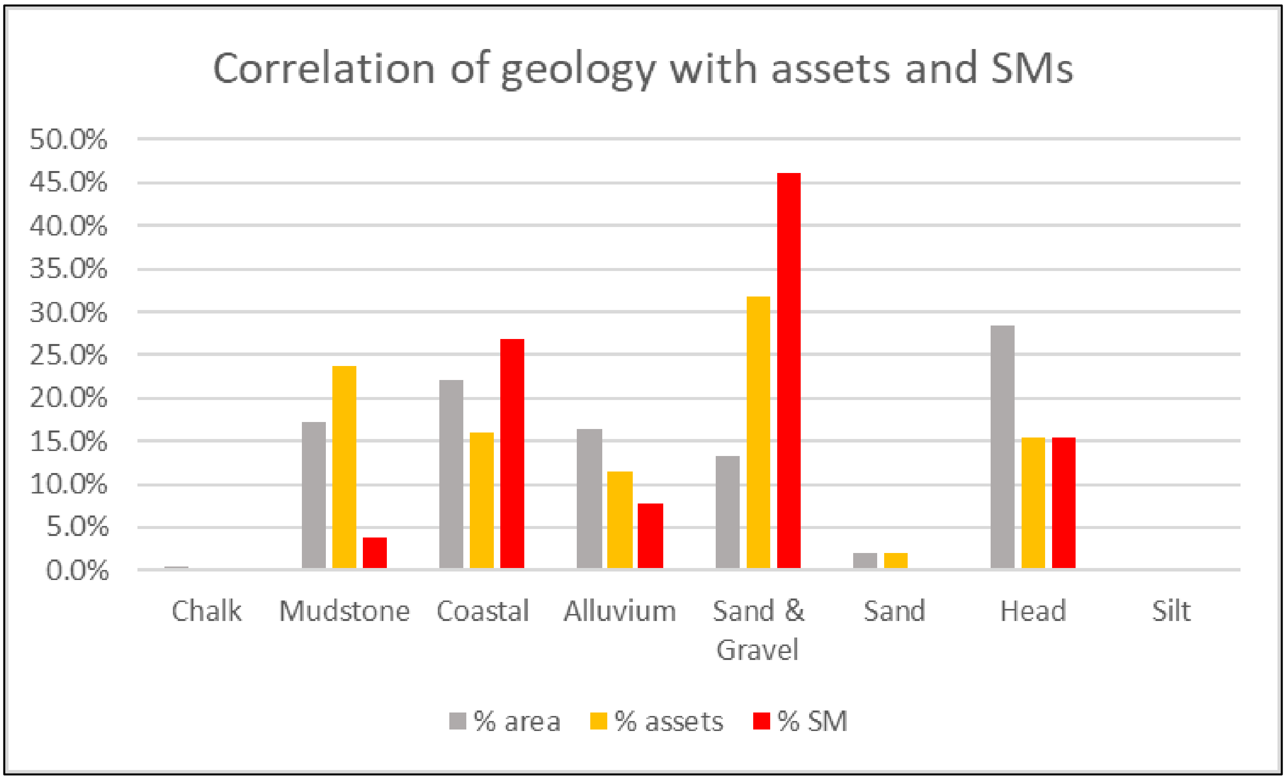


Figure 5.32: Graph showing percentage of asset centroids which fall within each surface geology

Proximity to a limited range of topographical indicators was explored, comprising watercourses and local high points, the latter simply located by eye from contours (Fig. 5.33). High points had a strong positive correlation with assets at a high density of 4.58 per km^2, comparable to sand and gravel geology. Watercourses, on the other hand, surprisingly had a strong negative correlation with assets and a density of 1.16 per km^2, comparable to the head deposits. In large part these correlations might be explained by the relationship between topography and geology, with high points being found mostly on sand and gravel and mudstone whilst watercourses mainly run through the alluvial and coastal deposits (Fig. 5.34), suggesting that these indicators largely duplicate patterns evident from the geologies, although in the time available the study was not able to interrogate these relationships statistically. Scheduled monuments did not show any statistically significant correlations.

A wider range of cultural indicators was investigated, with mixed results (Fig. 5.35). Roman roads proved, rather counter-intuitively, to have a strong negative correlation with assets, only having a density of 0.59 assets per km^2 within 200 m, roughly a quarter of the average density. None of these are major roads and even their status as Roman is uncertain so the reason for this outcome is not readily apparent. However, in the Vale of Aylesbury Roman roads did not prove to be a strong predictor either (4.3.6), nor have they been found to be in relation to Roman rural settlement (Paul Chadwick, pers. comm.).

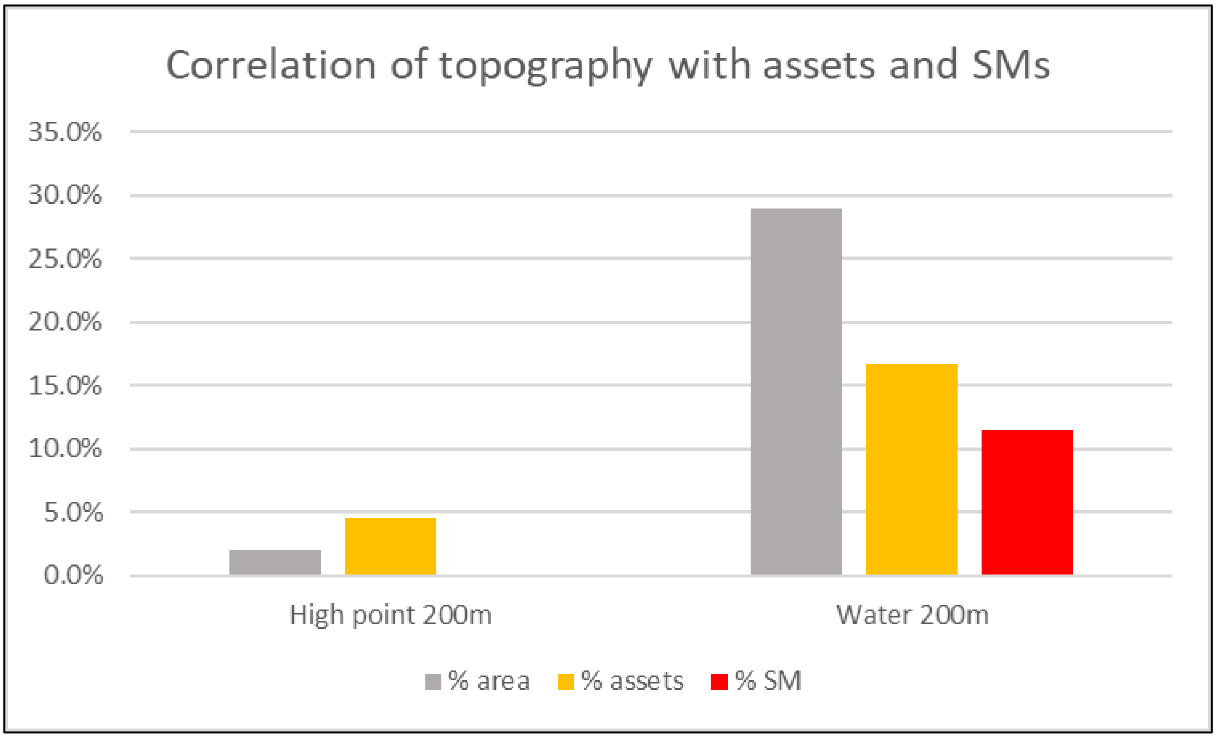


Figure 5.33: Graph showing percentage of asset centroids which fall within 200 m of a local high point or watercourse

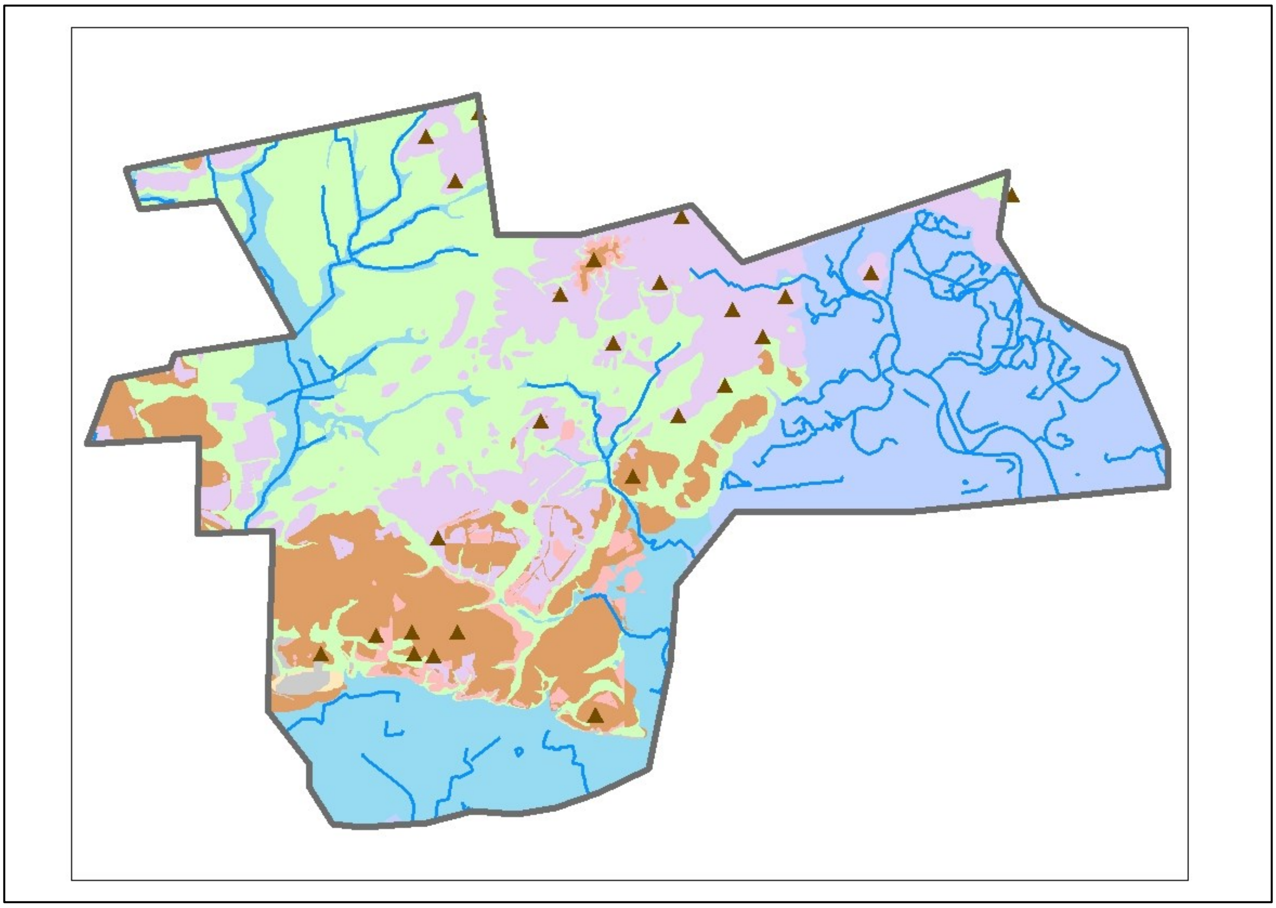


Figure 5.34 (previous page): Distribution of local high points and watercourses in relation to geology (see Fig. 5.3; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

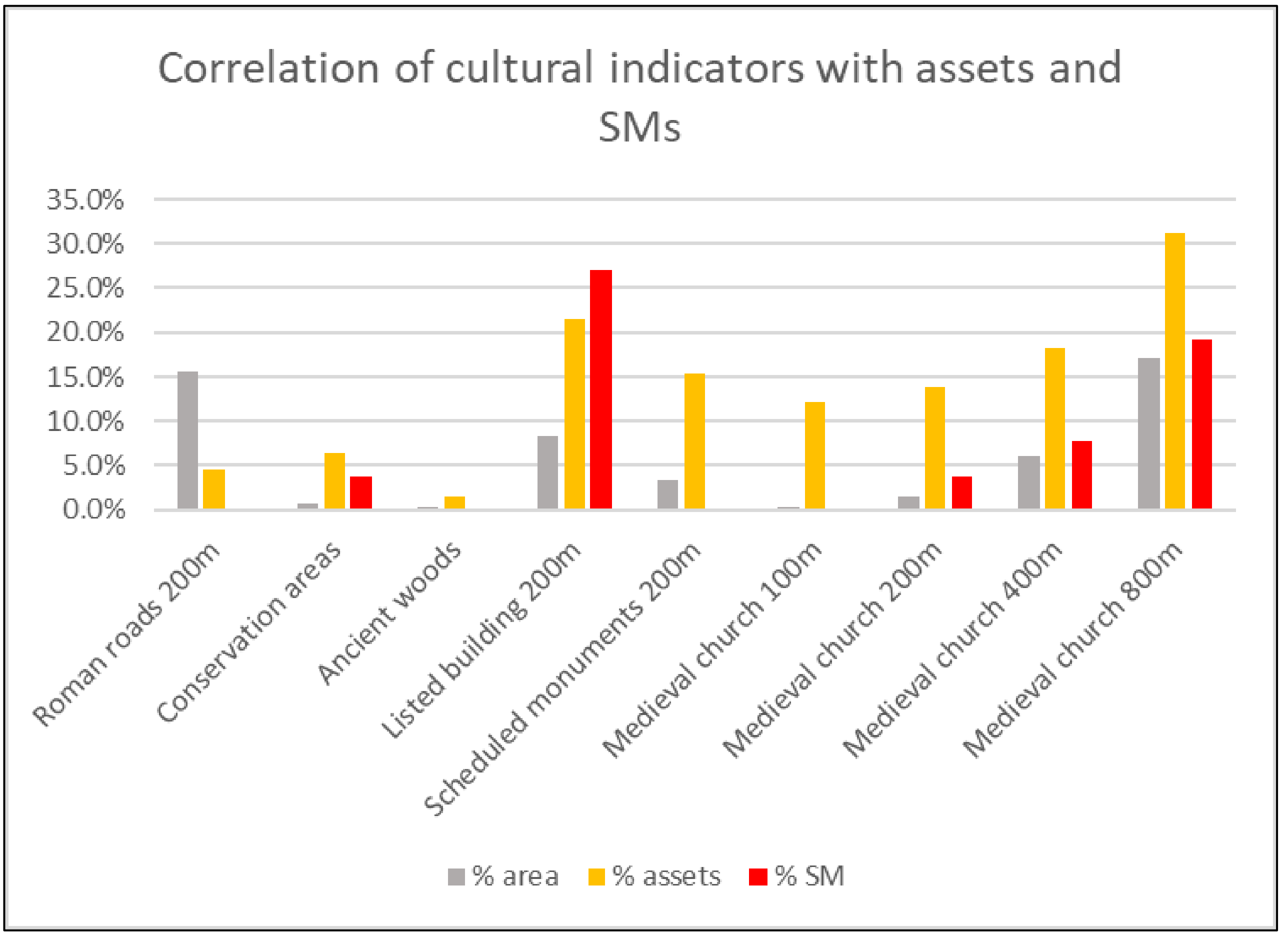


Figure 5.35: Graph showing percentage of asset centroids within each cultural category compared to the overall proportion of the study area covered by that category

Hardly surprisingly conservation areas, listed buildings, medieval churches and SMs all show strong positive correlations with non-designated assets at densities even higher than sand and gravel or high points. Analysis of the fall-off of positive correlation around medieval churches indicates that only within 200 m is the effect significant.

An overview of the factors that emerge as significant indicators of presence can be summarised as shown in Table 5.5. The table attempts where possible to give some indication of how much each indicator increases (or decreases) the probability of encountering significant archaeology in relation to the norm for the study area.

Table 5.5: Indicators of presence

Indicators of presence			
Topographical		***Cultural***	
Favourable	***Less favoured***	***Favourable***	***Less favoured***
Sand and gravel (x 2.4)	Head (x 0.5)	Proximity to medieval church (mainly LM/PM) 200m (x1.5–x9)	Proximity to 'Roman road' (x 0.25)
Local high point 200m (x2.3)	Watercourse 200m (x 0.6)	Proximity to SM 200m (x5)	
		Proximity to listed building 200m (x2.5)	
		Within conservation area (x9)	

These indicators can be merged and mapped (Fig. 5.36). In all, the favourable presence indicators cover 3614.4 ha and the less favourable indicators 9000.7 ha, but of these 1112.8 ha have overlapping positive and negative indicators. Analysis of the overlap areas found a strong positive correlation with assets, indicating that favourable indicators more than outweigh less favourable indicators, reducing the extent of the latter to 7887.9 ha.

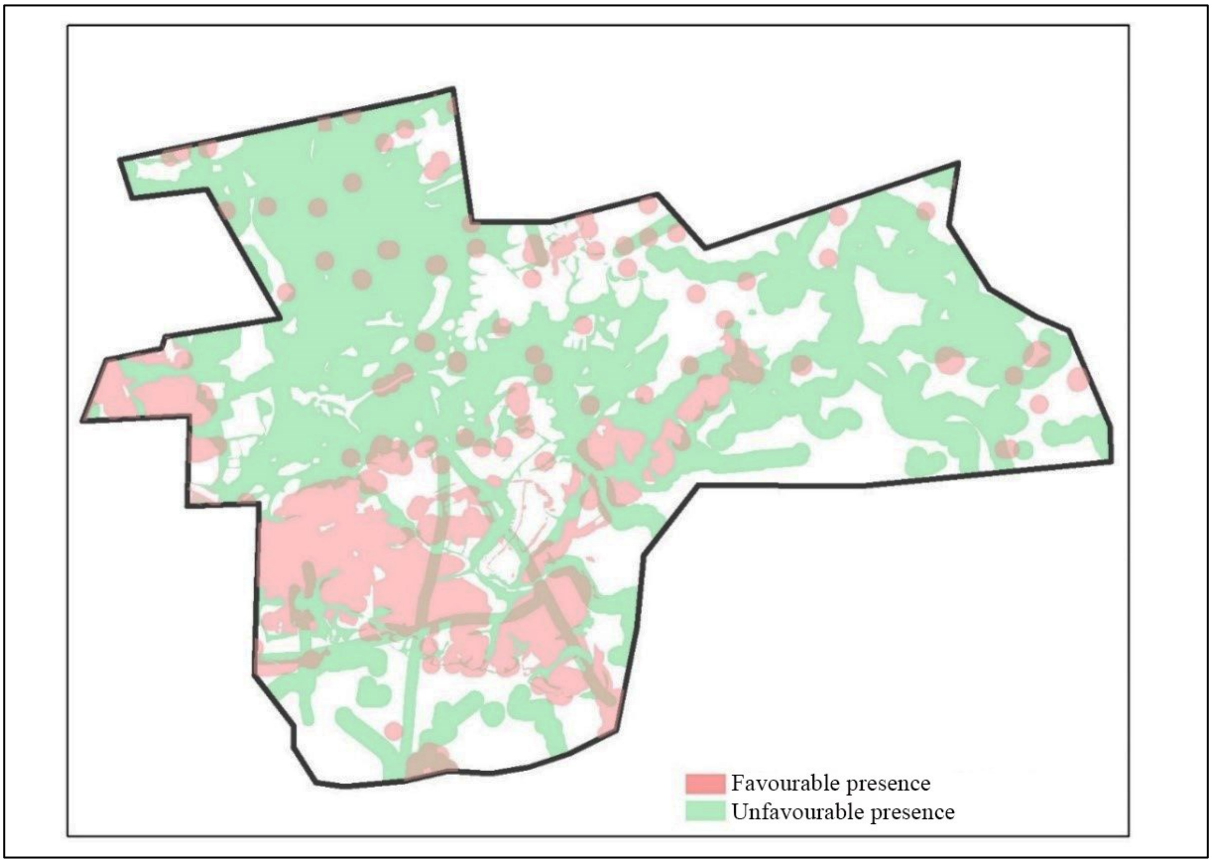


Figure 5.36 (previous page): Favourable presence indicators (pink) overlain on less favourable (green). Where the two overlap the land is assigned as favourable. The remaining land (white) will be neutral – neither particularly favoured nor less favoured.

The identified assets and presence potential can then be assigned to levels as outlined above (3.2.1) and mapped (Fig. 5.37). Note that assigning Level 0 requires polygonised event data that can be linked to outcomes but this was not generally available for the study area so has not been classified. Recognising and mapping 'blank areas' is something HERs have understandably perceived as problematic and not a priority but might be a useful tool in future now that large-area evaluations and mitigations are becoming increasingly widespread, at least in some parts of England.

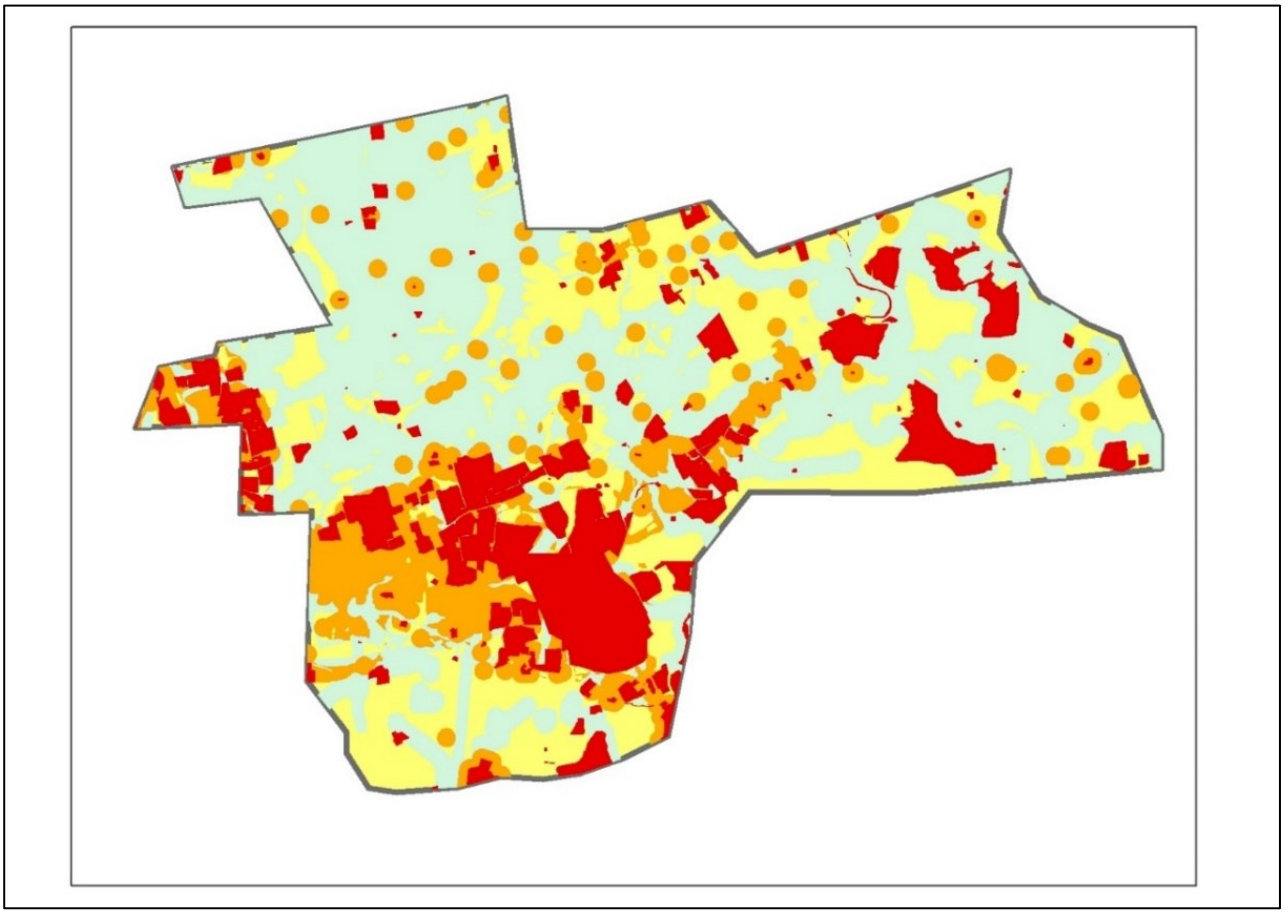


Figure 5.37: Presence model for London Gateway: red = Level 4 (known assets); orange = Level 3 (favourable locations); yellow = Level 2 (neutral [average] locations); green = Level 1 (less favourable locations). Level 0 was not mappable due to limited coverage of event polygons.

Notably the HER known asset density for all periods (including undated) is 1 per 0.5 km^2, whereas the case studies generated a very high figure of 1 per 0.1 km^2 (or if the exceptional Mucking site is excluded 1 per 0.2 km^2). These figures imply an overall visibility of 20–40% across all periods, i.e. the Essex HER contains sufficient information to identify between one and two fifths of extant heritage assets.

5.5 Condition mapping

Mapping condition used HLC as the basis for assessment, supported by land cover maps (for physical impact of modern land), geological mapping (for soil chemistry) and scheduled monument form, manually classified from individual records. GIS data was extracted following the rules outlined in Appendix 4 in order to allocate each land parcel one of the condition codes outlined in Table 3.3 (with the minor inconsistencies outlined in 4.5). For London Gateway coding condition proceeded in three steps:

Step 1 involved classifying the known condition of SMs and non-designated assets where the information was available (Fig. 5.38). For the Vale of Aylesbury it was possible to classify form for Bucks ANAs (a much larger dataset) using a combination of data included in the ANA shapefile augmented by personal local knowledge. Unfortunately, the available Essex HER Monument GIS dataset did not contain sufficient information to be used for this purpose. However a few assets had been mapped by HLC and for SHINE (although in practice the HLC dataset almost entirely duplicated the other two so SMs and SHINE would be sufficient in this case). Built structures and earthworks were coded U whilst ‘flat’ sites were removed and simply classified by land use in step 2 as there is insufficient information on below-ground survival.

Step 2 addressed the land not classified by step 1 (the vast majority) using Essex HLC and supporting GIS datasets (Land cover 2019 and BGS alluvium) to code the likely condition of archaeological assets. It is important to emphasise that this approach does not depend on an asset being known or expected to be present – it considers what the likely physical condition of an asset would be *if* one is present. Essex HLC uses the Broad Group and Type codes outlined in Fig. 5.39.

The coding procedure is set out in Appendix 4. The HLC Broad Code was mainly used to structure this analysis. In the study area some broad codes could be allocated directly to a condition code, e.g. COM (communications) was mapped directly to code DF. Others required further processing, e.g. broad code WOD (woodland) was divided by type between ancient woodland (aw), assigned to condition code V, and plantation (wp) assigned to code SF. Unfortunately HLC classifies the main (small) areas of surviving ancient woodland in the study area as modern recreation, thus failing to recognise their preservation potential; such anomalies would need to be addressed either in HER enhancement or in detailed work for site allocations.

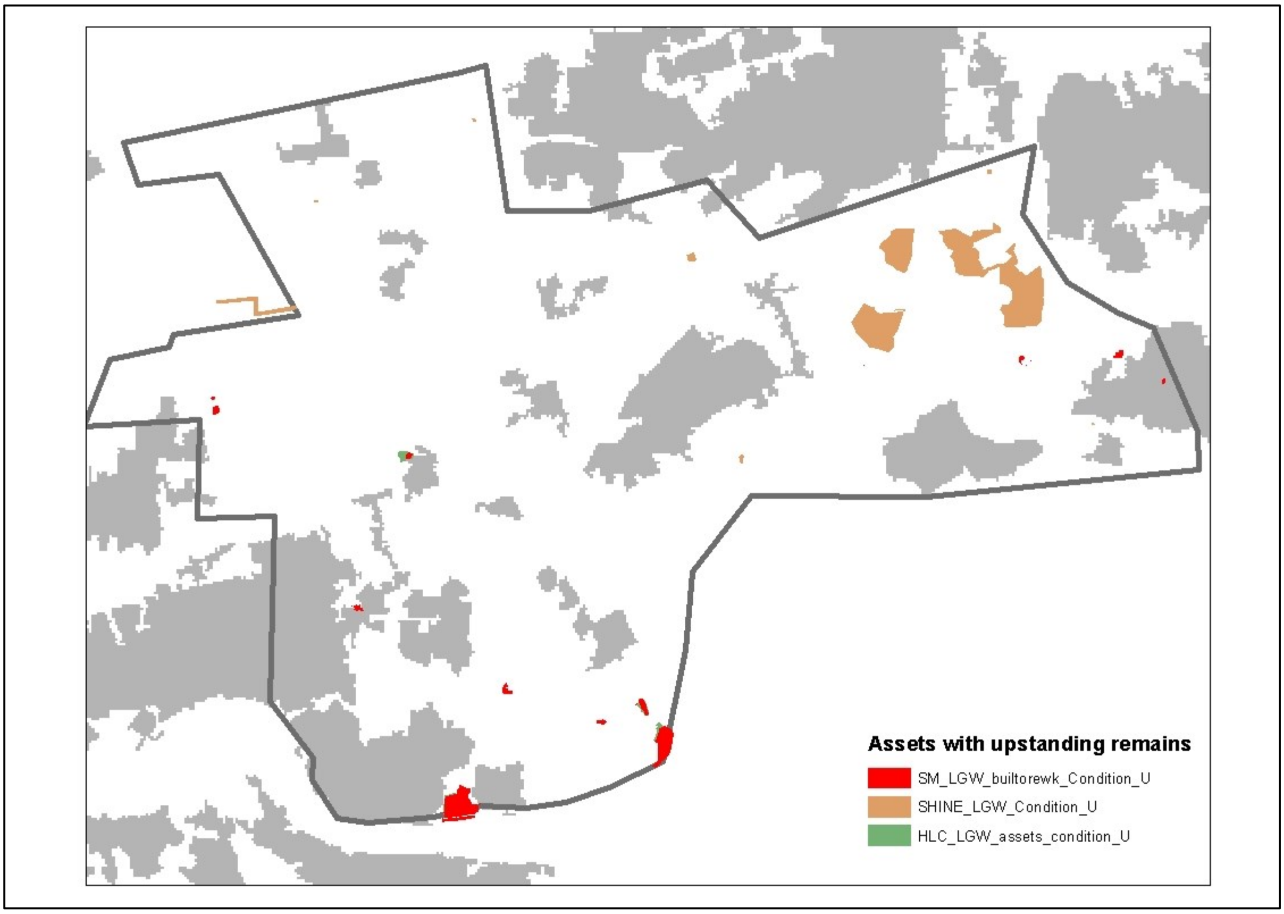


Figure 5.38: Known assets with built structures or earthworks coded U, derived from SM and SHINE datasets

The most complex (and extensive) group of codes was that for enclosed land, which in the study area is almost entirely land that has remained in agricultural use for at least several hundred years, and in many cases at least a thousand years. Factors in favour of better preservation would be modern grassland land cover and protective alluvial cover. Conversely, factors indicating lesser preservation would be modern fields (typically 'prairie fields' used intensively for modern mechanised arable) and modern arable land cover. Condition on HLC enclosed land can therefore range from code D (modern fields in arable cultivation) through S (historic fields in arable cultivation) to V (inland managed wetlands and fields under alluvium or pasture). For the time being these distinctions are theoretical and require ground-truthing.

Coastal types are also of key importance, with both managed wetlands and drained enclosure coded V despite the latter presumably having been more heavily impacted.

For settlements, it should have been relatively easy to distinguish between historic and modern using the HLC broad codes. Unfortunately, the Essex HLC did not actually use the historic built-up area (bh) code in the study area, thus failing to identify historic settlement cores. To remedy this the conservation area layer and Chris Bland Associates urban_1858_1873 layer have been used, as all these polygons included listed buildings; each was coded UF. There are 211 listed buildings in the study area, of which 84 are in conservation areas and 25 are in the 19th-century ‘urban’ settlements mapped by CBA (Fig. 5.40).

Report Group	HLC Broad Group Name	Broad Code	HLC Type codes
Enclosed Land	Pre-18th century enclosure 18th to 19th century enclosure 20th century agriculture Inland managed wetlands Miscellaneous Marginal	AEF LEF TEF IMW MIS MAR	ca, cf, df, ds, if, rf, sf le, pe, ps, bl, br, te mp, mw, wm mo rp
Open Land	Commons, Wastes, Heaths	CWH	cb, cm, gn, ht
Woodland	Woodlands	WDS	aw, wp
Parks and Gardens	Parks and gardens	PGR	ip, tl
Coastal	Coastal drained enclosure Coastal managed wetlands	CDF CMW	dc, dr mm, sa, ui
Settlements	Built-up areas - historic Built-up areas - modern	BUH BUM	ri, bh ba, hs, pl
Industrial	Mineral Industry	MIN IND	de, me, rl di, in
Horticulture	Horticulture	HOR	ag, at, ng
Military	Military	MIL	dm, ma, pm
Land use	Historic Water features Communications Miscellaneous Inland managed wetlands Coastal managed wetlands	EAR WAT COM MIS IMW CMW	he wr ap, mr, ww dd, rw, st wb ob

Figure 5.39: Essex HLC Broad Groups and Types

The historic settlement pattern was highly dispersed, perhaps excusing the absence of historic settlement cores, but together with the case of ancient woodland this analysis highlights an issue with the HLC. The workaround method used here has probably missed the smallest historic settlements and cannot capture the highly dispersed pattern indicated by listed buildings, highlighting potential areas for HER enhancement.

The completed structural condition model shows a clear former wetland/dryland distinction with an overlay of modern disturbance (Fig. 5.41; note that a few white areas have slipped through uncoded in this first iteration). Good structural preservation is still expected in the alluvial and coastal deposits whereas on the higher ground modern arable is predicted to have caused serious and extensive truncation.

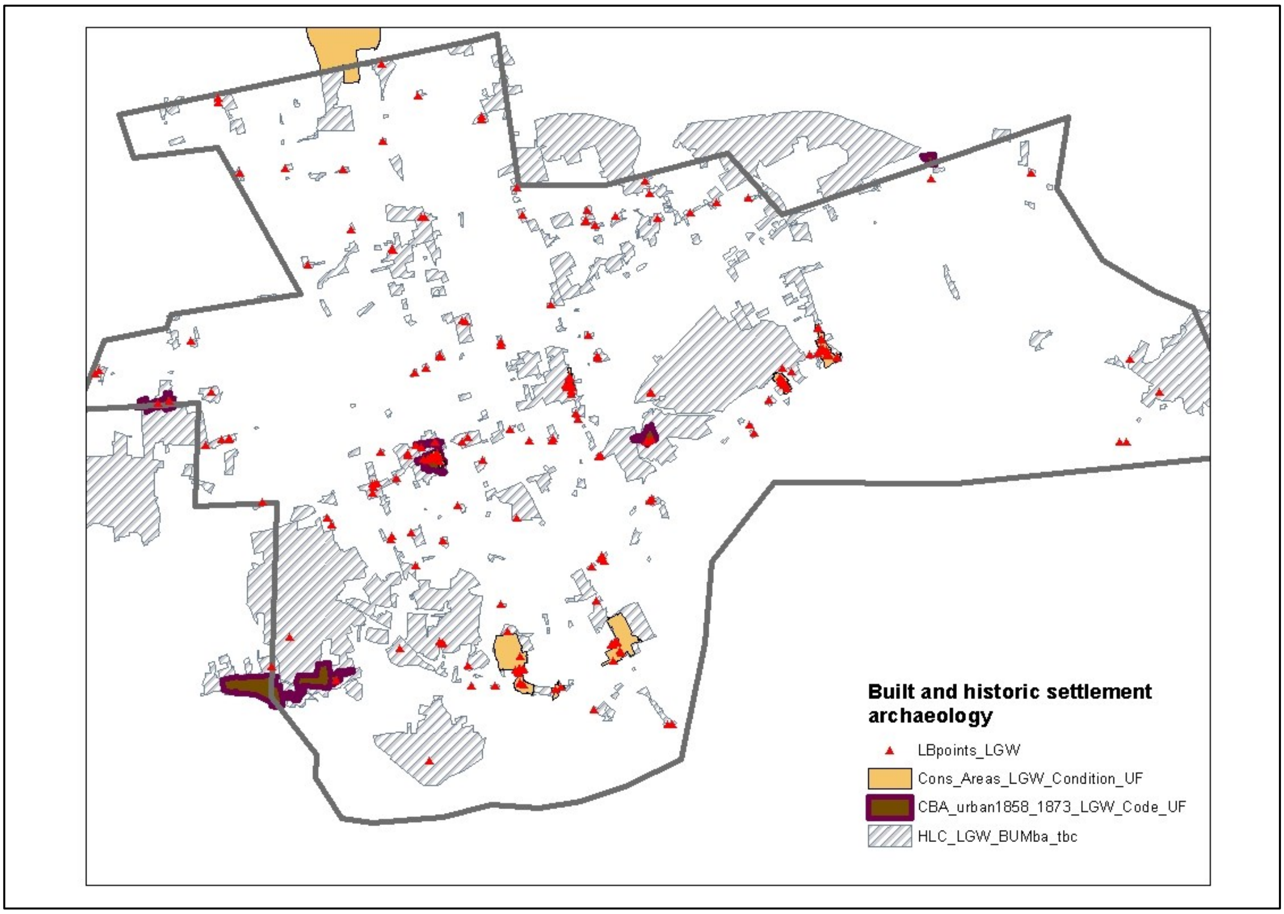


Figure 5.40: Built and historic settlement archaeology illustrating how the historically sparse dispersed pattern has been overlain by extensive modern development from which it needs to be disentangled for sensitivity mapping purposes

The case studies supported this model, with plough-truncated sites (Codes D or S) on the dryland gravel and well-preserved buried remains (Code V) in the alluvial/ coastal deposits. Interestingly, on the gravels, Mucking, which was excavated 50 years ago, was better preserved (Code S) than the post-2000 case studies, which are borderline D/S, supporting the suspicion that these sites have experienced active plough erosion. Use of HLC to map areas of destruction (Code X) from mineral working proved problematic because restored former quarries mapped by the BGS were not recorded as a modern HLC type, leading to a substantial underestimate of loss. BGS mineral sites up to 2012 were therefore added to the model, coded X (Fig. 5.42).

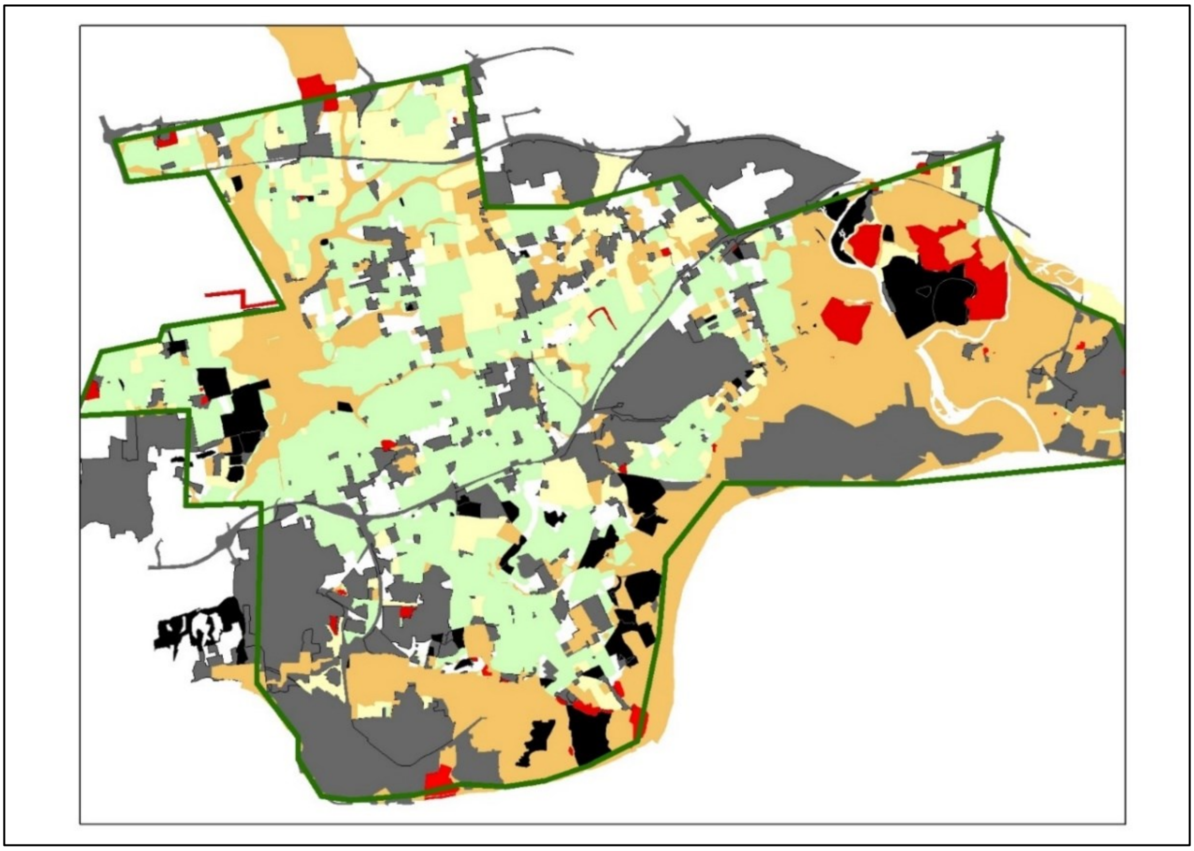


Figure 5.41: Condition model based on HLC (structural condition only): red = level 4 (exceptional); orange = level 3 (good); yellow = level 2 (fair); green = level 1 (poor); grey = level 0 (degraded); black = destroyed

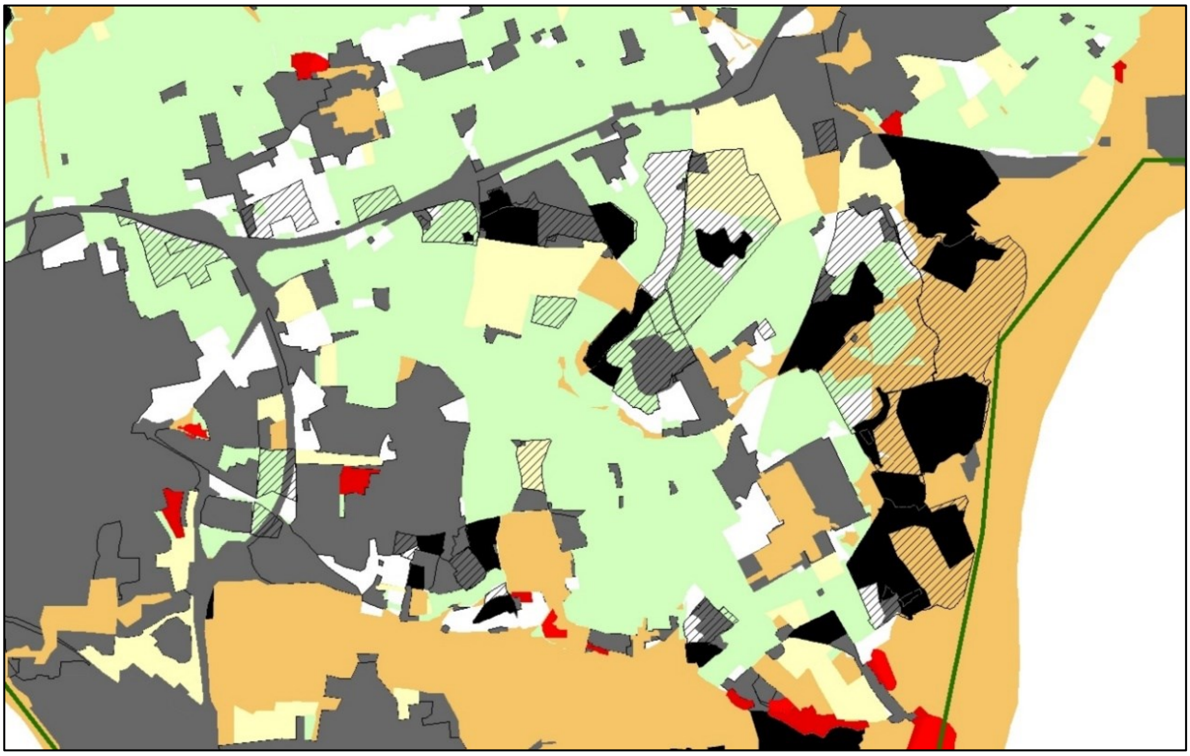


Figure 5.42 (previous page): Detail of condition model with BGS mineral sites (to 2012) overlain, illustrating limitations of HLC mapping where quarries (black) cover much smaller areas than historically worked land (hatched)

There are also large areas of artificial land recorded by BGS, mainly along the estuary and to the east of Tilbury, which are indicative of deep modern made ground. Where they overlap with mineral workings it is assumed archaeology will have been removed by the earlier extraction but where no mineral working is recorded then made ground will have covered but not necessarily destroyed archaeological deposits beneath. The current version of the deposit model may underestimate survival in these locations, although that will depend on the nature of the works involved in landfill – and if surviving remains are deeply buried beneath made ground then their sensitivity will be limited to deep groundworks. In practice it is known that deep alluvial sequences with archaeological potential do survive under modern made ground in the Thames Estuary, but away from these alluvial environments shallow archaeological remains will probably have been lost during landfill engineering operations. BGS artificial land areas that were unquarried (not on BGS minerals sites) and overlie alluvial or coastal deposits were therefore extracted as areas where deeply buried archaeology may survive (Fig. 5.43).

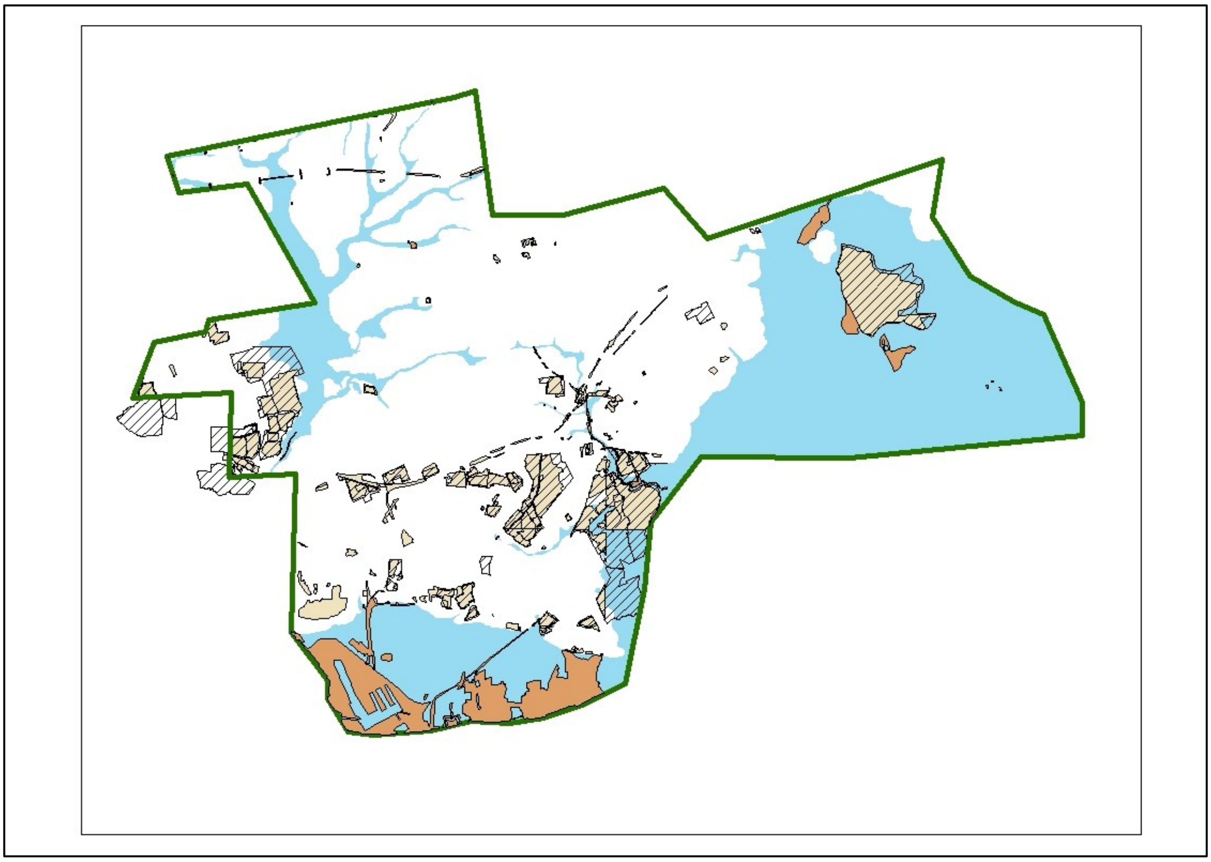


Figure 5.43 (previous page): BGS mineral extraction (hatched) overlain on artificial ground (tan and orange) and alluvial or coastal deposits (blue) (derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

In the revised model note the cross-hatched areas where deeply buried deposits may survive under made ground, and a few white areas which have again slipped through uncoded (Fig. 5.44).

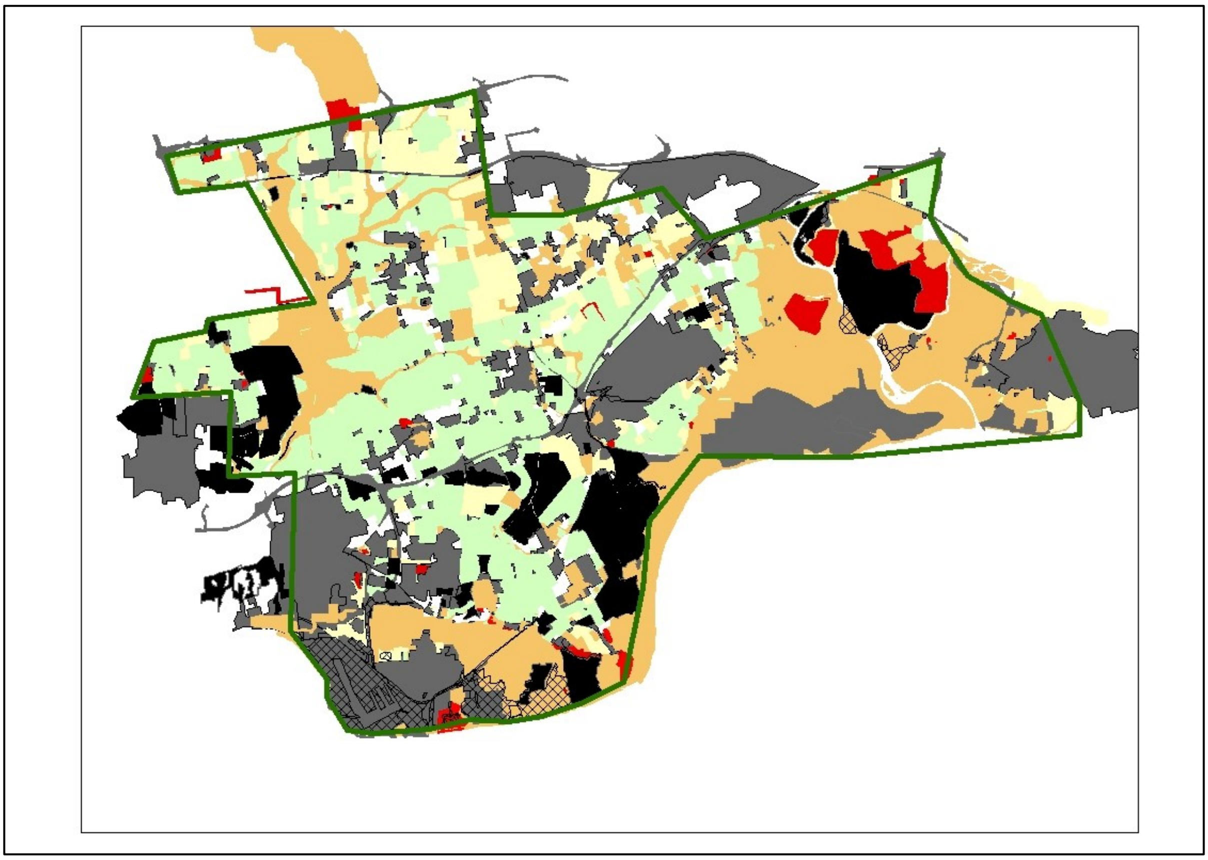


Figure 5.44: Revised structural condition model based on HLC and BGS mapping (derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved); key as for Fig. 5.41

Step 3: involved coding the soil's chemical survival conditions in the simple threefold schema of A (Anoxic), B (Basic) and C (Acidic). This categorisation aims to identify wetlands where widespread waterlogged structural and environmental remains are expected (code A; Fig. 5.45) – note that localised anoxic contexts can be found almost anywhere so are not modelled here. For this study BGS alluvium and coastal deposits, which cover 6334.6 ha (38.6% of the study area), have been classified A but this could be refined by identifying known waterlogged monuments or other topographical features having anoxic potential in addition to mapped wetlands. Case studies for Stanford Wharf and DP World London Gateway support this model.

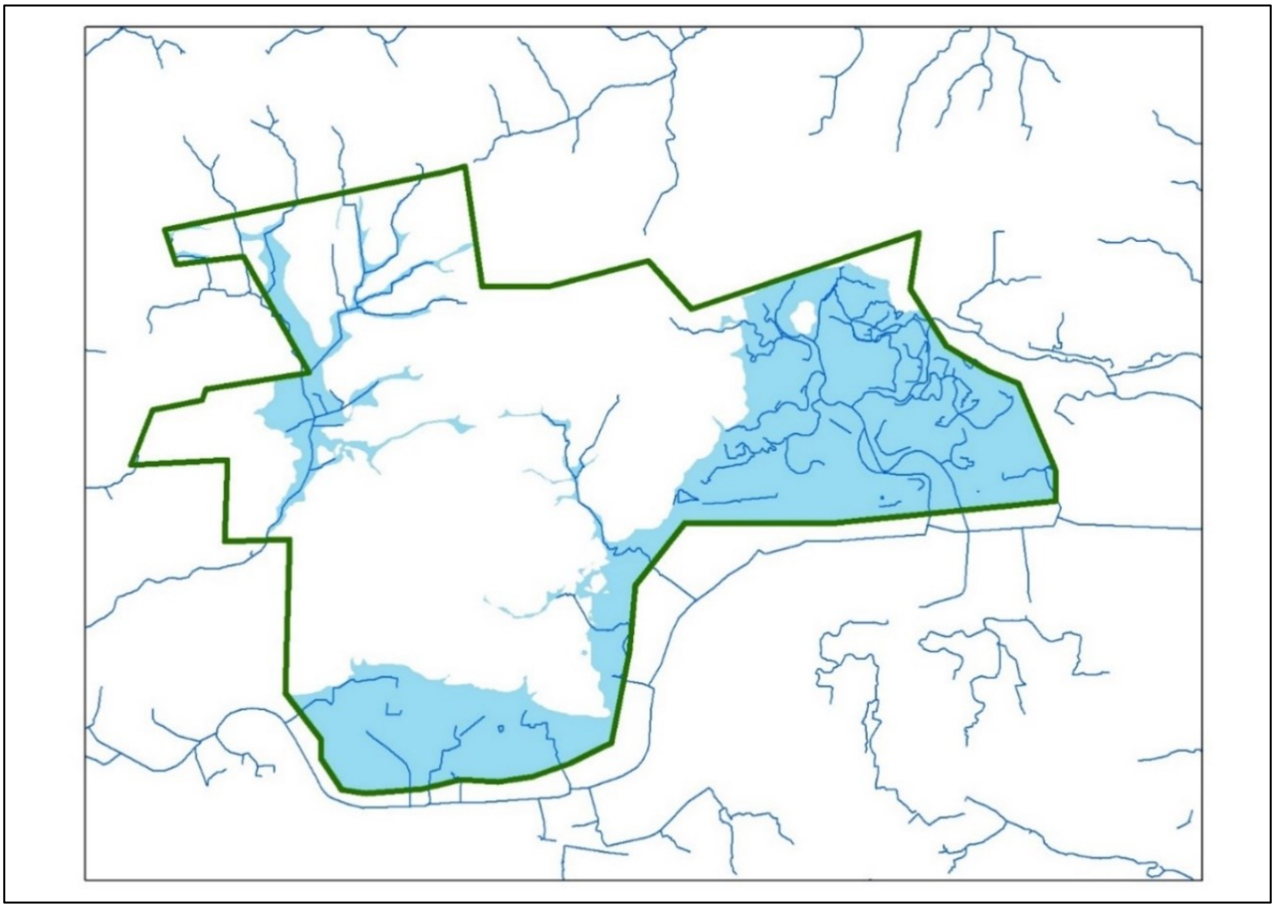


Figure 5.45: Anoxic potential map showing alluvium and coastal deposits plus modern watercourses (derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Dryland is divided into those soils with fair to good preservation of bone, metalwork etc and those where such remains are vulnerable to destruction. Across the study area soils are predominantly basic or neutral or mildly acidic mostly with no carbonate content (Fig. 5.46). Despite huge resources put into excavation, finds and environmental assessment in recent decades we still have no formal framework for landscape-scale prediction based on soil geochemistry (cf. Ward et al. 2009).

The case studies confirm widespread observations that the dry well-drained Thames sands and gravels generally have poor survival, although the geochemical explanation for this is not entirely clear. For example, Mucking's bone preservation on dryland sand and gravel was 'very poor' (Evans et al. 2016, 5) whereas on alluvium at Stanford Wharf Nature Reserve it was very variable (Strid in Biddulph et al. 2012). Unfortunately, the UK Soil Observatory pH map proved of little predictive value as there are only localised areas of highly acidic soils. It was therefore decided that in addition the sand and gravel deposits would be coded C (acidic) with the rest of the dryland coded B (basic/neutral).

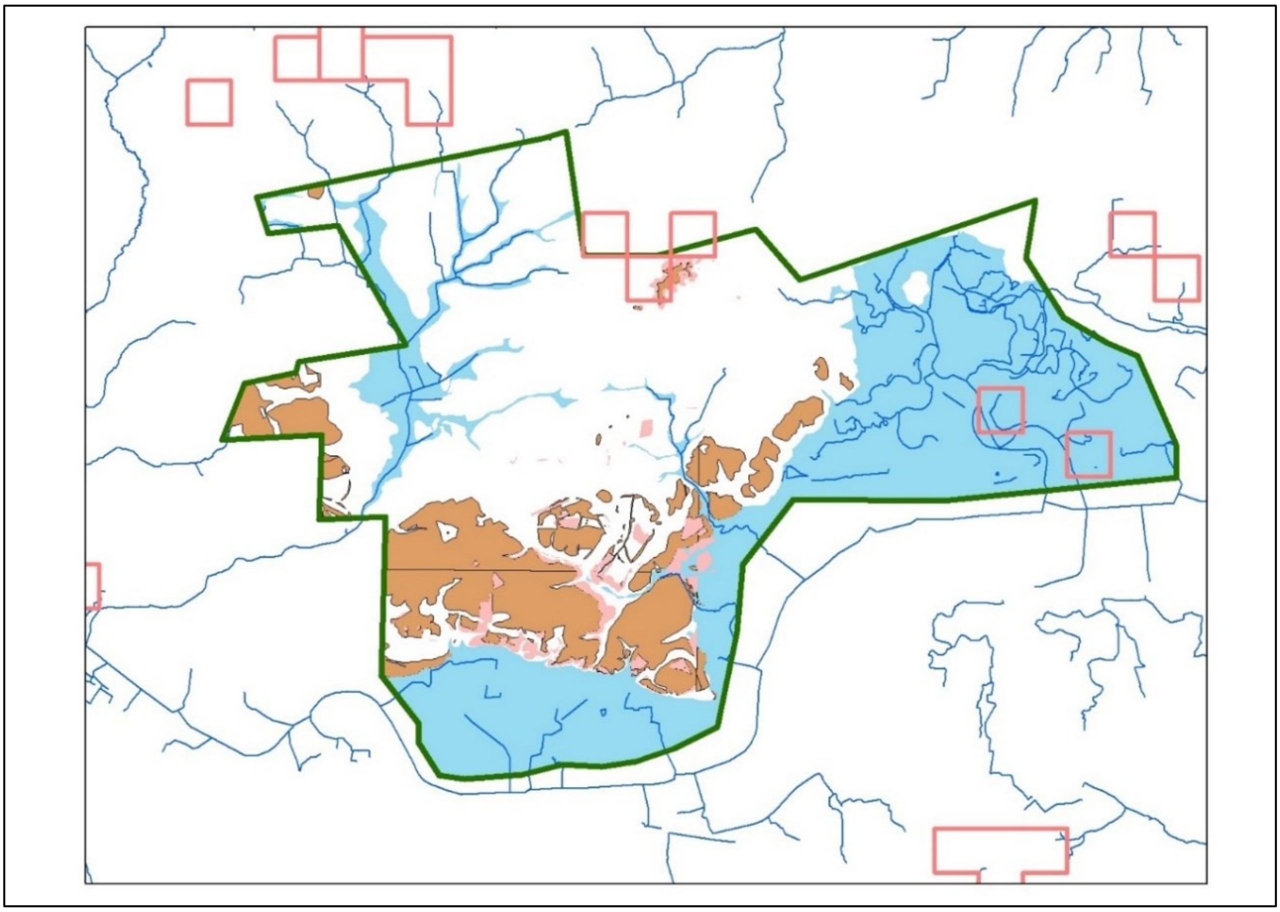


Figure 5.46: Strongly acidic soils pH 6 or less (red) overlain on selected geology (brown = sand & gravel; pink = sand; blue = former wetland alluvium and coastal deposits; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.). Geochemical condition coding: anoxic (A) = blue; dryland basic/neutral (B) = white; dryland acidic (C) = brown/pink. Model estimates of topsoil properties [Countryside Survey] © Database Right/Copyright NERC — Centre for Ecology & Hydrology. All rights reserved.

Assembling the condition model involved overlaying the chemical and structural models. The southern area (Fig. 5.47) shows a distinction between small areas of ‘upstanding archaeology’ (red), alluvial areas with good preservation potential (blue), plough-truncated and chemically impoverished landscapes (green), and degraded landscapes (grey – but with potential for deep survival cross-hatched). Destroyed areas (black) cannot be enhanced but degraded ones potentially can be.

The northern area (Fig. 5.48) is similar but with possibly less truncated agricultural land (yellow) while the eastern area (Fig. 5.49) shows larger areas of ‘upstanding archaeology’ (red) on former marshland.

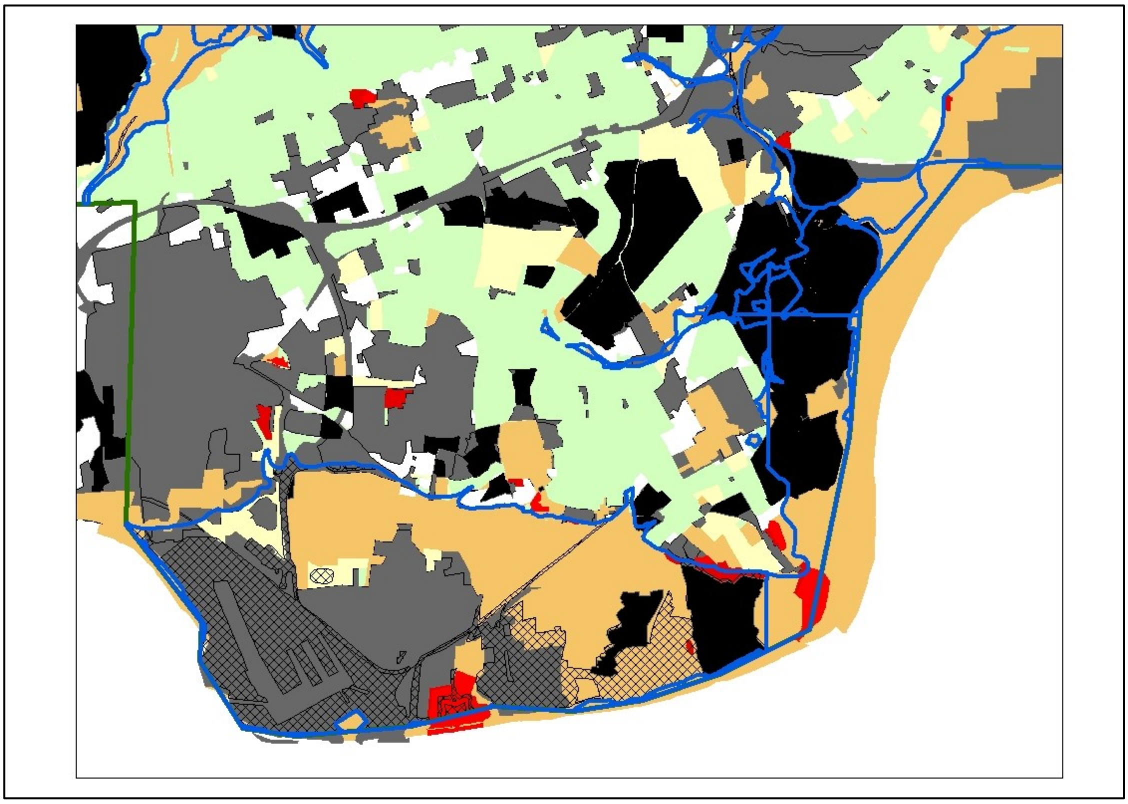


Figure 5.47: Combined condition model for southern area showing physical condition levels 4 (red), 3 (orange), 2 (yellow), 1 (green) and 0 (grey or black) with soil chemistry outlined blue for anoxic (waterlogged) potential (+1 level) and orange for acidic (-1 level). All other soils are basic/neutral. Hatched areas show where significant deposits may survive under deep made ground.

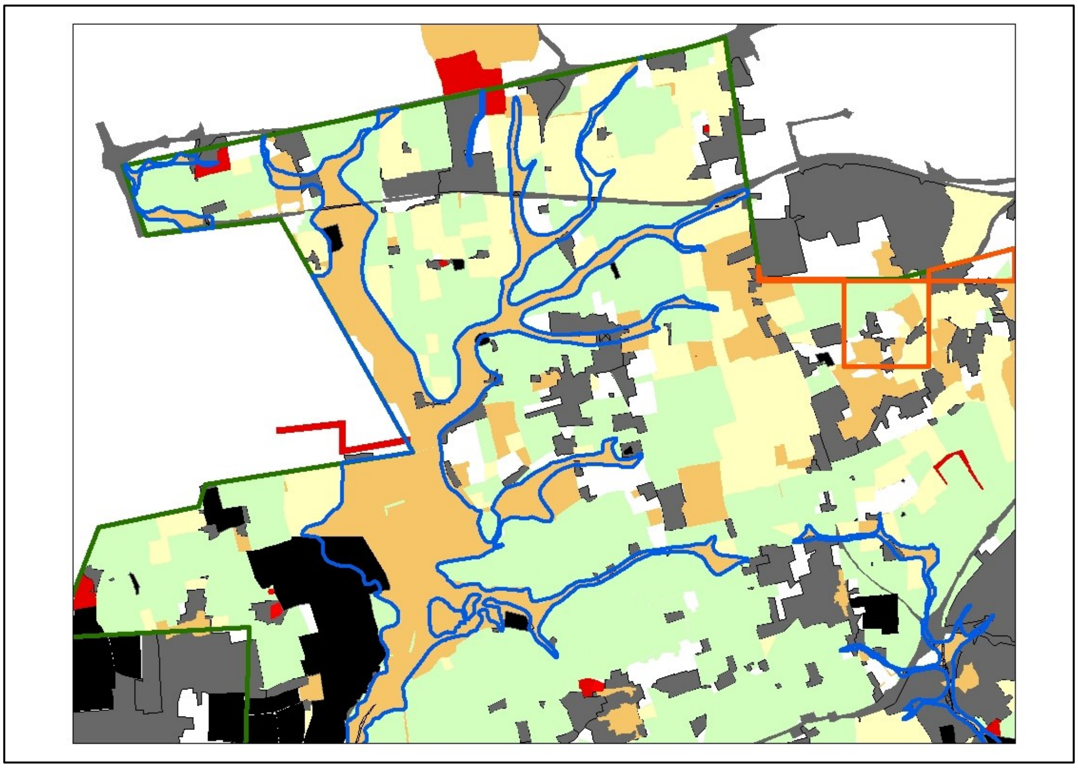


Figure 5.48 (previous page): Combined condition model for northern area (for key see Fig. 5.47)

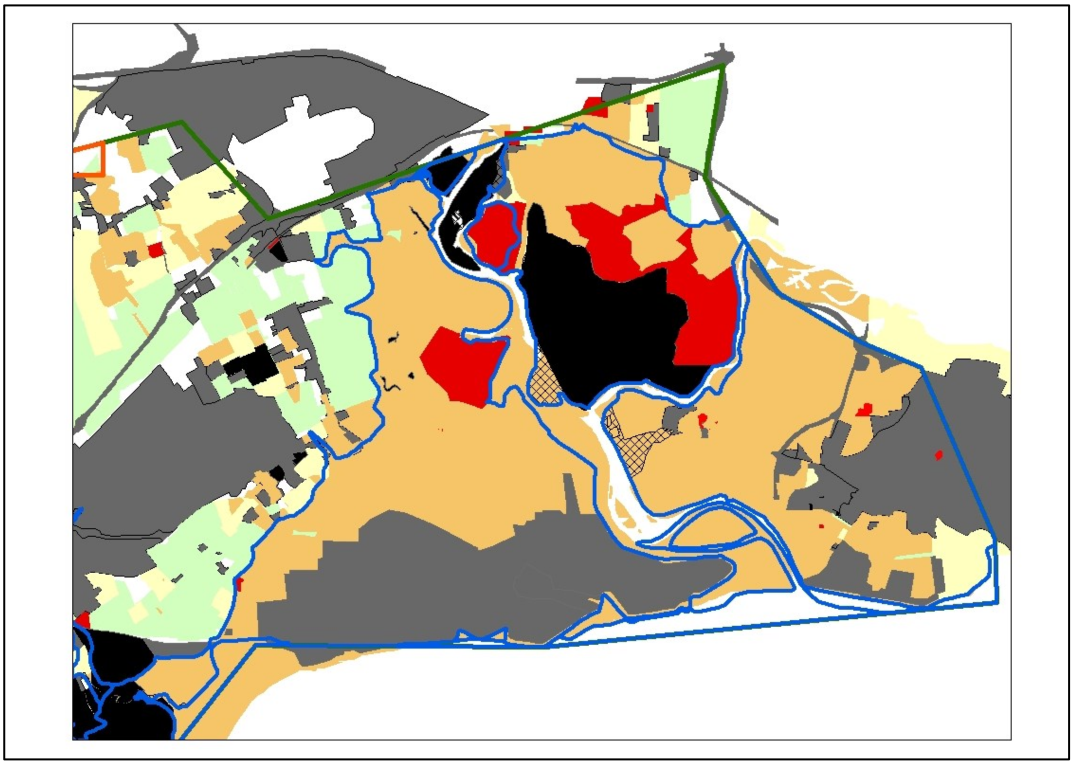


Figure 5.49: Combined condition model for eastern area (for key see Fig. 5.47)

5.6 Significance

5.6.1 Scheduled Monuments

There are 17 SMs within the study area (Figs 5.50–51) covering 110.4 ha (0.67% of the study area) comprising:

- 7 x modern military structures
- 1 x post-medieval coastal defence fort (Tilbury)
- 1 x later medieval moat
- 1 x later medieval castle earthwork
- 1 x later medieval industrial quarry
- 1 x Romano-British barrow
- 2 x Romano-British salterns
- 1 x later Bronze Age/Iron Age Springfield-style enclosure
- 1 x Neolithic causewayed enclosure (with early medieval barrow cemetery)

- 1 x undated defensive earthwork
- 1 x multi-period and presumably multi-functional cropmark complex at Orsett.

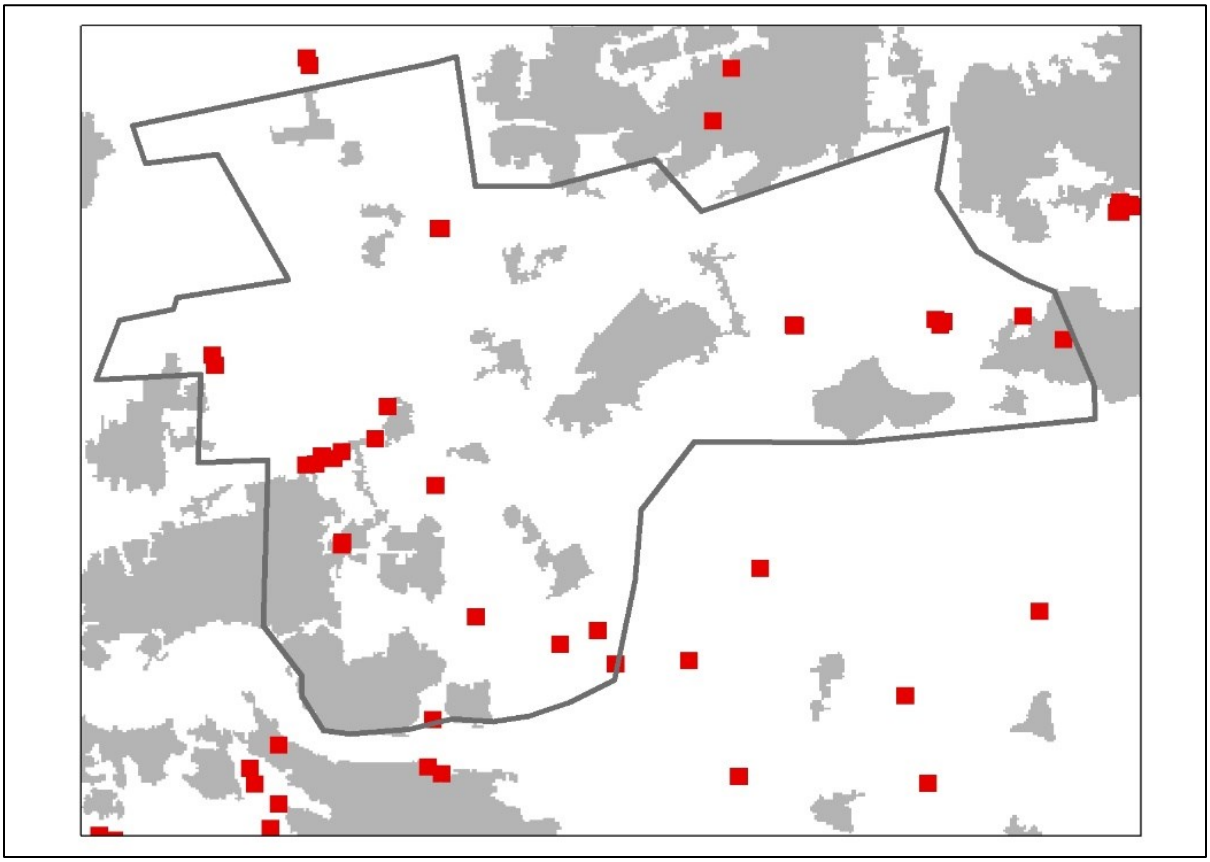


Figure 5.50: SM locations (note that a few monuments have more than one point, each covering a sub-area of the site)

The schedule is dominated by defensive structures, mainly of modern date but for other periods coverage is sparse and lacking obvious patterns. Most SMs in the study area are built structures or earthworks (Fig. 5.52). Only three (17.6%) are ‘flat’ with no or negligible visible components – although this does include the large cropmark complex at Orsett.

Scheduling has been sporadic, comprising an ‘inheritance’ of six monuments from before the 1979 Ancient Monuments Act (five of which are Old County Number records still lacking descriptions) supplemented by another 11 made under the MPP between 1994 and 2004 (Fig. 5.53).

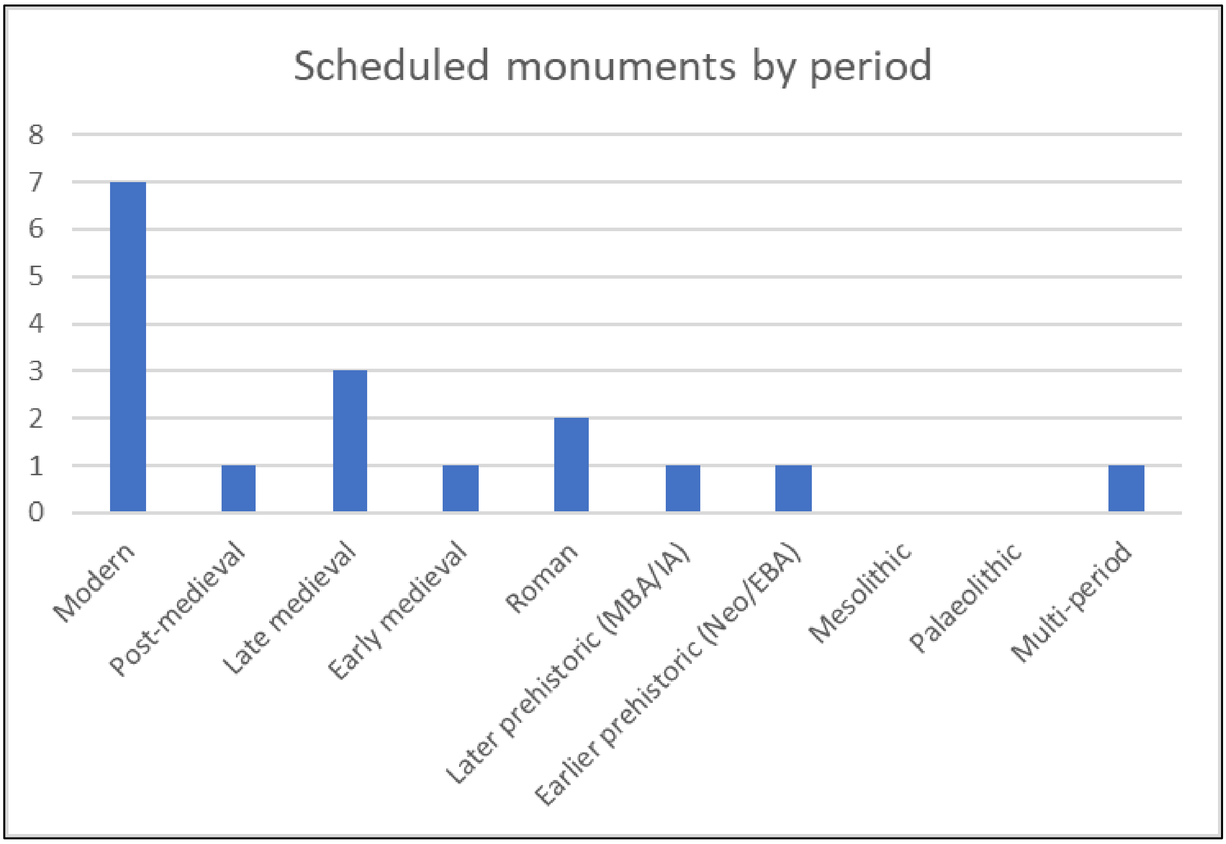


Figure 5.51: SMs by period. Note that the causewayed enclosure and Anglo-Saxon cemetery 500 m ENE of Heath Place is counted as both Neolithic–Early Bronze Age and early medieval.

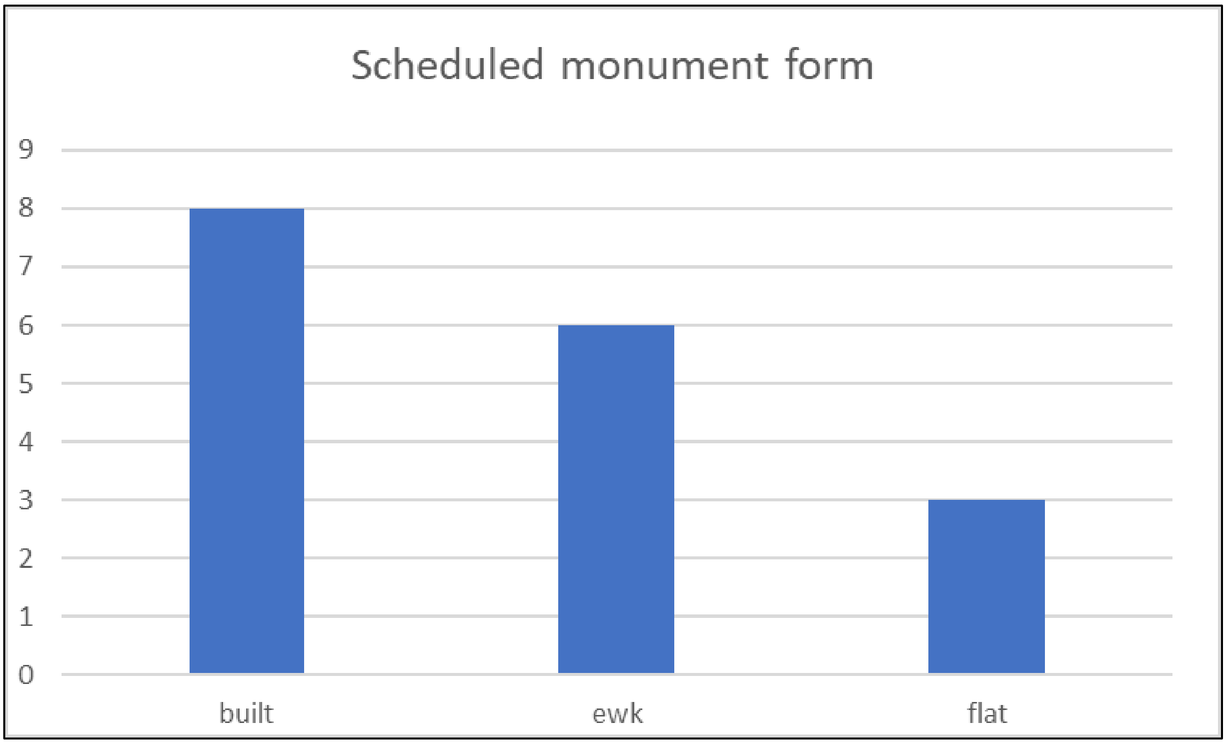


Figure 5.52: SMs by form

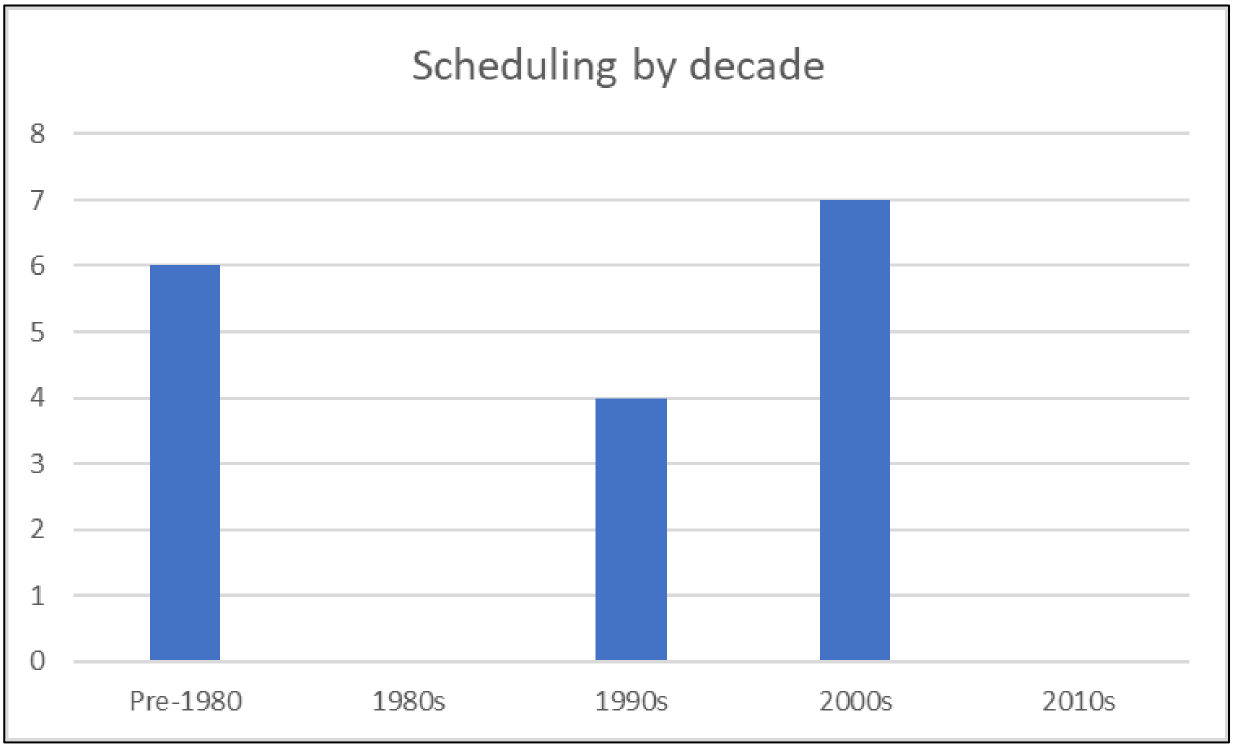


Figure 5.53: Scheduling by decade

The point of this analysis is to establish what precedents and trends there are for formally recognising national importance in the study area, the type and condition of such monuments and the risk of encountering more of these types. There is also a question as to whether there are other types that might reasonably be anticipated or ought to be better recognised despite not currently being represented in the local schedule.

5.6.2 National importance

As noted above, Essex has developed an approach defining Historic Environment Character Zones rather than discrete assets. The Essex HER for the study area contains 732 monument polygon records covering 6410.3 ha (39.1% of the study area); some locations lie within more than one overlapping polygon but the cited area covered does not double-count these overlaps. There are also 1354 monument points and 23 monument lines (Fig. 5.54).

Due to the quantities of data involved and apparent high overlap between the point and polygon datasets it was decided not to analyse the point data (which illustrates the need for HERs to polygonise significant known assets so that they can be managed). In addition to SMs, SHINE monuments can be drawn out as sufficiently well defined to merit identification as heritage assets. However, this still left about 90% of monument polygons to be reviewed (Table 5.6; Fig. 5.55).

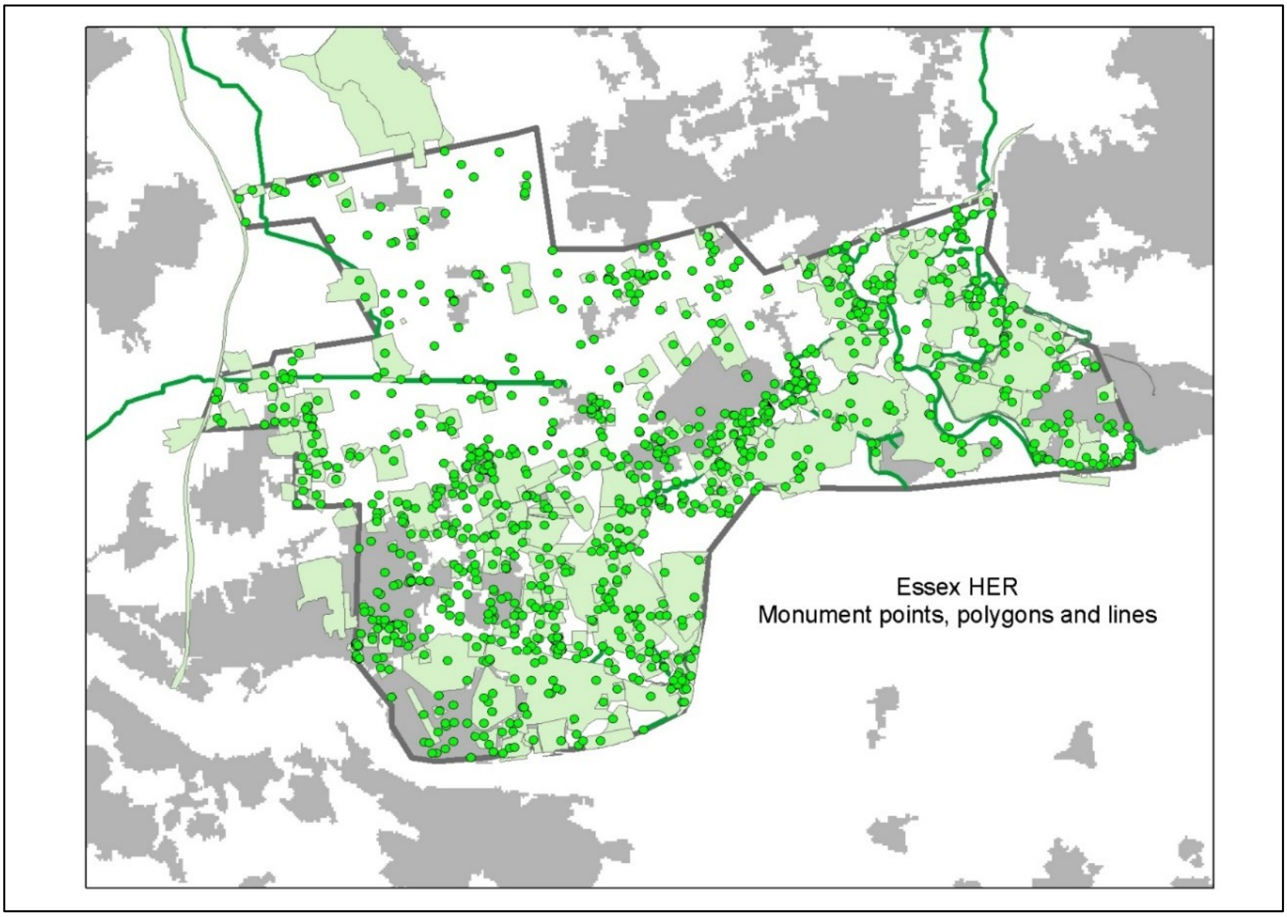


Figure 5.54: Essex HER monument points, polygons and lines

SHINE monuments can be further subdivided by form and significance, the latter rated low, medium and high. Under the current system, high-significance SHINE monuments would include assets potentially of national importance, and in selecting these the 1990s MPP scores may be referred to.

Table 5.6: Monuments reviewed for identification of assets

Asset type	***No.***	***Area (ha)***	***% study area***
Scheduled monuments	17	110.4	0.67%
SHINE monuments	59	466.9	2.8%
Essex HER monument polygons	732	6410.3 (10277.8 including overlaps)	39.1%

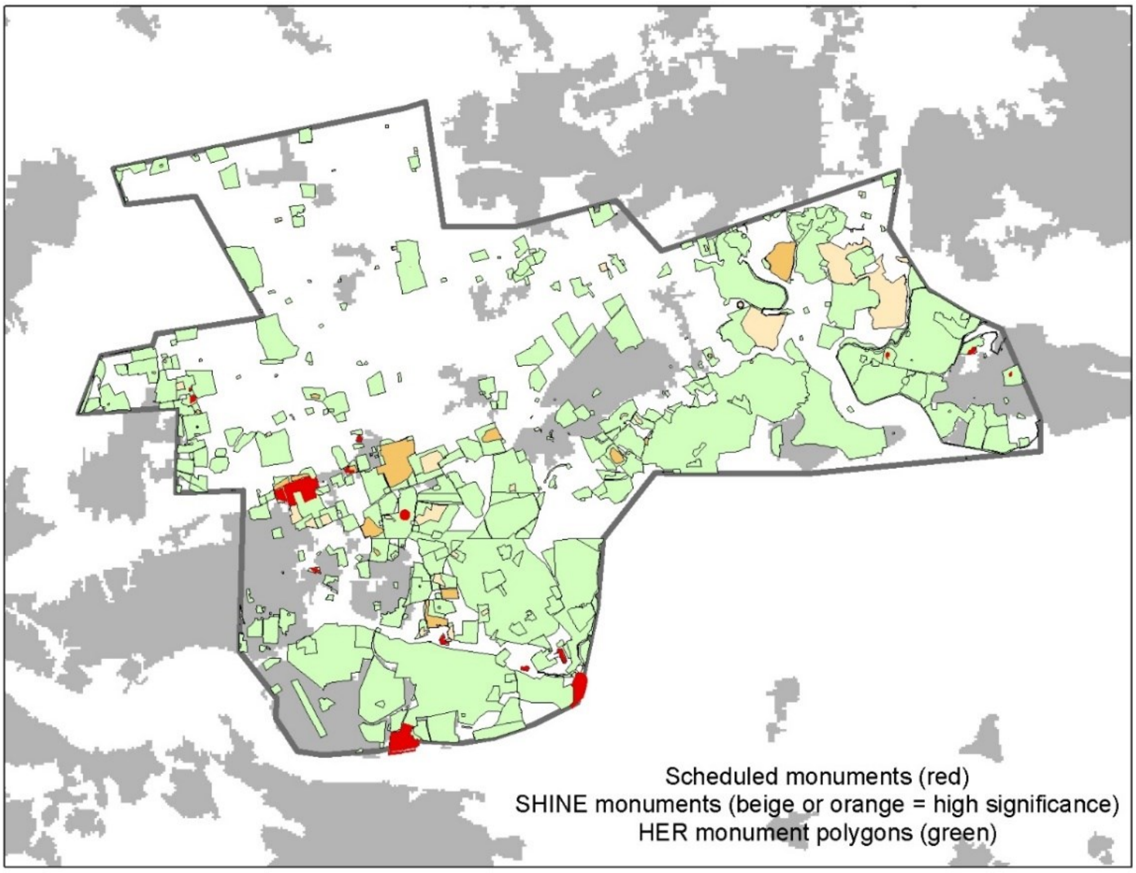


Figure 5.55: Monuments reviewed for identification of assets

The Essex HER does not use the old MPP ratings (Maria Medlycott, pers. comm.). However, of the 59 SHINE monuments in the study area, 15 are flagged as of high significance, covering 168.9 ha (1.0% of the study area). This study has not sought to interrogate the assumptions behind these judgements but assumes these are sensitive sites with sufficient evidence to be potentially of national importance. Assets of potential national importance have also been encountered in the case studies, including:

- Mucking North and South Rings
- Mucking Anglo-Saxon cemeteries and settlement
- Roman boathouse at Stanford Wharf
- Iron Age saltworks at Stanford Wharf.

Mucking was clearly an exceptional site and after a further 50 years of plough erosion the potential for equivalent discoveries on the sand and gravel must be somewhat moot. The discoveries at Stanford Wharf illustrate the much better condition of remains within the alluvial and coastal deposits.

The 732 Essex HER monument polygons were divided by record type and selected as ‘assets’ using the criteria in Table 5.7.

Table 5.7: Criteria for selection of assets

Record Type Code	***Number (selected)***	***Commentary***	***Archaeological asset recognition recommendation***
BLD (Buildings)	19 (1)	A small number of medieval, post-medieval and modern buildings including one post-medieval chapel and cemetery. Most appear not to be listed and it is not clear that all are still standing.	Exclude all except the chapel and cemetery. Standing buildings of local interest to be identified in local lists.
FS (Findspots)	35 (8)	Findspots of all periods, most with evidently poor provenance and/or isolated stray finds	Well-defined medieval or earlier artefact scatters and find locations are identified as assets
IND (Industrial)	21 (6)	A heterogenous mix of post-medieval and modern industrial sites ranging from gasworks and quarries to a hospital and post-mill. The current condition of these monuments is mostly undefined.	Quarries have been excluded as have possibly extant unlisted workers cottages which might be covered by local listing. Others excluded if apparently poorly preserved.
LB (Listed buildings)	13 (0)	Only 13 out of 211 listed buildings in the study area have a LB record, presumably due to *ad hoc* nature of HER reports/enhancement	Exclude all because this is a very partial dataset. Archaeological interest associated with listed buildings to be addressed elsewhere.
LND (Landscapes)	22 (3)	Only selected marshes and woodland recorded	Include woodland where earthworks are recorded, exclude where not. Exclude marshes lacking defined archaeological interest
MAR (Marine)	1 (1)	Undated wreck	Include as a discrete heritage asset
MON	598 (284)	See section 4 for period-based discussion.	Exclude fragmentary, destroyed or poorly defined monuments
NFF (No Features or Finds)	23 (0)	An evaluation or watching brief where nothing was found	Exclude

5.6.3 Other designations

There are no World Heritage Sites, registered battlefields or parks in the study area. There are only seven small conservation areas covering 117.6 ha and 211 listed buildings, the latter including 20 medieval churches. Many of these designated assets will likely hold or be associated with archaeological interest, mainly related to the medieval and post-medieval periods. Finally, there are 15 small patches of ancient woodland covering 59.2 ha which have archaeological potential; for example, Thurrock HEC notes important earthworks surviving within ancient woodland in Langdon Hills (HECZ 3.1) (Fig. 5.56).

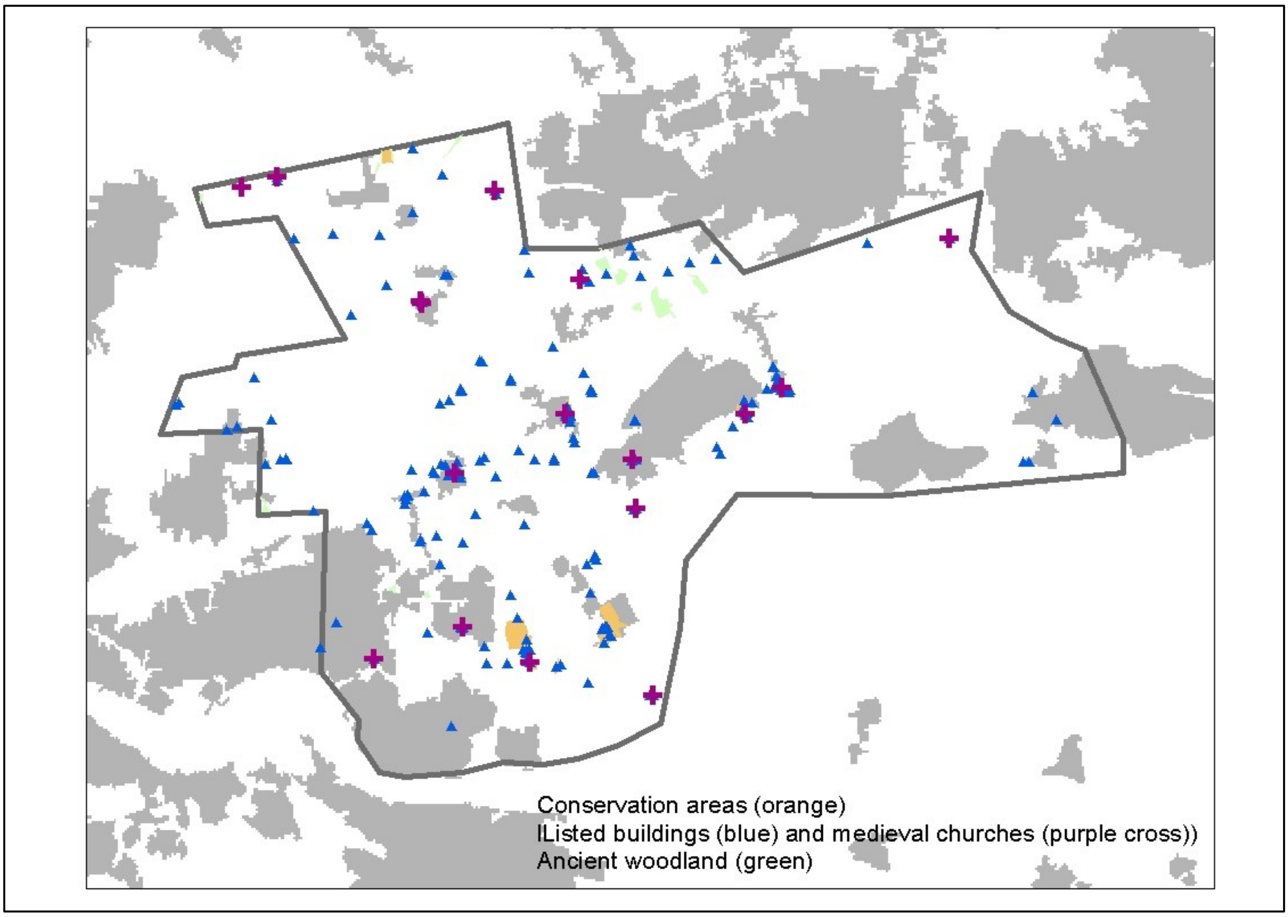


Figure 5.56: Other designations relevant to archaeological interest and significance

5.6.4 Research frameworks

Archaeological significance rests ultimately on an ability to articulate how investigation might advance understanding of matters of research interest. The relevant research frameworks for the study area are those for the East of England[22] and the Greater Thames

Estuary[24]. Like most such documents these frameworks do not generally map research priorities – and for many topics it is indeed hard to see how that could be done.

5.6.5 Identifying and mapping significance

Significance of known assets (expressed in planning rather than research framework terminology) can be identified by scheduling, other designations and high significance assets highlighted for SHINE. Significance might then be addressed spatially by dividing into levels along the following lines (Table 5.8; Fig. 5.57):

Table 5.8: Significance levels

Level	***General definition***	***London Gateway expression***
Level 4 Exceptional	SMs or other asset formally identified as of national importance	Only SMs
Level 3 High	Candidate NI sites and areas where archaeology is associated with designated assets or landscapes conservation areas, listed buildings, registered parks and battlefields) and close to scheduled monuments. Areas with enhanced cultural heritage policy protection (National Parks & AONB) or identified as research priorities or having demonstrably high potential for new discoveries of nationally important assets.	SHINE high significance sites Conservation areas 200m buffers around listed buildings and scheduled monuments The gravel terraces have a locally high density of scheduled monuments and the nationally significant Mucking sites
Level 2 Fair	Baseline areas without known national importance indicators (but still some potential for such new discoveries)	Default rating
Level 1 Low	Areas where survey has shown that non-designated archaeological heritage assets are likely to be sparse and fragmented or 'background signature'	Not assigned due to lack of spatial information on survey, and especially negative results from it

[24] https://historicengland.org.uk/images-books/publications/greater-thames-estuary-res-framework-2010/gt-research-framework-2010-pt1/

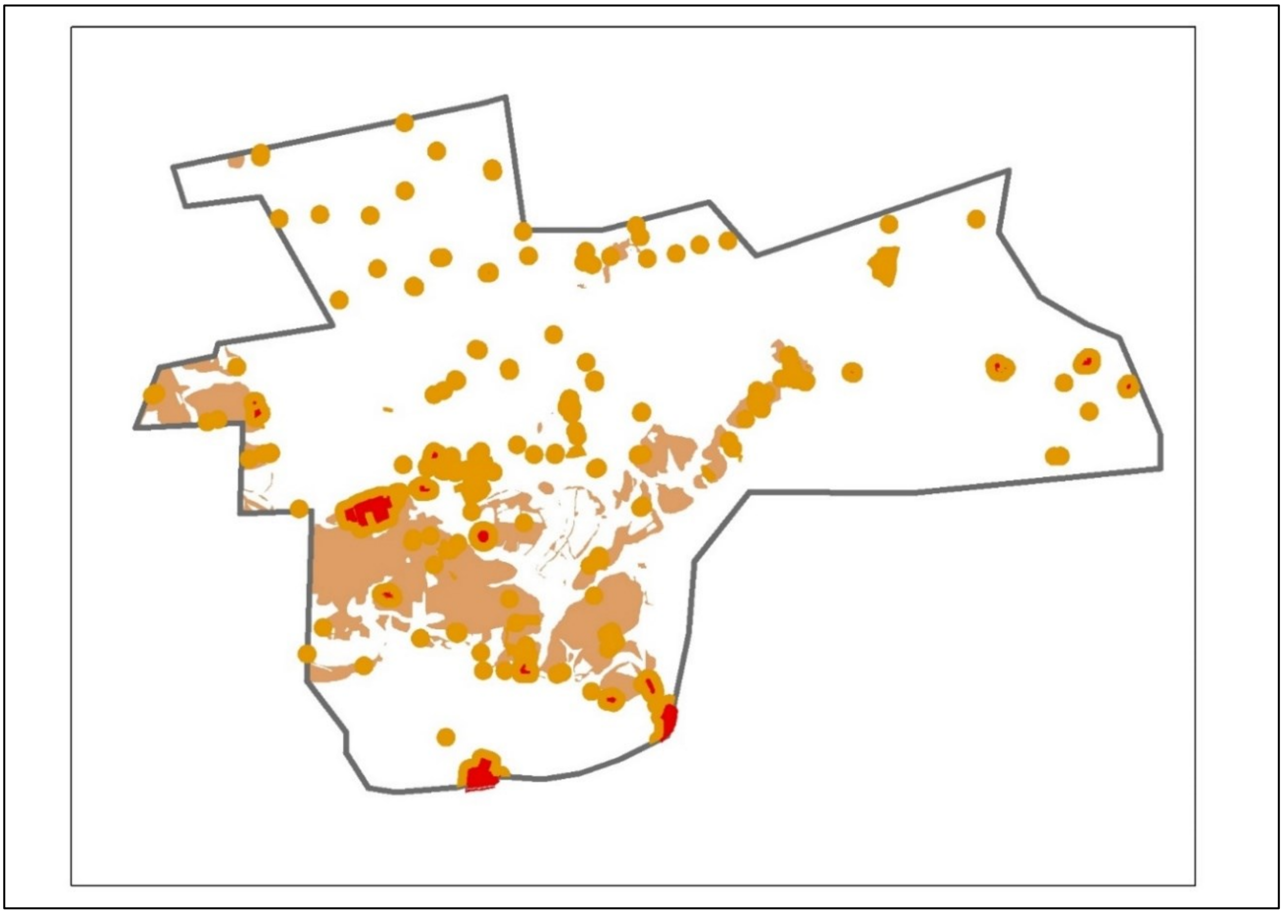


Figure 5.57: Mapping significance levels: level 4 NI = red; level 3 potential for/association with NI = orange; level 2 = all other areas

5.7 Summary

The study concludes that heritage assets of archaeological interest are widespread but show strong patterning, particularly in relation to local geology and topography. The density, distribution and character of archaeological assets enables some qualitative and quantitative propositions to be made about correlations between cultural and physiographical indicators and new discoveries. Six case studies of archaeological interventions covering just over 5% of the study area have helped ground-truth the model, although they do display considerable variation.

The main proposition emerging from the study is that London Gateway divides into broadly four zones with different sensitivity characteristics:

- The first is the **Coastal zone** that can be broadly equated with the Greater Thames Estuary LCA. Here the condition of archaeological remains is likely to be exceptional with both extant historic earthworks and structures and waterlogged buried remains and environmental evidence. The density of assets is poorly understood due to the obscuring effects of alluvial, coastal and reclamation deposits but the documented HER resource is not far below the average for the study area. However, the case studies encountered only a very low density (< 5%) of well-preserved assets.
- The second is the **Gravel Terrace zone** defined by the sand and gravel deposits with high-density archaeology (almost 2.5 times the average) including nationally significant sites but where condition is expected to be average or below due to truncation by arable cultivation and poor survival of environmental evidence. The zone is a focus of prehistoric assets. The case studies supported the high density of substantive assets (c 40%), generally poor preservation and ongoing plough erosion.
- The third is the **Mardyke zone** covering all the land north of the gravel mainly on alluvial, head and London Clay geologies. This zone is characterised by variable densities of known archaeology, noticeably low on the head (roughly half the average). Land use and geology imply variable condition, generally average or below but potentially good under alluvium and the small patches of ancient woodland. Pre-medieval assets are sparse. The limited case study evidence suggests a low to moderate density of assets (c 10%).
- The fourth is the **Modern development zone** characterised by damaged, fragmented or destroyed areas that would formerly have been part of one the other zones.

Across the study area, conservation areas and 200 m buffers around medieval churches, listed buildings, SMs and local high points were identified as positive indicators. Conversely, proximity to water and (inexplicably) Roman roads are identified as strong negative indicators.

The quantitative and spatial analysis that underpins the model differentiates this study from the Thurrock Unitary Historic Environment Characterisation Project (Essex County Council 2009) which identifies more detailed local character areas and zones (Fig. 5.4). It is notable that these appear to show some significant differences from the present study which would repay further analysis, perhaps alongside a test on the Lower Thames Crossing.

6 Holderness results

6.1 The study area

6.1.1 Introduction

The third pilot study area represents a transect across the landscape of Holderness. It lies entirely within the modern unitary authority of the East Riding of Yorkshire with its southern edge just to the north of Beverley and about 8 km from the city of Hull. The study area is rectangular (apart from the coastline), measuring 20–24 km east-west by 8 km north-south and covering an area of 175 km^2 (Fig. 6.1).

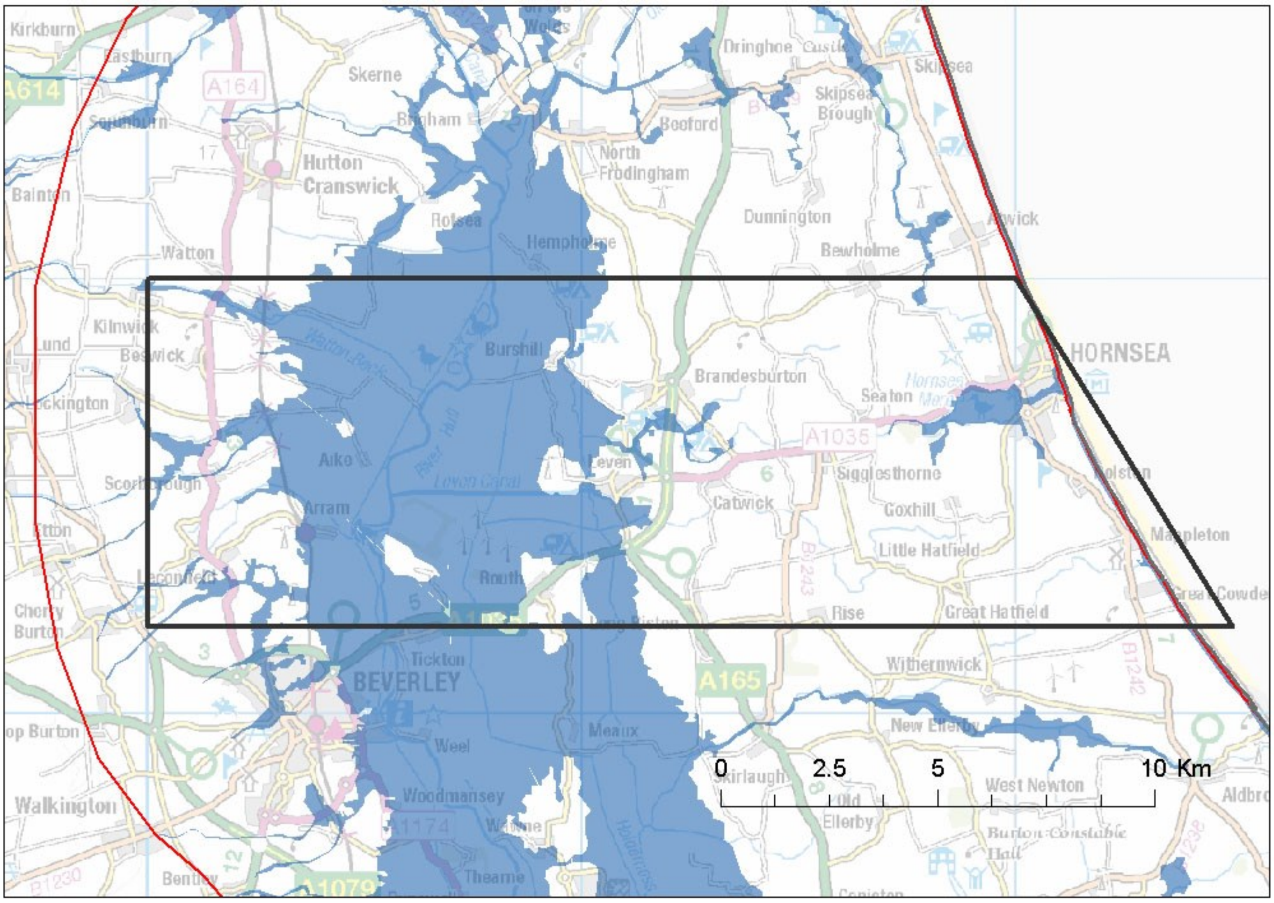


Figure 6.1: Boundaries of the Holderness pilot study showing Environment Agency flood alert areas (dark blue) and the boundary of the Holderness NCA (red). Base map © Crown Copyright [and database rights] 2023. OS 100024900.

Holderness was chosen as the location for a pilot study for a number of reasons. It represents a fairly well researched archaeological landscape for northern England and the study has local curatorial support, having been identified as an area producing unexpected discoveries. It includes a variety of lowland landscape types including river valley, low-lying plain and coastal former wetland. Pressures for change include flood risk, agriculture causing wetland desiccation, coastal erosion, aggregates extraction and potentially afforestation as part of the Northern Forest. The study area is not subject to great construction pressure although most of the settlements have some level of housing development allocated. However, the model could be extended to other areas of Holderness, especially around Hull and Beverley, which will be under greater pressure.

6.1.2 Topography and geology

The study area lies entirely within the Holderness NCA[25], which is a low-lying, undulating plain that contains the broad, shallow valley of the river Hull flowing sinuously southwards towards the Humber estuary. This is a glacial landscape of till (boulder clay), gravels and alluvium (Table 6.1) over chalk (though there is no exposure of bedrock in the study area), with a rapidly eroding coastline of soft clay cliffs; an estimated 6 km has been lost since the 4th millennium BC, assuming consistent erosion at the modern rate. The study area contains five SSSIs including Hornsea Mere, the largest freshwater lake in Yorkshire and a relic of the once-extensive marshes and lakes of Holderness, and two areas of remnant fenland, as well as the 19th century Leven Canal (now disused) and two artificial reservoirs.

Table 6.1: Major surface geological deposits in the study area

Type	*BGS_LEX Code*	*Area (ha)*
Till	TILLD	10,325 (59.0%)
Sand & Gravel	GFDUD	2198 (12.6%)
Alluvium	ALV	4349 (24.9%)

6.1.3 Landscape character

The landscape is largely rural, the only town within the study area being Hornsea, which has a population of around 8000. Small villages are dispersed throughout the area. Arable cultivation accounts for 82 per cent of land cover, generally in large fields, and woodland is sparse throughout. The flood plain of the river Hull, in the west of the study area, is important for vegetables and root crops, with cereals predominating on higher land towards the coast in the east (Natural England 2015).

The area has full recent Historic Landscape Characterisation (HLC) coverage (Wastling and George 2018) which for the study area shows a predominance of modern fields (post-1870) with areas of Parliamentary enclosure (post-1770) and early enclosure. Fig. 6.2 shows a simplified version of the HLC map, distinguishing natural/semi-natural habitats,

[25] http://publications.naturalengland.org.uk/publication/8569014

early enclosure, 18th–19th century enclosure, and modern fields. This shows little clear differentiation between different parts of the study area, though 20th century character types seem especially dominant in the centre of the area. Nevertheless, four distinct character areas were distinguished within the study area by the HLC exercise (Fig. 6.3). These are not available in GIS format but from west to east are as follows:

- CA9 Eastern Wolds Dip Slope
- CA10 River Hull Valley
- CA11 Central Holderness
- CA12 Holderness Coastal Strip.

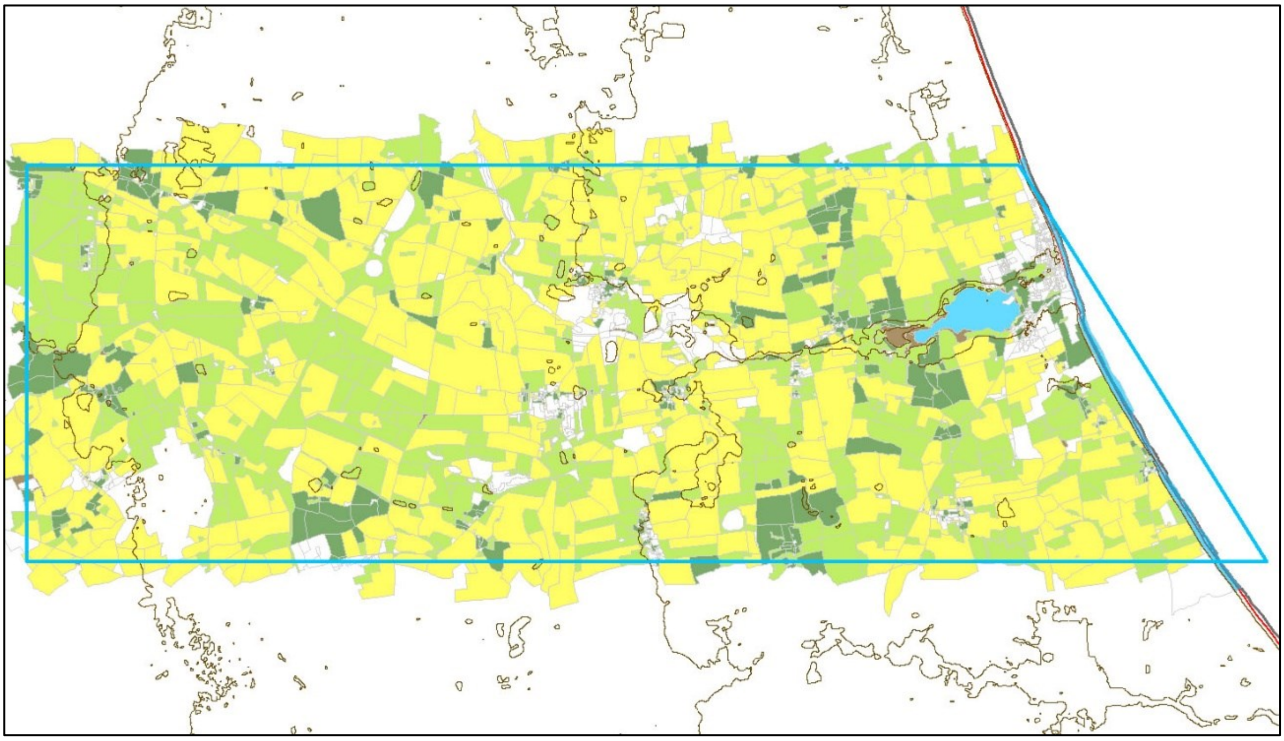


Figure 6.2: Simplified map of HLC types in the study area: beach/natural water in blue (note Hornsea Mere in the east); woodland, heath and scrub in brown; early enclosure and earthworks in dark green; pre-20th century planned enclosure in light green; and modern fields in yellow. Also shown is the 10 m contour. Base map © Crown Copyright [and database rights] 2023. OS 100024900.

The western edge of the study area (CA9) is an open, gently rolling landscape dropping gradually down to the alluvial plain of the Hull valley. Today generally large arable fields make up over 75% of the character area; these are primarily modern (40%) with some surviving Parliamentary planned enclosure (25%). The mean HLC polygon size, which may say something about the degree of uniformity or grain of the modern landscape, for the Fields and Enclosures broad type is 13.2 ha.

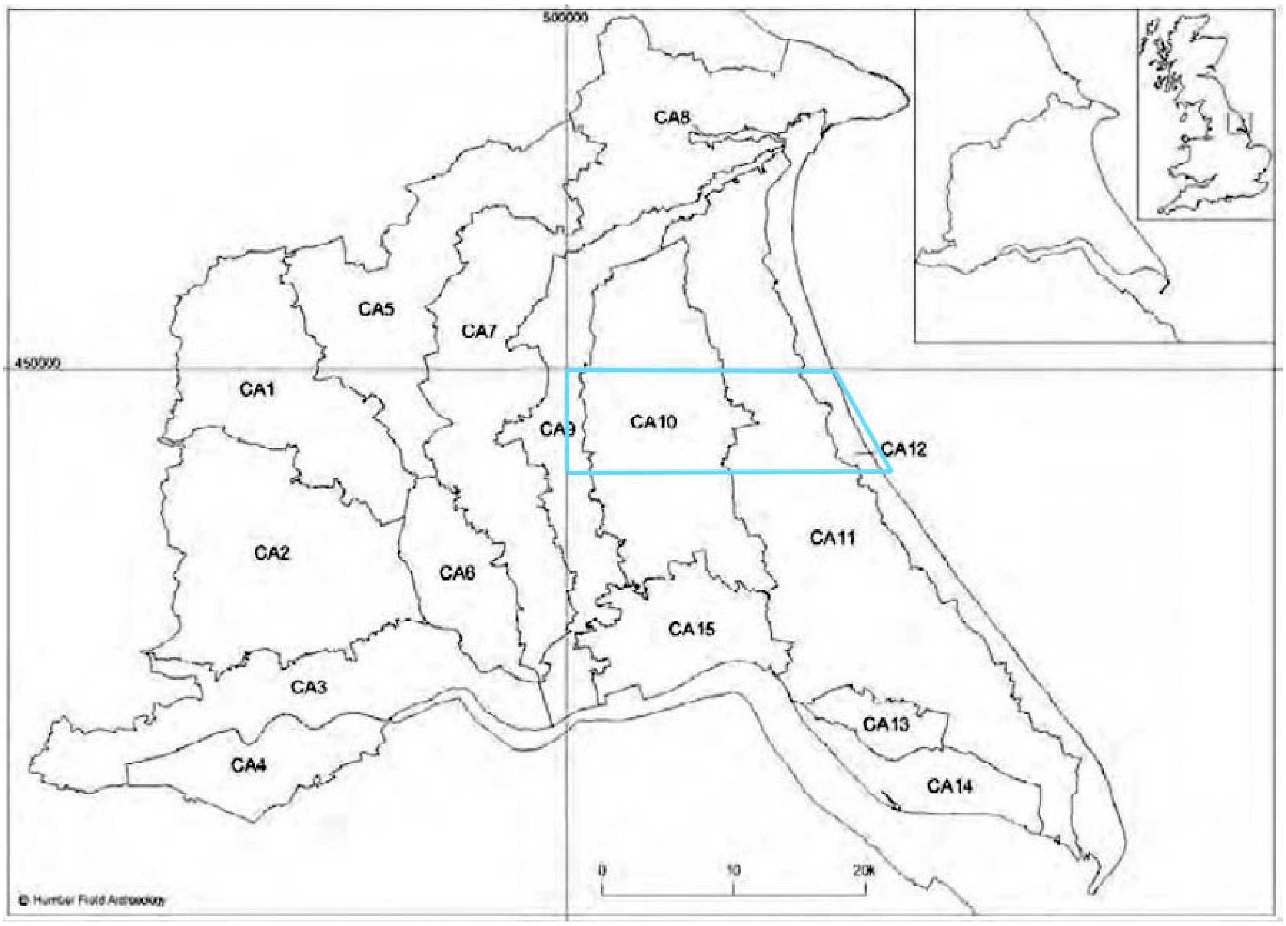


Figure 6.3: HLC character areas in relation to the study area (blue): CA9 = Eastern Wolds Dip Slope; CA10 = River Hull Valley; CA11 = Central Holderness; CA12 = Holderness Coastal Strip (Wastling and George 2018, 18)

Most of the western half of the study area lies within the River Hull Valley (CA10), defined by the 10 m contour (Fig. 6.2), which also served as the division between the Hull valley and Holderness for the Humber Wetlands Project (see below). Here generally large fields (those to the west of the river are slightly smaller than those to the east), both arable and grass, make up over 85% of the character area, with a mean HLC polygon size of 15.6 ha. The current settlement pattern was largely established during the early medieval period, with mostly linear villages on the margins of the valley, though some sites are now shrunken or deserted (see below). In the south of the study area the A1035 follows the main historic route across the valley.

Some farmsteads and villages are located on till 'islands' in the centre of the valley but the general remoteness of this historically wet area encouraged the foundation of religious houses, including Watton Priory on the northern edge of the study area. These were involved in the initial drainage of the valley, cutting channels that also served as canals for transport, and establishing monastic granges. A further phase of drainage from the later

17th century onwards enabled the development of arable land, ensuring that only patches of wet pasture survive today. Enclosure occurred gradually, and dredging of the river along with construction of floodbanks in the late 19th century protected agricultural land but also isolated the river from its floodplain.

The modern agricultural landscape is divided by drainage ditches, some of which are now historical features themselves, notably the Leven Canal which was officially closed in 1935 and is no longer accessible from the river. A former RAF airfield lies to the east of Leconsfield, while gravel and sand extraction along a glacial ridge on the eastern side of the valley has created a line of artificial lakes.

The eastern part of the study area lies mainly within the Central Holderness character area (CA11) which has also been much altered by artificial drainage. Medieval settlements lay on areas of raised ground with open fields on the better drained land around them and marginal, wetter lands used as summer pasture. From the late medieval period the surviving meres and wetlands were drained for agricultural use, with the exception of Hornsea Mere. Enclosure began by the 16th century and the majority of land had been enclosed by 1780.

Today this is a rural agricultural, mainly arable landscape with large, modern, rectilinear fields interspersed with more irregular fields in areas of early enclosure. In all, fields make up almost 90% of the character area, with a mean HLC polygon size of 18.0 ha, a little larger than in the Hull valley. Otherwise wind-farm developments are increasingly common, while the former RAF Catfoss lies to the west of Hornsea.

Finally, the coastal strip (CA12), which is bounded to the west by a series of small hills, has a similar character to Central Holderness. Here former meres have been lost to artificial drainage for agriculture and to coastal erosion, which has also led to several historic settlements disappearing or becoming coastal. Unlike in Central Holderness, enclosure was mainly by Act of Parliament. Today fields make up over 60% of the character area (with a mean HLC polygon size of 14.4 ha), coastal land almost 20%, and recreation and leisure facilities around 7.5%.

Local landscape character assessment (AECOM 2018) has also divided the study area into several character areas, though these are defined rather differently from the HLC areas (Fig. 6.4). In particular the LCA reduces the Hull valley to a narrow corridor (18A) and picks out the former watercourse linking Hornsea Mere to the river Hull (18B–D), which may have had considerable significance in prehistory (see below).

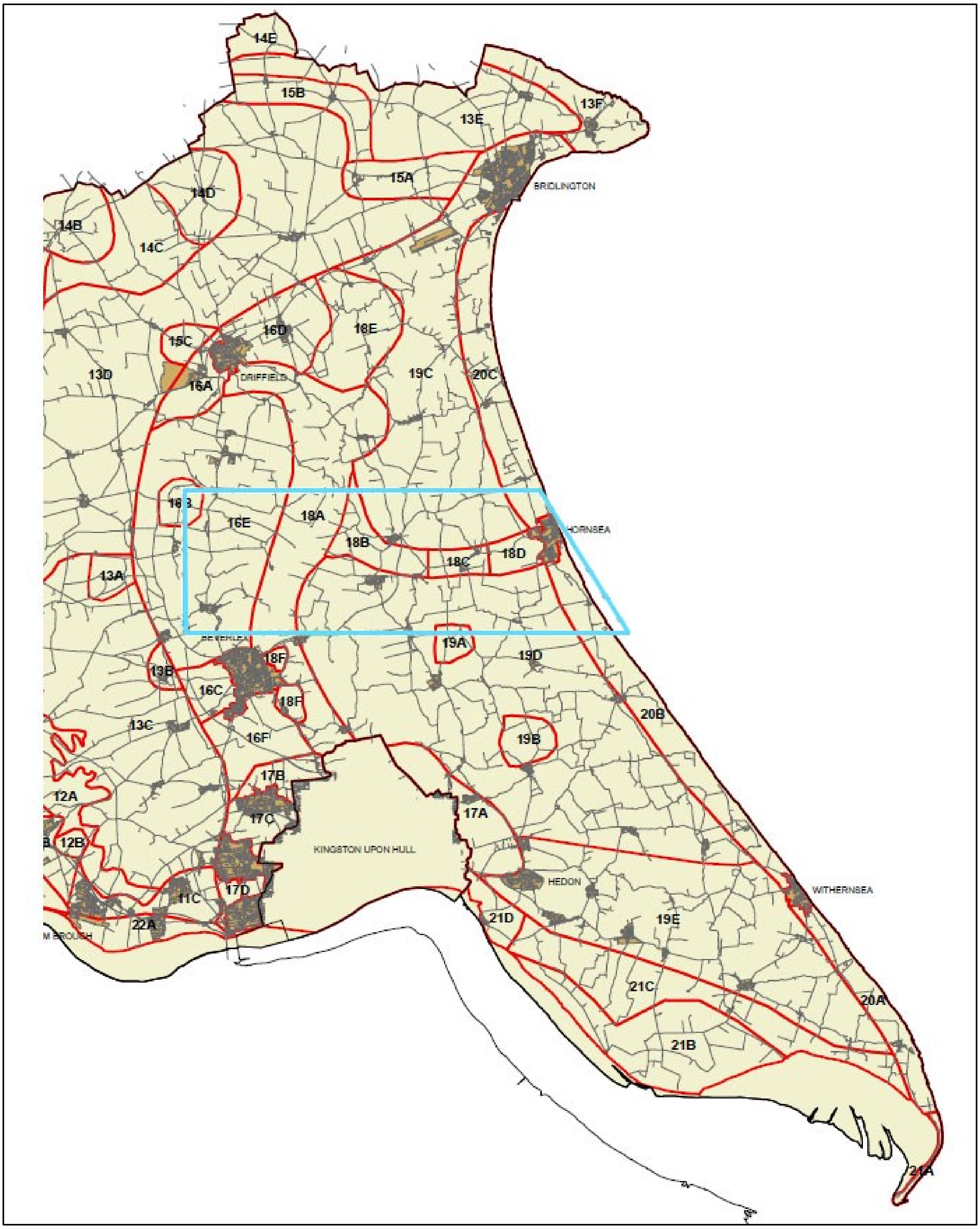


Figure 6.4: LCA character areas for the East Riding of Yorkshire in relation to the study area (blue outline): 16E = Lund Sloping Farmland; 18A = River Hull Corridor; 18B = Quarry Farmland; 18C = Catfoss Dyke; 18D = Hornsea Mere; 19C = North Holderness Open Farmland; 19D = Central Holderness Open Farmland; 20B = Hornsea to Withernsea Coast; 20C = Bridlington to Hornsea Coast (AECOM 2018, 18)

The major LCA character areas (with HLC equivalents in brackets) are:

- 16E Lund Sloping Farmland (CA9/CA10)
- 18A River Hull Corridor (CA10)
- 18B Quarry Farmland (CA10)
- 18C Catfoss Dyke (CA11)
- 18D Hornsea Mere (CA11)
- 19C North Holderness Open Farmland (CA10/11)
- 19D Central Holderness Open Farmland (CA10/11)
- 20B Hornsea to Withernsea Coast (CA12)
- 20C Bridlington to Hornsea Coast (CA12).

In the west of the study area the Lund Sloping Farmland has a less regular field pattern than the low-lying drained farmland of the River Hull Corridor, though the latter also contains pockets of wet grassland and marsh. Running eastward from the Hull valley towards Hornsea are three more areas of low-lying drained farmland: Quarry Farmland around Brandesburton, where a series of artificial lakes have resulted from mineral extraction; the Catfoss Dyke, a shallow valley through which the watercourse draining Hornsea Mere would once have run; and Hornsea Mere itself. Either side of these the open farmland of North Holderness and Central Holderness are both mainly arable with generally large fields and little woodland. Finally, the coastal farmland is divided between the Hornsea to Withernsea Coast, where land use is predominantly arable with camping/caravan sites and a firing range south of Mappleton, and the Bridlington to Hornsea Coast, where small-scale field systems contrast with surrounding large-scale agriculture and tourism facilities.

In both schemes, therefore, the major character area divisions run north-south, following the topography and watercourses, but only the LCA picks out the east-west corridor between the river Hull and Hornsea Mere as a distinctive part of the landscape.

6.1.4 Archaeological background

The key volumes of synthesis for the study area are those produced by the Humber Wetlands Project (van de Noort and Davies 1993; van de Noort and Ellis 1995; 2000; van de Noort 2004), though fieldwork finished over 20 years ago. Regional archaeological synthesis of a similar vintage is available in the Yorkshire Archaeological Society's volume on *The Archaeology of Yorkshire* (Manby *et al*. 2003a), with chapters on the Neolithic and

Bronze Ages (Manby *et al*. 2003b, 78–80), Iron Age (Mackey 2003) and Roman periods (Ottaway 2003, 142–3). More recent overviews for parts of the study area are contained in the aerial investigation and mapping reports for the Hull valley (Evans *et al.* 2012) and aggregate-producing areas of East Yorkshire (Deegan 2008), as well as the Rapid Coastal Zone Assessment Survey (RCZAS; Deegan 2007; Brigham et al 2008).

The HWP volumes highlight the palaeoenvironmental potential of Hornsea Mere (see Fig. 6.2) and the wetland archaeological potential of wider areas of Holderness and the Hull valley, despite the impact of recent drainage and agriculture. This work emphasises the importance of the history of wetland formation and drainage for understanding both the distribution of past activity and the survival of archaeological remains in the present. It sets out the difference between the Hull valley, where the wetland landscape is linked to the river, and central Holderness, where meres developed within depressions in the Devensian tills that cover the landscape. Notably, while the HWP survey found late-glacial deposits at a number of former meres within the study area (in Great Hatfield, Mappleton and Seaton parishes), Holocene wetland deposits were absent at most sites, which might indicate that sediments have been wholly destroyed or that these were only seasonal wetlands, i.e. marshes rather than lakes (Dinnin and Lillie 1995, 82–3). **Hornsea Mere** is the only known wetland site in Holderness with the potential for a complete Holocene environmental record.

The Hull valley saw a period of incision prior to 5000 cal BC followed by aggradation as sea-level rose and then a series of alternating marine transgressions and regressions until around 1000 cal BC, by when the middle part of the valley was estuarine with widespread peat formation upstream. A further transgression around 800 cal BC pushed the estuarine influence further inland, leaving the valley bottom in the study area generally inhospitable for settlement. However, episodes of regression later in the Iron Age and in the early Roman period left the floodplain drier and more suitable for settlement until further transgressions occurred in the late Roman period. These oscillations continued during the medieval period but flooding was gradually alleviated by the drainage operations mentioned above.

The meres found in the Hull valley tend to contain inorganic late-glacial deposits overlain by Holocene lake mud with peat, and often later by minerogenic deposits linked to slopewash from clearance. Particularly important in this respect is **Routh Quarry** in the south of the study area, which lies beyond the river floodplain and probably represents deposits formed in a kettlehole. The site has provided a radiocarbon-dated pollen sequence from the late-glacial interstadial, a record of Holocene wetland development and possible indicators of Neolithic agriculture (Lillie and Gearey 2000b; Lillie *et al*. 2003;

Gearey 2008). The presence of such sequences means the regional vegetation history is fairly well understood (Table 6.2), at least until around 2500 years ago, although the evidence of prehistoric human impact on the landscape remains patchy and poorly dated.

Specific sites are discussed in 6.3 below but various national studies provide context for certain periods, including the Roman Rural Settlement Project (RRSP), which has noted a concentration of sites in Holderness, mostly identified during work in advance of a gas pipeline to the south of the study area (see below). However, there appears to be a continuous decline in the number of sites in use through the Roman period from a peak in the Late Iron Age, indicative of a relative lack of new settlement after the conquest. In terms of the economy, sheep and goat predominate over cattle, similar to the Yorkshire Wolds but in contrast to the Vales of York and Mowbray (Allen in Smith *et al*. 2016, ch 7).

Table 6.2: Regional Holocene vegetation (after Lillie and Gearey 2000a)

Date range (cal BC)	***Landscape vegetation***
10,000–9000	open birch woodland with pine and willow
9000–8000	hazel and elm woodland with less pine than other parts of the Humber region
8000–5200	mixed deciduous woodland with alder in wetter parts of the landscape, hazel, elm and oak on till soils, and lime on sand and gravel soils
5200–4000	dominance of alder on floodplain (persisting for about 3500 years) with mixed oak woodland in drier areas
4000–800	elm decline, followed by oak-dominated woodland with evidence of Neolithic clearance and heath formation
800–	major episode of clearance, peaking in later Iron Age/Roman period, before woodland regeneration in early medieval period (to c AD 1200) and a sustained decline thereafter

Holderness forms the north-eastern end of the ‘Central Zone’ defined for the *Fields of Britannia* project, which looked at continuity between Roman and later landscapes. Rippon *et al.* (2015, 195–6) cite studies suggesting Holderness was a largely open landscape by the Late Iron Age, with a decline in arable land relative to grassland in the post-Roman period but only limited woodland regeneration, along with increased wetness. They also cite work by Mary Harvey showing the planned creation of open fields across some entire townships in Holderness during the late 1st millennium AD, which contrasts with the general pattern within the Central Zone where ‘in many cases open fields were created within a pre-existing framework of boundaries’ (Rippon *et al.* 2015, 330). Perhaps this reflects a later Roman decline, as hinted at above.

The landscape zones defined for *Fields of Britannia* were influenced by the work on medieval settlement by Roberts and Wrathmell (2002), for whom Holderness falls within a rather varied East Yorkshire sub-province of their Central Province, where '"preferred settlement zones" … reflect the underlying geological structure'. Within this diversity, which is 'in many respects a microcosm of England', Holderness is one of the areas noted for the appearance of moated sites, along with 'a distinctive type of townfield layout'.

Aside from the HWP, archaeological fieldwork in the study area has been relatively limited. For this study, the Humber Historic Environment Record (HER) provided GIS Event datasets in a combination of point, line and polygon format. Generally, more recent and larger investigations are mapped as polygons (around 30% of the total) whilst older and smaller events are recorded as points. This data was manipulated to remove desk-based research and to classify fieldwork using the simplified investigation types defined by the EngLaId project (Table 6.3; Gosden et al 2021, table 2.3). To estimate the area investigated, event point data within event polygons was deleted and if no further information was available a 50 m buffer was applied around remaining point data to give a nominal extent felt appropriate for small-scale fieldwork.

Table 6.3: Categorisation and quantification of investigations recorded on the HER

Code	***Simplified EngLaId investigation type***	***Number***
1	Intrusive: open area excavation	3
2	Intrusive: keyhole (evaluation, watching brief)	110
3	Non-intrusive survey (geophysics, earthwork, boreholes)	18
4	Fieldwalking	2
5	Other (e.g. historic building recording)	3
Total	Land in the study area subject to any form of investigation	136

This analysis gives an estimated total of around 300 ha that have been investigated in some form within the study area (Fig. 6.5), or 1.7% of the total area, considerably less than the 14% and 8% in the Vale of Aylesbury and London Gateway respectively. Moreover, around 60% of this area (approximately 180 ha) comprises just two investigations: watching briefs at Wilfholme (groundworks associated with overhead and underground electricity cabling) and Mappleton (a waste water pipeline). The former recorded no archaeological finds (including from fieldwalking) while the latter recorded a ditch and gully of Romano-British date. It may be that these large-scale monitoring projects do not provide a fair representation of the archaeology of the whole area covered.

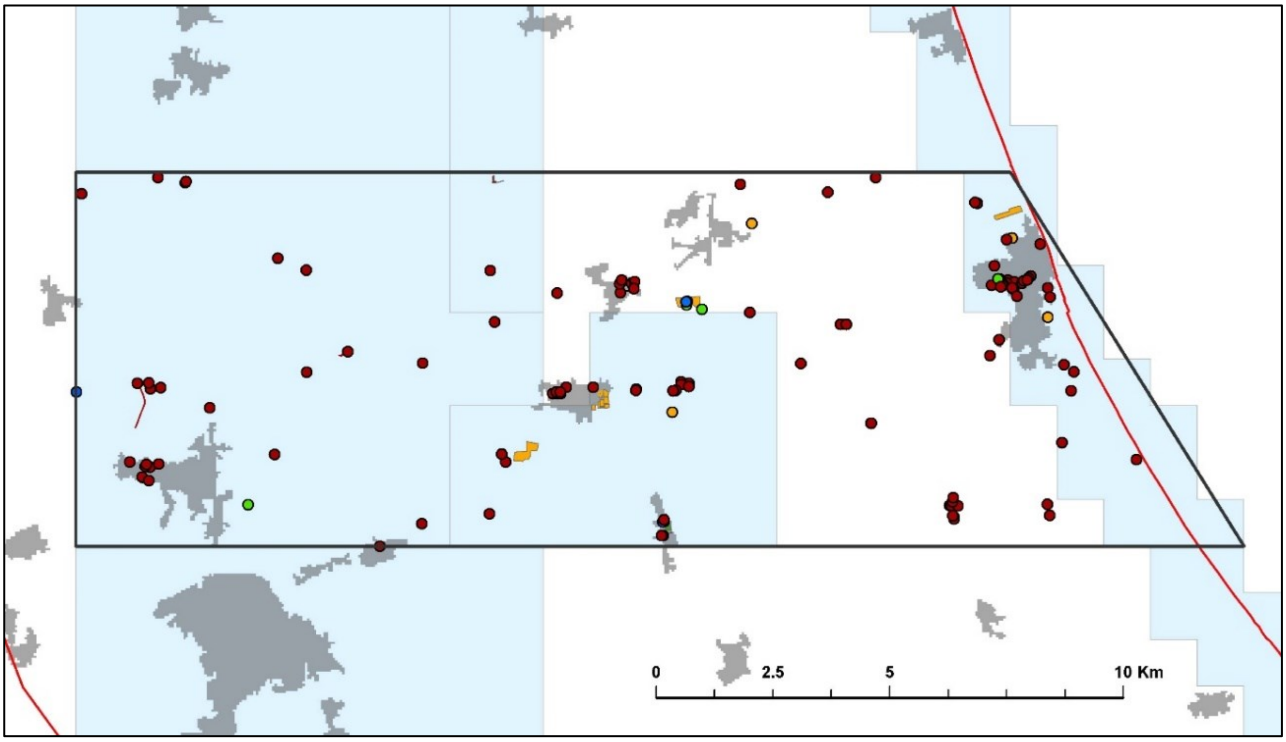


Figure 6.5: HER events in the study area (yellow = geophysical surveys; green = other surveys; red = evaluations/watching briefs; blue = excavations) in relation to built-up areas (grey) and aerial mapping coverage (light blue)

Apart from these, investigation has an uneven spread across the study area with most in and around the settlements of Brandesburton, Catwick, Great Hatfield, Hornsea, Leconfield, Leven, Long Riston and Scorborough, though there is a scatter of small evaluations and watching briefs across rural parts of the area. Other large areas investigated are mainly in the centre of the study area, with geophysical surveys near Routh (finding three enclosures), Leven (limited archaeological features) and Brandesburton (various anomalies), as well as near the coast at Hornsea Leisure Park (possible prehistoric features).

A key feature of the study area is the very limited number of open-area excavations, both in absolute terms and as a proportion of all intrusive investigations (2.5% compared to 17.8% in the Aylesbury pilot study area). The low level of excavation in the study area severely reduces the level of certainty with which judgements of sensitivity can be made. However, some indication of archaeological presence is provided by 15 formal evaluations (trial trenches or monitored soil strips) covering between 50 and 800 m^2, of which nine produced features and finds of Iron Age to post-medieval date. In a total of 3800 m^2 there were four Iron Age, three Roman, one early medieval, six medieval and two post-medieval 'sites'. On the other hand two larger evaluations covering 10,000 m^2 of monitored strip produced just a single post-medieval ditch and some furrows.

The three excavations recorded on the HER were at Winthorpe Manor in Lockington, Sandsfield Quarry near Brandesburton, and Long Riston, though no details are provided for two of these. However, not evident in the records supplied are known excavations on the Leven-Brandesburton bypass, at Little Catwick Quarry, Leven and at Chapel Garth, Arram (see below), suggesting the HER events record is not comprehensive. Time precluded further investigation of these projects, however.

6.2 Character of the archaeological resource

6.2.1 Overview

The intention of this section is not to reiterate the published syntheses referred to in the introduction, albeit these provide an initial interpretative framework as outlined above. Rather it is an attempt to summarise what we know about that subset of the archaeological resource with (potentially) some strategic significance. It considers what we might infer from this data about as yet undiscovered assets, a process that relies on the assumption that the known dataset is a useful, albeit imperfect, indicator of the undocumented dataset. The limited amount of HER data compared to the southern case studies means that all archaeological data is included in the model, not just selected ‘assets’ (cf. 3.2.3) – although the objective remains the same, to identify the potential for assets of the necessary level of significance.

With buildings excluded, HER data divide into monuments and findspots, the latter representing about 11% of the total. The study area includes 961 records which were allocated to broad periods and types (Table 6.4); some are counted more than once if they have components of multiple periods. About 50% are post-medieval or modern: most of the post-medieval records are distributed across the categories of settlement, agriculture, industry and transport while the modern records are almost all military sites or structures associated with the Second World War, which are not considered in detail here. Around 16% of HER entries are medieval or early medieval, about half of which are settlement-related with another 14% agricultural. Roman or Iron Age/Roman records represent 4% of the total, a similar number to those assigned to the later Bronze Age/Iron Age. Neolithic and Early Bronze Age records, mostly ring-ditches indicative of round barrows, account for 7% of the total while just 1% are Mesolithic, primarily findspots of barbed bone or antler points. Around 15% of the records are undated or not clearly assigned to a period, while 27% are unclassified in terms of type; many of these are undated ditches and similar recorded on aerial mapping.

The following sections aim to assist strategic planning by identifying patterning within different broad periods and key monument types which are particularly relevant because of their frequency within the study area, good condition or high significance.

6.2.2 Palaeolithic

The study area contains no known Lower or Middle Palaeolithic sites; the only find assigned to this period is a mammoth tooth found on a beach, which must be Pleistocene but is not indicative of human presence. The entire study area was glaciated during the Devensian (MIS3) and *in situ* Palaeolithic material is not to be expected other than possible late-glacial Upper Palaeolithic remains, which are best considered together with the Mesolithic period (6.2.3).

Table 6.4: Categorisation and quantification of HER monuments and findspots

	Settlement	Agriculture	Industry	Transport	Religious & Funerary	Defence	Recreation	Unclassified	**TOTAL**	**%**
Modern	-	-	1	-	2	113	-	-	116	12.1
Post-Med	49	52	88	80	18	1	21	53	362	37.7
Med-PM	12	6	-	-	-	-	-	1	19	2.0
Medieval	70	20	11	3	7	4	-	24	139	14.5
Early Med	4	1	-	-	3	-	-	6	14	1.5
Roman	3	1	-	1	1	-	-	16	22	2.3
IA-Roman	11	6	-	-	-	-	-	2	19	2.0
MBA-IA	4	1	-	2	15	-	-	23	45	4.7
Neo-EBA	4	-	-	-	38	-	-	24	66	6.9
Meso	-	-	-	-	-	-	-	10	10	1.0
Pal	-	-	-	-	-	-	-	1	1	0.1
Undated	11	15	8	7	4	-	-	103	148	15.4
TOTAL	168	102	108	93	88	118	21	263	961	

6.2.3 Mesolithic

The earliest archaeological finds in the study area are a number of Mesolithic (and possibly Late Upper Palaeolithic) barbed bone and antler points, mainly found during gravel quarrying around **Brandesburton** (Fig. 6.6; Clark and Godwin 1956). Barbed points are characteristic of the Early Mesolithic at Star Carr, North Yorkshire, and the cluster of findspots within the study area is the largest group outside that site. The map shows a close association between these finds and the former watercourse connecting Hornsea Mere to the Hull valley, now followed by the Catfoss Dyke (a further find from close to Hornsea Mere does not appear in the supplied HER data: see Brigham et al. 2008, 75). Lithic finds, in contrast, are rather more dispersed though still mainly associated with sand and gravel deposits and riverine locations. There are no major sites known within the study area though these have been found elsewhere in Holderness, notably at Stone Carr near Aldbrough where evidence of Late Mesolithic knapping was found on a till outcrop on the east side of the river Hull, surrounded by wetland deposits (Chapman et al. 2000, 160–9).

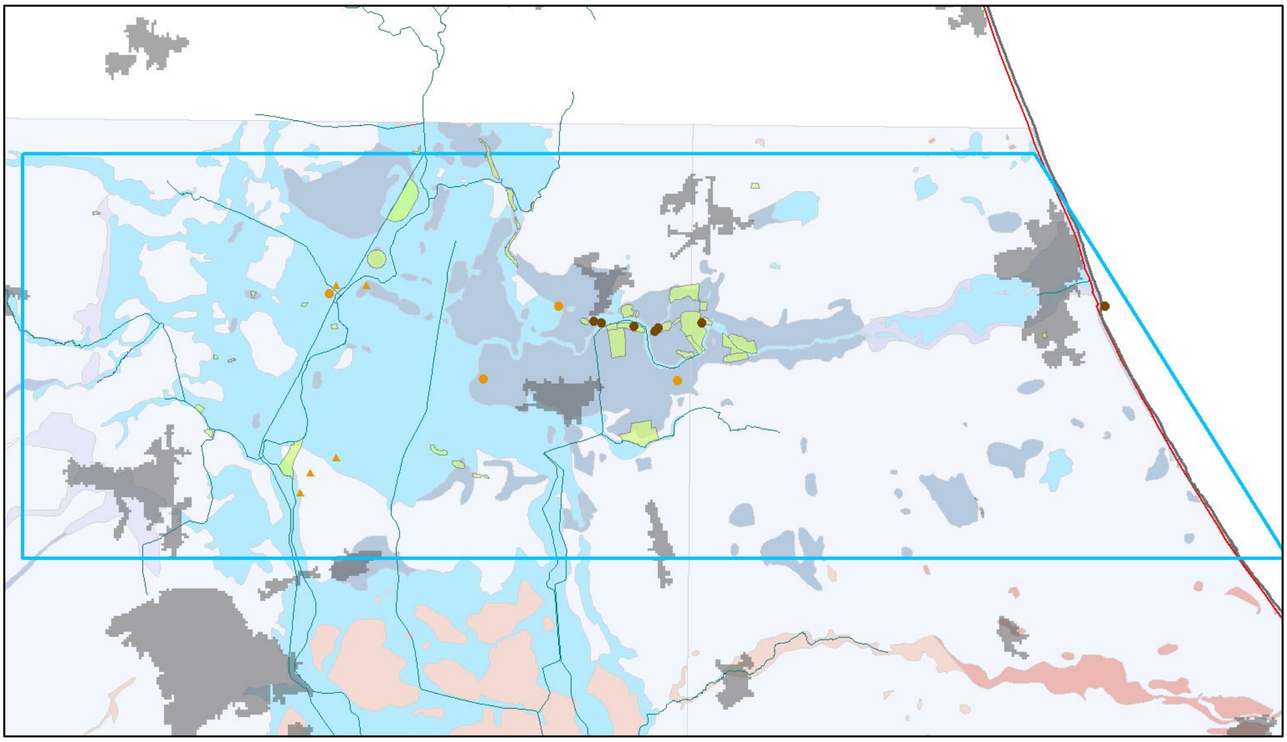


Figure 6.6: Findspots of Mesolithic barbed points (brown) and lithics (orange; triangles show HWP finds not in the HER), overlain on the geology (light pink = till; blue-grey = sand & gravel; light blue = alluvium) with former quarries (light green) (derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Factors giving enhanced potential for Mesolithic finds include low elevation (all known findspots are <10m OD); proximity to water (all are within c 750 m of a watercourse – though so is around 75% of the study area); and for lithic finds an association with areas of modern fields on the National HLC (NHLC). Known Mesolithic finds occur at a mean rate of 1 per 700 ha across the project area although, as described, the distribution is far from random.

Conclusion: at present the Mesolithic of the study area makes a limited contribution to archaeological sensitivity in relation to strategic planning decisions because it

only comprises findspots, although it should feature in evaluation and research strategies where favoured locations, such as outcrops offering local vantage points and/or access to flint from local watercourses, are affected. While the lack of in-situ sites would suggest low potential for significant remains the concentration of historic barbed point finds could indicate a landscape used in a way akin to that around Star Carr and the former Lake Flixton, so the presence of one or more major site(s) is possible. Furthermore, old land surfaces with lithic scatters could be preserved beneath later alluvium, especially on the wetland edge and where small rises may be indicative of former drier 'islands'.

6.2.4 Neolithic and earlier Bronze Age

The key monuments identified for the Neolithic and Bronze Age are classed as 'religious and funerary' assets (principally Early Bronze Age round barrows) supplemented by lithic scatters and stray finds (Fig. 6.7). However, Neolithic ceremonial monuments are also represented, with possible henges near **Hornsea** (scheduled) and **Leven** (excavated), the latter not recorded on the HER but reported in the press in 2017–18.

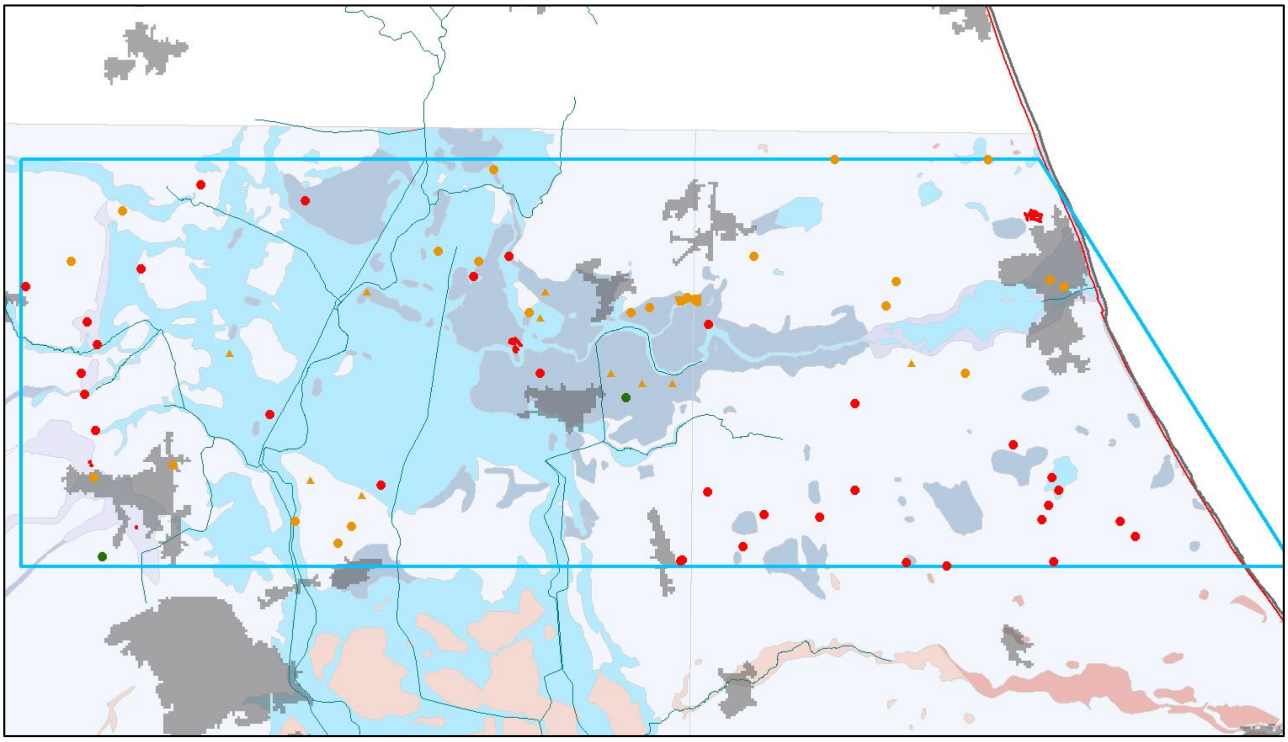


Figure 6.7: Neolithic and Early Bronze Age monuments (red), settlement sites (green) and lithic findspots (orange) overlain on the geology (see Fig. 6.6 for key; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

There are 36 Neolithic or Early Bronze Age funerary or ceremonial monuments on the HER, primarily ring-ditches but also an enclosed Middle Bronze Age cremation cemetery at **Catfoss**. This gives an asset density of around 1 per 500 ha. Four sub-areas were defined based on the HLC character areas: the Wolds edge and Hull valley; west-central Holderness [with NMP coverage]; east-central Holderness; and the coastal strip. Although a Chi-square test shows no significant difference between the numbers of sites in each area, at a more local level they are not evenly distributed, with the majority either on the Wolds edge (the western side of the Hull valley) (ten locations) or in the southern part of central Holderness (18 locations). There is also a cluster north-west of Leven, including a linear group of three barrows adjacent to the palaeochannel precursor of the Catfoss Dyke. The location of these monuments and the cremation cemetery 4 km to the east, as well as the lack of barrow sites north of the Catfoss Dyke, might suggest this channel formed some kind of cultural boundary in the Early Bronze Age. Overall, however, there is no particular association of Neolithic and Early Bronze Age sites and finds with watercourses or contours. Early Bronze Age records (though not Neolithic ones) are slightly over-represented on NHLC post-war enclosed land (67% of sites on 58% of the study area), perhaps reflecting greater visibility from the air in these areas.

Known settlement sites are restricted to one or two locations. There is a vague record of 'Neolithic-medieval settlement' south of **Leconfield**, and rather more certain information about two small Neolithic pits found on the **Leven** to Brandesburton bypass (Head *et al*. 1995, 193). Another small pit with a sherd of Peterborough Ware was found just outside the project area in Kilnwick (Dennison 2006). However, various findspots hint at significantly higher levels of occupation, especially given the presence of 14 locations with stone or flint axes and one with a pebble macehead. The distribution of lithic finds may also suggest a continuing focus of activity along the Catfoss Dyke palaeochannel, as do the remains of a coppiced stool of alder worked by bronze and stone axes at **Seaton**, to the west of Hornsea Mere, in shallow peat indicative of fen carr (Van de Noort and Ellis 1995, 195 and 353). As 'the first example to date of a prehistoric in situ managed woodland site in England' (Van de Noort and Ellis 1995, 364) this was assessed as nationally important, although unsustainable as a wetland site in the long term.

For sites of this period, as with the Mesolithic, the possibility of masking by later deposits of peat, alluvium and colluvium needs to be considered. Only two round barrows are mapped within areas of alluvium: it is unclear if this is down to such masking or whether the alluvium marks areas that were avoided in prehistory as being too wet.

Conclusion: the Neolithic and Early Bronze Age make a moderate contribution to archaeological sensitivity though as in so many parts of the country, it is easier to

assess the contribution to sensitivity of monuments of these periods than of settlement evidence. However, current knowledge suggests the Wolds edge, south-central Holderness and Catfoss Dyke are key locations for occupation, while the possibility of alluvial masking of sites in the central Hull valley needs to be considered in strategic planning.

6.2.5 Late prehistoric and Roman

Later Bronze Age, Iron Age and Romano-British activity is considered together because many sites mapped from the air cannot be assigned more specifically. This broad period has a rather different pattern to that preceding, with considerably more activity on the Wolds edge and in the Hull valley than in central Holderness, though the gap between Brandesburton and Hornsea is at least partly explained by the limits of systematic aerial mapping (cf Figs 6.5 and 6.8).

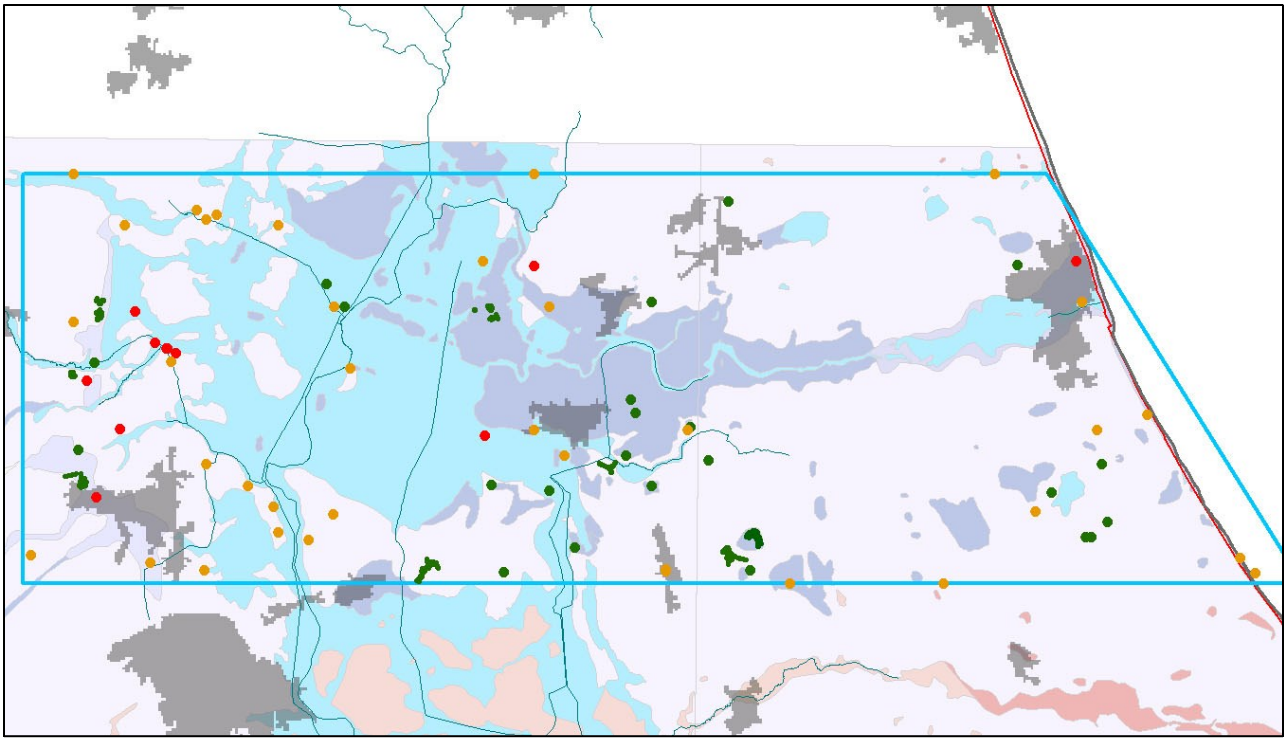


Figure 6.8: Later Bronze Age, Iron Age and Roman funerary monuments (red), settlement sites/field systems (green) and findspots (orange) overlain on the geology (see Fig. 6.6 for key; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Later Bronze Age metalwork is concentrated on the edges of the Hull floodplain alluvial deposits, mainly recovered as stray finds during drainage operations, including a hoard with five Ewart Park swords from **Leven**; however, more recently a LBA hoard with 23 objects has come from drier ground on the Wolds edge near **Leconfield** (Fig. 6.9). In terms of the model, such finds, which are often isolated in the landscape, may not indicate the presence of significant assets such as settlements but they speak to an ongoing interest in the wetlands and their edges where sites or findspots of regional or national importance could be preserved. At present few are known in the study area but as well as the probably Early Bronze Age coppice mentioned above, there is a possible trackway at **Watton Carrs** in the central Hull floodplain, where drainage improvement in the 1980s uncovered a series of split oaks with axe marks and a Late Bronze Age spearhead nearby.

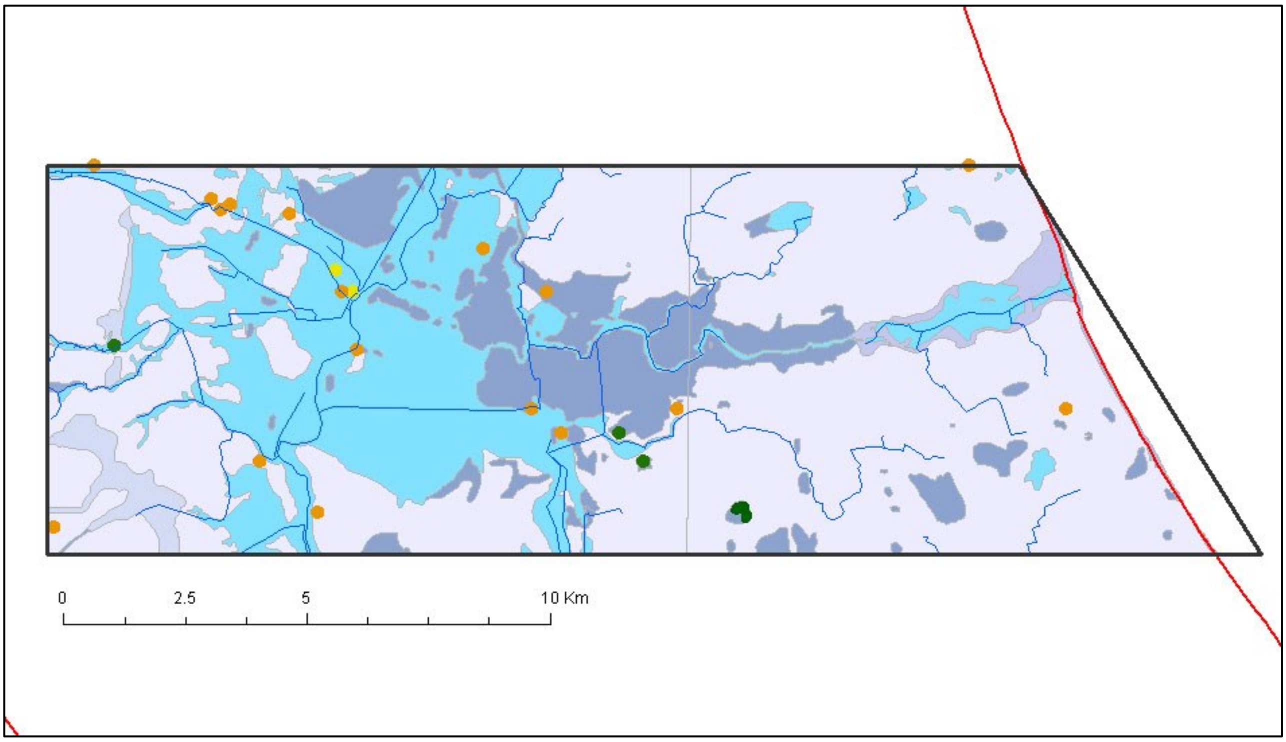


Figure 6.9: Later Bronze Age metalwork (orange), timbers (yellow) and other sites (green) overlain on the geology (see Fig. 6.6 for key; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Iron Age square barrows favour the western edge of the study area, representing a continuation of the distribution known across the Yorkshire Wolds (Fig. 6.8); they include a (scheduled) cemetery of approximately 120 barrows at **Scorborough**. Two possible square barrow sites are known on the east side of the river Hull but the burial marked near Hornsea might be early medieval rather than Iron Age, so there are no definite Iron Age barrows in central Holderness.

It is notable that demonstrably Roman sites and finds are rather scarce throughout, supporting the RRSP pattern mentioned above, though a possible Roman road has been noted near the former RAF Catfoss in the south-west corner of the study area.

Settlements, field systems and enclosures of general Iron Age and/or Roman date are more widely distributed, especially where aerial mapping has been undertaken, giving a far better sense of the extent of these features (Fig. 6.10). On the Wolds edge and in the Hull valley this has revealed some examples of multiple ditched systems (Evans *et al.* 2012, 13), though not the highly structured landscape organisation seen on the Yorkshire Wolds proper. Fig. 6.10 also indicates some possible wetland trackways across alluvial areas. The SHINE dataset (see 6.5) assigns some sites categorised as undated on the HER to this broad period, at least provisionally, hence the appearance of a large area of 'Iron Age to medieval' field systems and trackways on a gravel island in the Hull valley at Watton Carrs (Figs 6.10 and 6.20b). In the eastern half of the study area, beyond the 10 m contour, there is only limited aerial mapping evidence but it is notable that the area where this is present, along the coastal strip, lacks visible prehistoric and Roman remains (Deegan 2007, 6). However, the HER has a number of records of enclosures and other finds within or just beyond the area of RCZAS mapping, so the degree of difference between the Hull valley and central Holderness remains uncertain.

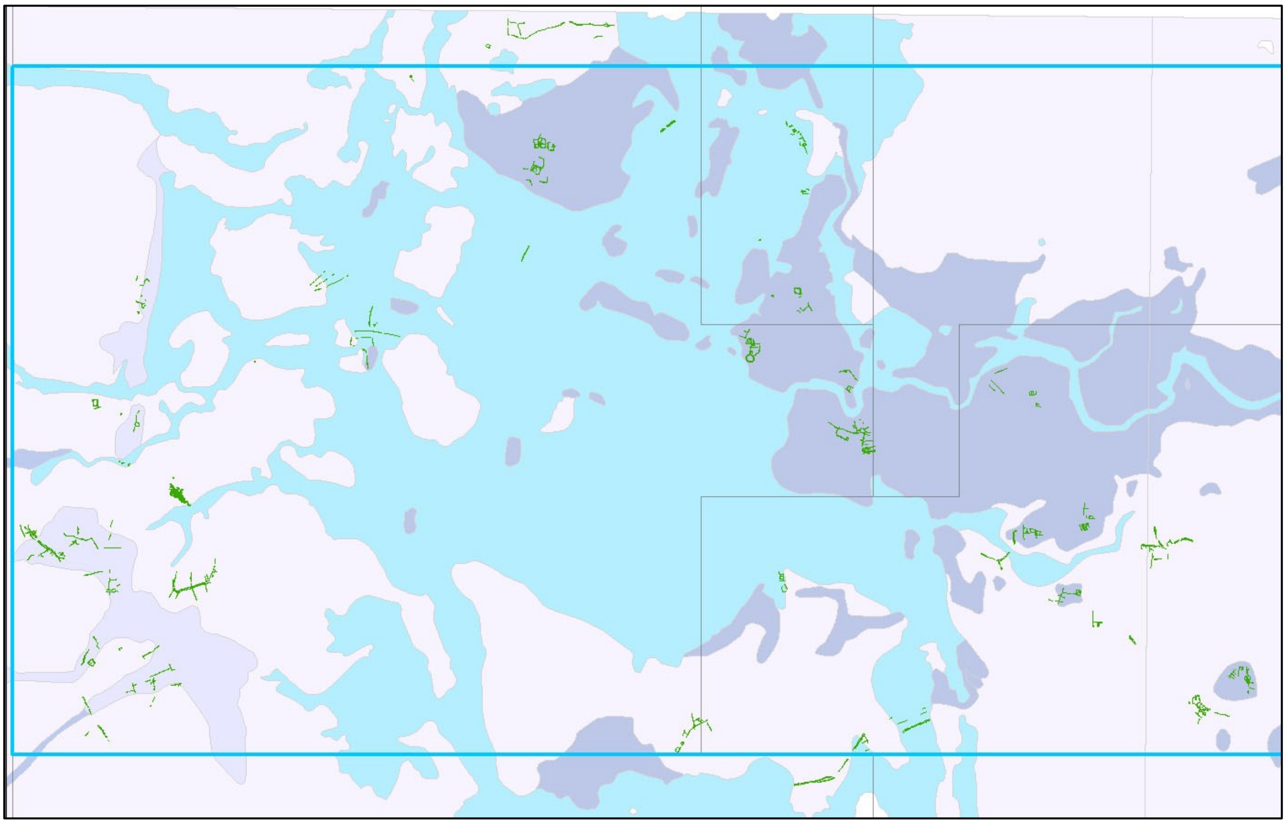


Figure 6.10: Iron Age and Roman cropmarks (green) in the Hull valley, overlain on the geology (see Fig. 6.6 for key; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Excavations providing more insight into the chronology and function of these sites are relatively scarce, although settlement remains were excavated at **Leven** and **Arram**. The site on the Leven-Brandesburton bypass comprised a sequence from enclosed Iron Age settlement to small early Roman farmstead and a larger late Roman successor (Head *et al*. in van de Noort and Ellis 1995, 194). Meanwhile at Chapel Garth, Arram, a multi-phased settlement also spanned the Late Iron Age to the 4th century AD, with evidence of Iron Age copper-alloy working (Wilson 2009; Halkon 2011). These sites suggest continuity of settlement is a key feature through the late prehistoric and Roman periods, perhaps because the wetness of the local environment restricted the availability of suitable locations. They also imply that while there is no evidence of a settlement hierarchy with particularly large or complex enclosures, there were specialist functions undertaken within a rather busy landscape.

Conclusion: later prehistoric and Roman archaeology makes a strong contribution to archaeological sensitivity since the more extensive nature of assets of these periods, including enclosures, field systems and trackways, means the likelihood of encountering such features is relatively high, although the distribution of significant assets (settlements) is less well understood. However, the two excavated sites lie on either side of the Hull valley, close to the wetland edge and the 5 m contour, which might suggest a preferred location, with access to both arable and grazing land.

Overall, later prehistoric and Roman assets (excluding findspots) occur at a rate of about one every 500 ha, similar to that for Bronze Age round barrows, though the average size of a 'site' is of course much larger. In the areas with aerial mapping, cropmarks of these periods occur in 8% of NHLC 250 m grid squares, or 10% of those classified as Post-War Enclosed Land. They are found in 16.7% of the grid squares that are on sand and gravel, compared to just 7.7% of those on till and 5.1% of those on alluvium.

6.2.6 Medieval

With the exception of a significant 6th-century Anglian cemetery from **Hornsea**, there is little archaeological evidence from the early medieval period in the study area, though Watton Priory (see below) was the site of an earlier, 7th-century nunnery and just to the south is the important early monastic site at Beverley. The scarcity of settlement evidence perhaps reflects the increased wetness and arable decline mentioned above; it may have been the perceived remoteness of the location that attracted the religious foundations. What evidence there is for early medieval activity is focussed in the vicinity of existing settlements, with the exception of the imprecisely located lost Domesday settlement of

Arnestorp, and a spearhead from close to the river Hull. It is quite likely that early medieval sites remain to be discovered as they are typically under-represented in the aerial mapping record.

In contrast, later medieval settlement remains are well distributed across the study area, again with the exception of the alluviated areas of the Hull valley (Fig. 6.11). They mainly comprise moated sites, as mentioned above, and deserted or shrunken settlement remains, along with the significant monastic site of **Watton Priory**, which was founded around 1150.

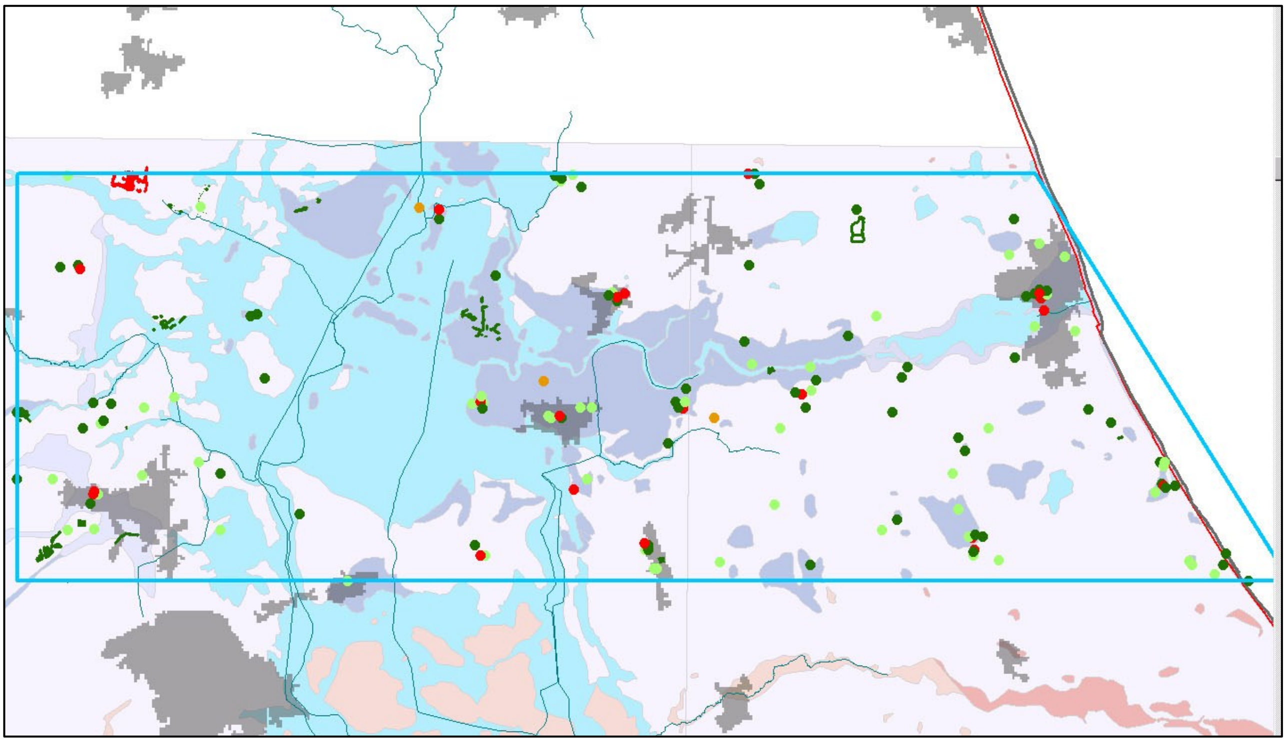


Figure 6.11: Medieval religious sites (red), settlement sites/field systems (dark green), findspots (orange) and other sites (light green) overlain on the geology (see Fig. 6.6 for key; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Evans *et al.* (2012, 15) argue that most moated sites in the Hull valley lie on the western side of the river at elevations above 10 m (i.e. corresponding with the Wolds edge HLC character area) and are associated with nucleated settlements (Fig. 6.12). The study area in fact shows them on local high points right across the valley, but there does appear to be a relationship with the 10 m contour. About half the moated sites lie within 500 m of a known settlement site, notably at Scorborough, Routh, Catwick, Long Riston, Sigglesthorne, Great Hatfield, Mappleton and Great Cowden. Particularly notable is the group of moats at **Scorborough**, which shows the diverse origins and functions of these sites (Evans *et al*. 2012, 20; see cover image).

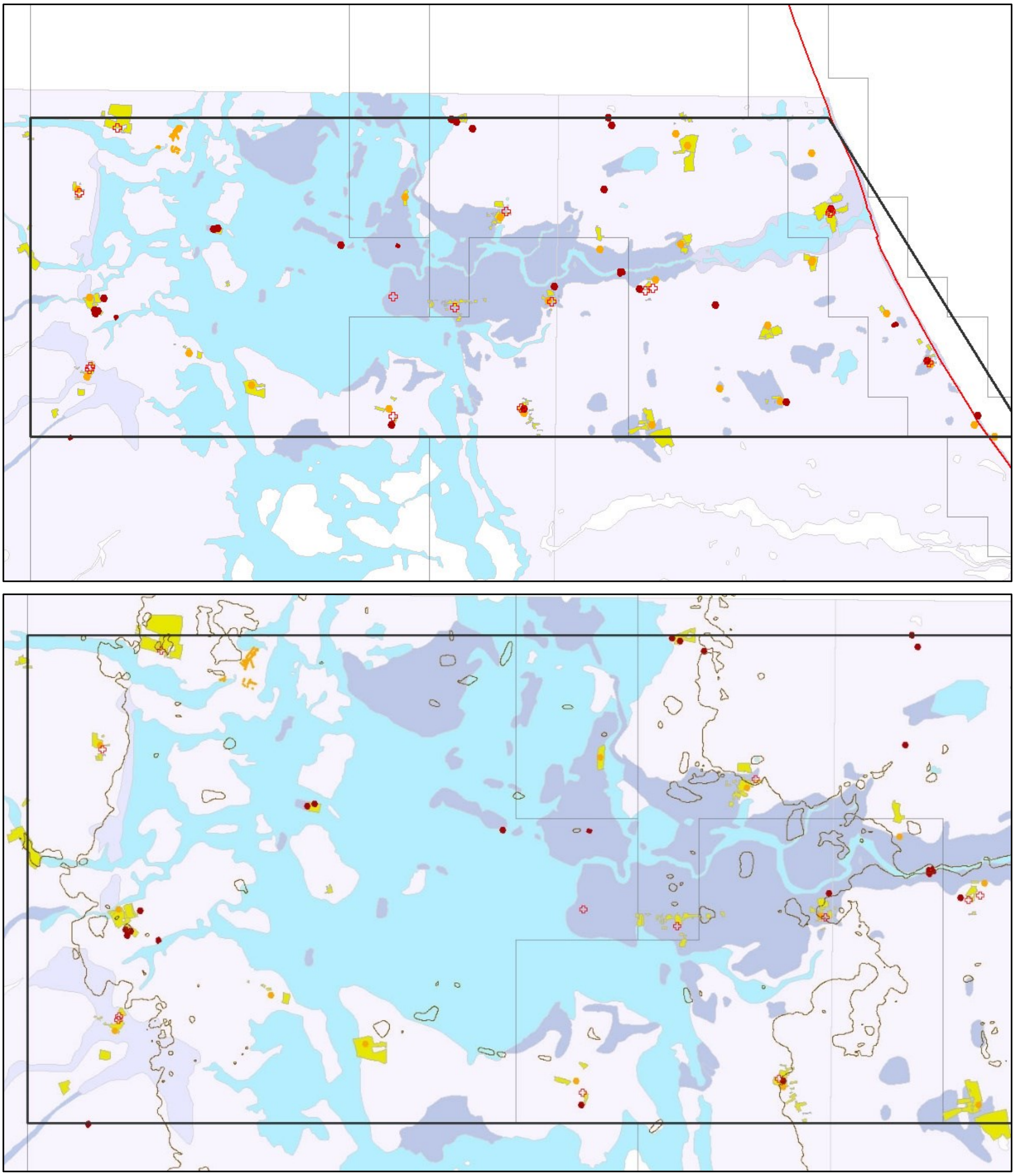


Figure 6.12: (a) Moated sites (red) and deserted/shrunken settlements (orange), including those not assigned to a period, with churches (red crosses) and HLC areas of historic settlement (yellow), overlain on the geology (see Fig. 6.6 for key; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved); (b) Detail of the western area with the 10 m contour

The majority of the medieval settlement sites in central Holderness are on the edge of the Catfoss Dyke or on sand and gravel 'islands' to the south, but there are several on the till as well. In the areas with aerial mapping, ridge-and-furrow earthworks provide evidence of the wider medieval landscape; conspicuously these avoid low-lying, alluviated areas (Fig. 6.13). This figure also illustrates that earthwork survival is rare, as noted by Evans *et al*. (2012, fig 32), with most of these remains ploughed or developed over the last 50 years. In areas where aerial mapping has been undertaken there are very few medieval sites not associated with ridge and furrow; the main exception is the settlement marked by the sites of Hallytreeholme Grange and St Nicholas' Chapel on a small gravel 'island' near Tophill Low.

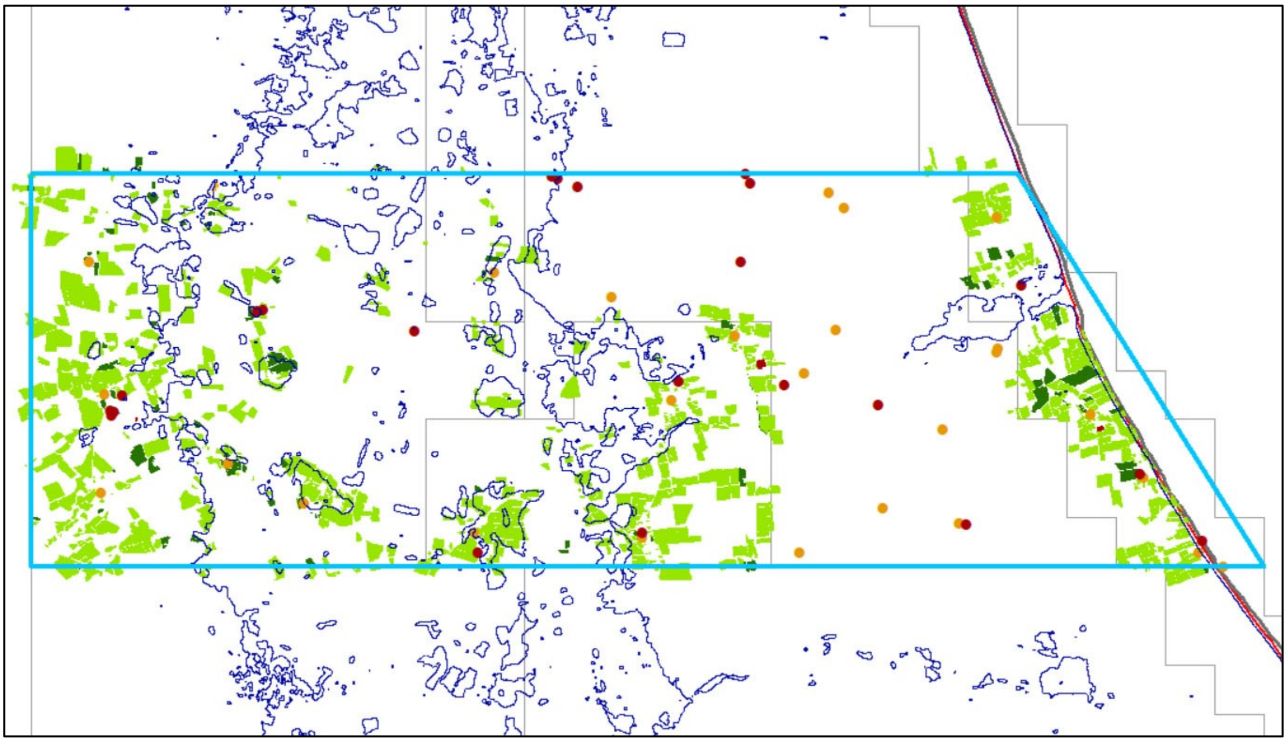


Figure 6.13: Ridge and furrow (light green = levelled; dark green = extant) in relation to medieval settlement sites (see Fig. 6.12) and the 5 m contour (© Crown Copyright [and database rights] 2023. OS 100024900)

Conclusion: the later medieval period makes a strong contribution to archaeological sensitivity because it is well represented across the study area in terms of both settlement and agricultural features. However, compared to earlier periods it is likely that the majority of significant assets have been identified and the potential for wholly new discoveries (as opposed to additional assets in areas of known presence) is correspondingly reduced (see 6.3).

6.2.7 Post-medieval

Unsurprisingly, post-medieval sites and finds cluster around the main extant settlements, particularly Brandesburton and Leven, but also notable is the spread of settlement (historic farmsteads) into the alluvial areas of the Hull valley, reflecting the drainage of the carrs (Fig. 6.14). For this period, the SHINE dataset picks out the 16th century deer park and 1930s airfield at **Leconfield**.

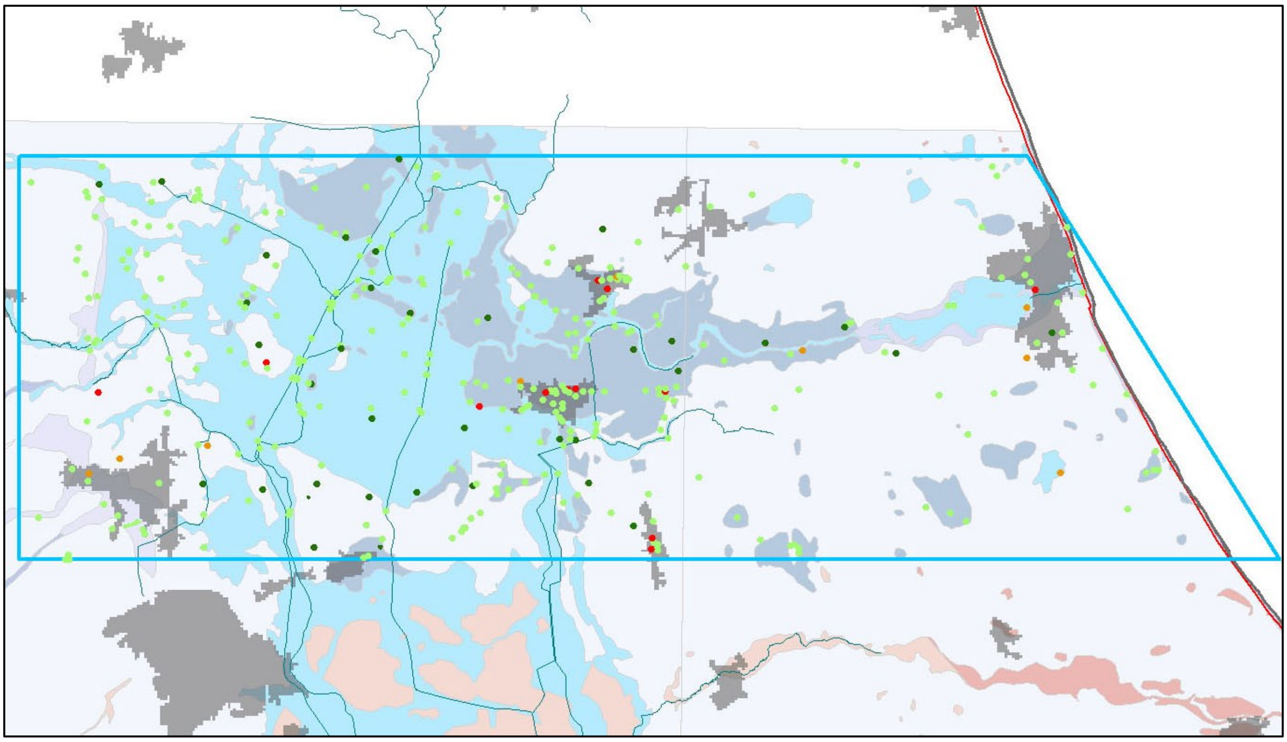


Figure 6.14: Post-medieval religious sites (red), settlements/farmsteads (dark green), findspots (orange) and other features (light green), overlain on the geology (see Fig. 6.6 for key; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

HLC data can in theory be used to reconstruct past landscape using information on 'Previous Types' (cf for Aylesbury: Fig. 4.21), but for Holderness, although recorded for the HLC project (Wastling and George 2018, 9), this information was unfortunately not included in the GIS data, which prevents full consideration of this period in the present study.

Conclusion: for this period archaeological interest is often associated with other heritage interests and the key to managing it is to ensure archaeological engagement in decision-making affecting buildings and landscapes.

6.3 Overview of Presence

As outlined above (Table 6.4), the local archaeological record is dominated by medieval and later sites and finds but there are significant Neolithic–Bronze Age and Iron Age–Roman components, and numerically more modest but still potentially significant Mesolithic remains. Of the periods that predate the formation of the historic settlement pattern only the early medieval period is hard to get a clear sense of in terms of patterns of inhabitation.

The predominant asset types vary by period, with findspots dominant in the Mesolithic (barbed points) and later Bronze Age (metalwork), burial monuments in the Neolithic and Early Bronze Age, settlement and boundary features in the Iron Age and Roman periods (through which there appears to have been substantial continuity of occupation), and settlement with ridge and furrow in the medieval and post-medieval periods: a far from unusual pattern for this type of landscape.

The spatial patterning of these assets across the study area shows that the main distinctions are between the Wolds edge, the Hull valley and central Holderness, which were also distinguished as separate character areas for HLC. Oscillations in the occurrence of evidence from different broad periods seem to relate to the changing affordances of wetter and drier areas. For the Mesolithic the Catfoss Dyke environs and the Hull valley appear to have higher potential, the Holderness till and Wolds edge less so. In the Neolithic and Early Bronze Age visible activity expands into both the latter areas, though the distribution of settlement evidence may remain more similar to that of the Mesolithic. Later prehistoric and Romano-British activity appears more focussed on the wetland edge in the Hull valley, though the incomplete aerial mapping coverage may well under-represent its distribution in central Holderness. Medieval settlements are well spaced across the area except in the alluviated areas of the Hull valley, where the major expansion of activity is later, associated with post-medieval drainage.

The extent to which these patterns of discovery are representative of the true distributions of assets (i.e. the key question of visibility for any given period: see 3.2.3) is easier to answer for later periods. The ubiquity of (former) ridge and furrow above 5 m OD (Fig. 6.13) suggests a fully settled medieval landscape, while the key settlement indicators seem rather evenly spaced at around 2 km intervals. If we draw buffers with a radius of 1 km around these, and exclude alluviated areas in the central Hull valley, we are left with only a few gaps for potentially ‘missing’ settlement, mostly in central Holderness (Fig. 6.15). This seems to indicate good or very good visibility of later medieval settlement sites (3.2.1). Similarly, Fig. 6.16 shows potential correlations of medieval sites on the HER with ridge and furrow specifically identified as medieval, and with HLC polygons characterised as early enclosure or similar. The few areas where there is 'early' landscape without known medieval archaeology could certainly be considered as potentially sensitive.

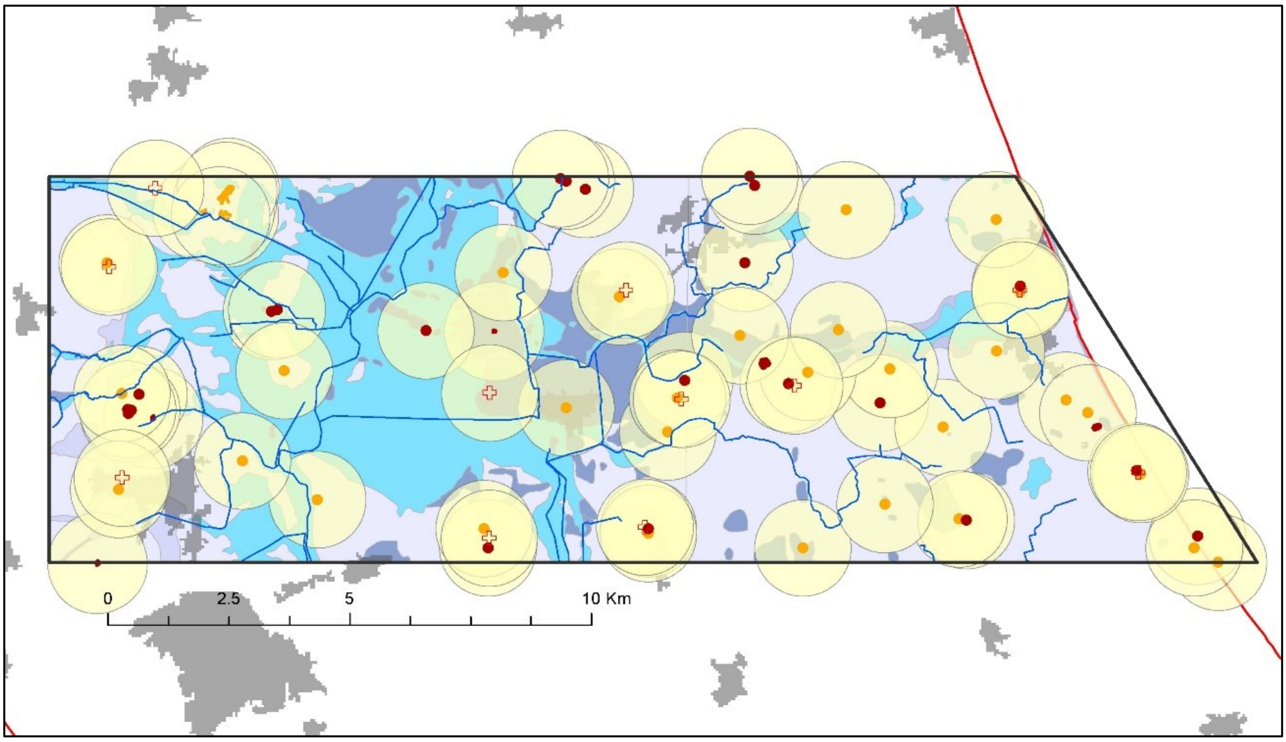


Figure 6.15: Buffering of medieval settlements (orange), moated sites (red) and churches (crosses)

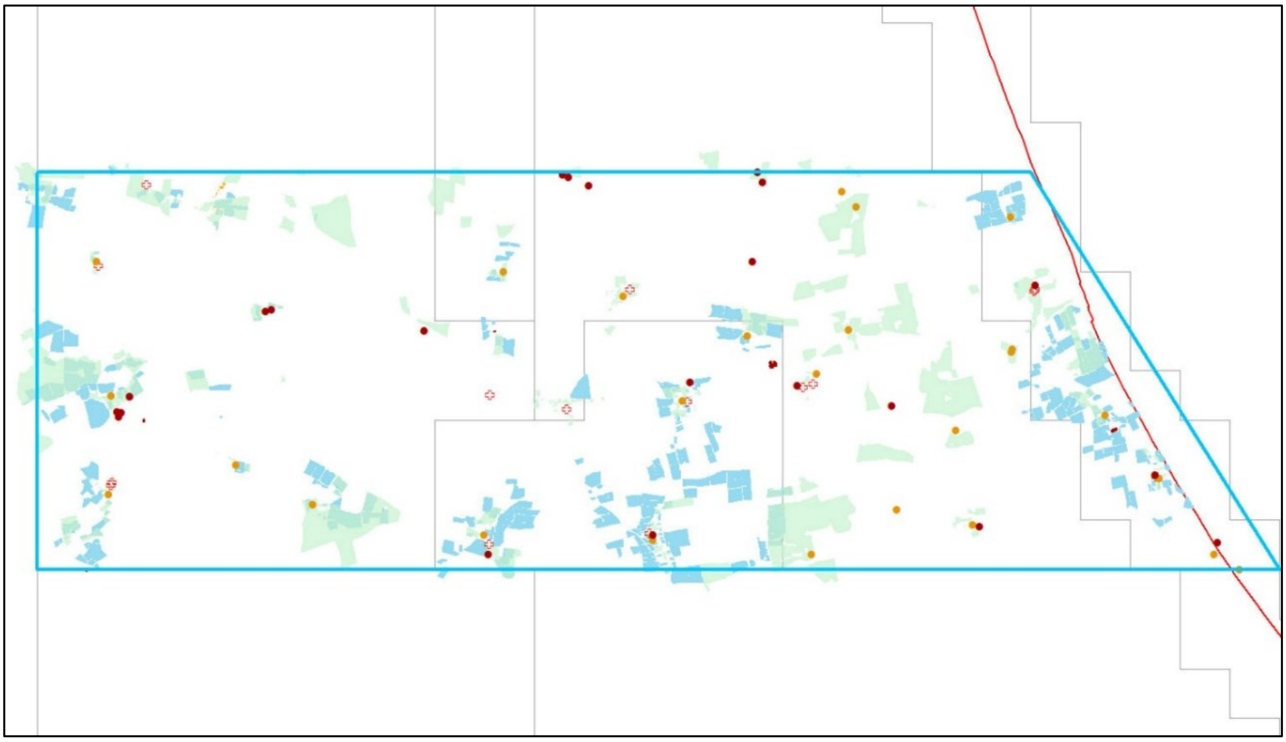
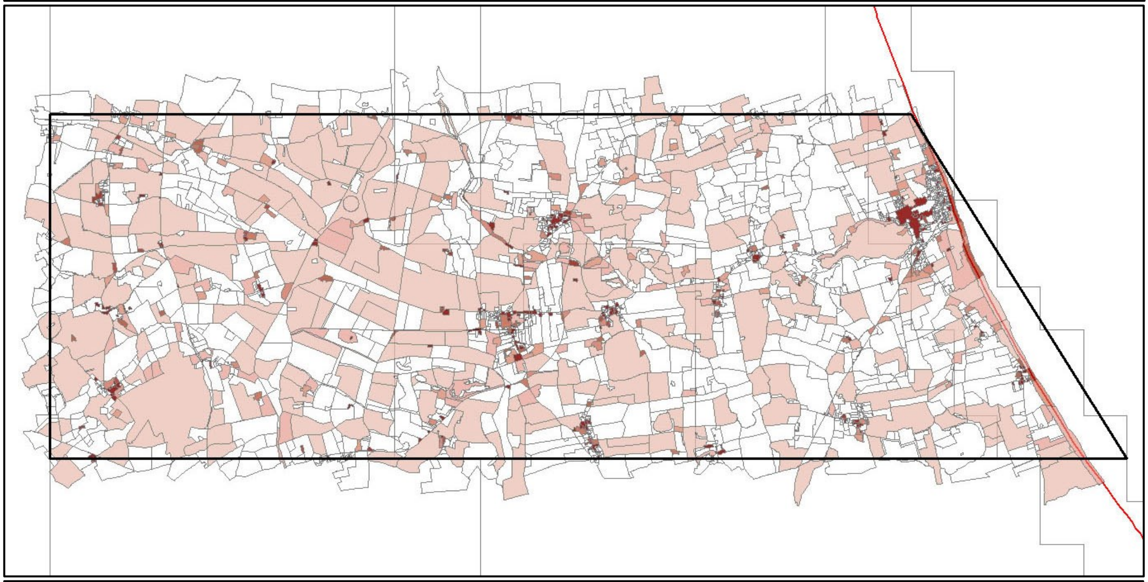


Figure 6.16 (previous page): Medieval settlements (orange), moated sites (red) and church sites (red crosses) overlain on HLC early enclosure types (green) and medieval ridge and furrow (blue)

For earlier periods the extent to which distributions reflect differences in visibility rather than actual presence needs further investigation. Nevertheless, a key question is whether there are correlations of known sites with particular landscape characteristics from which we could infer where assets are more likely to occur. The assumption is that areas of shared character might have had similar affordances for past occupation. HLC is an obvious starting point, although, as discussed above, the Holderness fieldscape (Fig. 6.2) does not clearly distinguish different landscape character areas, showing instead the extent to which drainage has elided the deep-rooted historical distinction between wetland and dryland, the till and the floodplain – even though, as Environment Agency mapping shows (Fig. 6.1), these divisions have a tendency to reassert themselves when the modern watercourses flood. Accordingly, neither Neolithic/Bronze Age nor Iron Age/Roman sites show area-wide correlations with any particular HLC type.

However, as mentioned above (3.3), HLC polygons are also potentially useful as units of analysis in an area-based approach. For example, we can model trends in presence by mapping the number or density of HER monument records in each HLC polygon. A simple map of numerical presence (Fig. 6.17a) favours larger polygons but apart from Hornsea and the coastal strip suggests a greater likelihood of records in the Hull valley than in central Holderness. Mapping density, on the other hand, favours single records within small polygons but shows a similar pattern (Fig. 6.17b). To remove variability due to land use we could restrict the mapping to polygons coded as fields, which also shows an east/west difference; or take arable land use data, which provides more evenly sized polygons and shows more of a central focus, arguably connected to the presence of sand and gravel geologies (Fig. 6.17c).

To overcome the variability in HLC polygon size altogether we can use the NHLC which records the main HLC type in a grid of 25 ha (500 x 500 m) or 6.25 ha (250 x 250 m) squares (see 3.3). Using the latter shows (via a Chi-square test) that both HER monument records and findspots are significantly under-represented within modern fields, and over-represented on developed land (as might be expected) and rough ground (mainly at the coast). However, ‘pre-modern’ and ‘ancient’ field patterns did not show any difference between observation and expectation.



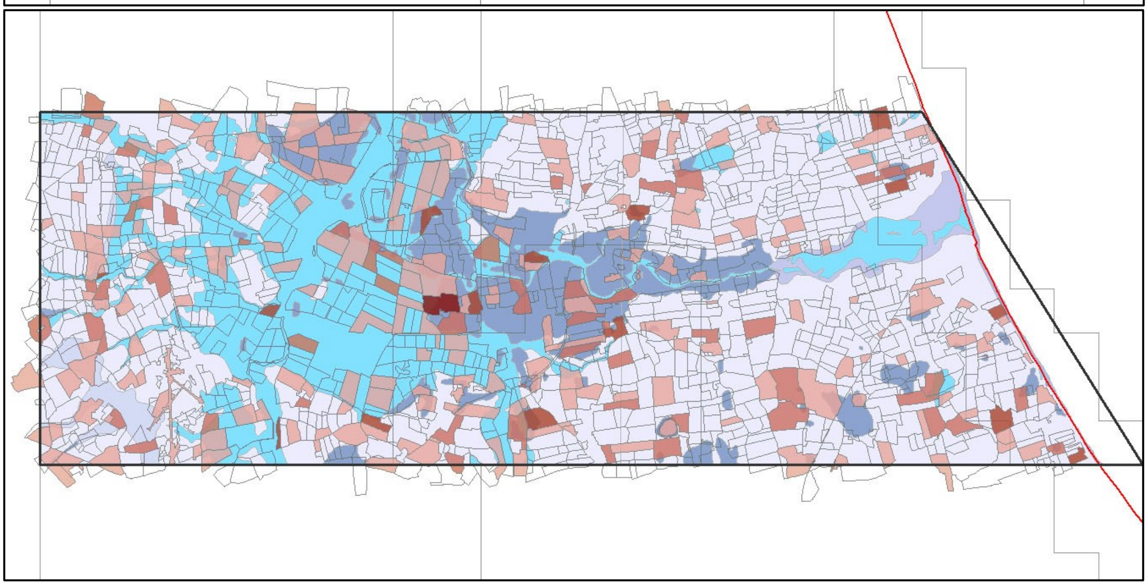


Figure 6.17 (previous page): (a) Number of records by HLC polygon; (b) Record density by HLC polygon; (c) Number of records by arable field, overlain on geology (see Fig. 6.6 for key; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved); darker shading indicates higher counts

Looking at geological and topographical indicators, there is a much higher density of sites and finds on glacio-fluvial sands and gravels (one record per 8.1 ha) compared to till (20.7 ha) and alluvium (23.0 ha). If the post-medieval period is excluded, the alluvium – the edge of which largely coincides with the 5 m contour – has a much lower density of HER entries.

For three periods with a statistically valid number of assets (Early Bronze Age, Iron Age/Roman and medieval) in each case simple Chi-square tests show that those assets are significantly over-represented on the gravels and under-represented on the alluvium compared to the baseline of the till. Soil drainage characteristics largely coincide with the geology, i.e. freely draining soils are found on the sands and gravels, impeded drainage on the till and naturally wet soils on the alluvium. The soil map picks out a few areas of better (or at least less impeded) drainage within the till but there is no evidence from the HER that these were favoured for past occupation.

Until the post-medieval period it therefore seems alluviated areas were generally avoided because of their wetness but there remain questions of the age and duration of alluviation and whether significant sites predating the alluvium (or interdigitated within it) are present but not visible to survey and remote sensing. In fact the HER records little by way of wetland structures: in the Hull valley the only place timbers have been reported is the Wilfholme/Watton Carrs area. Of course while wetland deposits may be a positive indicator of preservation (see below) they are also potentially a negative indicator of presence; the wetland edge or subtle rises such as levees are more likely to be favoured locations, though the discovery of Must Farm has shown that later prehistoric communities could settle within wet areas.

On the other hand, biogenic floodplain sediments also have significance in their own right for understanding past environments and the exploitation of the landscape from the Mesolithic period onwards, so this potential should be factored in to any archaeological assessment. There remains a dearth of securely dated sequences for the mid- to late Holocene (Lillie and Gearey 2000, 81–2) but at **Arram Grange**, in the south of the study area, peat formation occurred between around 4300 and 2350 cal BC. Conversely, it should be noted that the HWP found certain areas mapped as floodplain deposits by the BGS had little alluvium and no biogenic sediments, and were therefore lacking in wetland or palaeoenvironmental potential (Lillie and Gearey 2000), though better mapping of alluvium would be required to distinguish areas of higher and lower sensitivity. We should think in terms of the potential for small wetlands across Holderness rather than an extensive wet landscape so deposit modelling would be essential for assessing sensitivity locally.

The pre-modern archaeology of the coastal zone does not look greatly different to the rest of central Holderness, which may reflect rates of erosion: this was not the coast in the medieval period and before. However, subtle variations are evident elsewhere within the landscape, with the palaeochannel that was the natural predecessor to the Catfoss Dyke apparently a significant feature in the landscape in many periods, attractive to occupation and perhaps forming a boundary between different landscape zones.

Some correlations with other cultural features may also be apparent: 14% of HER monuments and findspots lie within 400 m of a SM (which corresponds to 6% of the project area) but the degree of positive correlation varies by period in a predictable fashion (8% of Mesolithic to Early Bronze Age records; 12% of later prehistoric and Roman; 18% of post-medieval; and 30% of medieval). Areas within 200 m of a listed building (4.6% of the project area) are equally positive indicators, containing 20% of HER monuments, but again this is almost entirely due to medieval (49%) and post-medieval (39%) records. Around half of listed buildings lie within built-up areas but almost 80% are associated with areas mapped as historic settlement in the HLC (Fig. 6.18). The main exception is an area west of Hornsea where a cluster of listed buildings is not associated with areas of significant historic or current settlement, perhaps reflecting a more dispersed pattern of post-medieval settlement on freely draining soils at the western end of Hornsea Mere. In any case, existing designations seem to be positive indicators for archaeology of more recent periods, as might be expected.

Although not within the study area, some calibration of the presence model is provided by the Easington to Ganstead gas pipeline, south-east of Hull, which represents an archaeological transect 32 km long and around 50 m wide, a total area of some 160 ha. Like the central Holderness part of the study area the superficial geology mainly comprises glacial till with pockets of sand and gravel. Within this transect 20 excavation areas were defined, spanning the Mesolithic to the medieval periods (Glover et al. 2016, table 1).

The main (Early) Mesolithic site, the largest assemblage from southern Holderness and perhaps representing a base camp, lay on gravels at Sproatley. Lithics of the period came from five other sites, but diagnostic Late Mesolithic material was very sparse, suggesting a contraction in activity. This fits with the evidence from the study area where we might suspect an Early Mesolithic base camp from the distribution of barbed points, but there are few Late Mesolithic finds.

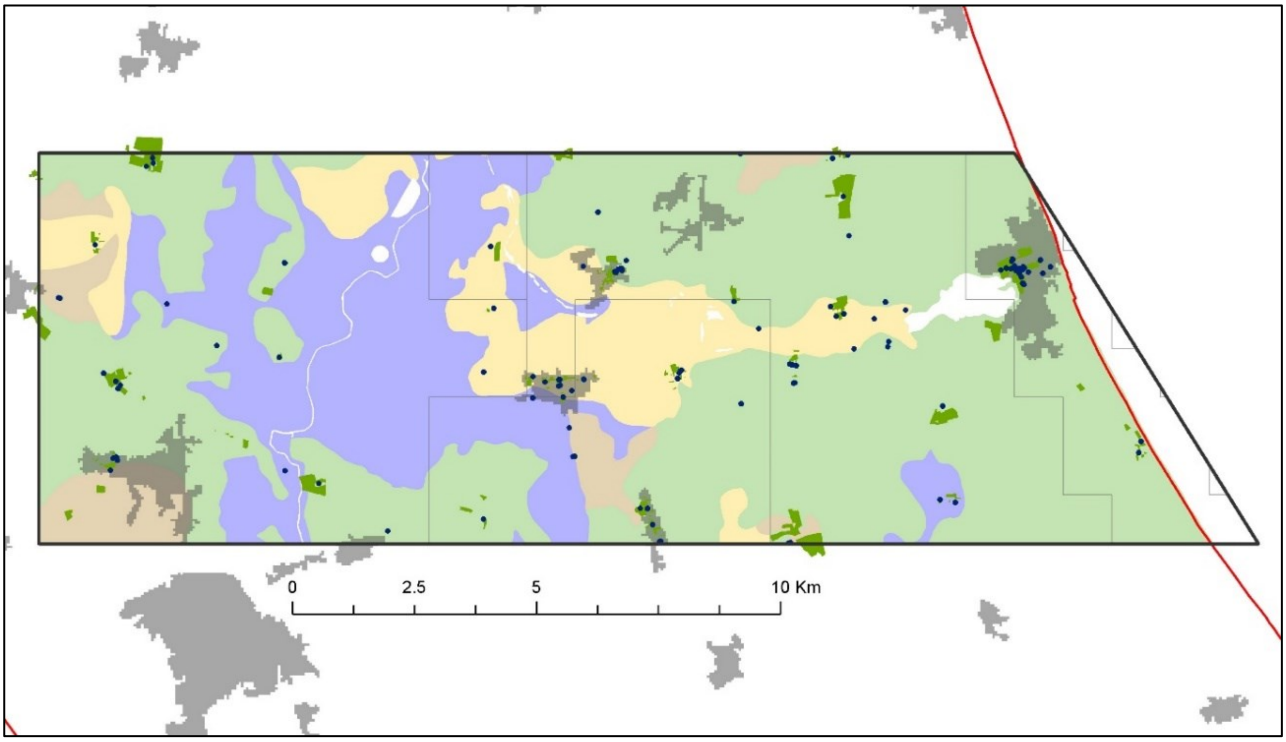


Figure 6.18: Listed buildings (dark blue) in relation to historic settlement (bright green), built-up areas (grey) and freely draining soils (yellow) (Soils data © Cranfield University and for the Controller of HMSO 2024 used with permission)

Neolithic features and finds were rare along the pipeline except for Late Neolithic-Early Bronze Age flintwork, which came from four sites. Early-Middle Bronze Age features were found in small numbers at five sites, along with two possible round barrows at Sproatley (though they lacked datable material). Late Bronze Age material was lacking. This is not inconsistent with the density of evidence from the study area.

The predominance of Iron Age sites (a third of which continue into the Roman period) is notable – all but two of the 20 excavation areas included Iron Age remains and 16 produced ring-gullies suggestive of settlement. Roman features came from eight sites, mainly ditches and field systems (there were no settlement structures), all of which had preceding Iron Age activity. Without knowing the precise areas covered by the assets it is hard to extrapolate densities from a narrow linear sample, except to say that simply dividing the number of settlements by the length of the pipeline (1 per 2 km) is an underestimate, because there must be sites that the easement just missed, while dividing the area of the strip by the number of sites (1 per 10 ha) is an overestimate, because only part of each settlement lies within the transect (one asset per 10 ha does conform with the estimates from the southern case studies, though these were mostly not linears). However, any figure in between still implies there are many Iron Age/Roman sites yet to be discovered within the study area, assuming settlement densities are comparable.

Early medieval activity was found at two sites along the pipeline (possible ditched enclosures at one and a charcoal-rich deposit at the other), but finds were scarce. Medieval activity other than agriculture was restricted to a single occupation site, identified with a settlement known from documentary evidence.

In general therefore, these results seem to corroborate the patterns inferred from HER data in the study area. There is a Mesolithic presence on the gravels, including occasional sites of considerable size and significance; Neolithic and Bronze Age occupation is more dispersed but barrows are found in moderate numbers. The Iron Age represents a step change in site densities and there is plenty of continuity into the Roman period but little expansion. Early medieval remains are sparse and medieval settlements have mainly already been documented or are still occupied, so would tend to be bypassed by pipelines and similar development.

6.4 Condition model

Mapping condition of archaeological remains (not including standing buildings) uses HLC as the basis for assessment supported by land cover mapping (for physical impact of modern land), geological mapping (for soil chemistry), SHINE data (see 2.2 and 6.5) and aerial mapping of ridge and furrow (for known condition). GIS data was extracted in order to allocate each land parcel one of the following physical condition codes:

- U (upstanding earthworks present or likely): includes SHINE sites recorded as upstanding, earthworks identified on aerial mapping, medieval earthworks and historic parkland on HLC.
- V (deep stratigraphy present or likely): includes land cover mapped as grassland, areas of alluvium on geological mapping, and areas mapped on HLC as historic settlement, open land (commons, heath, etc) and ancient or semi-natural woodland.
- S (shallow cut features likely to survive): includes woodland, arable fields (early or Parliamentary enclosure) and recreational (e.g. golf courses).
- D (deep cut features only likely to survive): includes areas mapped on HLC as modern (19th–21st century) housing or arable fields.
- X (destruction of most archaeological features and deposits): includes areas mapped on HLC as quarries/extraction and artificial water.

It is important to emphasise that this approach does not depend on an asset being known or expected to be present – it considers what the likely physical condition of an asset would be if one is present. There is of course a degree of uncertainty about this approach which could be checked by assessing the results of HER events (which have not been used directly in the assessment, except where they have informed SHINE data) against the predicted condition.

One uncertainty that should be further reviewed concerns the impact of agriculture and development in areas mapped as alluvium; for the map below (Fig. 6.19a) areas of housing and modern arable fields have been coded ‘D’ regardless of the presence of alluvium on geological maps, whereas areas of early or Parliamentary enclosure with alluvium have been coded ‘V’.

Figure 6.19a suggests that earthwork survival (U) is more likely in the west of the project area while surviving deep alluvial sequences (V) are most widespread in the Hull valley, as would be expected, but especially in the southern part of the study area. Compared to the Hull valley, central Holderness has more of a patchwork of condition scores, while the north-eastern part of the study area in Brandesburton, Seaton and Bewholme parishes has the largest area coded ‘D’. It is possible this relates in part to the absence of aerial mapping data in this area but there is a similar north/south division in the coastal strip where aerial mapping has been undertaken.

The physical condition assessment can be supplemented by soil chemistry mapping that broadly distinguishes anoxic/wetland (A), basic (B) and acidic (C) soils. Figure 6.19b shows that wetland (peaty) soils are basically coextensive with the alluviated areas, while there are only small patches of acidic (sandy) soils on the eastern side of the Hull valley and in Holderness on the southern edge of the study area. Whether the soil acidity in these areas is sufficient to affect bone preservation remains unclear; a series of watching briefs in Great Hatfield, in the south-east of the study area, found little except for a few medieval potsherds.

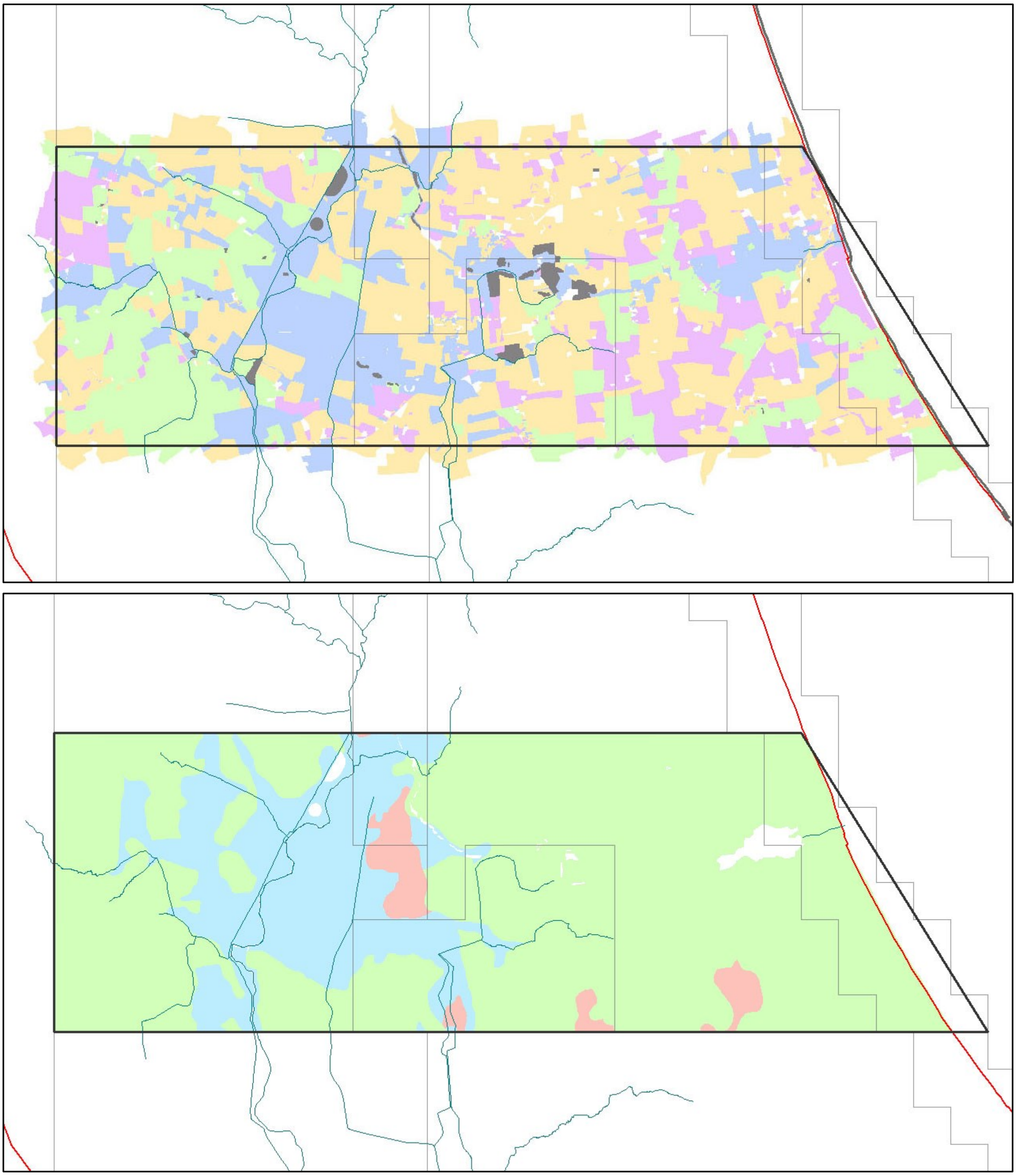


Figure 6.19: (a) Physical condition categories as described in 6.4 (green = U; blue = V; pink = S; orange = D; grey = X); (b) Soil chemistry categories (blue = A; green = B; red = C) (Soils data © Cranfield University and for the Controller of HMSO 2024 used with permission)

6.5 Significance

Seventeen SMs are found within or directly adjacent to the study area (Fig. 6.20a), three of which have components of more than one broad period. In contrast to the range of HER sites and finds, 21 of these (80%) are medieval and three (12%) are later prehistoric; there is also a post-medieval component (Civil War earthworks) and a Neolithic henge (Fig. 6.21). The SMs have a largely peripheral distribution within the study area and are more representative of the distribution of earthworks than of the wider archaeological resource. In contrast the selection of records for SHINE (Fig. 6.20a) has identified a much larger part of the study area as reaching the significance threshold for consideration for environmental stewardship, covering the full range of periods (Figs 6.20b and 6.21). In total, just 0.5% of the study area is scheduled while almost 10% has been validated for SHINE.

Consideration of SM designation dates shows one predating 1940, six in the 1940s and 1950s, four in the 1960s and 1970s, five in the 1990s and just one since 2000; therefore the steady rate of the later 20th century has not been matched in the last 20 years, suggesting nationally important archaeology may be under-represented in the National Heritage List (NHLE). The SHINE dataset, which has been compiled over the last decade, compensates for this to a large degree. It suggests that the most significant site types are medieval settlements and ridge and furrow, prehistoric barrows (Bronze Age and Iron Age), and Iron Age/Roman enclosures and fields. A significance level is assigned to each record, which refers to the significance of achieving protection through Entry Level Stewardship, though it is not immediately clear what the different levels mean. The features assigned high stewardship significance (Fig. 6.20a) represent 40% of the total and include examples of all of these types: 26% of the sites with Bronze Age barrows; 75% of those with Iron Age barrows; 60% of Iron Age/Roman enclosures and fields; 68% of medieval settlements and ridge and furrow. There are also WW2 pillboxes, a variety of post-medieval features and numerous undated cropmark enclosures, mostly assigned medium significance. The few features assigned low significance are all post-medieval.

As with presence, mapping potential significance requires extrapolation from known assets, which is tricky, but can perhaps be visualised initially in terms of HER polygons associated with key asset types (Fig. 6.22), based on the same assumption outlined in 6.3. This indicates a broad distribution of potential for Early Bronze Age barrows other than in the north-east quarter of the study area; a focus of Iron Age-Roman settlement on either side of the Hull valley; and a dispersed distribution of medieval settlement reflecting a rather regularly spaced settlement pattern. Again as with presence, the next step is to extend the mapping into areas of similar affordance. For example we might reasonably expect the presence of Early Bronze Age and Iron Age/Roman assets in the north-west corner of the study area, where geology, topography and landscape character differ little from the areas further south. It also seems highly likely that Iron Age/Roman assets will be found in the area not yet covered by aerial mapping, though at a lower density than in the Hull valley. The map of medieval settlement, on the other hand, has fewer evident gaps and we might expect the broad location of the majority of significant assets is understood.

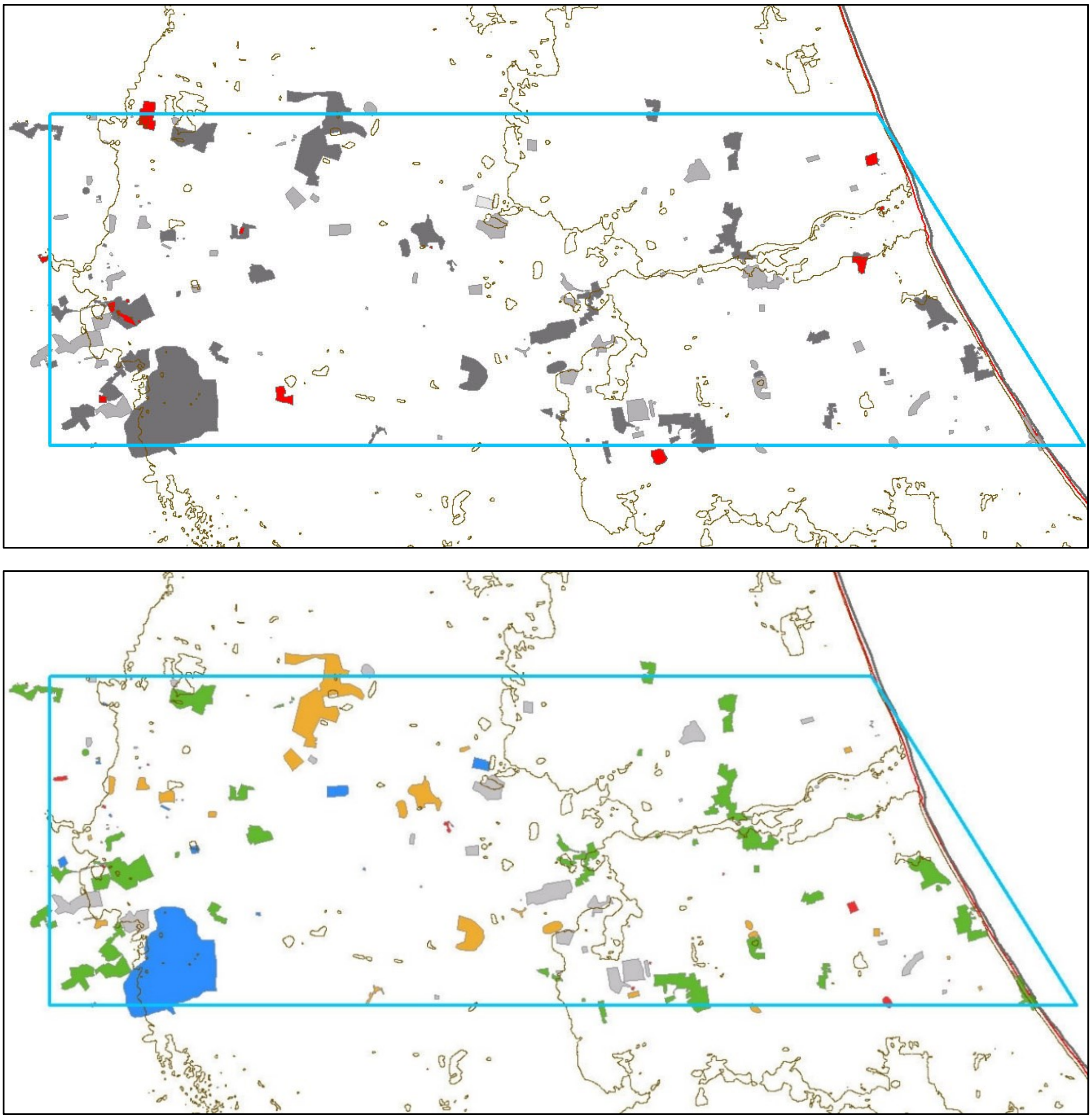


Figure 6.20: (a) SMs (red) and validated SHINE areas (grey; darker = higher significance), overlain on the 10 m contour (© Crown Copyright [and database rights] 2023. OS 100024900); (b) SHINE areas by period (red = Neolithic/Bronze Age; orange = Iron Age/Roman; green = medieval; blue = post-medieval; grey = uncertain)

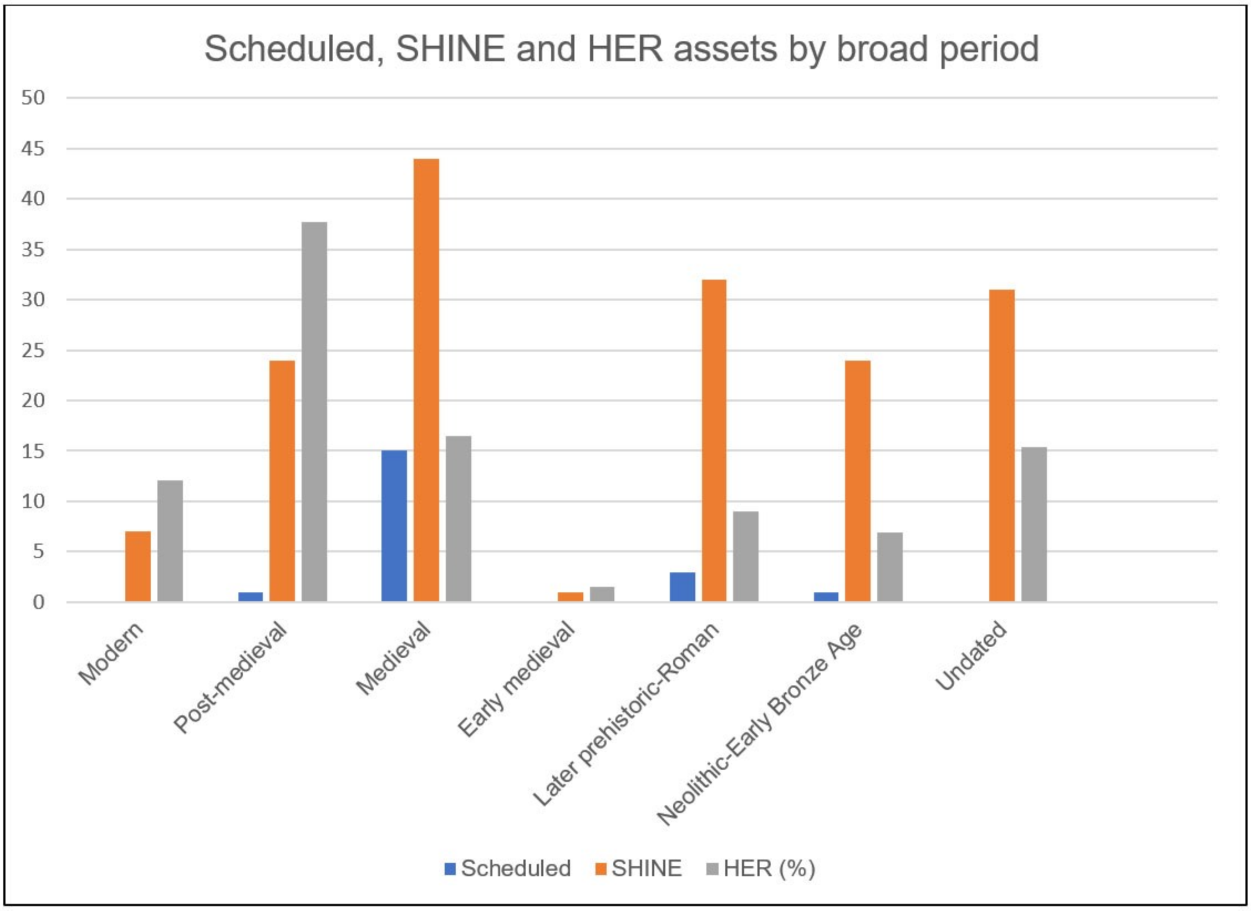


Figure 6.21: Comparison of SMs, SHINE and HER assets by assigned period

Archaeological significance is not, or at least not wholly, an intrinsic quality of a site or monument. It varies over time according to how we might articulate its value, be that in terms of its potential contribution to archaeological understanding (evidential value) or in other forms, such as aesthetic or communal values (which link to issues of opportunity around proposed change). The evidential value of a site is most clearly expressed in its potential to address current research frameworks. The period priorities for Yorkshire were set out by Roskams and Whyman (2007). For the Mesolithic they include improving chronological resolution and the collection of more material from under-represented zones, which suggests further investigation of the distributions outlined above would be worthwhile. For the Neolithic, the patchy evidence from the study area nevertheless contains both substantial monuments and more ephemeral settlement remains, better understanding of the relationships between which would help address research priorities linked to studying transitions, mobility and socio-economic dynamics in this period; areas with multiple lithic finds might therefore be added to the significance map.

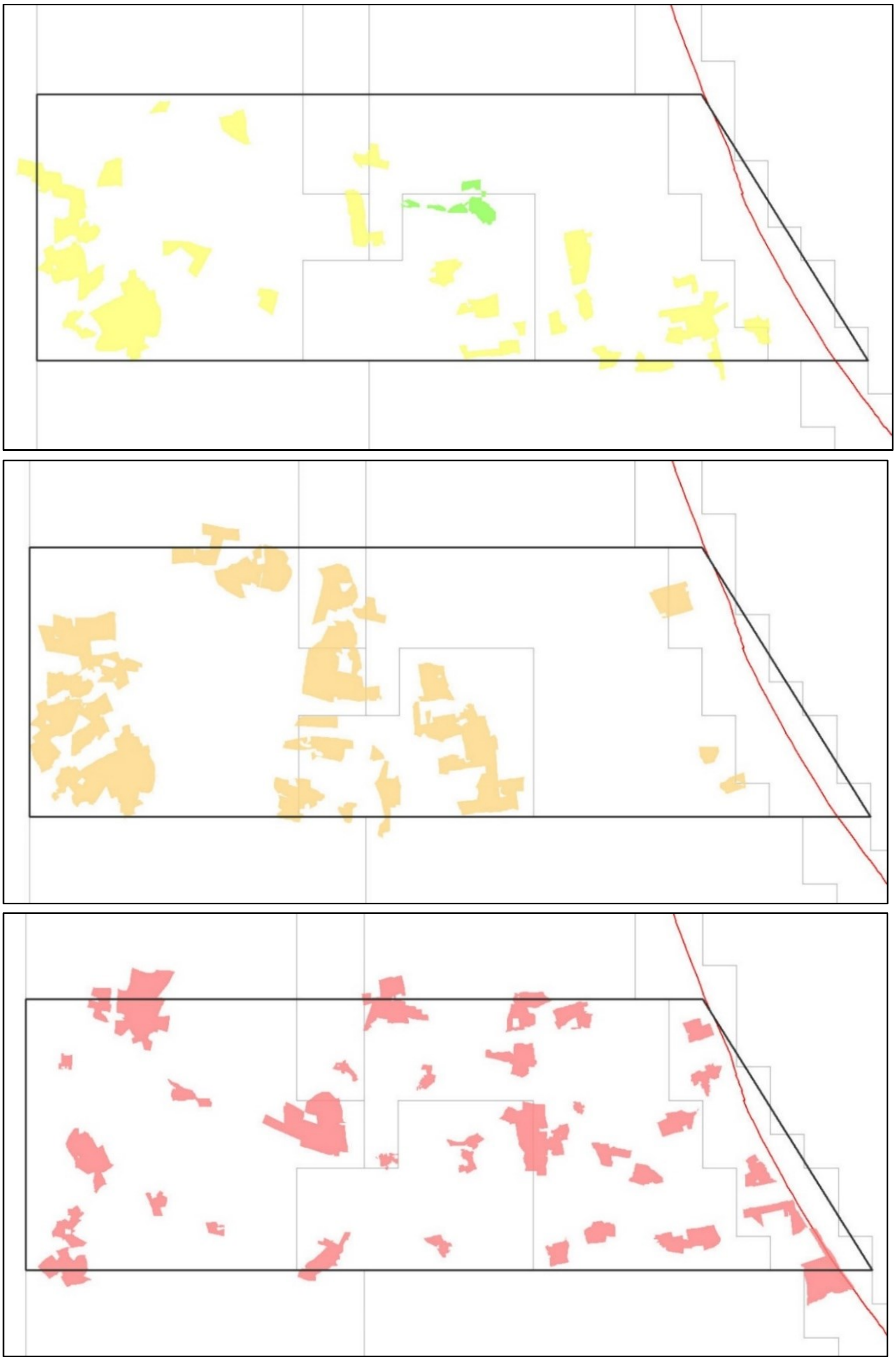


Figure 6.22: Significance mapping by period (HER polygons associated with significant assets): (a) Mesolithic (green) and Early Bronze Age (yellow); (b) Iron Age-Roman (orange); (c) medieval (red)

Priorities for the Bronze Age include understanding the variations within the corpus of barrows and ring-ditches as well as the relationship between these sites and the wider exploitation of the landscape, a question 'not posed frequently enough'. However, identifying non-monumental Bronze Age sites within the project area, especially those contemporary with the barrows, is far from straightforward, as the Seaton coppice site shows, while distinguishing specifically Early Bronze Age lithics from the broad category of 'Late Neolithic/Early Bronze Age' also remains tricky.

In the Iron Age 'those cases where burial can be related to settlement are all too rare' so a focus on the sides of the Hull valley, where square barrows and potential settlement enclosures co-occur, might indicate significant locations where this could be explored. Landscape divisions appear in this period but what they might indicate about the relationship between pastoral and arable elements of the economy remains unclear; locations where fields and enclosures coincide could shed light on this question. The nature of Roman occupation also requires further investigation; there are strong suggestions of continuity from the Iron Age which suggests a different form of 'Romanisation' to other parts of Yorkshire: as the research agenda puts it, 'data distributions point up particular pockets showing either more speedy development or marked delay' and Holderness may be one of the latter cases.

While the early medieval period remains very hard to characterise, understanding of the later medieval rural landscape would clearly benefit from better integration of archaeological, historic landscape and documentary evidence, but we appear to already have much of the settlement framework for this kind of work (Fig. 6.15). Finally, the post-medieval evidence could contribute to the wider agenda 'covering landscape setting and environmental impact' advocated in the research framework.

6.6 Conclusions

The main propositions emerging from the study are that:

1 The data imply that no sizeable areas are entirely devoid of archaeological (including palaeoenvironmental) potential, except for land removed by historic quarrying, mostly south of Brandesburton. However, differences in distributions are evident between the Wolds edge, the alluviated Hull valley and central Holderness, linked to topography. Local character areas therefore have some value in defining archaeological presence.

2 There are 17 SMs within the study area covering around 80 ha (0.5% of the study area) but the schedule is highly selective and biased. The

SHINE dataset (see below) appears more representative of the archaeology of the study area and covers a much larger proportion of the study area (nearly 10%), with Iron Age/Roman cropmarks highlighted in the Hull valley and medieval settlement on the Wolds edge and in central Holderness.

3 The very limited number of open-area excavations in the study area severely reduces the level of certainty with which judgements of sensitivity can be made. Nonetheless the potential for significant remains of different periods is shown by the henge at Leven and the metalworking evidence from Arram.

4 Late Upper Palaeolithic and Mesolithic archaeology shows a focus on riverine locations, especially a major palaeochannel linking Hornsea Mere to the river Hull, while Neolithic and Early Bronze Age remains are distributed more widely, though the channel may have retained some significance, as demonstrated by the presence of two likely henges in the vicinity. However, many sites of these periods may be masked by alluvium.

5 Aerial mapping has contributed significantly to our understanding of later prehistoric and Roman archaeology, showing a broad distribution of field systems and trackways in the areas that have been mapped, though with some indication of higher densities in the Hull valley.

6 Medieval archaeology is found across all parts of the study area, with the exception of the alluviated areas of the Hull floodplain, onto which settlement only spread in the post-medieval period (post-drainage). It is likely that the majority of medieval settlement locations have been identified through the recognition of settlement earthworks, moated sites and places of worship.

7 The potential condition of archaeological remains can be mapped regardless of whether the presence of an asset has been confirmed in that location, though aspects of the model require further validation. There are few known wetland archaeological sites in the area, but enough to demonstrate the potential for prehistoric trackways and evidence of woodland management in the Hull valley, while the possibility of small wetlands (kettleholes) of palaeoenvironmental significance exists across much of the study area. Hornsea Mere is a significant landscape feature.

It is hard at present to construct a reliable overall map of archaeological potential for Holderness but Fig. 6.23 presents a combination of the significance and condition maps. There is a clear difference between the Hull valley as a zone of general high potential and central Holderness where it is more intermittent, though we need to remember the uneven distribution of aerial investigation. The areas shown in orange on Fig. 6.23 could be coded as broadly level 3 in the scheme outlined above (section 3). For greater nuance more detailed investigation at the level of the individual HLC polygon would be required.

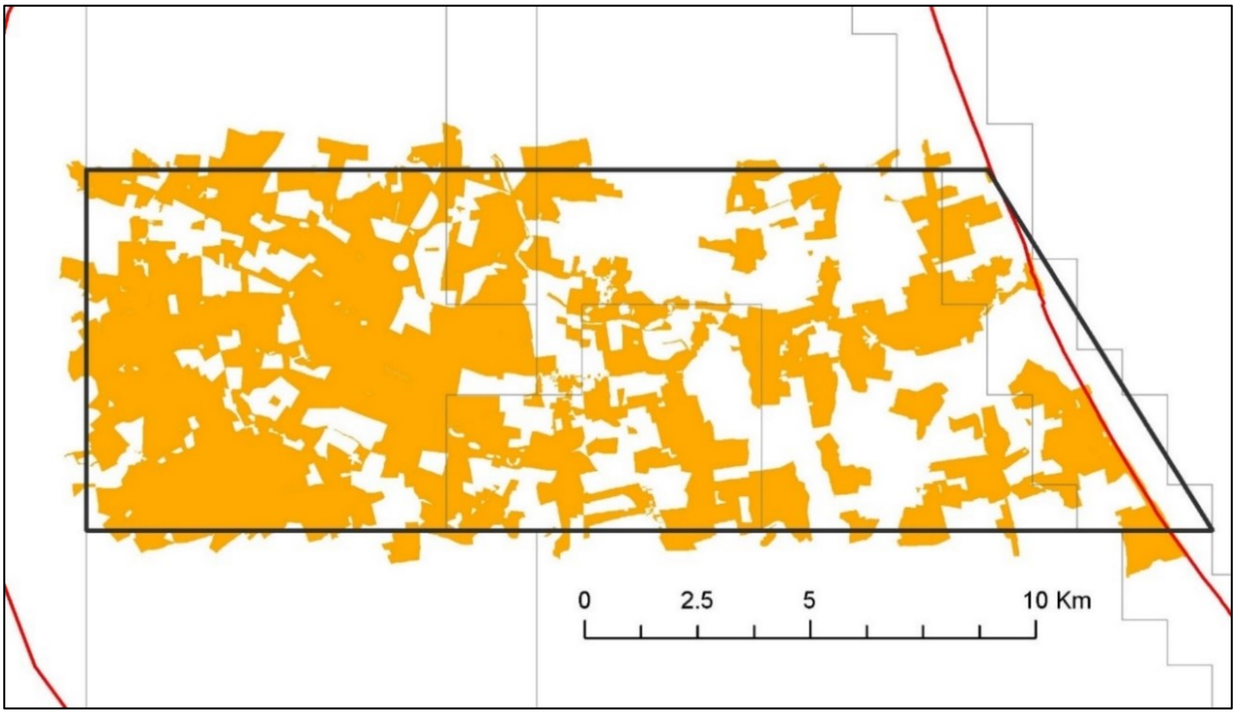


Figure 6.23: Overall potential represented as a combination of significance and condition (areas scored as U or V)

The NHLC provides another way of looking at it, by selecting grid squares with certain characteristics (Fig. 6.24). The approach combines known presence (squares with more than one HER monument), known condition (evidence for earthworks) and known significance (presence of key site types), with geomorphological indicators (sand and gravel geology; potential for waterlogged deposits; the 5 m contour). This further emphasises the importance of the Wolds edge and the patchiness of potential on the central Holderness till.

Then to move from potential to sensitivity proper requires some understanding of threat and opportunity. While arable impacts are rather continuous across the whole project area flood management and coastal erosion are more localised; the same goes for any future development or infrastructure. Unlike attritional agricultural and natural processes, development (including afforestation) offers potential public benefit in the form of mitigation or compensation. These risks and opportunities need to be factored into sensitivity models in a scenario-based way. For example tree planting may protect earthworks from arable erosion but could disturb less robust buried deposits.

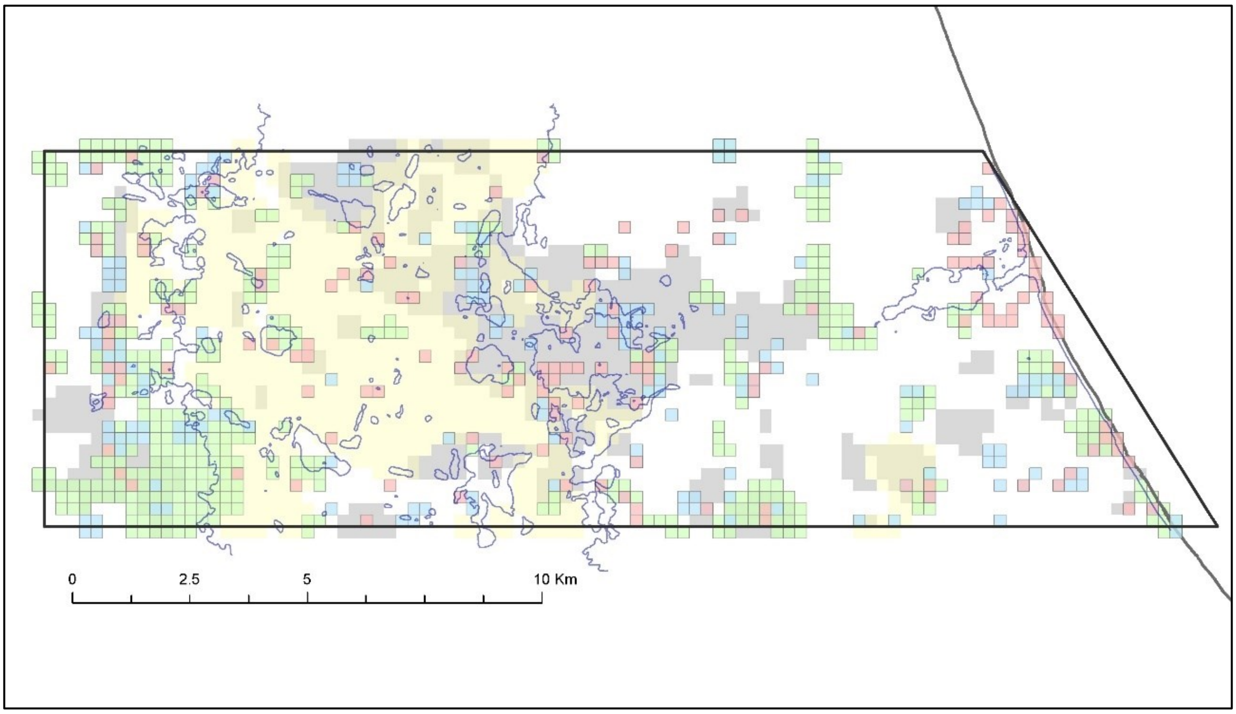


Figure 6.24: Overall potential represented as 250 m NHLC squares with (in order of hierarchy) more than one HER monument (pink); significant site types (light blue); earthwork presence (light green); waterlogged potential (yellow); sand and gravel geology (grey; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved); in relation to the 5 m contour (© Crown Copyright [and database rights] 2023. OS 100024900)

7 Eden Valley

7.1 The study area

7.1.1 Introduction

The fourth pilot study area represents a transect across the Eden valley and adjacent areas south of Carlisle. The study area is rectangular, measuring 21 km east-west by 8 km north-south and covering 168 km in area (Fig. 7.1). It lies entirely within the modern county of Cumbria with its northern edge about 1 km from the built-up area of Carlisle.

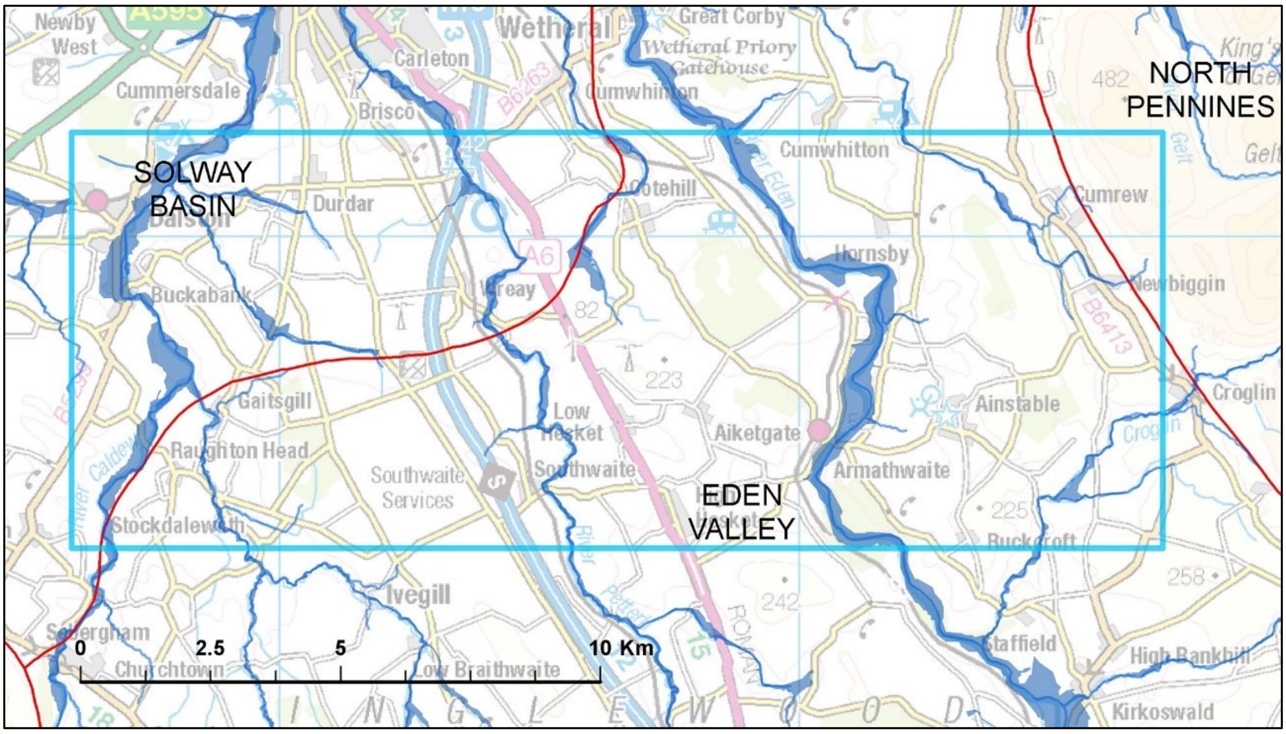


Figure 7.1: Boundaries of the Eden Valley pilot study (light blue) showing Environment Agency flood alert areas (dark blue), and the NCA boundaries (red). Base map © Crown Copyright [and database rights] 2023. OS 100024900.

The Eden valley was chosen as the location for a pilot study for a number of reasons. Other pilot areas are located in the south and east of England and it is important to consider areas in the west as well. The Eden study has local curatorial support and includes a variety of lowland and upland landscape types. Pressures for change in this area include development around Carlisle, especially the Carlisle Southern Link Road (CSLR), and flood risk in the river valleys.

7.1.2 Topography and geology

The study area (Fig. 7.1) largely covers parts of the Solway Basin and Eden Valley National Character Areas (NCAs), with a small part within the North Pennines NCA. Three major rivers flow northwards through the area: from west to east these are the Caldew, Petteril and Eden.

The Solway Basin NCA[26] is an area of gently undulating low hills, dominated by pastoral agriculture in rectilinear fields bounded by hedges (grass and uncropped land account for about 80% of the agricultural land area in the NCA) but with increasing arable farming, particularly on the more elevated land – in the study area this is especially evident in the north-west between Dalston and the M6. The solid geology is mixed but within the study area is entirely overlain by glacial (Devensian) till and fluvial deposits. The NCA has lower than average tree and woodland cover, with native, often ancient, woodland cover largely confined to river valleys. To the north of the study area Carlisle is a major crossing point of the River Eden while smaller settlements (farmsteads, hamlets and linear villages) are mainly found on higher ground and often linked by road networks that have Roman origins. The wider NCA has a rich archaeological heritage, particularly in relation to the Roman landscape of Hadrian’s Wall and its accompanying infrastructure, but also a medieval borderland legacy of abbey ruins, fortified farmsteads and a nucleated rural settlement pattern as well as areas of ridge and furrow.

The Eden Valley NCA[27] has an undulating landform that is largely the result of glacial deposition in the form of drumlins and eskers, giving rise to fertile soils. This gives the NCA its characteristic intimate blend of mixed farmland with significant areas of woodland, farm copses, mature hedgerow trees, stone walls and historic villages. In the eastern half of the study area, there are exposures of sandstone without a cover of till; arable agriculture is absent on this geology. Land use in the Eden valley itself developed in close association with the neighbouring upland areas, with many farms in the valley sending livestock to graze on their commons in the summer months, and upland stock overwintering in the valley. The valley is also an important transport corridor through a predominantly upland region though the convergence of rivers and streams that drain the adjacent uplands creates the potential for severe flooding events. The river Eden, which is of European importance for its habitats and wildlife, narrows to a gorge where it cuts through an isolated sandstone ridge north of Kirkoswald, as well as at Wetheral and Armathwaite.

[26] http://publications.naturalengland.org.uk/publication/5276440824119296

[27] http://publications.naturalengland.org.uk/publication/5866662964232192

The scarp along the west side of the North Pennines NCA forms a striking backdrop to views from the Eden valley; an area characterised by massive moorland summits. It is a largely undisturbed landscape, with sheep and cattle rearing the predominant farming practice. The small area of the North Pennines within the study area is covered by acid grassland and heather.

Looking at the geology of the study area as a whole, around 87% is covered by superficial deposits, primarily till, which is found over 69% of the area (Table 7.1; see Fig. 7.5). Other superficial deposits can be summarised as Quaternary sands and gravels (14%) and alluvium and peat (5%), and (13%). The areas without superficial deposits include exposures of bedrock sandstone (St Bees, Penrith and Stainmore formations), limestone (mainly Alston formation and Ravenstonedale group) and mudstone (Eden Shales formation). These lie mostly in the eastern half of the study area, east of the Petteril, which also has larger areas of glacio-fluvial deposits. River terrace deposits, on the other hand, are more extensive around the Caldew in the west. The east/west split is even more evident in terms of soils, with seasonally wet red loam predominating in the west while sandy soils are more common in the east (Table 7.2).

Table 7.1: Major superficial deposits in the study area

Type	***BGS_LEX Code***	***Area (ha)***	***Percentage of study area***
Till	TILLD etc	11526	68.6
Glacial Deposits	GFDUD/GFICD/ GLLDD/GECL	1671	9.9
Terrace Deposits	RTDU	676	4.0
Alluvium	ALF/ALV	591	3.5
Peat	PEAT	177	1.1

Table 7.2: Major soil types in the study area

Type	***Area (ha)***	***Percentage***
Peat	275	1.6
Wet loam	5364	31.9
Loam	7143	42.5
Sandy	4006	23.8

7.1.3 Landscape character

The landscape is largely rural, the only significant settlement within the study area being Dalston, which has a population of around 2500. The county has full recent HLC coverage

(Cumbria County Council 2009), which for the study area shows a predominance of planned Parliamentary enclosure with significant areas of ancient enclosure and former common arable, along with areas of woodland along the river valleys (Fig. 7.2). The Eden Valley and North Pennines NCAs appear to have a higher proportion of planned enclosure than the Solway Basin.

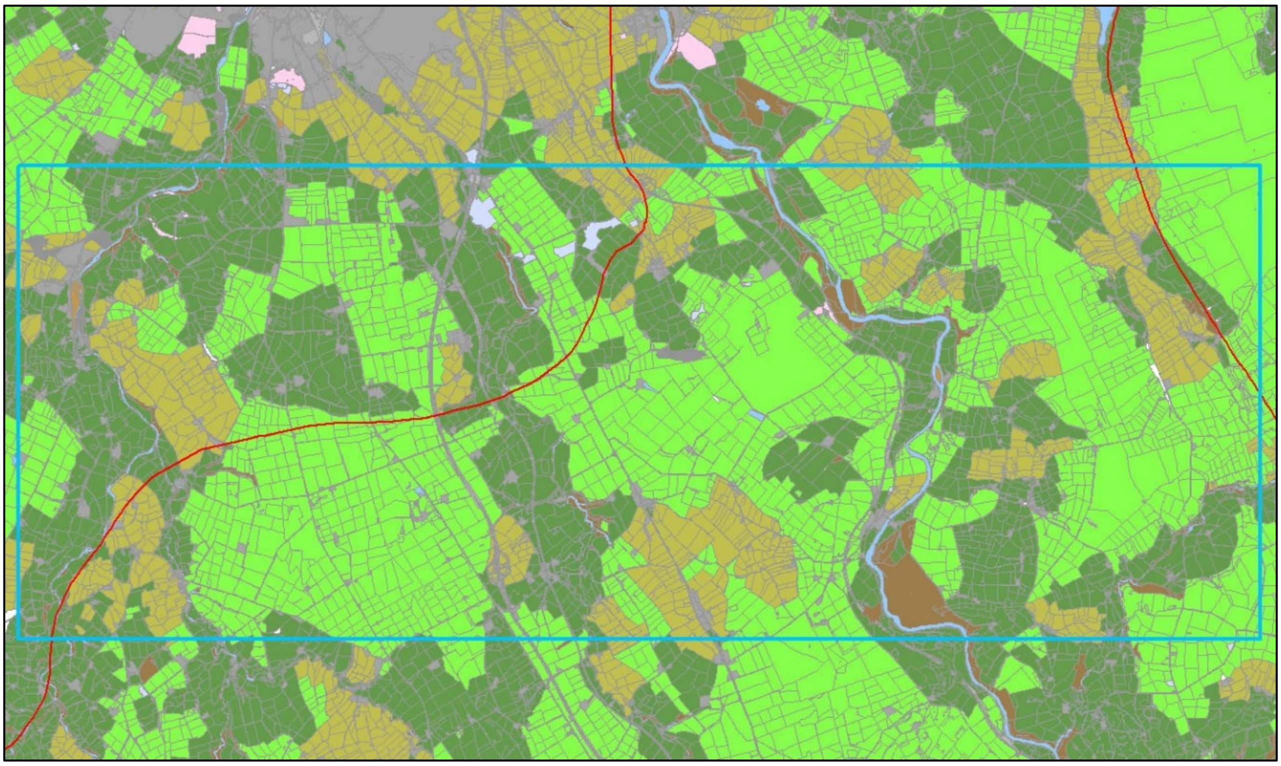


Figure 7.2: HLC types in the study area: light green = planned enclosure; dark green = ancient enclosure; olive = former common arable; brown = woodland

The study area also falls into a number of different character areas, as defined by the HLC exercise (Fig. 7.3). These are not available as GIS files but from west to east are as follows:

- 26 Inglewood
- 33 Lazonby Ridge
- 14 Cumwhitton and Kirkoswald.

There are also very small parts of character areas 9 (Caldbeck and Caldew Valleys), in the south-west corner of the study area, 10 (Carlisle), in the north, and 37 (Pennines), in the north-east corner.

The Inglewood character area, which straddles the Solway Basin and Eden Valley NCAs, has a gently rolling topography with a mixture of medieval and 19th century settlements, the latter relating to enclosure and improvement. Dalston also expanded during the 19th century for industrial reasons. The field pattern is mixed, though late 18th- and 19th-century planned enclosures are dominant, reflecting the formerly extensive areas of moorland common grazing. The road system has many straight routes, including some Roman roads and others that were straightened at the time of enclosure. There are a large number of former deer parks, particularly to the south of Carlisle, but despite the wooded nature of much of the character area in the early medieval period, woodland is no longer extensive, with small blocks of plantation and a few areas of ancient gill woodland. Although many of the individual character elements within Inglewood are of modern derivation, the overall character owes much to its former status as a medieval forest.

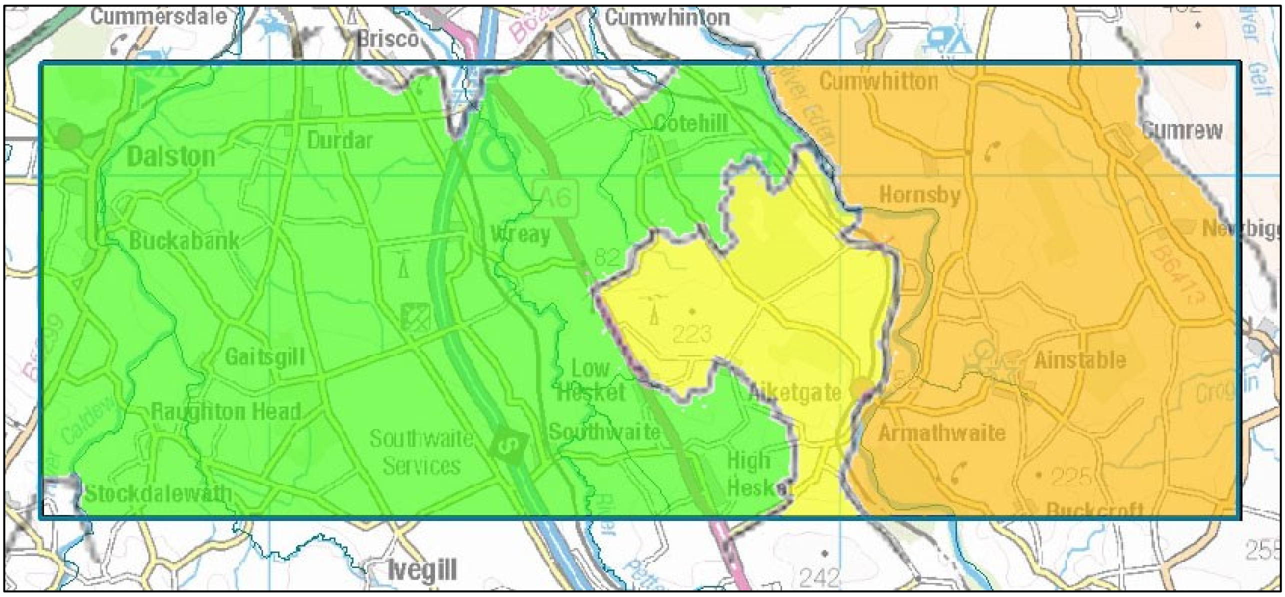


Figure 7.3: Major HLC character areas in the study area: green = Inglewood; yellow = Lazonby Ridge; orange = Cumwhitton and Kirkoswald. Base map © Crown Copyright [and database rights] 2023. OS 100024900

Lazonby Ridge is an area of low fell stretching southwards from Cumwhitton which remained unenclosed until the 19th century and still has sparse, largely dispersed settlement. The area is dominated by planned enclosures with very few areas of surviving ancient woodland, although there is some modern conifer plantation. Whilst settlement and field patterns are of relatively modern origin, their development – as well as the generally sparsely population – is a consequence of the area’s former use as medieval hunting forests or deer parks.

As indicated above, the whole of the study area west of the Eden was part of the former Inglewood Forest, which remained largely unenclosed until the late 18th or early 19th century (Hope 2011). Here ‘climate and geology combined to create a wooded area unattractive to settlement and agriculture. Its management as a royal "forest" preserved the wildness of this area well into the fourteenth century' (Hope 2011, 160). However, from the 16th century the common 'waste' was divided into two distinct areas by the encroachment of settlements and cultivated land along the Petteril valley, indicated by place-names such as Birkthwaite and Southwaite; while to the west there was further encroachment along the Caldew valley. On the other hand, this only amounted to 'a nibbling away of the edges of the manorial common or "waste", while large areas of open common or "waste" remained unenclosed, criss-crossed by unfenced drove roads' (Hope 2011, 160). In the end it was Parliamentary enclosure which 'replaced the woodland scrub and grassland with rectangular fields, long straight roads, hedgerows with trees, and farm steadings' and meant that 'an area which retained its natural character the longest, now exhibits a landscape which is the most modern' (Hope 2011, 161).

To the east, the Cumwhitton and Kirkoswald character area is sandwiched between the Pennine escarpment and the Eden valley. It is a generally hilly area whose geomorphology has influenced the settlement and field pattern. Many settlements are nucleated and medieval in origin, with ancient enclosures clustered around; some of these appear to have originated as assarts, such as Armathwaite, while along the Pennine edge former common arable fields surround small, planned settlements of medieval origin, such as Cumrew. There are also several former medieval deer parks and castles. In the 19th century new farms were established in previously unenclosed areas and planned enclosures now dominate in areas of former unenclosed fells; the field pattern therefore reflects this mixture of discrete farms and medieval settlements. The area is quite well-wooded, with around a third of woodland being ancient, clustered in the valleys of the Eden and Croglin Water.

Landscape character assessment for Cumbria[28] has also divided the study area into several character areas, though it is important to note that the study area only contains small portions of each character area, so not all the features described below may be present within the study area.

The LCA character areas are defined rather differently from the HLC areas, except for the Sandstone Ridge (10) which is equivalent to the Lazonby Ridge. The LCA adds that this area has significant areas of improved heathland and some important sandstone exposures. Roads run along and across the ridge between the summits, connecting isolated farmsteads and dwellings found in dips and hollows.

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[28] https://cumbria.gov.uk/planning-environment/countryside/countryside-landscape/land/LandCharacter.asp

The LCA divides the Inglewood HLC character area into Lowland (5) and Intermediate Farmland (6), following the division between the Solway Basin and Eden Valley NCAs. Most of the Lowland character area within the study area is part of the Low Farmland subdivision (5b) though there is a small strip of Ridge and Valley (5a) along the western edge. All of these are broadly characterised by regular pasture fields, with arable fields providing an occasional contrast. The differences lie in the settlement patterns. Area 5a has historically dispersed settlement, with scattered farms and linear villages found along the ridges, and considerable evidence of Roman occupation. In area 5b there is a varied pattern, with nucleated settlements of different size and dispersed farms, as well as cropmark sites of prehistoric and Roman settlements. In area 6 medieval planned villages with greens or rows are surrounded by former open common field areas; there are well-preserved earthworks of late prehistoric and medieval settlements and a variety of Roman remains, while the M6 motorway provides a more recent landscape feature.

The Cumwhitton and Kirkoswald HLC character area is subdivided in the LCA into Rolling Lowland (5c) in the north, Gorges (8a) along the Eden, and Foothills (11a) in the east. Area 8a is a short section of the Eden forming a deep linear sandstone gorge with waterfalls, rocky cliffs and hanging woodlands. Pasture fields lie above the gorge sides and there are settlements around bridging points. The Settle to Carlisle railway, with its striking viaducts, runs through the area, and there are elements of ornamental designed landscapes on the river banks. Area 11a, along the North Pennines scarps, includes moorland with occasional rocky outcrops, areas of improved grassland, unimproved heathland and extensive conifer plantations. Settlements are generally dispersed and the field systems mainly a product of late enclosure. There are widespread upstanding archaeological remains including prehistoric stone circles and cairns, medieval shielings and droveways, remnants of late medieval deer parks and remains of past industries.

There are also small areas of Scarps (13a) and Moorland High Plateau (13b) in the Pennines area of the HLC. The former is characterised by unimproved grassland and heath, sharply incised by streams and gullies. Rocky features such as limestone pavements and scars are common and while there is virtually no modern settlement there are some abandoned post-medieval farmsteads, evidence of coal and lead mining, and relict prehistoric field systems and settlements. The majority of Area 13b is covered in blanket bog, interspersed with a mosaic of other vegetation. This remains an unenclosed area, with no settlements or field systems, used mainly for extensive sheep grazing.

7.1.4 Archaeological background

A recent overview of the archaeology of the study area is contained in the aerial investigation and mapping report for the Eden Petteril Caldew Transect (Deegan 2019), which covered an area of 317 km^2, extending a little further north and considerably further south than the present study. Relevant studies of the wider region include Barrowclough's (2010) synthesis of prehistoric Cumbria and the resource assessments produced for the North West Regional Research Framework in 2007 and 2020[29].

Barrowclough (2010, 13) states that the natural vegetation of the Carlisle and Solway Plains was 'mixed oak forest with dense wet undergrowth, which discouraged settlement', except where the Eden valley crosses the plain. In the Eden valley there is evidence from palaeoenvironmental sites to the south of the study area for small-scale Late Mesolithic and more substantial Early Neolithic clearance, though intensive occupation did not occur before the Late Neolithic or Early Bronze Age. North of the study area, pollen profiles at Knockupworth, on the line of the Carlisle Northern Development Road (CNDR), suggest an increase in agricultural activity and associated woodland/scrub clearance by the end of the 1st millennium cal BC.

Potentially Upper Palaeolithic barbed bone points have been found at Crosby-on-Eden (Barrowclough 2010, 60), to the north of the study area but showing the potential for early post-glacial hunting activity in the wider landscape. The Early Mesolithic landscape was largely open but boggy, before hazel, elm, oak and alder expanded successively until, by around 6000 cal BC, there was considerable forest cover, though with fewer species than would have been found further south or east (Barrowclough 2010, 61–2). In recent years significant Mesolithic finds have been made around Carlisle, notably at Stainton West where the route of the CNDR crosses the terraces of the River Eden (Brown *et al* forthcoming).

For later periods Deegan (2019, 5) reports that cropmarks are more frequent east of the Petteril while earthwork survival is sporadic across the area, and mainly restricted to post-medieval and later extraction sites on the Eden-Petteril interfluve and east of the Eden around Cumwhitton. However, not all of the study area has been subject to lidar survey (Deegan 2019, fig. 4).

For the Neolithic and Early Bronze Age Deegan (2019, 13) reports that while there are several finds (mostly axe or arrowheads) and monuments (burials, cairns and megalithic structures) recorded west of the Petteril and east of the Eden they are rather sparse on the Petteril-Eden interfluve. The most striking group of monuments is the line of standing stones, small stone circles and other stone settings that runs between Carlatton and Broomrigg on the east side of the Eden. The limited number of new cairn/barrow finds during the aerial mapping project may tally with a levelling off in the number of discoveries

[29] https://researchframeworks.org/nwrf/

of Bronze Age pottery in Cumbria generally, which might fit a model whereby the number of known sites is approaching the number of potentially recognisable barrows (Barrowclough 2010, 28), i.e. very good visibility, as defined above (3.2).

Later prehistoric and Romano-British remains are far more widespread, most visible as cropmarks or soilmarks but some surviving as very shallow earthworks in pasture. The highest density of finds is on the east side of the Petteril. Deegan concludes that small-scale unenclosed settlement is not represented on the air photos or lidar imagery and excavated evidence of later Iron Age settlement is sparse. However, there is a distinctive type of Roman defended farmstead, with good access to the river and the Wragmire Roman road, and farms in this area may well have supplied the military and urban population at Carlisle and the frontier. Aerial mapping has increased the evidence for field systems, but dating evidence would be required to connect them definitively with the enclosures.

The Eden basin (incorporating the study area) formed a case study for the EngLaId project (Gosden *et al.* 2021, 142–8). This notes that the Eden (and Cumbria in general) has far fewer HER entries than other parts of the country. These show sparse prehistoric activity, with more Bronze Age than Iron Age records, 'an active Roman period' and sparse early medieval remains. The preference for dry soils in the Bronze Age drops over time, with later periods showing more activity on seasonally wet soils. Early activity on the more erosion-prone higher ground gave way to lower impacts in later periods when occupation stayed on the valley floor. The river itself was not large enough to be a focal point for settlement, or to be commonly used for power (water mills). However, we are hampered in our understanding of trajectories over time by a relative lack of knowledge of certain periods and of hydrological/soil changes.

The Roman Rural Settlement Project records a particular concentration of excavated field systems in the Eden Valley and Solway Plain, perhaps suggesting these were a focus for arable farming, supported by various finds of agricultural tools (Smith *et al.* 2016, 327). The area was also largely aceramic, as it had been in the Iron Age, with the few production sites linked to the military, though imports are found on some rural settlements (Allen *et al*. 2017, 200).

The study area lies within the North Cumbrian Vales 'pays' of the Northern Uplands region, as defined for the *Fields of Britannia* project, which looked at continuity between Roman and later landscapes. According to Rippon *et al.* (2015, 290) this area has greater evidence for such continuity than the uplands, 'with mixed arable and pastoral farming during both periods and any woodland regeneration seemingly restricted to the areas most peripheral to settlements'.

The landscape zones defined for *Fields of Britannia* were influenced by the work of Roberts and Wrathmell (2002) on medieval settlement, in which the study area falls within the Cumbria and Solway Lowlands sub-province of their Northern and Western Province, though the Eden Valley is seen as 'an area of nucleations and townfields which effectively forms a north-western outlier of the Central Province' (Roberts and Wrathmell 2002, 121), with 'versions of the mixed farming types characteristic of' that area (Roberts and Wrathmell 2002, 62). In their terms the study area is a zone of hamlets and small villages in the main, split between three local settlement regions: the Northern Lake District Fringe in the west and Eden Valley in the east (actually to the east of the river), both with medium dispersion densities (as defined by Roberts and Wrathmell), lying either side of Inglewood, between the Petteril and the Eden, which has very low densities. The interfluve between the Petteril and the Eden also formed the core monastic estate of Wetheral Priory (Newman 2014, fig. 5.5).

Roberts and Wrathmell (2002, 128–9) note that townfield systems based upon very long strips appeared after the Norman conquest, replacing 'an earlier pattern of more scattered hamlets, each surrounded by small enclosed fields', though there were variations, for example at Cumwhitton where 'a wedge-shaped pattern of … consolidated farms [was] arranged radially around a small strip-field core'. They also note 'hints of the temporary cultivation of some areas of common waste as "outfields", though primarily these areas 'allowed the keeping of substantial numbers of animals'. Population levels were generally low, while the persistence of border conflict necessitated substantial fences and banks as field boundaries. Gradually this arrangement was transformed into something more akin to the 'Midland system' of open fields by the 17th century.

In and around the study area, aerial mapping has recorded archaeological remains around several significant medieval and/or post-medieval sites, including Rose Castle and Dunwalloght Castle. Former medieval or post-medieval farmsteads may also be recognised, such as an example near Ellerton Grange (Deegan 2019, 37–9). The majority of the mapped ridge and furrow appears to be post-medieval in morphology (Deegan 2019, 33–4). It is widespread along the valley floors but sparser on the interfluves, particularly west of the Eden which corresponds with the historical evidence for wide expanses of common and uncultivated lands across Inglewood until the 18th or 19th centuries. There is also diverse evidence for extraction of gravel in small or medium-sized pits across the whole study area, except the edge of the fells, where there are extensive limestone quarries and numerous lime kilns (Deegan 2019, 33–4).

Adding detail to these broader landscape studies is more difficult because archaeological fieldwork in the study area has been relatively limited, particularly excavation, which reduces the level of certainty with which judgements of sensitivity can be made. For this study, the Cumbria HER provided GIS Event datasets in a combination of point, line and polygon format. Generally, more recent and larger investigations are mapped as polygons whilst older and smaller events are recorded as points. This dataset does not include the mid-20th century investigations of prehistoric and Roman sites that are discussed below.

The event data was manipulated to remove desk-based research and to classify fieldwork using the simplified investigation types defined by the EngLaId project (Table 7.3; Gosden *et al.* 2021, table 2.3). To estimate the total area investigated, the area of event polygons was calculated and duplicates (where different types had occurred at the same place) removed. This gives an estimated total of around 113 ha that have been investigated in some form within the study area, or 0.7% of the total area (Fig. 7.4). Around two thirds of this area comprises just two geophysical surveys, for the CSLR (57.5 ha within the study area) and Wreay Solar Farm (15.2 ha). A summary of results for the first of these, included in the planning application, refers to 140 features 'of low value', including banks, ditches, ridge and furrow, former buildings, former tracks and roads, the sites of a deer park, rifle range and mill race, and a probable settlement (not all within the study area). It appears that significantly less archaeology has been identified on the route of the CSLR than on the CNDR, and known cropmark sites have been avoided (Mark Brennand, pers. comm.). Other geophysical surveys have been conducted at Low Hesket and near Ainstable.

Table 7.3: Categorisation and quantification of investigations recorded on the HER

Code	***Simplified EngLaId investigation type***	***Number***	***Area (ha)***
1	Intrusive: open area excavation	6	6.6
2	Intrusive: keyhole (evaluation, watching brief)	23	26.6
3	Non-intrusive survey (geophysics)	6	89.0
4	Fieldwalking	-	-
5	Other (historic building recording)	23	0.7
Total	Land in the study area subject to any form of investigation	58	113.2

Excavations recorded as events are mainly focussed in the west of the study area, an exception being work at Castle Hewen in 1978–81 (Clare 2019). Excavations also took place in the late 1970s at Dobcross Hall Farm near Stockdalewath (Higham 1981) and more recently at Rose Castle (1994), Cocklakes (2001) and Townhead Road, Dalston (2014). A large (>10 ha) evaluation took place at Thackwood landfill site in 2006.

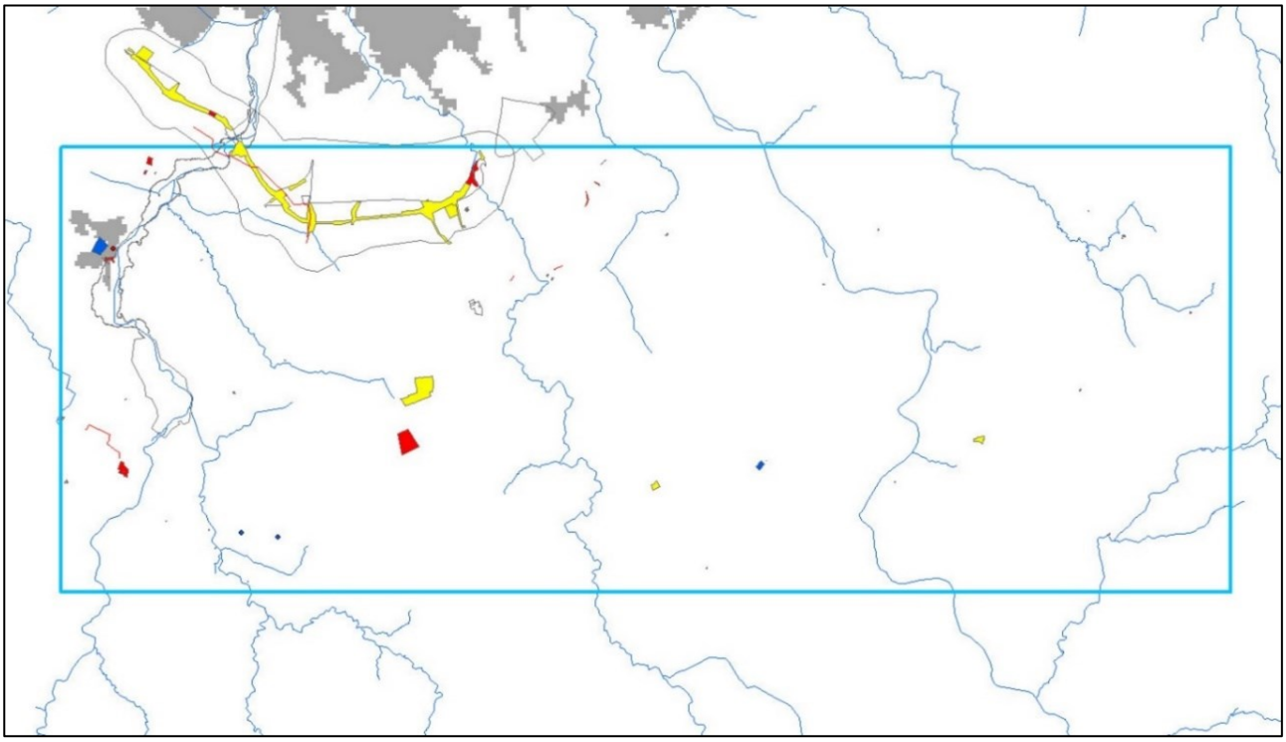

Figure 7.4: HER events in the study area (yellow = geophysical surveys; red = evaluations/ watching briefs; blue = excavations) in relation to built-up areas (dark grey) and rivers

7.2 Character of the archaeological resource

7.2.1 Overview

The intention of this section is not to reiterate the published syntheses referred to in the introduction, albeit these provide an initial interpretative framework. Rather it is an attempt to quantify what we know about that subset of the archaeological resource which has (or potentially has) some strategic significance. It considers what we might infer from this data about as yet undiscovered assets, a process that relies on the assumption that the known dataset is a useful, albeit imperfect, indicator of the undocumented dataset.

Assets were allocated to broad periods and types (Table 7.4). The study area includes 379 HER monuments and findspot records, of which about 40% are undated; these undated records are fairly evenly divided between quarries/pits, enclosures, trackways/ditches/ dykes and other sites. The remainder show a fairly even distribution across the post-medieval, medieval, Roman and later prehistoric periods, although early prehistory and the early medieval period are under-represented. Post-medieval records are predominantly industrial (quarries etc) while Iron Age and Roman records are mainly settlement and agricultural features. Neolithic and Early Bronze Age records are predominantly ‘religious’ (i.e. ritual and burial monuments).

Table 7.4: Categorisation and quantification of HER monuments and findspots

	Settlement	Agriculture	Industry	Transport	Religious & Funerary	Defence	Recreation	Unclassified	**TOTAL**	**%**
Modern	-	-	1	1	-	2	-	-	4	1.1
Post-Med	4	3	28	6	2	1	-	8	52	13.7
Med-PM	-	1	-	1	2	-	5	-	9	2.4
Medieval	5	3	-	-	3	9	-	4	24	6.3
Early Med	-	-	-	-	1	1	-	-	2	0.5
Roman	3	-	1	3	1	7	-	8	23	6.1
IA-Roman	24	11	-	5	-	2	-	2	44	11.6
MBA-IA	9	3	-	1	-	-	-	4	17	4.5
Neo-EBA	1	-	-	-	32	-	-	15	48	12.7
Meso	-	-	-	-	-	-	-	1	1	0.3
Undated	28	13	34	9	-	4	-	67	155	40.9
TOTAL	74	34	64	26	41	26	5	109	**379**	

There are no registered parks and gardens but 16 SMs are found within the study area and fall into three clear groups, geographically and chronologically (Fig. 7.5). In the north-west by the river Caldew are various sections of the medieval Bishop's Dyke; in the centre by the Petteril is a group of Roman and later prehistoric sites; and in the uplands to the east are a number of primarily Neolithic and Early Bronze Age monuments, with a notable cluster at Broomrigg (also including a pair of Bronze Age hut circles and a medieval shieling).When considering strategic issues it is helpful to identify key monument types which are particularly relevant because of their frequency within the study area, good condition or high significance. This scoping exercise is broken down by broad periods.

7.2.2 Palaeolithic and Mesolithic

The study area contains no known Palaeolithic or Mesolithic sites, with the only findspot on the HER being a single Mesolithic or Early Neolithic chert core recovered during trial trenching in Dalston. At present these periods remain unknown and therefore make no contribution to sensitivity in relation to strategic planning decisions, though there is potential for finding Upper Palaeolithic and/or Mesolithic remains in the future, as outlined above (7.1.4), with terrace deposits and areas of peat the most likely location of significant evidence (Fig. 7.5).

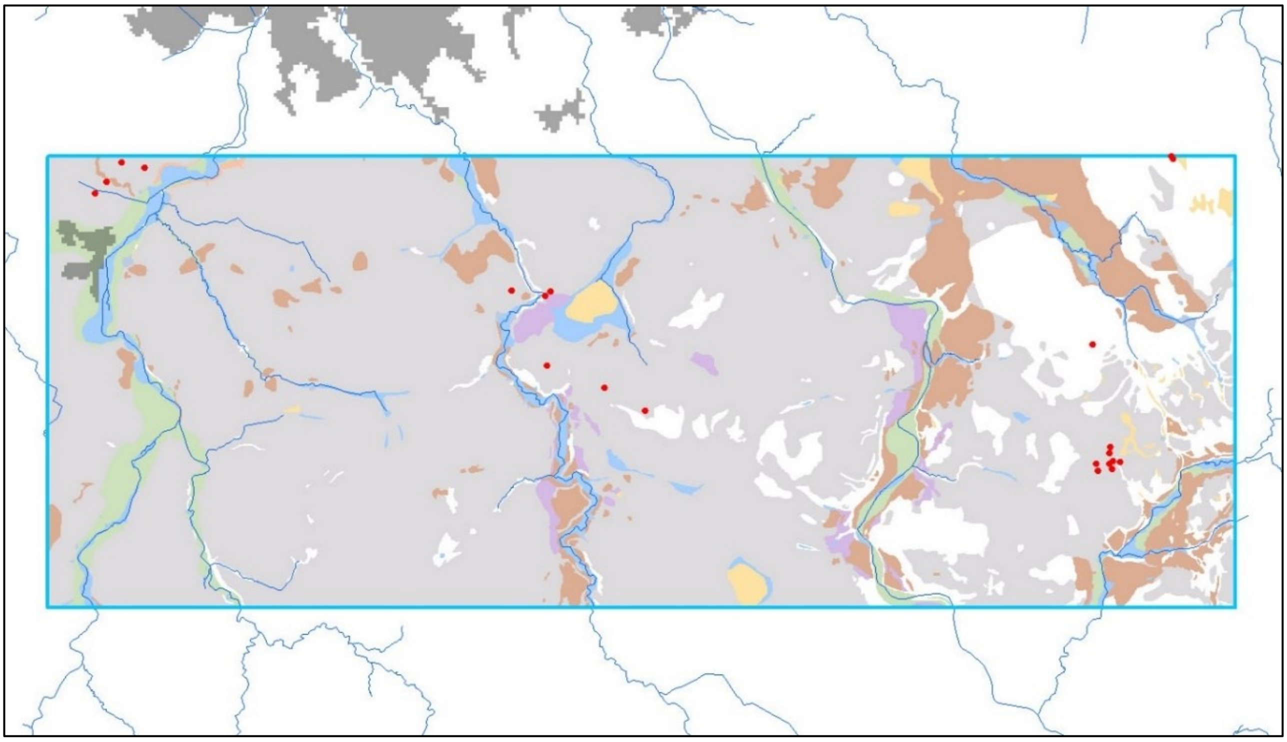

Figure 7.5: SMs (red) in relation to the superficial geology of the study area: white = bedrock; grey = till; brown = glacio-fluvial; mauve = glacio-lacustrine; green = terrace deposits; blue = alluvium; yellow = peat (derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

7.2.3 Neolithic and Early Bronze Age

The key Neolithic and Early Bronze Age sites identified in the study area are principally stone monuments and barrows or cairns, supplemented by stray finds (Fig. 7.6). Most notable are the various stone circles and cairns at **Broomrigg**, some of which were excavated in the post-War period (Hodgson and Harper 1950; Hodgson 1952; Richardson and Fell 1975; see also Evans 2005, ch 5 on the distinction between stone circles and funerary monuments). These are part of a chain of monuments lying parallel to the edge of the fells, with the Broomrigg group clustered around the head of a beck (Deegan 2019, 16). **Cardunneth Pike** on Cumrew Fell is the location of one large cairn and several small stone mounds, with a commanding view westward toward the River Eden. A further possible cairn was identified on aerial photographs 1.7 km to the south-east (Deegan 2019, 19). **Grey Yauds** stone circle, which sits below the summit of Lawson Hill, with a view towards Newbiggin and its eponymous beck, comprised 88 stones in the late 18th century but was much broken up in the next 100 years and now just a single monolith remains standing. Evans (2005, 170) argues that the location of this and similar monuments elsewhere in Cumbria suggests strong connections between prehistoric communities and visible landmarks. In the west of the study area, between the Caldew and Petteril, were two monuments described by Rooke in 1789, the **Stone Raise** cremation cemetery and stone settings, and the **Druidical Temple**, perhaps a large barrow with cist graves, though there are doubts about the precise locations of both (Deegan 2019, 13–16). Despite the uncertainty they do indicate that stone settings are (or were) not entirely restricted to the Pennine fringe. Another antiquarian find in the vicinity was a group of some 15 Early Bronze Age Collared Urns from a site c 1.5 km north of the study area (Jackson 2016).

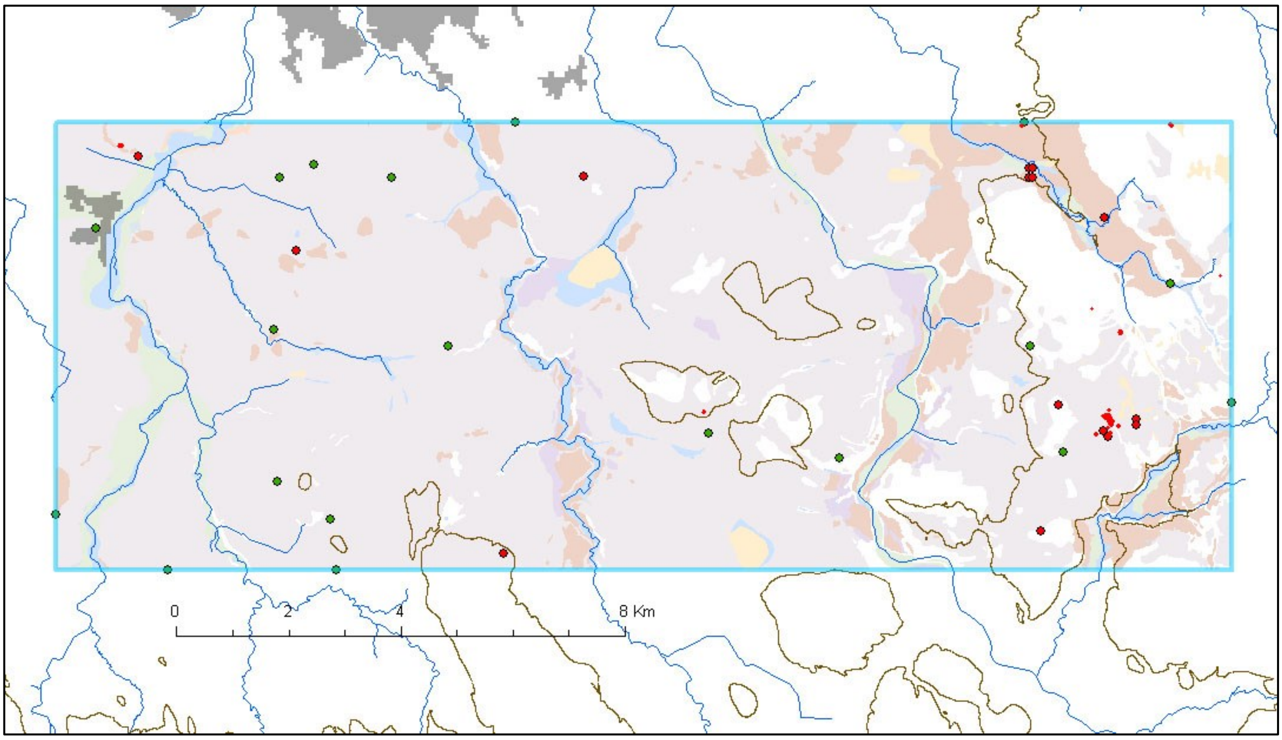

Figure 7.6: Neolithic and Early Bronze Age sites (red) and findspots (green) in relation to the geology of the study area (see Fig. 7.5 for key; (derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved) and the 150 m contour (© Crown Copyright [and database rights] 2023. OS 100024900)

In terms of earthworks Barrowclough (2010, 14) warns that natural eskers are liable to be confused with barrow mounds, including two 'tumuli' near Dalston Hall. The only other references to Neolithic or Bronze Age barrows (as opposed to cairns) in the study area are antiquarian records of sites that are now destroyed or lost. Of the cairns or barrows previously recorded west of the Petteril, none were identified on air photos by Deegan (2019, 13), while east of the Eden there are a small number, including a Bronze Age round cairn at Carlatton and an undated mound at Cumrew, both close to the Cairn Beck in the north-east of the study area. Towards the centre of the study area on Barrock Fell is an undated ring-ditch with a diameter of c 16 m.

Neolithic settlement is also represented in and around the northern part of the study area, with Early Neolithic features excavated at **Cocklakes**, including a hearth radiocarbon-dated to 3650–3510 cal BC, and an extensive scatter of Middle to Late Neolithic pits at Durranhill, about 3 km to the north of the study area (Jackson 2016). Burnt mounds are a site type so far absent from the study area, though there is a possible example near Durranhill.

Conclusion: These periods make a moderate contribution to archaeological sensitivity, especially in the upland zone to the east, where we can assume most upstanding monuments are already known. There is no particular association with the major rivers, apart perhaps from the group of sites associated with the Cairn Beck (Fig. 7.6). Meanwhile the western side of the study area has a number of findspots but fewer monuments. In this area there is potential for buried occupation features (and quite possibly monuments) but that is hard to quantify at present.

7.2.4 Late prehistoric and Roman

Later Bronze Age, Iron Age and Romano-British activity has a rather different pattern, with a more riverine distribution in general as well as a concentration on the Petteril-Eden interfluve (Fig. 7.7), where earlier features are conversely scarce. The univallate hillfort on **Barrock Fell**, with an area of c. 1 ha, is Iron Age by implication though associated with surface finds of Roman pottery. Key Roman military sites that were investigated during the 20th century include a fortlet, also on Barrock Fell (Collingwood 1931), signal station at **Wreay Hall** (Bellhouse 1953), fort at **Park House** (Bellhouse 1954) and legionary tilery at **Scalesceugh** (Bellhouse 1971). Many of these lie close to the Roman road (Margary 7e) following the Petteril valley (and followed in turn by the modern A6), which may explain the higher density of sites in this area. There have been more recent excavations in the north-west around Dalston, at **Dobcross Hall Farm** near Stockdalewath, where two probably Iron Age/Roman enclosures were investigated (Higham 1981) and **Townhead Road**, where a Late Bronze Age or Early Iron Age structure was revealed (Robinson and Town 2015). The enclosed hilltop settlement at **Castle Hewen** was primarily of early Roman date, with limited occupation in the late Roman period or early 6th century AD (Clare 2019).

Deegan (2019, 21–32) provides detailed studies of two areas with extensive groups of field systems and enclosures mapped from the air: around **Castlesteads**, between the Caldew and Petteril, east of Stockdalewath; and around Barrock Fell, between the Petteril and Eden. The former includes remains of a possible field system as well as evidence of continuity between Iron Age and Romano-British settlement, while the latter has three enclosures and associated fields in **High Stand Plantation**, with other enclosures and evidence of land division to the west. Similar enclosures of likely Iron Age and Roman date were excavated to the north of the study area at Durranhill (Jackson 2016).

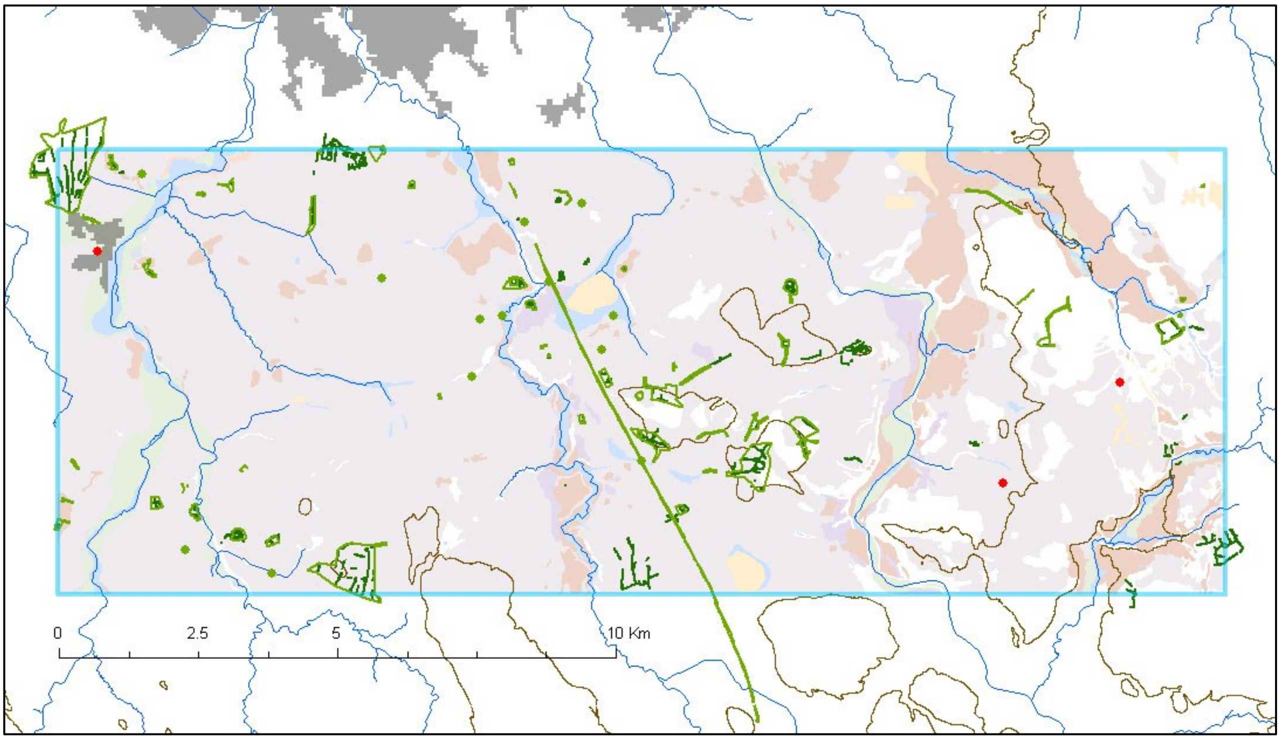

Figure 7.7: Late Bronze Age (red), Iron Age and Roman (green) sites and finds in relation to the geology of the study area (see Fig. 7.5 for key; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved) and the 150 m contour (© Crown Copyright [and database rights] 2023. OS 100024900)

Conclusion: The more extensive nature of the later prehistoric and Roman archaeological landscape with field systems and trackways makes the likelihood of encountering features of this period, and therefore their contribution to archaeological sensitivity, relatively high, although the distribution of significant assets (settlements) is less well understood (see 7.5). The HER includes some large monument polygons, such as the field systems mentioned above and others at Sowerby Wood, north-west of Dalston, and Ainstable. Recent aerial mapping has filled in some of the details and added further areas of field boundaries and enclosures (Fig. 7.7).

7.2.5 Medieval

With the exceptions of the possible post-Roman activity at Castle Hewen, a Viking-age hoard from the site of a barrow south of **Low Hesket**, next to the Roman road, and – more doubtfully – the alleged site of the battle of Degsastan (AD 603) near Dalston, there is no early medieval archaeological evidence in the study area. Just to the north, however, at Farbrow Road on the south-eastern outskirts of Carlisle, two possible kilns (of uncertain function) were dated to the 6th or 7th century AD[30], while at Cumwhitton six Viking-age burials of the early 10th century have been excavated (Paterson *et al*. 2014).

The later medieval landscape (Fig. 7.8) is dominated by a number of deer parks adjacent to the Caldew, Eden and Cairn Beck, and the Bishops Dyke boundary ditch in the north-west, which demarcated land belonging to Dalston Hall and may also have been used as a defence against Scottish raids. The sparse distribution of listed church buildings, which correlates with HLC areas of former common arable (Fig. 7.9), provides an indication of the dispersed nature of medieval settlement. From the HER, deserted villages are known or suspected on the Petteril (north of **Raughton Gill**), the Eden (**Northgill Bank**) and the Cairn Beck (**Carlatton**). Excavations at Cumwhinton, less than 1 km to the north of the study area, showed the potential for surfaces and structures of late medieval/early post-medieval date to be preserved under pasture (Railton *et al*. 2014).

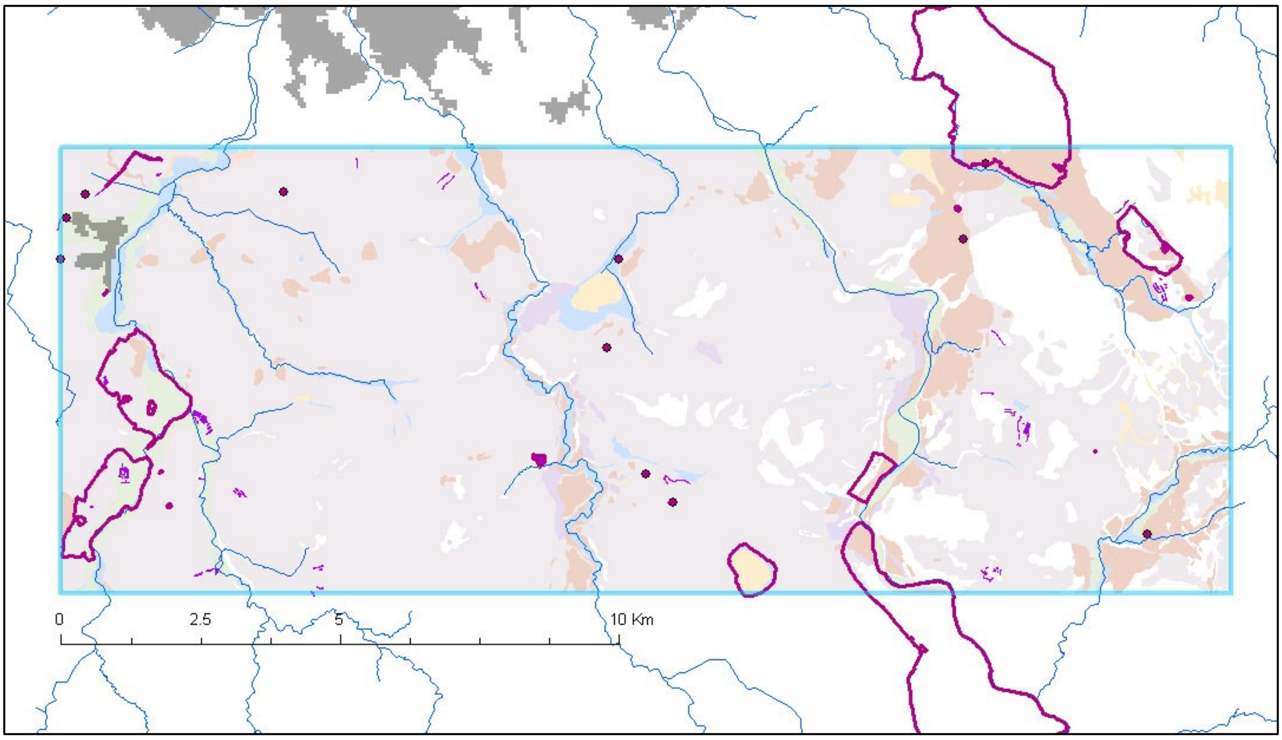

Figure 7.8: Medieval sites and finds (purple) in relation to the geology of the study area (see Fig. 7.5 for key; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

A few field boundaries and lynchets testify to the use of higher ground but little ridge and furrow is identified as definitely medieval (presumably because this was ‘forest’ land, as

[30] https://researchframeworks.org/nwrf/early-medieval-agenda/early-medieval-period/

discussed above), though that interpreted as ‘medieval/post-medieval’ shows a largely riverine distribution, at an altitude below 100 m OD (Fig. 7.10).

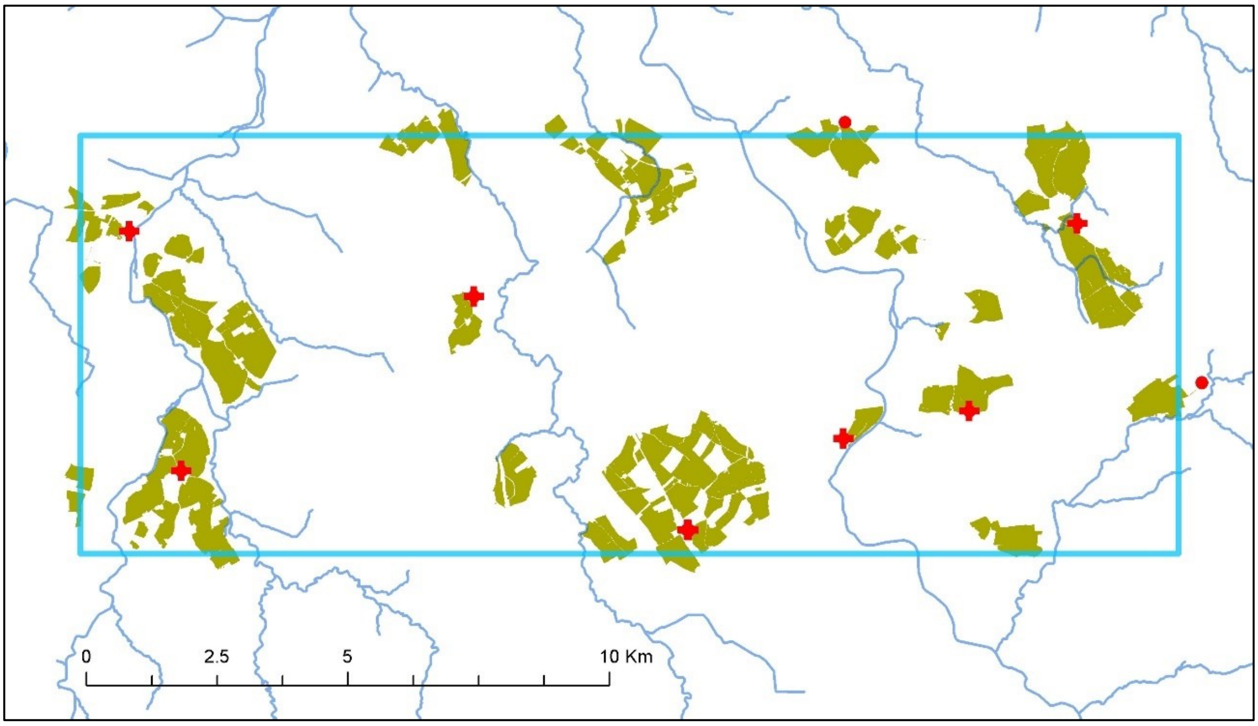

Figure 7.9: Listed church buildings (red crosses) in and around the study area with areas of former common arable (olive green)

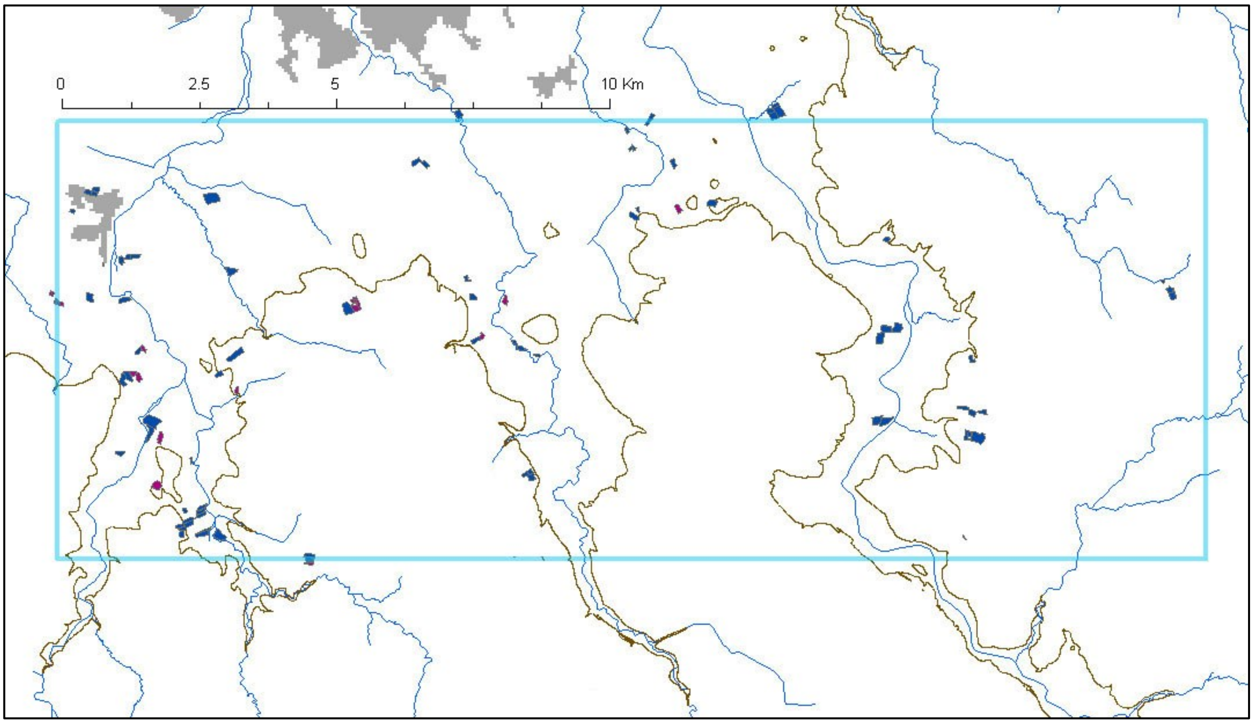

Figure 7.10: Medieval (purple) and medieval/post-medieval ridge and furrow (blue) in relation to the 100 m contour (© Crown Copyright [and database rights] 2023. OS 100024900)

Conclusion: compared to the other pilot study areas medieval assets are more sparsely represented in the Eden Valley so their contribution to sensitivity remains moderate. Listed buildings and HLC probably give a better sense of areas of medieval potential than the HER at present, with a punctuated distribution along river valleys and occasional incursions onto higher ground.

7.2.6 Post-medieval

Post-medieval records on the HER are a disparate group of industrial features (quarries, lime kilns, mills, etc), farmsteads, fields and parks (continuing from the late medieval landscape), so best discussed thematically.

Quarries and mines generally (regardless of assigned period) show a dispersed distribution but with a focus on the area between the Petteril and Eden, especially in the lower-lying northern part of the study area (Fig. 7.11). Mills and associated works are found on specific stretches of each of the main rivers, notably on the Caldew around Dalston.

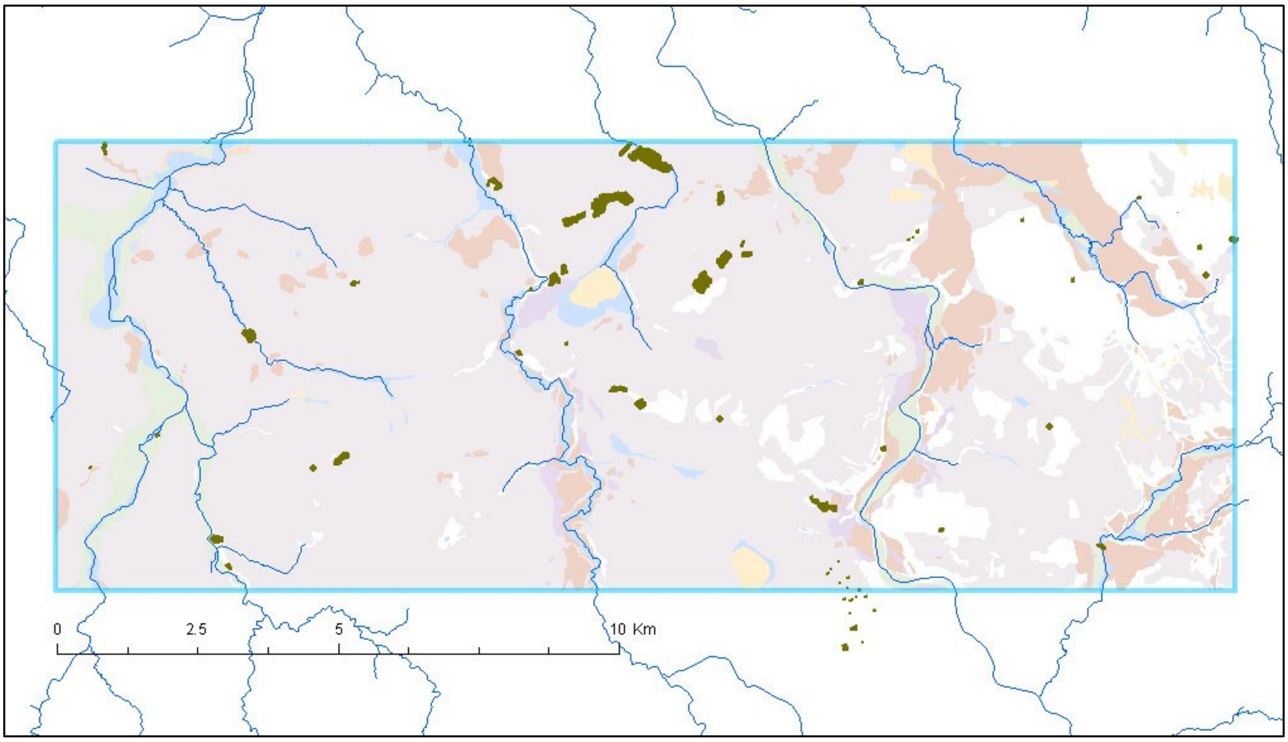

Figure 7.11: Quarries, mines and lime kilns in relation to geology (see Fig. 7.5 for key; derived from 1:50,000 scale BGS Digital Data under Licence No. 2021/083 British Geological Survey © and Database Right UKRI. All rights reserved.)

Ridge and furrow recorded by aerial investigation gives a better idea of the extent of post-medieval agriculture (Fig. 7.12). In the majority of the area, as for the medieval period (Fig. 7.10) but in greater quantity, post-medieval ridge and furrow is distributed across lower-lying riverine parts of the landscape, especially around the Caldew and Petteril. In the east, however, the Eden valley has much less evidence while the uplands have more, particularly around the 150 m contour. This suggests different farming regimes in the two local settlement regions defined by Roberts and Wrathmell, the Northern Lake District Fringe and Eden Valley (7.1.4).

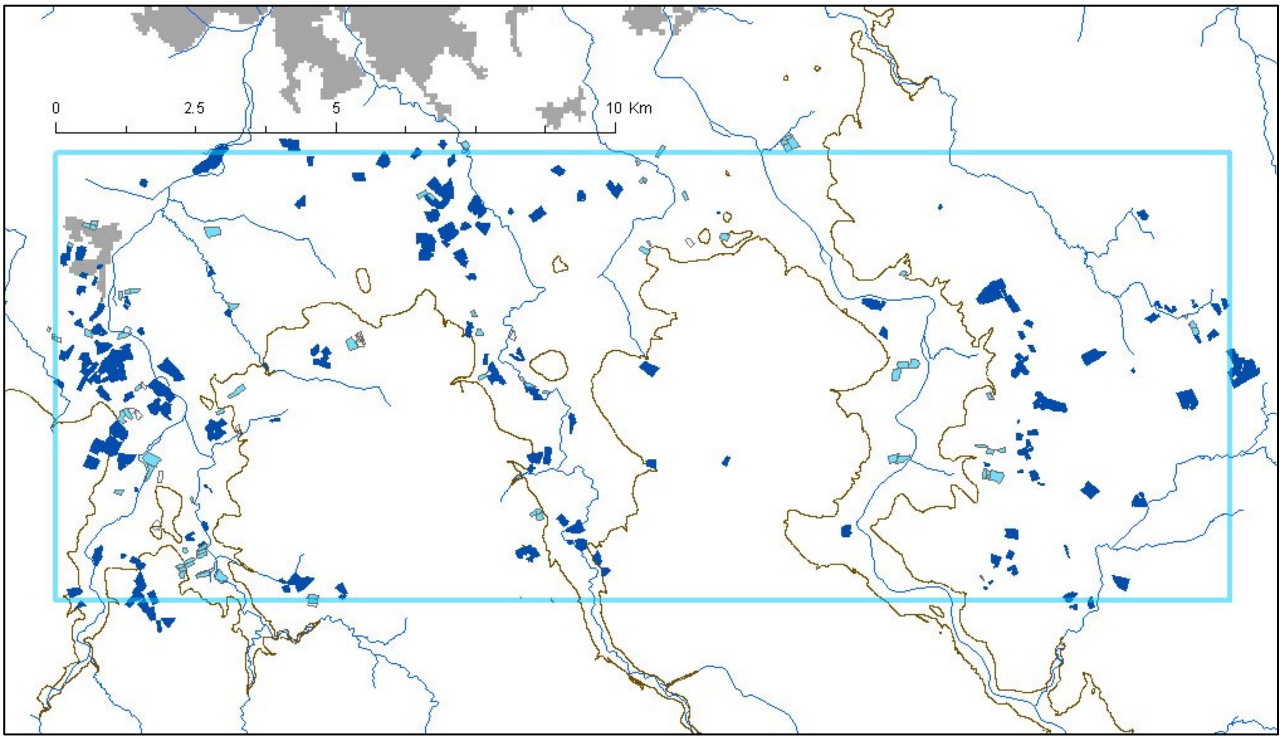

Figure 7.12: Medieval/post-medieval (light blue) and post-medieval ridge and furrow (dark blue) in relation to the 100 m contour (© Crown Copyright [and database rights] 2023. OS 100024900)

HLC data can be used to some extent to reconstruct past landscape, especially the information on 'Previous Types' (cf for Aylesbury: Fig. 4.21) or, in the case of Cumbria, 'Relict Use' (Fig. 7.13a). This shows that unenclosed land used to dominate the interfluves, with ancient enclosures, former common arable and deer parks mostly within 500 m of a watercourse, the main exceptions being on the east side of the Eden, but generally not above 150 m in altitude. The proportion of unenclosed land is significantly greater in the Eden Valley NCA than in the Solway Basin. This resembles Newman's (2014, figs. 6.34, 6.38) reconstruction of the late medieval landscape based on 18th-century maps, which also shows linear arrangements of organised land and settlement along the rivers separated by unenclosed land on the interfluves.

Conclusion: as in the other pilot areas archaeological interest in the post-medieval period is frequently associated with other heritage interests and the key to managing it is to ensure archaeological engagement in decision-making affecting

buildings and landscape character. Higher archaeological potential can be principally associated with selected HLC categories, based on a basic division of the landscape into areas of common arable, enclosures and unenclosed land.

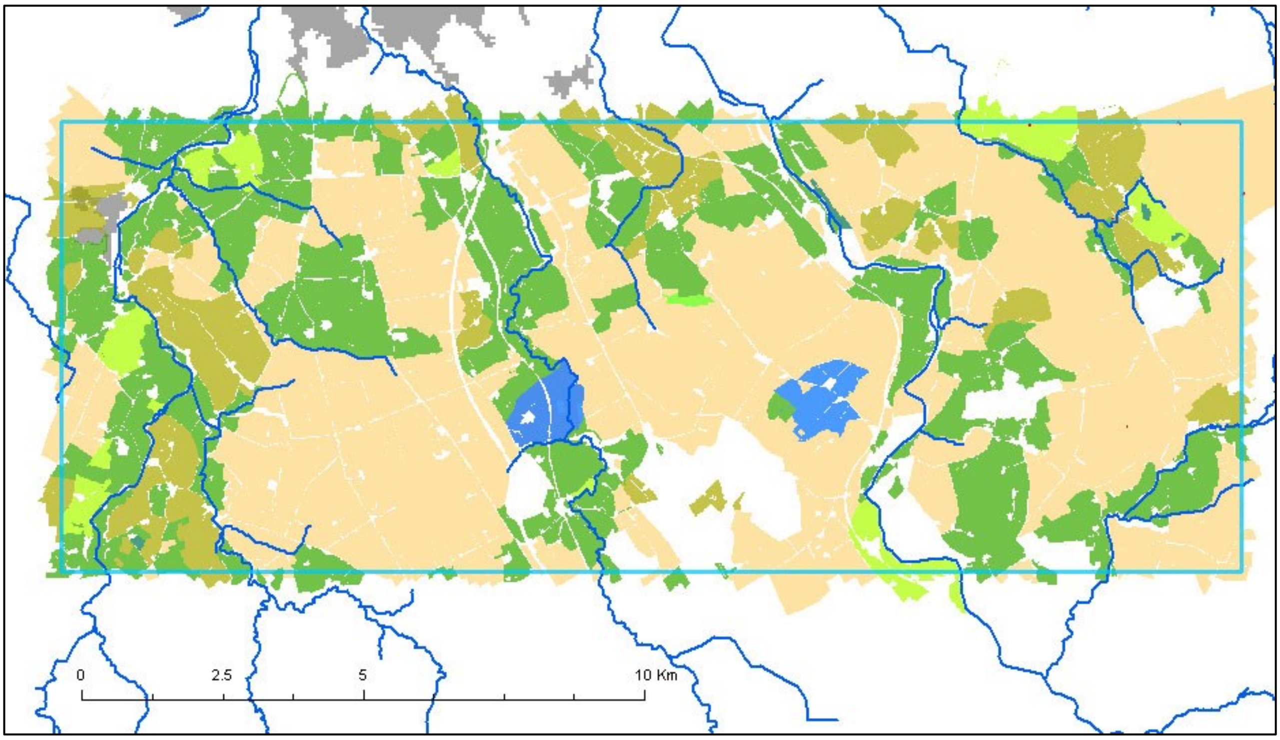

Figure 7.13: Relict land use on the Cumbria HLC showing unenclosed land (buff), ancient enclosure (green), former common arable (olive), deer parks (light green) and monastic land (blue) in relation to watercourses

7.3 Overview of presence

It is clear that in all periods altitude plays a key role in determining the likelihood of encountering features. Neolithic and Bronze Age monuments primarily survive in the uplands to the east because of their megalithic construction. While antiquarian records show that we should not completely rule out the discovery of more stone or earthwork monuments it is likely that we know about the majority of these, though the dubious ‘long barrow’ at Dalston Hall shows the difficulty of distinguishing natural and artificial earthwork mounds in this landscape. In the majority of the study area, however, the number of findspots suggest further, presumably buried, sites are likely to be present.

For the later prehistoric and Roman periods, especially in the eastern half of the study area, it is striking how much of the known archaeology falls beyond or on the edge of the enclosed, emparked and arable zone depicted in the HLC Relict Use, as shown on Fig. 7.14. This suggests there may well be more to be discovered, masked by later land-use, in the lower-lying riverine areas.

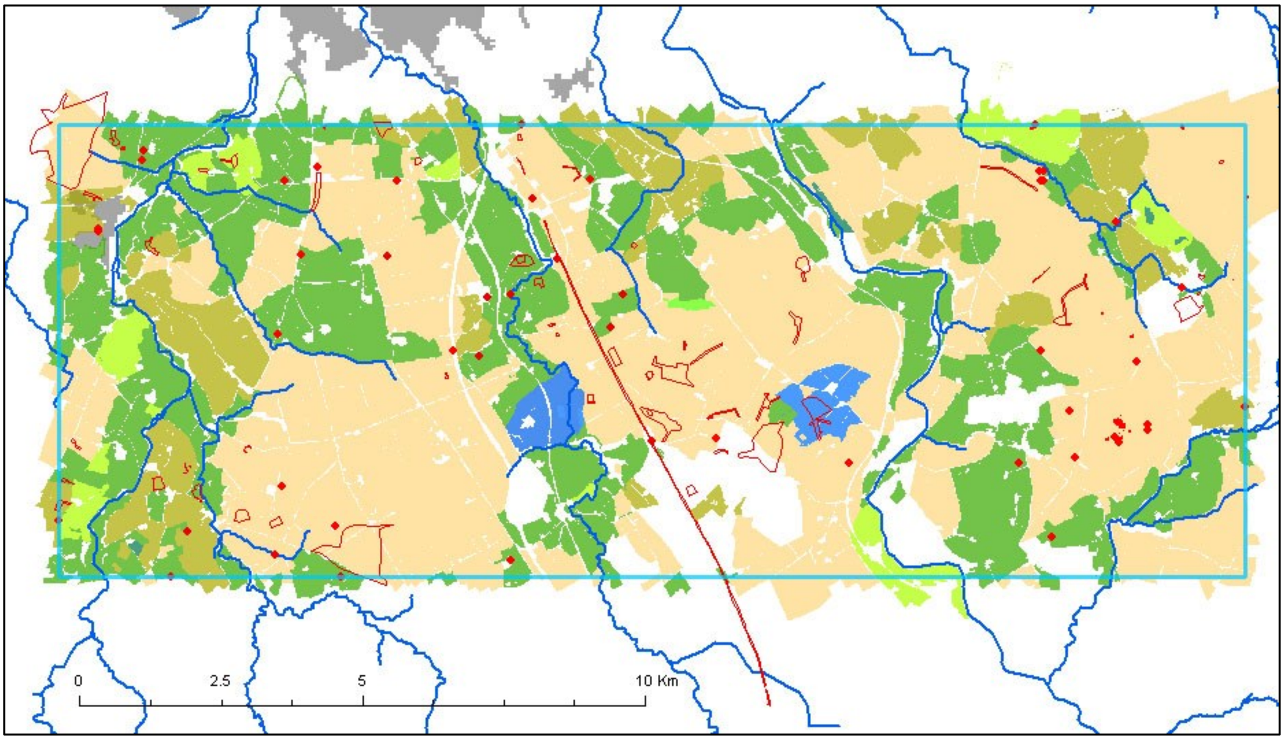

Figure 7.14: Relict land use on the Cumbria HLC (see Fig. 7.13 for key) in relation to known prehistoric and Roman archaeology (red)

A map highlighting NHLC squares with more than one HER entry provides a good visual representation of the areas of known presence (for all periods): around Dalston, along the main river valleys and more patchily across the interfluves (Fig. 7.15). Overall, however, proximity to rivers is a neutral indicator of presence, with 47.5% of HER entries and 48% of ridge and furrow mapped from the air lying within 500 m of a watercourse, though this represents 44% of the study area. However, SMs are under-represented in these areas (because of the number of upland prehistoric monuments) while listed buildings are greatly over-represented (72.5% are within 500 m of a watercourse). In accordance with this, proximity to rivers is a positive indicator for later periods, with 56% of medieval and 59% of post-medieval assets found within 500 m.

Records of the four main periods are found on almost all geologies, but with subtle differences: Neolithic and Bronze Age records are over-represented on the sands and gravels (especially significant assets; see 7.5) and absent on (or perhaps obscured by) alluvium/peat; Iron Age and Roman records are over-represented on the till but under-represented on the areas of bedrock in the east; medieval remains are over-represented on sands and gravels and under-represented on bedrock; and finally, post-medieval records (especially significant assets) are under-represented on till and over-represented on other deposits, reflecting the focus on the river valleys and the Pennine edge.

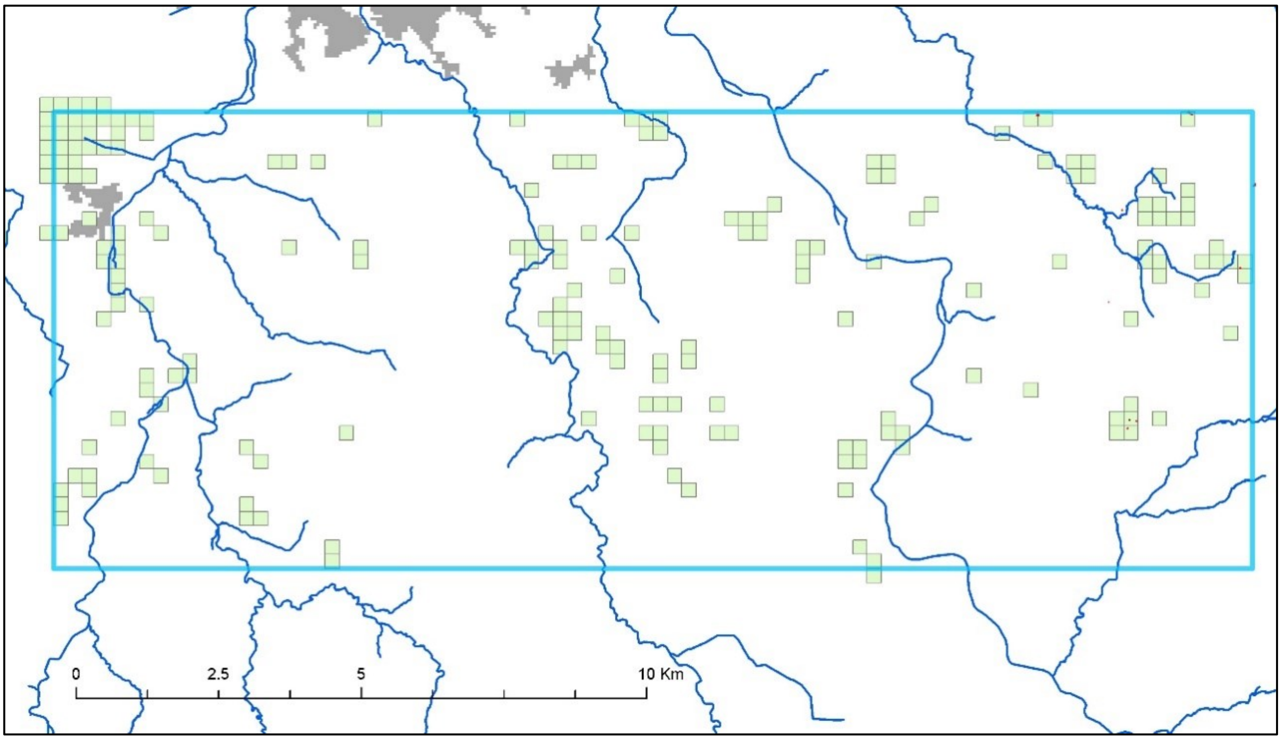

Figure 7.15: NHLC squares with more than one HER entry

In terms of cultural indicators, around 10% of HER entries lie within 400 m of a SM (3.2% of the study area) so this is a positive indicator of presence, but predictably higher for Neolithic/Early Bronze Age (13.5%) and later prehistoric/Roman remains (16.4%) than for medieval and later periods. In contrast the presence of listed buildings may be a positive indicator of remains of more recent periods: while only 6.5% of Neolithic/Early Bronze Age records lie within 200 m of a listed building (7% of the area) that increases to 18.3% of later prehistoric/Roman ones, 26.5% of medieval and 32% of post-medieval records. For ‘significant’ assets (see 7.5) the figures are similar but there is less difference between the Iron Age/Roman and medieval periods.

It is difficult to talk about asset densities because of the lack of large-area excavations, but comparison might be made to a series of investigations on the east side of Carlisle around Durranhill and Scotby, just to the north of the study area, within the Solway Basin NCA. Here an 18 ha evaluation at Garlands Hospital found just a single burnt mound (Neighbour and Johnson 2005); a 4 ha evaluation and excavation at Scotby Road revealed Neolithic pits and a series of Iron Age and Roman enclosures; and a 1400 sq m strip at Botcherby Nurseries found Bronze Age structures. This equates to one significant asset (if the enclosures are taken as a group) roughly every 7 ha.

7.4 Condition model

Mapping the condition of archaeological remains (not including standing buildings) uses HLC as the basis for assessment, supported by land cover mapping (for physical impact of modern land), geological mapping (for soil chemistry) and aerial mapping of earthworks (for known condition). GIS data was extracted in order to allocate each land parcel one of the following physical condition codes:

- U (upstanding earthworks present or likely): includes earthworks identified on aerial mapping and historic parkland on HLC.
- V (deep stratigraphy present or likely): includes land cover mapped as (unimproved) grassland or heather, areas of alluvium on geological mapping, and areas mapped on HLC as unenclosed land and ancient woodland.
- S (shallow cut features likely to survive): includes woodland, improved grassland and non-arable fields mapped on HLC as ancient enclosure.
- D (deep cut features only likely to survive): includes land cover mapped as arable and areas mapped on HLC as modern fields.
- X (destruction of most archaeological features and deposits): includes areas mapped on HLC as quarries/extraction.

The results of this exercise in relation to the NHLC grid are shown on Fig. 7.16, suggesting that preservation of earthworks and deep stratigraphy is most likely in the river valleys, and that while a large part of the area probably has good survival of sub-surface features, this is especially likely on the Pennine edge and less so in the north-west (that part of the study area within the Solway Basin NCA) where arable land-use is more prevalent.

It is important to emphasise that this approach does not depend on an asset being known or expected to be present – it considers what the likely physical condition of an asset would be if one is present. There is of course a degree of uncertainty about this approach which could be checked by assessing the results of HER events (which have not been used directly to inform the assessment) against the predicted condition. In the study area these are limited; however, the work at Townhead Road, in an area not mapped as arable but adjacent to it, found that agricultural activity, including modern deep ploughing, was ‘likely to have destroyed any shallower features associated with the group’ of Late Bronze Age postholes (Robinson and Town 2015). At Dobcross Hall, former earthworks of one of the enclosures were probably levelled soon after enclosure in the 1820s, and plough erosion of the subsoil was found across the site. Outside the study area, the burnt mound at Garlands Hospital had also been ploughed flat (Neighbour and Johnson 2005).

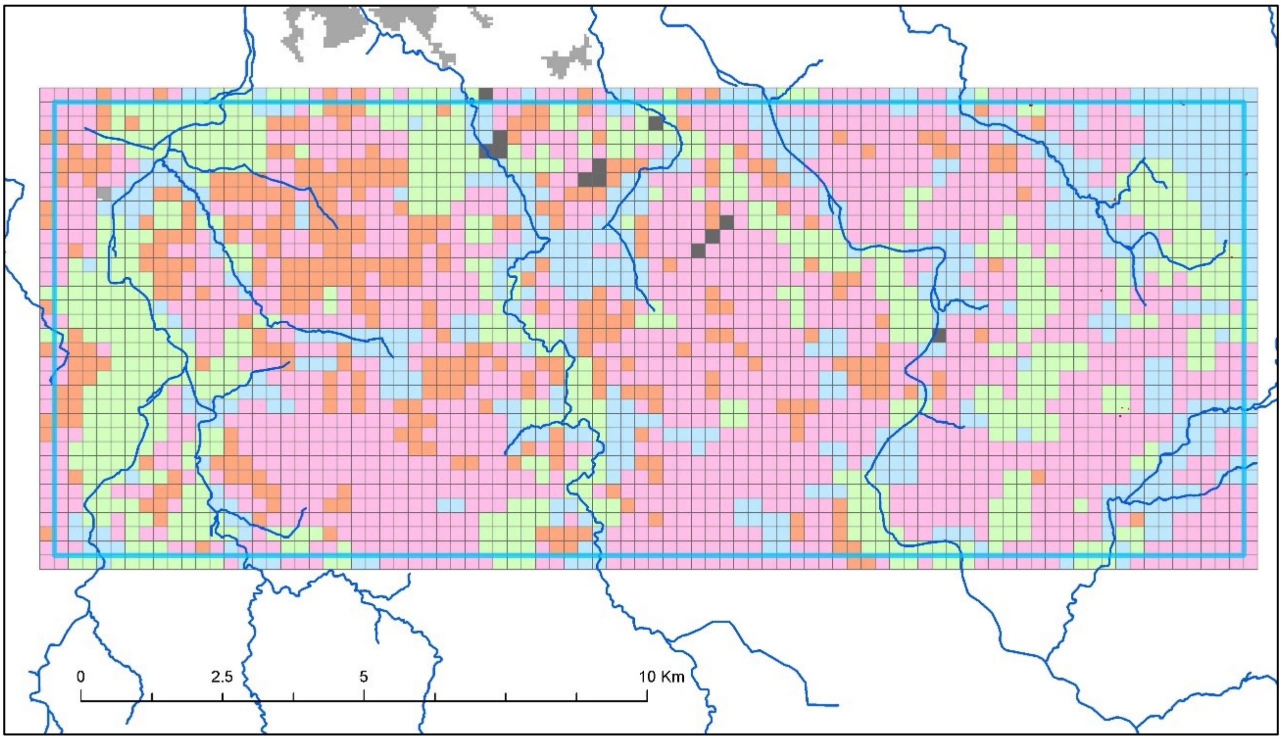

Figure 7.16: Condition mapping of NHLC squares (green = U; blue = V; pink = S; orange = D; dark grey = X)

For this reason all arable land in the study is coded ‘D’, even if it lies in an area of ancient enclosure. Not taken into account, however, is the observation at Townhead Road that ridge-and-furrow agriculture, which itself provides a level of sensitivity, has also impacted the survival of earlier remains, a complicating factor that needs consideration for any specific site.

The physical condition assessment can be supplemented by soil chemistry mapping that broadly differentiates anoxic/wetland (A), basic (B) and acidic (C) soils. Figure 7.17 shows a general distinction between acidic (sandy) soils on the eastern side of the study area and more basic (loamy) soils in the west, with wetland (peaty) soils confined to a few areas on the Pennine edge and at Wragmire Moss, which was identified as a potentially nationally important palaeoenviromental archive in the English Heritage Wetlands Strategy (van de Noort *et al*. 2004). However, how these differences in soils across the study area affect bone preservation, for example, remains unclear due to a dearth of reported fieldwork.

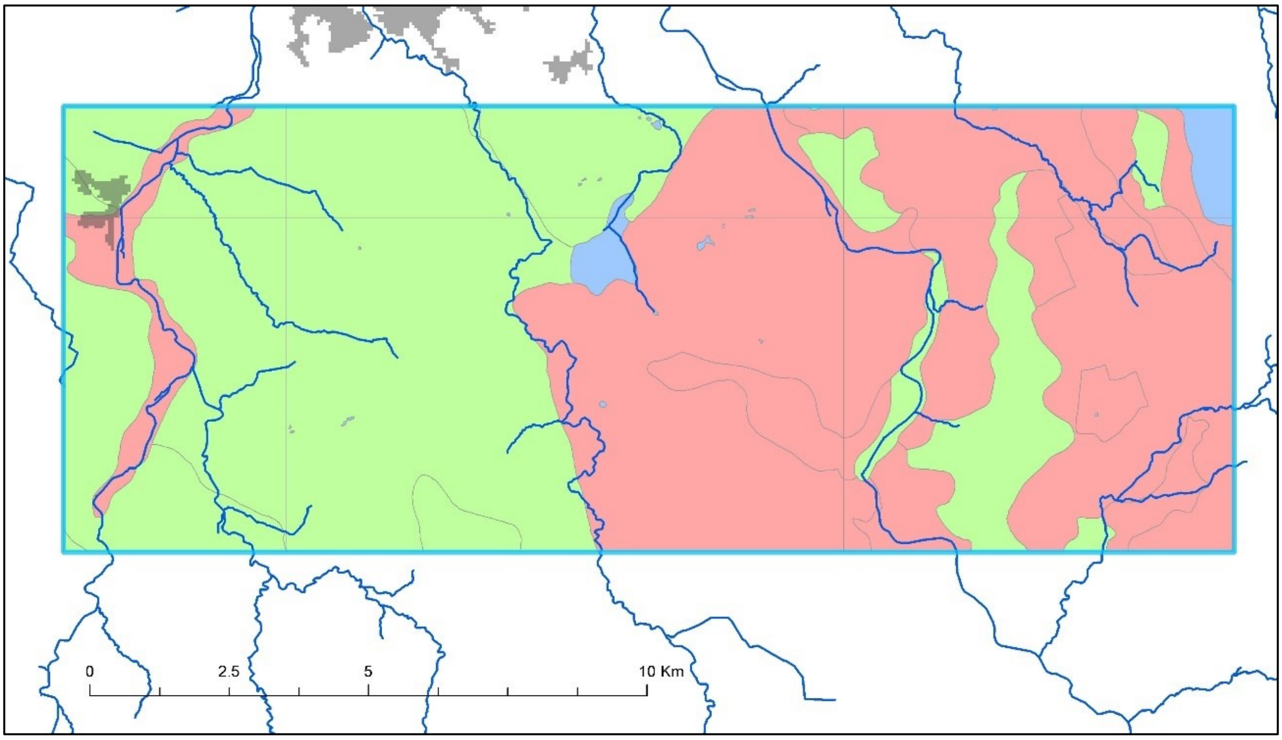

Figure 7.17: Soil chemistry categories (blue=A; green=B; red=C) (Soils data © Cranfield University and for the Controller of HMSO 2024 used with permission)

7.5 Significance

Of the 16 SMs found within the study area (Fig. 7.5), eight are Neolithic or Early Bronze Age, three are later prehistoric, three Roman and two medieval, representing a good spread of periods, though in the context of the wider study area the early monuments around Broomrigg are over-represented. Only one (Grey Yauds stone circle) was scheduled before World War Two, with nine sites scheduled in 1960–1 (mostly at Broomrigg) and the other six between 1966 and 1981. There has been no new scheduling, therefore, for 40 years; and recent aerial survey did not identify any undesignated monuments of potential national importance (Deegan 2019).

Even more than with presence, extrapolating significance is tricky but the distribution of assets of known significance (generally focussing on settlements and monuments rather than ditches and fields) can be visualised in terms of associated NHLC squares. This further emphasises a distribution of Neolithic and Early Bronze Age monuments focussed on the eastern part of the study area (Fig. 7.18a) and a westward shift of Iron Age-Roman enclosures, settlement and military sites (Fig. 7.18b). It is notable that the Eden valley is sparsely populated in both cases. For later periods there is a more even, generally riverine scatter of significant medieval sites (mainly settlements) and a northerly focus of post-medieval (mainly industrial) activity (Fig. 7.19).

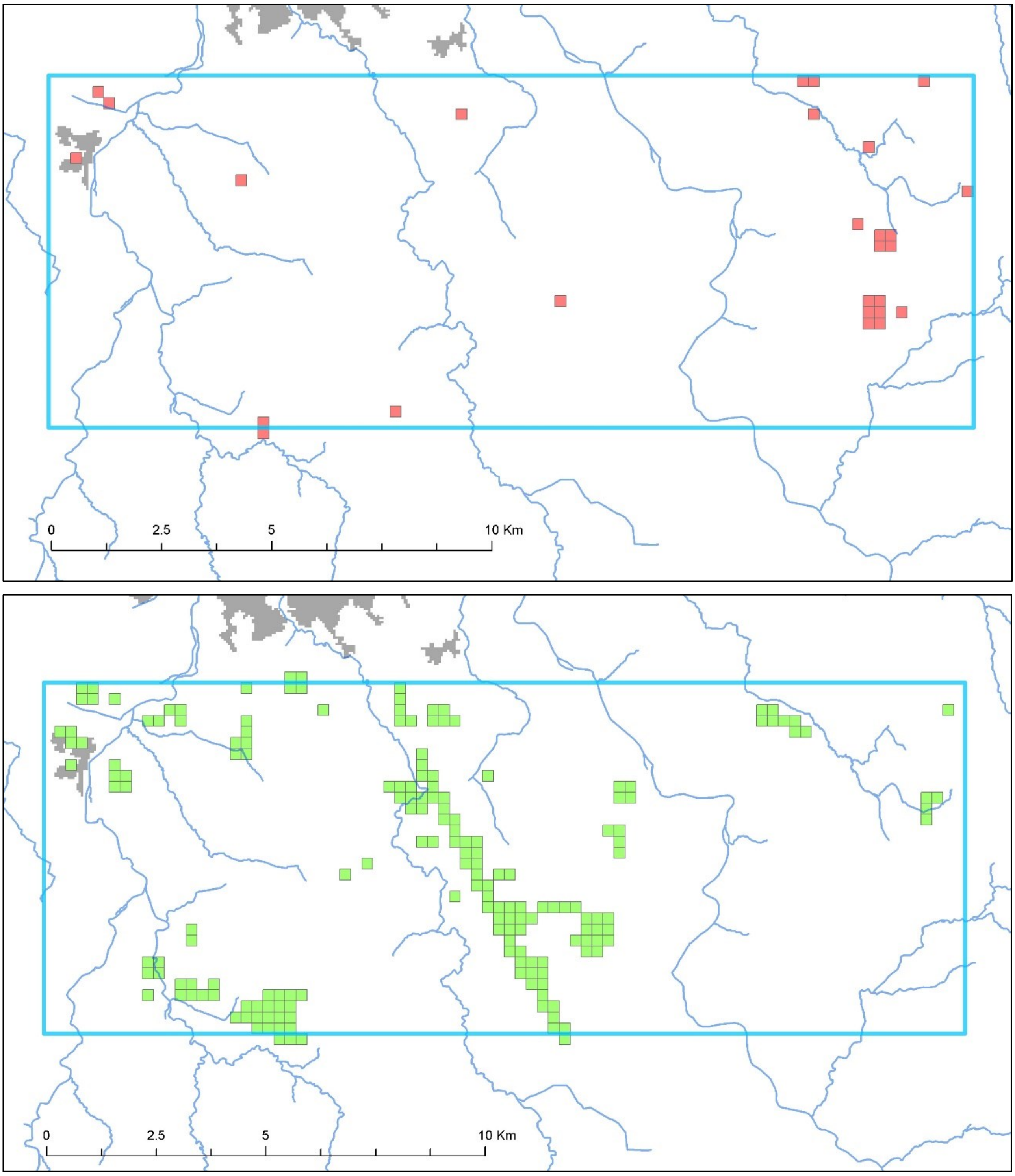

Figure 7.18: Significance map for (a) Neolithic-Early Bronze Age and (b) Iron Age-Roman remains

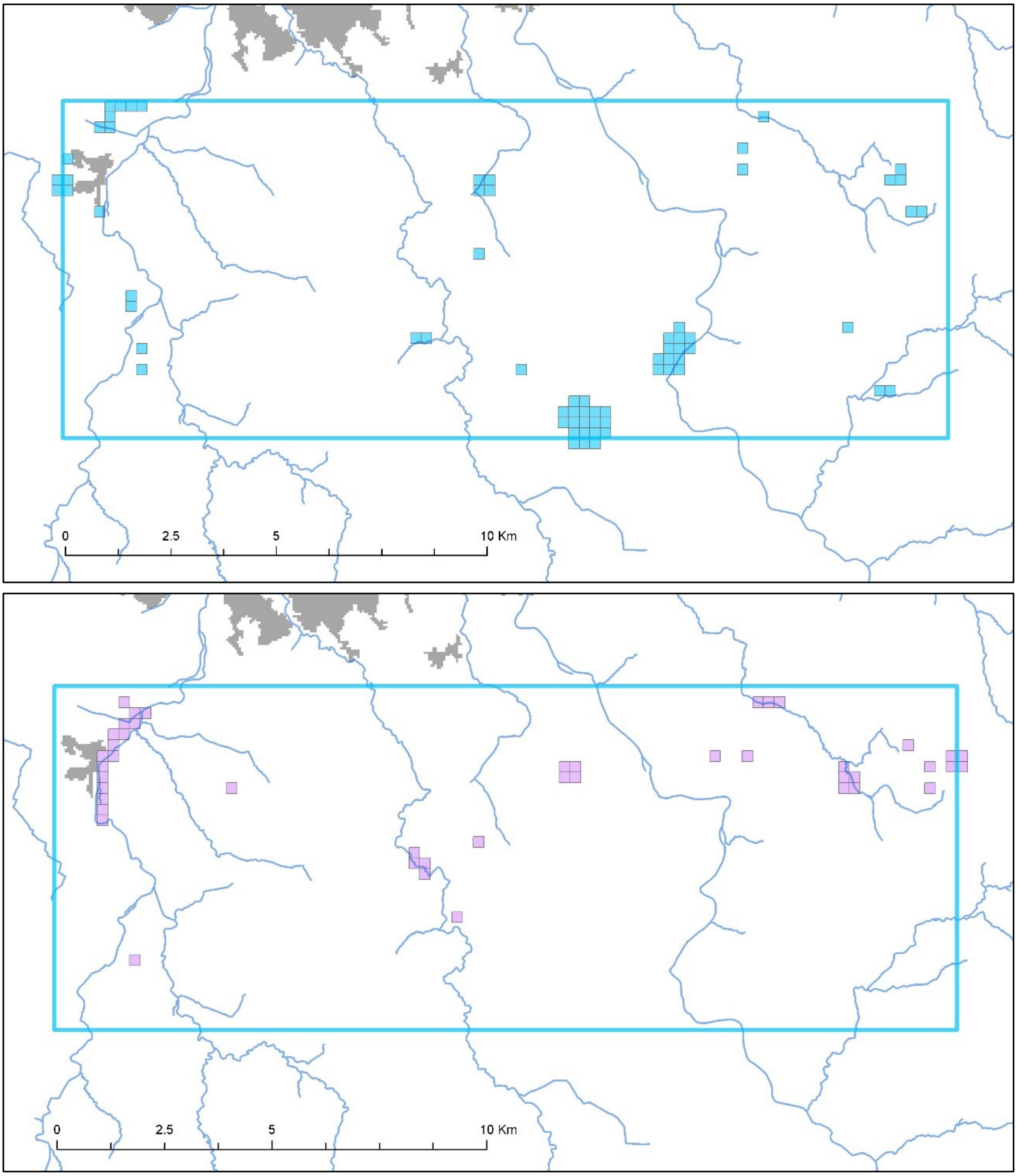

Figure 7.19: Significance map for (a) medieval and (b) post-medieval remains

For prehistory generally, the identification of previously unknown sites is highlighted, along with better understanding of the distribution of archaeology across the landscape (to which it is hoped the present study makes a contribution) and the changing nature of the relationships between people and their environment.

Fieldwalking, targeted survey and excavation for better understanding of Neolithic and Bronze Age settlement are referenced, including a review of the results of the Eden Valley fieldwalking project. Understanding the distribution of megalithic and other monuments is also a key question. The question of a settlement hierarchy for later prehistoric lowland settlements is raised, for which fieldwalking is again seen as an appropriate methodology. For the Roman period relevant questions focus on better understanding of rural society and economies, particularly in the uplands; evidence for the impact of Roman occupation on the environment; and the development of military sites and road systems.

Early medieval questions relate to the character of rural settlement and the nature of landscape change during the period, while the later medieval agenda includes understanding dispersed settlement, land-use patterns within townships, and the region's agricultural and landscape management practices.

For the post-medieval period the impacts of agricultural improvement and climatic events are highlighted, as well as understanding farming landscapes, including field patterns and farmstead abandonment, and leisure landscaping. These suggest that elements of the fieldscape should be added to the significance mapping (see Figs 7.10; 7.12–13). A separate industrial agenda emphasises the potential significance of historic water management features and the development and landscape impact of quarries etc, and restates the importance of recording and understanding farming landscapes and field patterns.

7.6 Conclusions

The main propositions emerging from the study are that:

1. The data are limited, but imply that no sizeable areas are entirely devoid of archaeological (including palaeoenvironmental) potential, except for land removed by historic quarrying. However, some differences in distributions are evident between the east and west of the study area (in certain periods) and between river valley and interfluve.
2. There are 16 SMs within the study area that despite the age of the schedulings represent a reasonable selection of the known archaeology, though the stone monuments of the Neolithic in the east of the study area are over-represented.
3. The very limited number of open-area excavations in the study area severely reduces the level of certainty with which judgements of

sensitivity can be made, though other work in the environs of Carlisle gives a sense of the likely density of assets.

4 Neolithic and Early Bronze Age monuments are restricted to the east of the study area, though findspots and smaller features, such as pits, are more widely distributed.

5 Aerial mapping has contributed significantly to our understanding of later prehistoric and Roman archaeology, showing a broad distribution of enclosures and field systems in the areas that have been mapped, especially between the Petteril and Eden, where there is a probable hillfort and a Roman road with associated military sites.

6 The late medieval/early post-medieval landscape can be tolerably well defined through a combination of HLC (relict land use) and ridge and furrow mapped from the air. It is likely that the majority of medieval settlement locations have been identified through the recognition of settlement earthworks and places of worship.

The potential condition of archaeological remains can be mapped regardless of whether the presence of an asset has been confirmed in that location, though aspects of the model require further validation. The results of fieldwork for the Carlisle Southern Link Road may be helpful in this respect.

It is hard at present to construct an overall map of archaeological potential for the Eden study area with any confidence but Fig. 7.20 presents an initial interpretation of high potential areas based on the NHLC, selecting grid squares with certain characteristics. The approach combines known presence (squares with more than one HER monument), known condition (evidence for earthworks) and known significance (presence of key site types), with geomorphological indicators (potential for waterlogged deposits). Predictably the river valleys have higher potential than upland areas in general, though the Eden valley registers less, presumably because of its steeper topography, while the interfluve between the Caldew and Petteril also has lower potential in this model.

Then to move from potential to sensitivity proper requires some understanding of threat and opportunity. For example, while arable impacts are focussed in the north-west, closer to Carlisle, flood alert areas are more extensive along the Caldew and Eden. The CSLR is likely to be a spur to further development in the north-west of the study area, between the road and the edge of the city. Unlike attritional agricultural and various natural processes, development (including afforestation) also offers potential public benefit in the form of mitigation or compensation. These risks and opportunities need to be factored into sensitivity models in a scenario-based way. For example, tree planting may protect earthworks from arable erosion but could disturb less robust buried deposits.

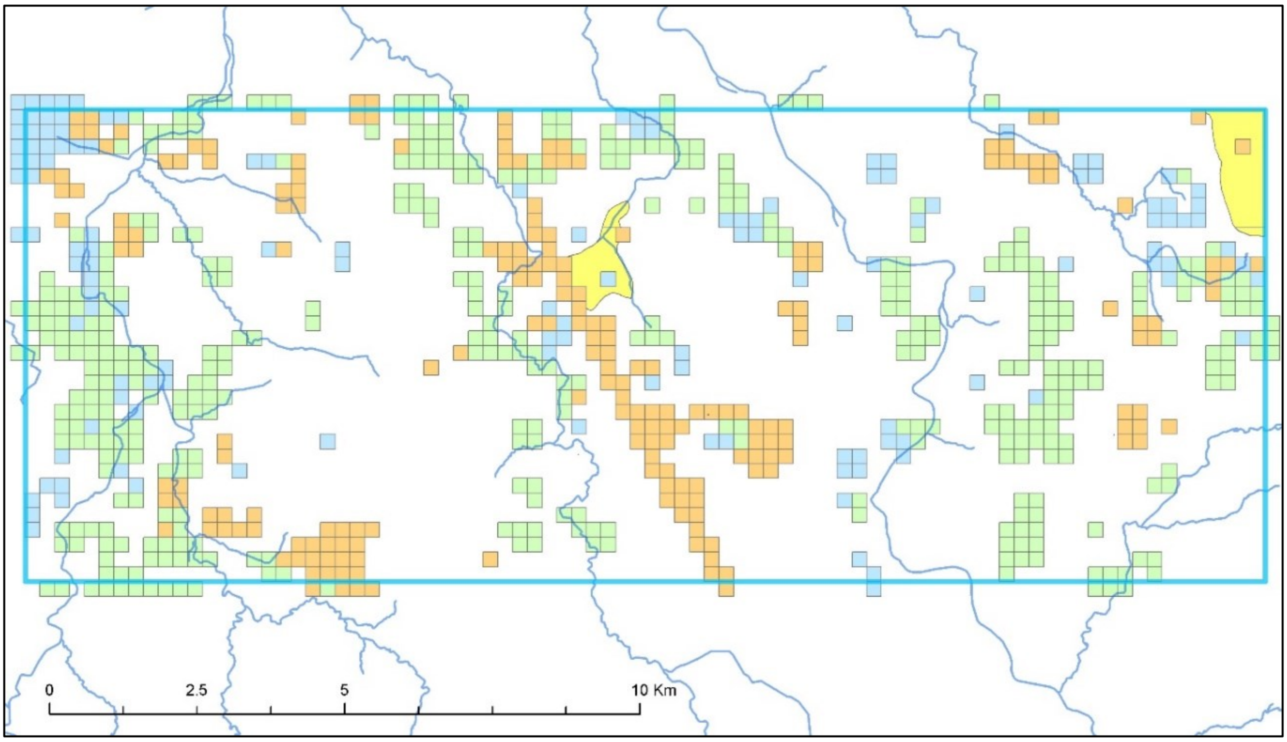

Figure 7.20: Overall high potential represented as 250 m NHLC squares with (in hierarchical order) more than one HER monument (light blue); significant site types (orange); earthwork presence (light green); plus areas of peat (yellow)

8 Discussion

8.1 Archaeological characterisation

The two southern case studies in the Vale of Aylesbury and London Gateway were selected in part because they had some contrasting characteristics – inland versus coastal for example – but also because they had support from the local archaeology services and were traversed by new infrastructure projects (HS2 and Lower Thames Crossing respectively) which could be used to test and calibrate the outputs. The northern case studies in Holderness and the Eden Valley represent different types of landscape potentially under different kinds of pressure or risk; as a result of lower rates of development they have more limited HER data, especially in relation to event records, but are bolstered by the results of recent aerial investigation and mapping projects. They too had support from the local archaeology services and in the case of the Eden Valley has the potential to be calibrated and/or improved when infrastructure project results (Carlisle Southern Link Road) are available.

Each study examined archaeological sensitivity through key parameters of presence, condition and significance. The methodologies explored how these parameters might be coded into existing or new systems linked to HERs and the outputs presented as comprehensive coverage maps. Different approaches have been taken in the different areas depending on the nature of available data and the limitations of time available. One point made at the outset (3.1) was that that the recorded resource needs to be sufficiently well-known and representative of the area of study to enable plausible and tolerably reliable inferences to be made about the unrecorded resource. For the south-eastern pilot areas the availability of a series of development-led 'case studies' allowed the general models to be tested and calibrated. For the Holderness pilot there was far less such information within the study area but the Humber Wetlands Project data, availability of digital aerial mapping, and data from a pipeline project in another part of the Holderness landscape allow tolerable inferences. In the Eden Valley, however, there is even less useful HER data and we are reliant on aerial mapping and results from the wider environs of the study area. While general trends can be discerned, especially in relation to topography, confidence is low for certain periods and types of site, which needs to be reflected in any application of the model. However, having a more systematic understanding of the trends and gaps is itself important.

It is notable that none of the pilot studies have produced a single, simple map of archaeological sensitivity. This is partly because of the complexities of the models explored at this pilot stage, but also because, as mentioned, sensitivity is contextual and scenario-based. A final stage was therefore envisaged to combine the model parameters into policy areas that might, if required by the new planning system, be directly linked to policy and delivery rules. These rules could then be expressed in terms of the vulnerabilities and opportunities that arise from proposed change. This last stage has not been completed, partly due to limited time but mainly because the government decided to pause and review its planning reform agenda. However, such work is still required to align the methodology with the wide range of potential large-scale change scenarios that could impact buried archaeology, from development within the existing planning system to national infrastructure projects, afforestation, flood relief, 'rewilding' and other land-use change. Various recommendations for next steps with this and other aspects of the approach are outlined in section 9.

The pilot studies above explore how the recorded resource might be used to infer (in general terms) the density and distribution of the entire resource, with a focus on those aspects of the resource which hold higher significance that might reasonably influence strategic planning decisions. They also explore how the likely condition of assets (known and unknown) might be inferred from documented topography and land use. Because the proposed planning changes envisaged a comprehensive zonal system expressed through digital mapping, it was decided to focus on characterisation-like complete landscape coverage using GIS methods.

In the English planning system archaeological interest is defined as an interest in carrying out an investigation (because, as the NPPF puts it, there is potential 'evidence of past human activity worthy of expert investigation at some point'). Characterisation therefore has the immediate advantage that it allows the method to escape, at least in part, the old-fashioned idea that we can only consider archaeological interest in relation to known sites or monuments, and the paradoxical situation that mapping known assets might lead to the potential for as yet unknown ones to be ignored in strategic planning. As explored above, the presence of known assets might be a positive predictor of archaeological potential in the vicinity but will also be correlated with the distribution of previous work in an area.

Instead we are able to embrace the idea that there is some archaeological interest, or potential for such interest, in most of the English landscape. In doing so we are drawn towards a philosophical concept of 'asset-character duality' somewhat akin to that of the wave-particle duality in quantum physics. In this formulation the archaeological resource can be conceived both as discrete entities (assets are like particles) and a continuously varying field (character is like a wave function). To push the analogy one step further, in quantum physics an intervention is necessary to 'collapse the wave function' and locate the particle-like quality. This is not entirely unlike what happens when an archaeological survey locates, say, a Roman farmstead in one field and not in the three neighbouring fields where it might just as well have been.

Thus we arrive at a formulation where most of the English landscape can be accorded some degree of archaeological potential through characterisation and the role of field evaluation is to locate and characterise undiscovered assets. Of course, evaluation might also find things that fall outside the model and such instances are likely to be flagged as of particular interest (just as a new type of particle is of special interest to a physicist because it challenges current understanding). To some extent this is just an expression of how archaeology has been practised for the last thirty years but where it differs is that we do not usually articulate the probabilities of new discoveries in terms of anything more than ad hoc ‘professional judgement’. What has been explored here is a form of ‘expert system’ that draws upon that professional judgement to articulate testable propositions which then inform a model that can itself be tested and refined. At this point it must be admitted that the pilot studies are intended as no more than ‘proof of concept’. They are not refined operational systems and could doubtless be improved in many ways, for example by further analysis of the data and the use of more sophisticated statistics. The requirements of a particular change scenario will also influence the level of detail or granularity required in a model.

8.2 Known assets and their significance

HERs contain a wide range of information of very variable quality and relevance to strategic decision-making. Some previous strategic studies have sought to ‘digest’ and score the entire contents of an HER but the results of this approach proved hard to understand and apply, and tend to bias scores towards more heavily studied areas. It was therefore decided early on to focus as far as possible on locations of clear archaeological interest as distinct from the ‘background noise’ of e.g. poorly provenanced artefact finds or vague antiquarian records which pervades all HERs. Locations of interest are places where existing evidence (typically in the form of maps or documentary records, earthworks, cropmarks, findspots, historic buildings or previous excavations, but excluding records below a certain threshold determined by professional judgement) indicates the presence or likely presence of an archaeological asset (see 3.2.3). It must be stressed that the evidence to identify an asset of archaeological interest simply needs to be enough to demonstrate that there is something that merits further investigation; in this way the fact that the asset is poorly understood may become part of the justification for its identification. Patterns in the distribution of these locations can then be extrapolated in order to identify other locations where as yet unknown assets are more or less likely to occur (see 8.3).

Again using a scientific analogy, this time from communications technology, the methodology thus consciously seeks to detach signal from noise. In areas or periods where HER data is more limited, however, the threshold may be lower: for example multiple older records of findspot data without highly precise locations may nevertheless indicate areas of higher potential; or single lithic finds will acquire greater significance in areas where flint does not occur naturally.

In the Vale of Aylesbury the identification of assets was easily done using the county's long-established Archaeological Notification Area (ANA) system. Within the study area there were (in the 2012 dataset) 316 ANAs covering 12.4% of the study area, which formed the basis for analysis alongside 67 SMs, covering 0.6% of the study area, and 14 case studies of modern evaluation and excavation sites, covering 3.9% of the study area.

Identifying assets in the London Gateway was more problematic as the Essex HER does not have an equivalent to the ANA system. For the pilot study the subset of SHINE monuments was supplemented by inspection of the HER's monument polygon dataset to select by professional judgement a total of 330 assets covering 26.2% of the study area (see 5.4). The higher density of assets in London Gateway compared to the Vale of Aylesbury is partly explained by the different methodology – for example, whereas Bucks ANAs merge multiple monuments, in Essex assets derived from the monuments dataset can overlap, thus generating increased numbers – but also by the availability of NMP-standard aerial survey leading to more extensive recognition of assets. It would be interesting to see what impact aerial survey in Bucks has on the ANA system and how much it increases coverage to narrow the 'gap' between the Vale of Aylesbury and London Gateway

In both northern pilot studies, however, given the lower number of events and lack of potential for case studies (though aided in Holderness by the availability of SHINE data), the presence model made critical use of the entire HER dataset, excepting most undated records. As this variability demonstrates, different areas warrant different treatment and thresholds and therefore a national, top-down approach to sensitivity mapping would be unlikely to succeed. One key question is the extent to which lower quantities of data in the northern pilot areas relate to the reduced visibility of archaeology as opposed to genuinely lower numbers of assets (see 3.2.1). Issues with the quality of HER data might also have a disproportionate effect in areas where there is quantitatively less information. Additionally it is worth noting that assigning Level 0 (known absence) requires polygonised event data that can be linked to outcomes, which is often not generally available.

Thus the presence model involves firstly using professional judgement to distinguish known assets of archaeological interest from within the HER dataset. The next step, bringing in significance, would be to identify assets which might be given greater weight in the planning system than the usual 'non-designated heritage assets' (NDHAs).

Scheduled monuments are the most obvious example but non-designated remains close to SMs might actually prove to be part of them, as might remains associated with registered parks or battlefields, or with listed buildings or their curtilage. Association of archaeological interest with other designated heritage assets is one way in which archaeology might have enhanced significance, as is an association with protected landscapes such as National Parks and Areas of Outstanding Natural Beauty. In such cases the degree to which the archaeology contributes to the asset's significance would have to be assessed on a case-by-case basis. All that sensitivity mapping can realistically do is flag where such associations might reasonably be anticipated, sometimes by adding simple buffer zones around designated assets. Hardly surprisingly, most designated heritage assets showed a strong positive correlation with other archaeological assets (see below) which would therefore be potentially more significant in policy terms.

Of course if an NDHA is demonstrably equivalent to a SM it should be given the same weight as a designated asset in planning decisions. The problem is how to recognise such assets. The Buckinghamshire HER mainly uses a combination of 1990s MPP assessments, association with designated assets and professional judgement to identify one third of its ANAs as potentially of national importance. In contrast the Essex HER does not identify potential NI sites, although for the purpose of this study SHINE 'high significance' sites were used in this way. In Holderness, a similar list of SHINE 'high significance' sites is available, though that is not the case for the Eden Valley. In both northern pilot areas the data was queried to provide a subset of key site types or features for each period (e.g. selecting records that mention settlement or enclosures but not those which only refer to ditches or fields; cf. 3.2.3 on key asset types).

The first key point here is that significance is central to the analysis of potential and must be considered at an early stage to ensure that the model of presence, and to a lesser extent that of condition, is based on a dataset of significant assets rather than, as in some previous strategic planning studies, a melange of data, much of which is of dubious relevance to decision-making. The second key point is that known assets should be identified and mapped as best they can so that they form part of the model and can influence decision-making.

8.3 More and less favourable locational factors

Having identified known assets the next step is to explore their distribution, with the aim of identifying positive and negative correlations with known natural and cultural features. If the distribution of known assets is a reasonable approximation to the distribution of all assets then this analysis should enable us to identify where as yet unidentified assets are going to be found more or less often. The method has an advantage over relying simply on HER entries because it allows us to establish rules that underlie the patterning – so, for example, if local high points show positive correlation in the study area it is inferred that all such locations have higher than average potential. However, this methodology could be problematic if the area is poorly studied or has strong biases introduced by patterns of research and/or asset visibility. Certainly, it is important to test the models generated in this way.

In practice the pilot studies examined a similar, but not identical, range of physiographical and cultural factors that the writers thought might correlate (positively or negatively) with the distribution of archaeological assets across the study areas. The aim was to spot local variation, not large-scale regional trends.

A complicating factor is the palimpsest effect. In common with most of the English landscape the pilot study areas have a long history of human interaction with the landscape stretching back into the Pleistocene (especially in the south-eastern studies) and encompassing modes of society ranging from hunter-gatherers through agriculturalists to industrial civilisation. Whilst it seems plausible that people at any particular time were influenced by environmental factors and social conventions to behave in ways that generate recognisable patterns, it is far from obvious that such patterns would persist over millennia. The pilot studies sought to investigate this issue by dividing assets into broad periods as outlined above (3.2.1):

1 Lower/Middle Palaeolithic: none of the pilot studies considered the Palaeolithic in any detail although London Gateway benefits from an existing study (Fig. 5.8) which correlates rather well with overall significance as modelled for this project (Fig. 5.57). As mentioned above, a separate Historic England project aims to provide a national model[9].

2 The Late Upper Palaeolithic and Mesolithic: the low levels of activity are localised to certain geological/topographical situations, leaving large blank areas. This was a period of sea-level rise that created the Essex coastline and marshes as well as a rich wetland landscape in Holderness. More

detailed deposit modelling would help improve understanding of the potential for nationally significant (in-situ) remains of these periods.

3 Neolithic and Early Bronze Age: in the study areas this primarily involved barrows and smaller numbers of other monument types along with lithic scatters; in the south sites are almost entirely located on permeable geologies (chalk, gravel, limestone); in the northern study areas such geologies are still often preferred but monuments are also found on the more ubiquitous glacial tills.

4a Middle Bronze Age to Iron Age: aerial photography shows that the Thames gravels were particularly intensively utilised but many sites are effectively undated palimpsests probably containing both earlier and later elements; the same goes for the aerial mapping coverage of Holderness and the Eden Valley, where the models combine the later prehistoric and Roman periods. Hillforts were absent in Holderness, a minor component in the London Gateway and Eden Valley, but more notable in the Vale of Aylesbury where boundary dykes also featured.

4b Roman: a continuation of Iron Age agricultural landscapes with more intensification and diversification plus the introduction of Mediterranean culture (towns, temples, roads and villas). The Vale of Aylesbury shows the expected marked intensification of agricultural land use but this is not seen in London Gateway where the coastal salt-making industry provides most evidence. In Holderness Roman occupation seems less intensive than in the Iron Age whereas in the Eden Valley there is considerable change connected to military activity alongside continuity in settlement.

4c Early medieval: characterised by open settlements and pagan cemeteries. Mucking on the Thames gravels is by far the standout site. Also limited evidence for early Christianity (e.g. Aylesbury minster). All studies show lower levels of activity than in the previous Roman and subsequent late medieval periods, although the difference is less marked in the London Gateway than other areas.

5a Late medieval: this is the first period for which a combination of historic maps and archaeological information allows a tentative reconstruction of settlement and land use patterns using HLC. More assets are assigned to this period than any other, probably reflecting its greater visibility. Reclamation of the Essex coastal marshes and Hull valley wetlands began.

5b Post-medieval (16th–19th centuries): settlement and land use patterns can be reconstructed with greater confidence and the issue becomes less one of recognising assets and more of selecting where to engage archaeological interest as so many are designated for other reasons (e.g. listed buildings). All study areas were essentially agrarian landscapes subject to enclosure, and in the Vale emparkment. The Chiltern woodlands were subject to commercial management while the Eden Valley saw relatively late enclosure of forest commons. Drainage continued in Holderness, eliding land-use distinctions between former wetlands and drylands. None of the study areas saw much early impact from the industrial revolution.

5c Modern: the precise distinction between the post-medieval and modern periods varied, but none of the studies did more than note where the HERs have identified 19th and 20th century assets of likely archaeological interest. These were mainly structures from WW2 and mostly found in London Gateway. Industrial-era features such as canals and railways have not generally been identified as archaeological assets, with certain exceptions such as the Leven Canal in Holderness.

Two consequences flow from these considerations. Firstly, that pattern blurring can be expected as human activity moves its emphasis across the landscape period by period. This effect was evident in the Vale of Aylesbury case study where the chalk was strongly favoured in the Neolithic and Bronze Age but as settlement moved out into the clay vale in later periods the chalk overall has a similar asset density to the clay mudstones. In Holderness, the medieval and post-medieval drainage of former wetlands leads to a similar blurring of patterns evident in earlier periods. Earlier patterns can also be masked or biased by later ones; for example, in London Gateway and Holderness, earlier sites may be masked by alluvium, while in the Eden Valley there is an association of visible pre-medieval archaeology with former unenclosed land, as opposed to the riverine zone of medieval and post-medieval arable, enclosure and emparkment.

Secondly, more intensive periods of activity will tend to dominate pattern recognition. In both southern studies, late medieval assets were the most common (excepting undated assets in London Gateway) with Palaeolithic, Mesolithic and early medieval (and modern in the Vale) being rare (Fig. 8.1). In the north there were some differences, with post-medieval assets dominant in Holderness and Iron Age-Roman ones (if taken together) in the Eden Valley. Whilst of concern in research terms (and worth flagging in relevant research frameworks) this may not matter so much from a resource management perspective unless assets of one period are deemed inherently more significant than those of another.

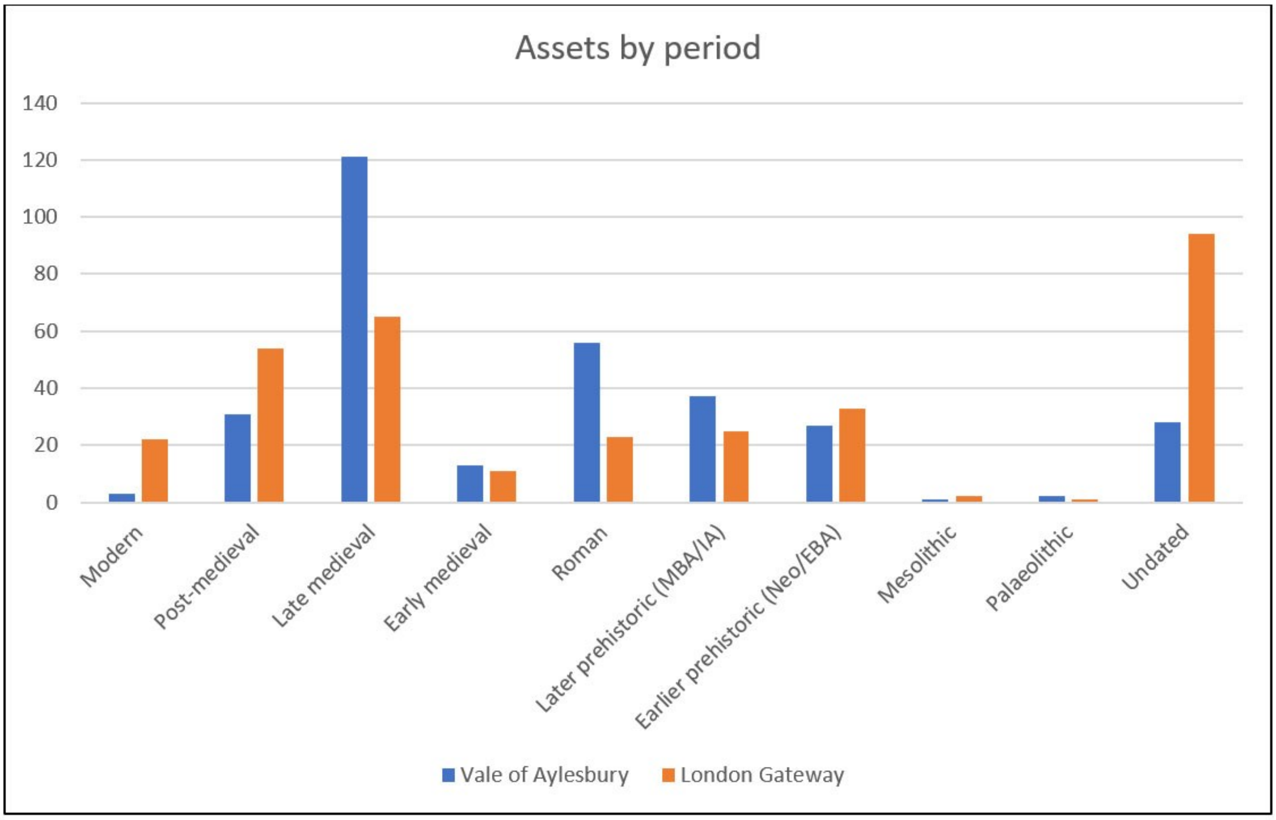

Figure 8.1: Number of known assets by period in the southern study areas

In order to assess correlations in the south-east studies, GIS polygons created for the asset maps were converted to centroid points and the numbers of these points within the target indicator polygons compared with what would be expected from a normal distribution, using a binomial test (using points instead of polygons simplifies computation but does make the results less precisely quantitative). Results that were within one standard deviation (σ) of the expected value showed no correlation (neutral), those within 2σ showed a weak correlation (roughly 1 in 3 of these might simply be chance), within 3σ was a moderate correlation (roughly 1 in 20 would occur by chance) and within 4σ was a strong correlation (less than 1 in 300 are chance). Correlations can be positive – that is more assets are within the target indicator than would be expected by chance – or negative, if there are fewer than expected. The indicators were chosen by professional judgement as likely to be either positive or negative. This aims to test the professional judgements and establish which correlations are strong enough to have predictive value. However, results must be interrogated with caution as many influences overlap and we need to remember that correlation is not causation.

Correlations between archaeology and surface geology are common, and one early task was to create a simplified surface geology map for each study area from British Geological Survey 1:50k mapping. The proportion of each area covered by each simplified type was calculated along with the proportion of assets and the proportion of SMs on each. If geology had no influence on asset distribution then the proportion of assets within each geological type should of course be roughly the same as the proportion of the study area covered by that type.

Comparing the two south-eastern study areas (Fig. 8.2), London Gateway shows much greater variation, with the asset density on sand and gravel being almost five times that known on head deposits, enabling the former to be identified as favoured and the latter less favoured. In the Vale of Aylesbury variation is more muted with only limestone standing out as favoured and alluvium less favoured. Note that for reasons discussed above the average known asset density in London Gateway is twice that of the Vale of Aylesbury.

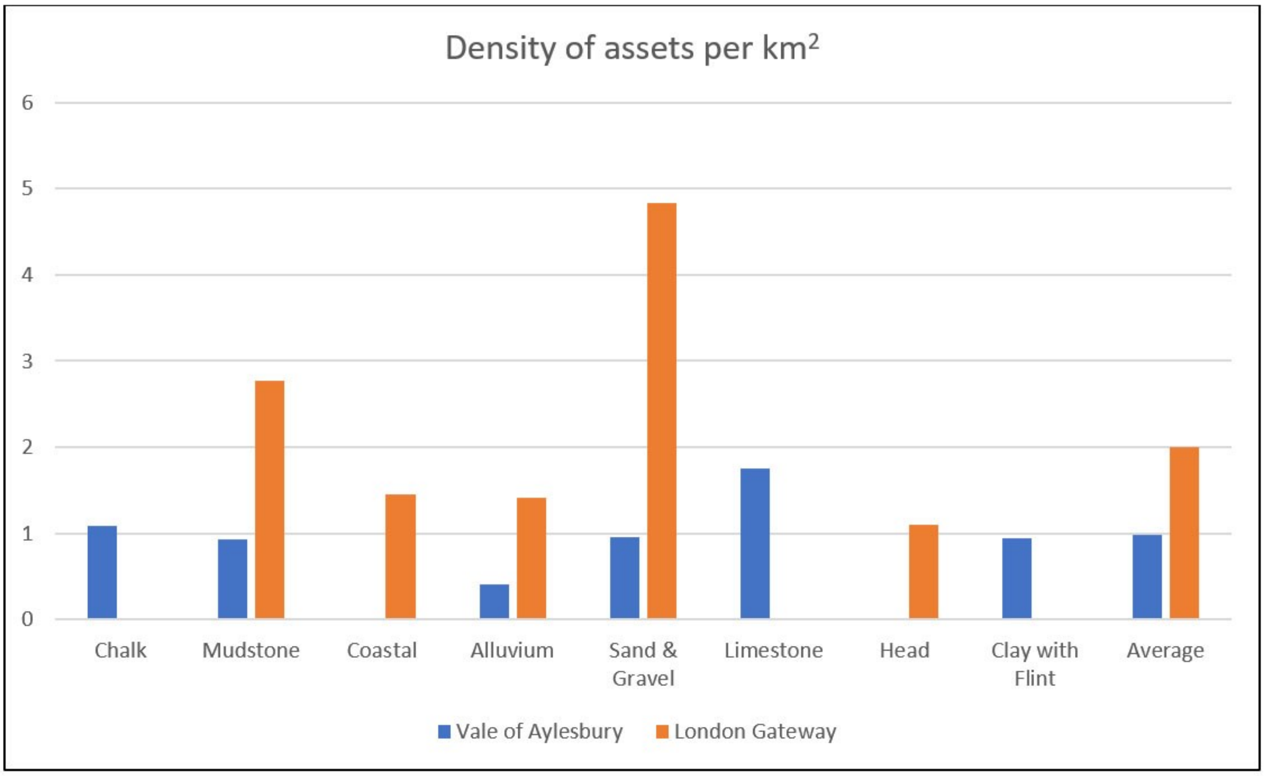

Figure 8.2: Density of assets on different geologies in the southern study areas

Two examples of this are:

- In the Vale of Aylesbury, chalk makes up 22.8% of the surface geology and contains 23.1% of the assets, giving a neutral correlation, but 36.8% of the SMs, giving a moderate positive correlation.

- In the London Gateway, sand and gravel make up 13.3% of the surface geology which contains a remarkable 31.8% of the assets and 46.2% of SMs, both strong positive correlations.

Surface geology is a useful indicator in both study areas but more dramatically from a numerical point of view in the London Gateway. In the Vale it has more value as an indicator of likely periods and types of assets than raw densities. The different performance of sand and gravel between the areas is notable.

Similar calculations (using Chi-square tests) were made for the northern pilot studies where sample sizes allowed. Geology is just as influential in these areas, with sand and gravel areas favoured in the till-dominated Holderness study area, and alluvial areas less favoured (or masking assets) until the post-medieval period. In the Eden, which is also primarily till-covered, the non-till geologies have a somewhat higher than expected proportion of HER entries (39% of the records in 31% of the area). There therefore appears to be a lowered potential on till generally.

Other physiographic factors considered were proximity to watercourses and local high points and (in the Vale of Aylesbury only) being on a steep slope. For the Vale, watercourses were taken from a GIS layer but then enhanced to reach the sources of streams mapped on 1880s 1st edition OS maps. Local high points were simply ‘eyeballed’ from GIS contour data. A 200 m buffer was then applied for ‘proximity’. Doubtless a more sophisticated topographical model could be created if the results from this pilot were encouraging. In fact, outcomes were rather mixed. It was thought that steep slopes, mainly found in the Chilterns, might show a negative correlation but in fact they were neutral – a case of statistics refuting instinct. The same goes for the Eden Valley, where steeper slopes are not a bar to the presence of assets, with the proportion occurring in these areas (12%) matching the proportion of the project area covered by such slopes.

Watercourses proved more intriguing: in the Vale they were neutral indicators for assets and SMs overall but strong positive indicators for SMs outside the Chilterns AONB – this is probably because most scheduled sites in the clay vale are medieval moats and deserted settlements for which access to water would be vital, whereas Chiltern barrows and boundary dykes have no such requirement. In London Gateway proximity to water proved a strong negative indicator, perhaps because of flood risk in already low-lying marshland. In the Eden Valley watercourses are a neutral indicator for HER entries, a negative indicator for SMs but a strong positive indicator for listed buildings. All this shows how nuanced the use of such indicators must be.

Local high points proved to be only weakly positive for assets in the Vale and neutral for SMs whereas in the London Gateway they were strongly positive indicators for assets (again neutral for SMs). The Gateway result might well be the flip-side of avoiding watercourses in a marshy landscape and if so the beginnings of a method for identifying favourable locations (noting also that earlier sites may have been lost to sea-level rise). The separate Vale case studies analysis provided some support for local high points as a predictive indicator so it was taken forward, albeit with caution. In the low-lying Holderness landscape elevation is also important, with the 5 m contour marking the approximate limit of alluviation and the 10 m contour on the edges of the Hull valley showing a relationship with medieval moated sites. In the Eden there are clear, albeit varying, relationships between the presence of ridge and furrow and the elevation.

A wider range of cultural indicators were identified. Unsurprisingly, designated heritage assets or proximity to them were strongly positive indicators of archaeological interest in both southern pilot studies: conservation areas, registered historic parks and listed buildings are all likely to hold archaeological interest themselves and to be associated with non-designated remains of medieval and post-medieval date. In the Vale, a buffer of 200 m around SMs was found to be a good predictor, particularly for medieval remains associated with medieval SMs. In Holderness 30% of medieval records are within 400 m of a SM and almost 50% within 200 m of a listed building, while in the Eden Valley 17% of records and 22.5% of significant assets are within 200 m of a listed building. However, in both cases there are significant (and largely predictable) differences in the correlation between designated assets and records of different periods.

Medieval churches are often on sites occupied since the 11th century AD or before so it is again hardly surprising to find them being strong positive indicators. Analysis of buffers around churches found that in the Vale their influence is stronger and extends out to about 400 m whereas in the London Gateway it is only 200 m (Fig. 8.3). Reasons for this were not investigated but might reflect the difference between a nucleated settlement pattern in the Vale and a dispersed one in Essex, as well as specific cultural choices in the Vale, where a number of them occupy sites of later prehistoric and Roman interest, such as the placing of Aylesbury minster within a hillfort and the location of Stoke Mandeville church over a Roman mausoleum.

In Holderness areas within 400 m of a medieval church cover around 3.5% of the project area, but these contain over a third of the (admittedly scarce) early medieval records, and around 16% of later medieval and post-medieval records. In the Eden Valley, in contrast, the dispersed churches provide no positive influence on archaeological presence for any period, though they are associated with areas of former common arable land as recorded on the HLC.

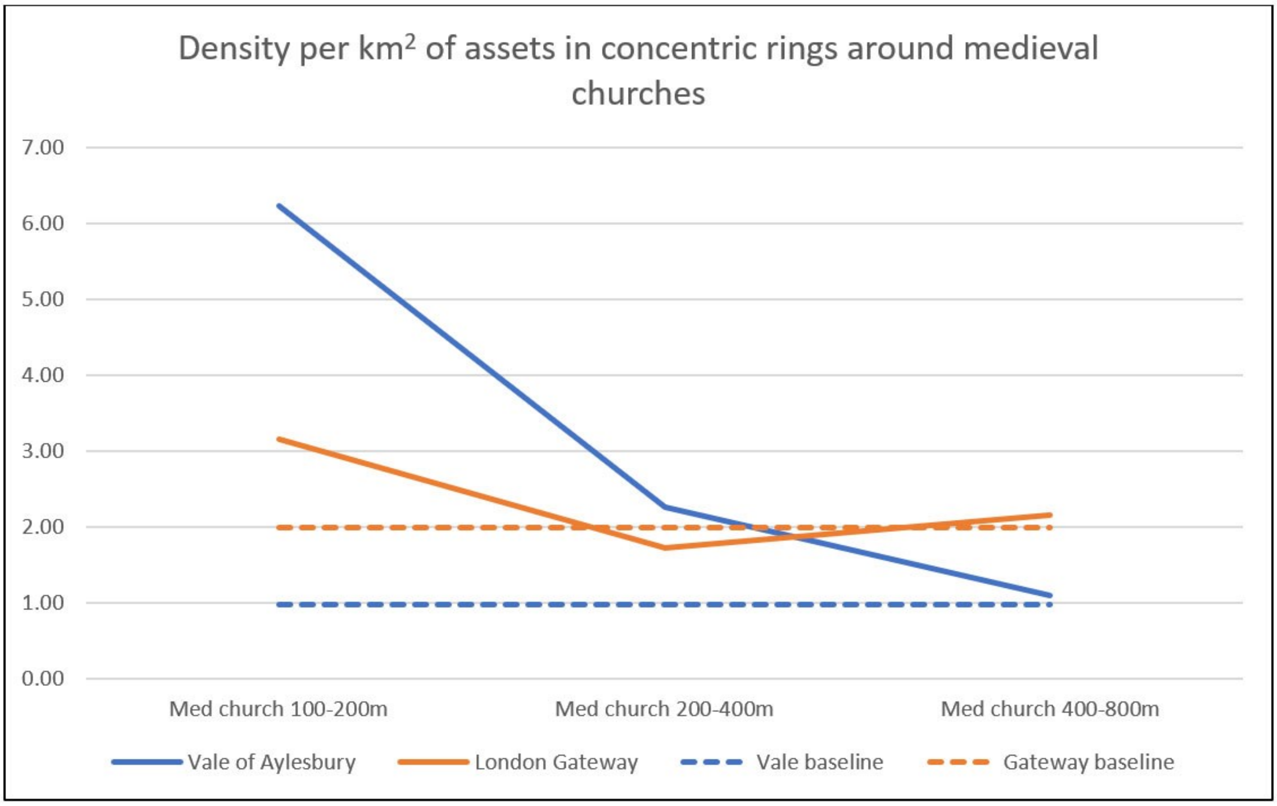

Figure 8.3: Density of assets around churches in the southern study areas

Some landscape types and routeways were also considered. As noted above, conservation areas and registered parks (only present in the Vale) showed strong positive correlations, with the former being amongst the strongest positive indicators encountered in both southern case studies, illustrating the potential for conservation areas to encompass archaeological interest more fully than they sometimes do at present. Other potential landscape indicators, such as former open fields (derived from HLC) and Domesday population densities, were tried in the Vale and generally gave widespread but weak correlations in the expected directions: medieval and post-medieval assets are less common in former open fields and more common in areas of higher Domesday population.

Ancient woodlands proved rather variable, being moderately positive indicators in London Gateway and moderately negative in the Vale. The latter result is almost certainly a reflection of limited survey and HER coverage of Chiltern woodlands, which is currently being addressed by the Chilterns Conservation Board's 'Beacons of the Past' project, which includes lidar survey. In Holderness and the Eden Valley land mapped as ancient woodland was too sparse to make judgements about correlations. However, given the right data, the analysis could be extended to look at the influence of other natural features of potential cultural significance, such as small wetlands or champion trees.

Roman roads proved problematic as indicators. This is partly because there is no definitive dataset, and what constitutes a 'Roman road' is debatable (while confirmed examples are of course assets in their own right, some proposed routes are conjectural or even fanciful while others were no more than local trackways). There are also discrepancies between HERs and the national dataset created by NRHE. It was thought that the Vale of Aylesbury would show a positive correlation as it is crossed by Akeman Street and has a nucleated settlement at a nodal point where a number of local roads meet (Fleet Marston), as well as being traversed by the Lower and Upper Icknield Ways (Roman and reputedly prehistoric respectively). In practice, however, there was no correlation of known assets (ANAs) with a 200 m buffer along all the Roman roads, but the case studies (many of which were close to Akeman Street and Fleet Marston) did show a modest positive correlation. London Gateway is not traversed by any major Roman roads and the minor (largely conjectural) routes proved to be strong negative indicators, a rather surprising result which defies obvious explanation (see 5.3.6).

In the Eden Valley the Roman road that runs on the east side of the river Petteril, part of that from Brougham via Penrith to Carlisle (Margary 7e), does represent a positive indicator, with 22% of Iron Age/Roman records within 600 m of the road (6% of the project area), though only a third of these are within 200 m of the road. It remains a slightly positive indicator for medieval records (11%) and for historic quarries (of all dates; 16%) but not for post-medieval records. There are no definite Roman roads in the Holderness study area.

It is therefore evident that Roman roads need to be treated with considerable caution and nuance. In places – the environs of Roman towns for example, or areas with military infrastructure – main roads surely must act as positive indicators for Roman and often later archaeology but minor and conjectural routes do not have the same effect and on occasion main roads may actually have repelled settlement, as in the numerous medieval villages set back from Watling Street in the south Midlands. Another consideration, as shown in the Eden Valley, is that a wider buffer might draw in settlements set back from a road – this would be worth exploring in promising cases but if taken too far risks generating very wide diffuse corridors of limited utility. A similarly broad corridor (800 m buffer) along the route of the Upper Icknield Way, a conjectural prehistoric routeway along the Chiltern ridge, coincides with a concentration of Neolithic and Bronze Age monuments.

Overall the analyses suggest that, perhaps unsurprisingly, the most consistent and strong positive indicators of archaeological interest are the presence of, or proximity to, designated heritage assets. More detailed study could probably refine which assets are better indicators for which types of archaeology and over what distances proximity buffers are best set. Physiographic indicators are often weaker and more variable; in the south the London Gateway pilot showed more clear-cut distinctions than the muted variability of the Vale, while in the north asset distributions were more sensitive to relative altitude in the low-lying wetlands of Holderness than the varied topography of the Eden Valley, though in the latter case there are still broad distinctions between the archaeological character of the river valleys and the interfluves.

So far this analysis has been based principally on the assets identified by or from the HERs. An alternative view and cross-check is provided by the Vale of Aylesbury and London Gateway investigations case studies, as summarised below.

8.4 Insights from case studies

A valuable element of the Vale of Aylesbury pilot was the 14 case studies of modern evaluation and excavation sites (Appendix 1), covering a total of 1138 ha (3.9% of the study area). These case studies almost all lay in the north-east quadrant of the study area around the town of Aylesbury. Three were clusters of small excavations in historic cores whilst the remainder were greenfield sites of which five had progressed to excavation and six were at evaluation stage.

The case studies provided a way of calibrating known HER patterns against discoveries made during the development process. Interestingly, the historic cores displayed the greatest intensity of sustained (albeit not continuous) occupation with all three producing significant early medieval and earlier evidence. Whilst the sample is small it does chime with the correlation of medieval churches and conservation areas with known assets.

The greenfield case studies usefully measure the proportion of these sites which contain substantive assets worthy of either preservation or further investigation. All large greenfield case studies contained heritage assets of archaeological interest. This is believed to be representative and leads to the conclusion that few such sites over about 10 ha would be devoid of archaeological remains in this part of the country. The study showed that, overall, the proportion of each site covered by significant archaeology averaged 13.6%, varying from just below 5% to about 35%, with most cases falling between 5 and 20% (Fig. 8.4). The outlier was a site covered by an ANA and adjacent to a SM so flagged in advance as sensitive.

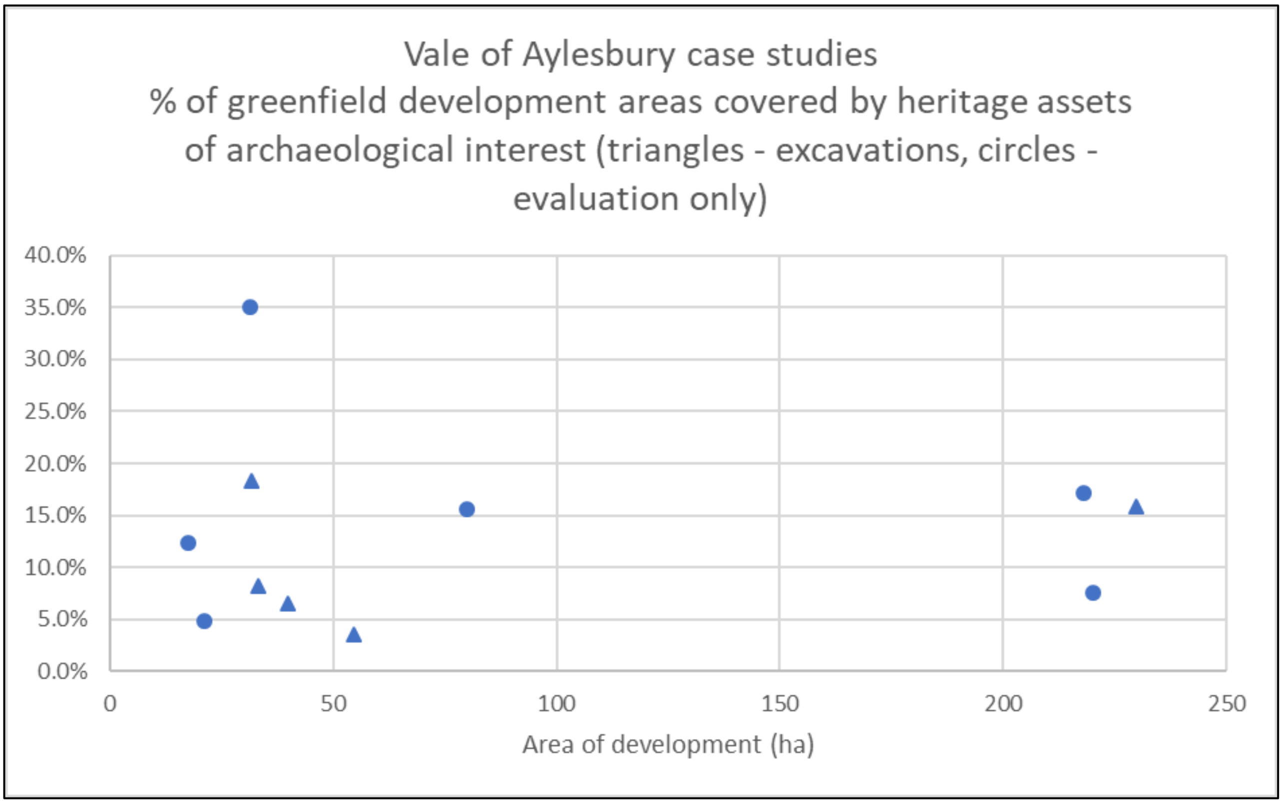

Figure 8.4: Proportion of development areas covered by heritage assets in the Vale of Aylesbury case studies

The case studies also looked at the correlation by area of discovered assets with natural and cultural indicators in order to calculate a 'multiplier effect' for each factor, i.e. how much more or less extensive is archaeology within the locational factor area compared to the average for the case studies (Fig. 8.5). The results once again emphasise association with designated assets, with densities roughly 1.5–3 times the average. ANAs based on interpretation of HER information perform slightly better than that – a reassuring endorsement of the HER's professional judgement! In contrast most physiographic indicators demonstrate weak predictive power except that alluvium is confirmed as less favoured. The dataset for chalk and local high points is small and so should be viewed with caution, although local high points appear worthy of further consideration and perhaps so do Roman roads, as noted above.

A further way in which the case studies help to calibrate the model is by comparing the period and types of archaeology encountered in them with the ANAs. If previously unknown assets are being discovered, then the frequency at which this happens will provide an indication of how incomplete the Historic Environment Record is, providing a measure of 'visibility'. In practice only a rough estimate was made that between 10% and 25% of Neolithic to early medieval assets are known – the calculations actually suggested about 10% of Neolithic/Early Bronze Age and Roman and 25% of later prehistoric and early medieval but are probably not robust enough to support these finer distinctions; the HS2 test (4.8) implies the lower end of this range is more accurate for all pre-medieval periods. Medieval assets are much better but not completely known (though the HS2 test found the number of new assets discovered was at the top end of the predicted range) – an estimate of two thirds might be better expressed by professional judgement as a range of 60–80%.

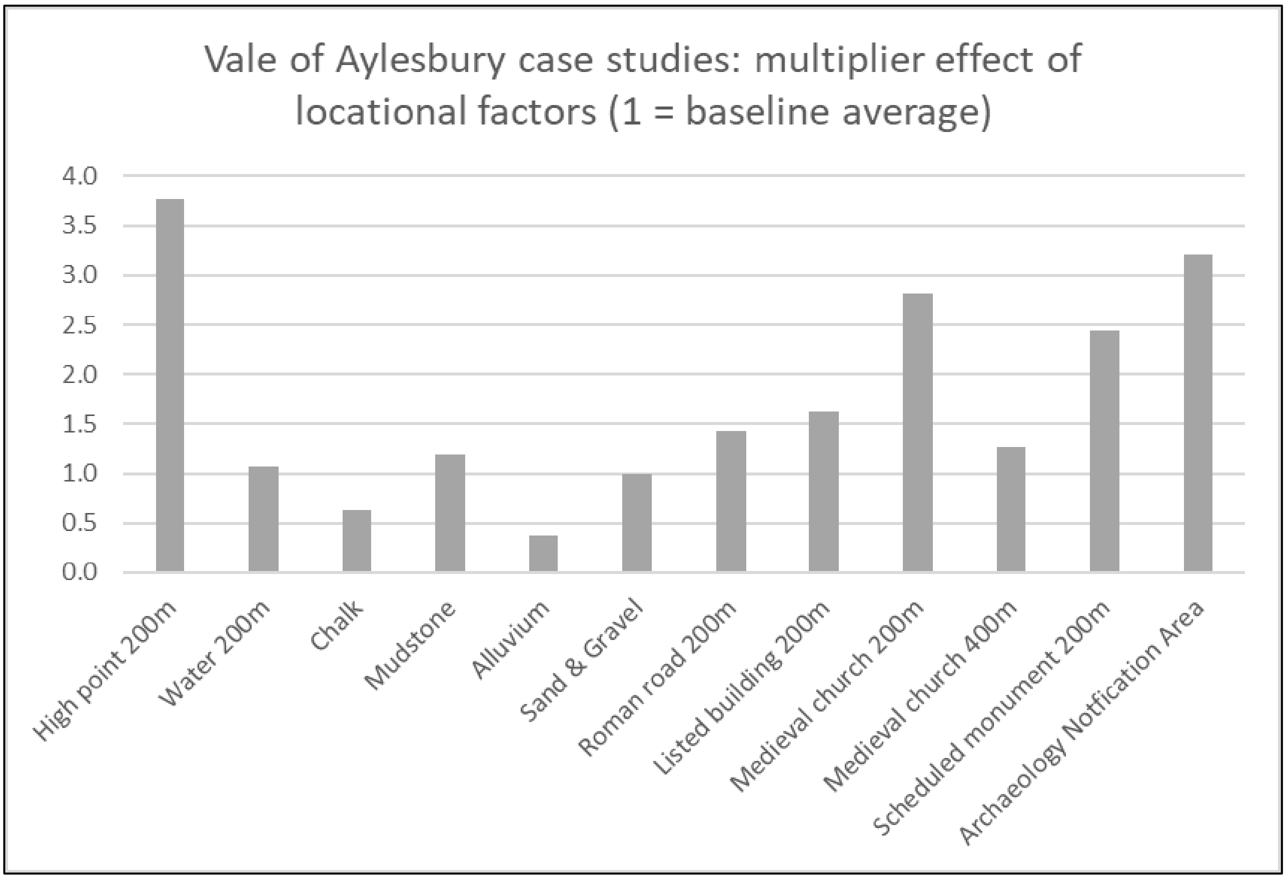

Figure 8.5: Effect of locational factors in the Vale of Aylesbury case studies

A number of case studies were also assessed for the London Gateway and are described in detail below (Appendix 3). Like the Vale of Aylesbury the London Gateway case studies returned an asset density of around 1 per 0.1 km^2 but the Bucks HER has only half the density of that in Essex. It seems possible that the lower visibility figure for the Vale of Aylesbury is largely explained by the relatively limited aerial mapping evidence – not just the lack of investigation to NMP standards but also less favourable geology and land use. It would certainly be interesting to see how much NMP-standard aerial mapping would add in this area.

8.5 Condition mapping

Having established that most of the English landscape has archaeological potential but the majority of assets have not yet been discovered, the third dimension of mapping the condition in which assets would be expected to survive comes into play. Essentially this means using spatial data on historic and modern land use, and selected geological data, to map defined categories of preservation. The main dataset used was HLC supplemented by information on the condition of known assets (where available), wetland geologies, soil geochemistry and modern land cover. A new schema for categorising condition was developed and tested applying codes for physical (structural) and chemical factors influencing the information content of the historic environment. This approach has several advantages:

- It avoids subjective terminology which can vary between practitioners.
- It enables recognition of areas of good preservation potential even if relatively little is known.
- It allows known condition to be coded on an asset-by-asset basis where that detail is available – although unfortunately it is notable that HERs do not always hold this information in a systematic or recoverable way.

Of course, the methodology only provides a model of the most likely condition of assets in a particular location. Local topography and land use factors will doubtless lead to some assets being in a better or worse condition than suggested by the model. The model provides idealised forms but in reality asset condition will vary around a norm and large assets will often display varying condition across their extent.

In both London Gateway and the Vale of Aylesbury only known 'upstanding' assets (built or earthwork sites) could be coded for condition; SHINE datasets are useful in this respect and easier to use than raw HER data. Although it was not possible to recover useful information on the condition of buried assets, in each study a systematic approach to coding HLC polygons for condition proved viable, with additional sub-division of the widespread 'enclosed fields' HLC type being achievable, partly using land cover data.

Potential areas of waterlogged deposits were identified from the geology dataset (alluvium, peat and estuarine deposits) and overlain on the physical preservation layer. In the Vale of Aylesbury the thin alluvium found in the upper reaches of the river Thame only occasionally seals waterlogged remains, whereas the much deeper deposits found in the

Lower Thames Valley have greater potential. The model could perhaps be refined in this respect, and potentially by use of the small wetlands toolkit[31].

Similar approaches were taken to develop models for Holderness and the Eden Valley. In the former area the inclusion of information on physical condition in the SHINE database was particularly useful, in combination with HLC and land cover data. However, there are also limitations, since the Humber Wetlands Project demonstrated that surviving wetland deposits were more fragmented than the BGS mapping of floodplain alluvium might indicate. The models therefore need to be taken as broad indicators of potential rather than predictions of where significant preservation will occur.

The most problematic part of the exercise was the idea that acidic dryland soils would yield a lesser range of evidence than basic or neutral soils, and that bone survival might act as a proxy for that effect. Attempts to map this effect using national soil-pH data were not successful and discussion with specialists discouraged progression of this idea. Nonetheless it is common experience and generally accepted that soils and geology do lead to different chemical survival conditions (Table 3.2). Many large excavation datasets now exist which could explore these correlations further.

The assembled London Gateway condition model drew a clear distinction between a coastal zone characterised by generally good preservation, a dryland agricultural zone characterised by intensive plough truncation and large areas degraded by modern development (Fig. 5.44). The Vale of Aylesbury model is much more locally varied and less polarised with more mid-range survival conditions, less degraded land but also smaller areas of exceptional preservation (Fig. 4.34). Holderness provides a similar patchwork with trends between the different broad character areas (Fig. 6.19) while the Eden Valley condition model is a combination of higher potential in the river valleys with trends in land-use. Further testing and calibration of these models is needed. The way they were created led to fragmenting into many sub-datasets (and a few ‘holes’ appearing), so the mechanics of HLC enhancement need improving.

8.6 Testing and refining the models

Since archaeological work is always proceeding across England and HERs are regularly augmented, so sensitivity models cannot remain static. Regardless of the mechanics of updating them (see section 9) they require checking and refinement in the light of new data. Much of this will be piecemeal but larger projects such as infrastructure works

[31] https://historicengland.org.uk/images-books/publications/toolkit-rapid-assessment-small-wetland-sites/

present opportunities for a more systematic approach. For the Vale of Aylesbury such an approach is demonstrated in the form of the HS2 test (4.8) which clearly demonstrated the broad validity of the sensitivity model, in terms of the number, location and condition of assets in the area. Meanwhile datasets from the Lower Thames Crossing and (potentially) the Carlisle Southern Link Road offer a chance for similar tests in other pilot areas in future.

For areas with less development-led archaeological data there are obvious limitations on the confidence we might have in a model, especially its quantitative aspects. We therefore need to ensure that the products from any given study are appropriate to the quality and quantity of archaeological data that have informed the model. We might also identify a need for specific programmes of HER enhancement and/or fieldwork that would provide value for money in terms of improving the value of a particular sensitivity model.

These considerations lead on to a broader set of recommendations for further work to develop the approach, which are outlined in the next section.

9 Conclusions and Next Steps

9.1 Summary

The pilot studies have demonstrated that sensitivity can be modelled as a combination of potential presence, condition and significance plus risk and/or opportunity. HLC (whether the standard approach with bespoke polygons or the NHLC grid) provides a useful framework for assigning values to areas of land, and moving beyond simple plots of known assets (helpful though those still are as a necessary starting point). The models show the importance of using cultural indicators alongside environmental ones as predictors for archaeological presence, demonstrating that predictive modelling is not simply a form of environmental determinism. The potential of HLC and related datasets for condition mapping needs recognition and further validation, however. Further exploration of the most appropriate statistical tests for different aspects of the model is also required.

The degree of confidence in a model varies depending on the quality and quantity of HER data (e.g. the availability of digital aerial mapping), as well as the number of large open-area excavations that can serve as case studies and/or tests of the model. What might be termed ‘background noise’ (or perhaps better ‘archaeological fingerprints’ of low-level activity: see Thomas and Darvill 2022) in some areas would have more significance in others where demonstrable assets are fewer – as non-assets they may have little influence on strategic planning decisions but would contribute to research agendas and, of course, help refine sensitivity models. However, some potential signatures of low-intensity land use, such as ploughzone artefacts, are not routinely recorded in current commercial archaeological practice.

The pilot study areas all measured between 150 and 300 km^2 in size (Aylesbury was larger than the others but benefited from the author’s familiarity with the area). This seems to be generally large enough for spatial patterning to be recognised and for subsets of the data (e.g. by period) to be large enough for simple statistical analysis. Anything smaller is unlikely to be reliable in these respects, while much larger areas would represent significant pieces of work and could result in an unhelpfully (for strategic planning) high level of generalisation – although the Eden pilot suggests that larger-scale studies might be appropriate for upland areas with lower densities of HER data. Fortunately these ideal case study sizes are in the same order of magnitude as the districts and boroughs for which local plans have been or are likely to be developed, so the approach should be suitable for the typical scale of plan-making. The advantage of working at a larger scale would be as a means of exploring the spatial limits of rules but larger studies are more likely to involve having to merge datasets from two or more HERs, inconsistencies between which would likely make cross-boundary studies more complicated.

However, the differences between the pilot studies in the types and quantity of available data demonstrate that there is no ‘one size fits all’ method for sensitivity mapping and at present no specific template for the kind of product that might be possible in a given area. Further thought is therefore required about the range of outputs that might be expected, and what a combined map of sensitivity might look like in different areas. For example, the Eden Valley – at least for some periods – may fail the basic precondition of these studies that the known is a reasonable basis for prediction of potential, although flagging up the limits of inference in each case is still valuable and will help frame the level of additional work that might be required to inform strategic planning. Table 9.1 summarises the datasets that have contributed to each model.

Table 9.1: summary of contributions to the models (brackets denote partial or limited data)

Dataset	***Vale of Aylesbury***	***London Gateway***	***Holderness***	***Eden Valley***
HER monuments	✓	✓	✓	✓
HER events	✓	✓	(✓)	(✓)
NMP-standard aerial mapping		✓	(✓)	✓
Development case studies	✓	✓		
HLC	✓	✓	✓	✓
NHLC			✓	✓
Geology & soils	✓	✓	✓	✓
Land use data	✓	✓	✓	

9.2 Issues, questions and recommendations

Despite the success of the sensitivity mapping approach in principle, many issues and questions remain, some our own (and often touched on in earlier sections), others raised by commentators on the approach and the models. These will require further work to address, and various recommendations are outlined here. The issues can be divided into a number of different areas, as set out below.

9.2.1 Building the model

The case studies have used different approaches and explored different aspects of the model in each case, while following the basic principles of taking into account presence, condition, significance and (albeit only to a limited extent so far) risk and opportunity. As mentioned above, some assessment is needed of whether a single step-by-step method can be defined or a more exploratory approach should be adopted to reflect the different character of the record in each area.

- What is the relationship of sensitivity to potential?

Sensitivity is rather loosely defined in a heritage context but the definition adopted here makes it clear that it should be defined contextually in relation to specific change scenarios. However the models so far have generally not gone beyond mapping presence, condition and significance. Together these three parameters might be described as archaeological potential, combining physical attributes and expert judgements. Sensitivity appears once opportunities and vulnerabilities or risks are added to the mix. Explaining this difference and the various components of the model is key to promoting acceptance of the utility of this kind of approach across the sector.

Recommendation 1: explain sensitivity mapping more widely (e.g. an article for HE Research) and ensure a consistent approach to terminology across different projects

- How should we combine presence, condition and significance?

The question remains of whether it is appropriate or helpful to present a single combined map of potential or to present the components as separate layers. The reduction of sensitivity to a single number or scale risks oversimplification but might be necessary for planning purposes (see 9.2.3). In particular there is a risk of different components conflicting or cancelling one another out. Alluvial landscapes like Holderness highlight this problem with likely a lower presence of remains but potentially better condition. Depending on whether we are more interested in quantity of remains (dryland cultivated gravels) or their quality (wetland) the components of the model could be weighted, but how to do this needs further consideration. The best ways to represent and merge condition, presence and significance have not yet been resolved, and the same goes for overall sensitivity, especially if quantity and quality do not correlate. The significance model in particular is poorly spatialised because research frameworks, with very rare exceptions, tend to be entirely textual documents with little reliance on digital mapping (see 9.2.2).

Recommendation 2: explore different approaches to the presentation of models

- How should 'assets' and other HER data be defined and valued/ weighted?

While there is no clear-cut definition of what constitutes a NDHA (see 3.2.3) some selection or weighting process is required to avoid potentially minor items (like single Roman coins) being given disproportionate weight compared to substantial assets (such as a Roman villa). In the Vale of Aylesbury these were filtered out using alert maps while in the other cases a review of HER monument records was required; the difference was that in Essex these were filtered out at the initial (presence) stage and in the northern case studies, where there was relatively less data, at the significance model stage.

Ultimately in a strategic planning context we are primarily interested in the protection or investigation of substantive heritage assets and there is a risk that the 'background noise' might obscure the actual signal. However, to easily filter out assets will usually require some HER enhancement (see below). Moreover, something like multiple coin records might be useful in defining hotspots within the background, such as potential 'persistent places' (cf. Daubney 2016). This also links to the question of whether presence is given too much weight at the expense of significance, and indeed whether the latter is adequately defined (see below).

Recommendation 3: develop protocols for filtering assets where alert maps/SHINE datasets are not available

- Can we model the likely condition of buried archaeology more systematically?

Condition is perhaps the most 'predictable' of the components of sensitivity if we have information on topography, geology, soils and land use, as existing guidance shows (see 3.2.2), although HERs do not always hold this information in a systematic fashion. However, there is complexity in terms of very local variation and especially in terms of the different components of the record: how do we combine the potential for earthwork survival, likely depth of features and survival of organic remains of different type in a single map? There is understandable reluctance, especially on the part of palaeoenvironmental specialists, around the development of a simple index of condition but there would be merit in exploring this further.

Recommendation 4: further discussion with specialists to assess potential for mapping survival patterns beyond wet versus dry

Recommendation 5: encourage archaeologists to adopt more objective assessments and descriptions of condition so judgements can be made relative to a norm and condition data fed into HERs and/or HLC

- How do we build in risk and opportunity?

As discussed, further work is required on methods for building a full sensitivity model that incorporates the variety of possible change scenarios. There is scope here for borrowing from the approach developed by Herring (2022) for using HLC in assessments of sensitivity, which can be summarised as:

1. Consideration of predictable effects and impacts of the change scenario, positive as well as negative
2. Assessment of the vulnerabilities and potentialities of the HLC Type in relation to the effects of the change scenario
3. Assessment of the significance of the heritage values of the Type in relation to the effects of the change scenario
4. Combination of assessments of impact, vulnerability and significance to present maps of and commentary on sensitivity and capacity.

In relation to this we can note that for archaeological sensitivity stages 2 and 3 can be combined since the model of potential has already been constructed. Also that, as noted above (1.1.2), the HLC model distinguishes sensitivity from capacity (the ability to accommodate change) which is perhaps a less nuanced category when it comes to buried archaeology, but could be linked to opportunity in our model.

Recommendation 6: work through specific model change scenarios for one or more of the pilot studies

- Can the modelling process be automated?

At present the model depends on expert judgement in terms of defining ‘assets’ and selecting subsets of the data for analysis. Variability in datasets like HLC and SHINE also make the condition models somewhat different in scope in different areas. Automation in general terms therefore looks difficult, but for given datasets ‘deep learning’ models that are increasingly available for GIS platforms could potentially offer a certain level of automation through machine learning. This might also allow a model to be kept up to date as new data is added to a HER, which is a key consideration.

Recommendation 7: scope potential applications of machine learning/artificial intelligence approaches

- How do we assess the appropriateness of the model for a given area?

Initial expert verification based on local knowledge is essential as a sense check. If testing data is available that did not influence the original model, as with HS2 in the Vale of Aylesbury (4.8), this can provide independent verification/correction of the model. But it is important to emphasise that any model is only appropriate for the area covered; it cannot simply be assumed that specific patterns of affordance or positive association continue for any distance beyond the area studied, though such an assumption might be strengthened by demonstrating the continuity of geomorphological or topographical features, or shared cultural characteristics identified through characterisation. The validity of National Character Areas as a framework for spatial rules could be explored, for example.

Recommendation 8: explore the spatial limits of rules identified for the pilot study areas

Recommendation 9: test the Lower Thames Crossing for London Gateway and Carlisle Southern Link Road for the Eden Valley

9.2.2 Dealing with data

The variable quality of what can be termed ‘characterful’ HER data (Cooper and Green 2016) is the main limiting factor for any modelling of archaeological potential that goes beyond simple environmental factors like geology and topography. That variability is caused both by the uneven distribution of previous work and the different ways in which things have been recorded over 200 or more years of archaeological endeavour. Some specific issues are expanded on here.

- How can biases from the uneven distribution of events be overcome?

The nature of archaeology is that research efforts have been and continue to be unevenly distributed so that the potential of some areas (at any scale) is much better understood than others. For example, all but one of the case studies assessed in the Vale of Aylesbury are located in one quadrant of the project area (Figure A1.1). There may be statistical methods of correcting for such sampling biases, while research frameworks might be used to recommend addressing some of the spatial bias introduced by patterns of development through academic or community projects, for example. The situation becomes easier to deal with, of course, if we consider that the patterns of development which produced the distribution of past archaeological work will continue to operate in the future.

Recommendation 10: explore statistical methods of correcting for sampling bias

- How should undated and unclassified records be utilised?

The proportion of unclassified records varies considerably, accounting for around 9% in the Vale of Aylesbury (ANAs),15% in Holderness, 29% in Essex and 40% in the Eden Valley. The high numbers in Essex relate primarily to the success of aerial photography in identifying archaeological features along with the difficulty in attributing reliable dating to many of them. The same goes for the Eden Valley, where the proportions are further bolstered by large numbers of undated quarries etc. In each case some analysis of what is being missed would be useful; for example, in the Eden Valley there appears to be a mutually exclusive relationship between the larger quarries and areas with ridge and furrow (Figs 7.11–12); attempting to map what was being extracted (e.g. connecting to building stone atlases[32]) might be a useful exercise. It should also be noted that alongside monuments of uncertain date, HER event records potentially indicate where monument records were not created because of difficulties with dating.

Recommendation 11: develop pilots and guidelines for assessing and utilising undated and unclassified records

- What are the key recommendations for enhancing HER data?

HERs need to map events as polygons where there is accurate modern data for large-scale interventions. HER classification of events is overcomplicated for this purpose and a high-level terminology similar to that used by EngLaId would be easier to use.

As per Recommendation 5, condition recording also ought to be improved, working from SHINE. An enhanced SHINE dataset would be a good alternative to a full alert map system, though it is recognised that SHINE itself is not recommended for use beyond its original purpose.

The importance of systematic digital aerial mapping has been shown by the London Gateway, Holderness and Eden Valley studies, though would be enhanced by targeted fieldwork to characterise and recover dating evidence from sites which cannot confidently be assigned to a period. The extent to which new mapping can contribute to the accuracy

[32] https://www2.bgs.ac.uk/mineralsuk/buildingStones/StrategicStoneStudy/EH_atlases.html

of a sensitivity model could be assessed by incorporating sensitivity mapping (before and after) into a current aerial investigation and mapping (AIM) project. The identification of areas with insufficient data for modelling, equivalent to 'Tier X' (3.4), would also provide a rationale for further prospection work, including aerial mapping.

Work to enhance HERs in order to improve sensitivity mapping could also be incorporated into a wider project to develop HER functionality within a digital planning system. Best-practice guidance and training could be used to facilitate a move from point to polygon-based data for events, aerial mapping records and other datasets.

Recommendation 12: trial a programme of HER enhancement akin to SHINE in a suitable area

Recommendation 13: incorporate sensitivity mapping into an AIM project, including condition assessment

- What is the impact of the selective nature of the NHLE?

The List Condition and Coverage Project (LCCP) gathered and reviewed data relating to variability in the quality and coverage of the National Heritage List (NHLE) across England, including Scheduled Monuments, and looked to identify needs in relation to corporate and government agendas. This revealed significant regional differences in the distribution of SMs and the quality of the record (e.g. the proportion of Old County Numbers [OCNs]) at a high level, as well as mapping sites against socioeconomic datasets, with the aim of identifying opportunities arising from major Government initiatives, such as priority areas for Levelling Up (Jamieson and Wormald 2021). There is considerable potential to build on the LCCP work in relation to sensitivity mapping, especially by interrogating the nature of the sites represented in the NHLE, not just their distribution and quality, and thereby considering the extent to which SMs are representative of the significance of the archaeological record in a given area. This could also help address the question of clarifying how 'non-designated heritage assets of national importance' are identified and mapped by HERs.

Recommendation 14: building on the LCCP, undertake further work to understand the character, representativeness and variability of the NHLE (SMs)

- What are the other contributors to the significance of an asset?

Academic or professional significance, as measured by designations and references in research frameworks, is of course only one way of considering how important an asset is (or indeed whether something constitutes an asset – see 5.6.2 etc). As *Conservation Principles* reminds us, there are other contributors to the value of heritage beyond the evidential, which might be assessed through public consultations, local lists (which are incorporated into HERs), neighbourhood plans and the like (community value, for example, is linked to the definition of 'opportunity' within the sensitivity model). We also need to consider the significance of remains in terms of their 'cultural heritage capital' value; the use of pseudo-financial terms is problematic in many ways but at least turns attention to the potential public benefit of archaeological features.

Assessments of significance are also contextually dependent on what sorts of things we are interested in finding out at any given time, criteria for which are set out in relevant research agendas; are things particularly sensitive or significant because they are rare in a given area or because they are common (and therefore contribute more to character)? Rarity is one of the principles of selection for SMs, but the DCMS policy statement says that 'a selection must be made of those monuments which best portray the typical and commonplace as well as the rare'.

Research frameworks might show, for example, that a ploughzone flint scatter would be the first indication of Mesolithic activity in a landscape and therefore of great significance despite its disturbed condition, while a Roman building, even if relatively well preserved, might be less significant if many such structures had previously been scheduled and/or investigated in the area. However, mapping the expected condition of remains will be useful in thinking about comparison between similar sites or between landscape areas – for example, both Mesolithic artefact scatters and Roman buildings will likely be better preserved in an uncultivated riverside meadow than in a sandy arable field. Developing a spatial aspect to research frameworks would be one way of addressing these points. There may also be potential for citizen science projects that will help build such models as well as engaging people with the historic landscape.

Recommendation 15: experiment with mapping cultural heritage capital and/or community values for archaeology

Recommendation 16: consider how research frameworks can inform significance, especially in spatialised form

- How do we unpick the contributions to sensitivity of different periods or layers, especially if one impacts another?

As an example, we might consider the question of how to assess the potential of areas with ridge and furrow, whether earthwork or ploughed down, given that while it provides a level of sensitivity in its own right, the ridge and furrow can also affect the survivial of earlier remains, either positively (protecting them from agricultural impacts) or negatively (the furrows impacting the earlier remains). Should these different sensitivities be summed or should only the uppermost or most evident layer be counted?

Recommendation 17: develop a method of summing multiple sensitivities

- What other datasets could be included?

The potential contribution of Portable Antiquities Scheme (PAS) and EngLaId data needs to be more fully assessed. The former can help provide evidence for other types of site (e.g. the 'persistent places' identified by Daubney [2016]) or suggest dating for cropmark sites. Meanwhile EngLaId and other 'big data' projects provide a kind of national background against which the density of archaeology of certain periods in any given study area can be judged. The current group of pilot studies all lie in areas mapped by EngLaId as of generally moderate to high affordance, with higher scores in the near vicinity (Fig. 9.1). The use of data from the Conservation of Scheduled Monuments in Cultivation (COSMIC) project, which provides a framework to assess the impact of arable cultivation, could also be explored in future. While HERs should include multiple datasets, not all available data is routinely incorporated at present.

The pilot studies explore the use of National Character Areas and local Landscape Character Assessments as structuring units for archaeological areas. The correlation between NCAs and other national characterisations (e.g. Roberts and Wrathmell 2002; 2003; Rippon *et al*. 2015; Smith *et al.* 2016) and their relationship to the concept of 'pays' could be explored further, while more attention could be given to LCAs as a means of structuring sensitivity maps, including further exploration of whether we would divide the landscape in the same way from an archaeological perspective (for example, in the Vale of Aylesbury there is an obvious distinction between the Chilterns and clay vale but the actual LCA boundary does not quite match the sensitivity model). However, there are also potential issues with the size of LCAs in some areas and the lack of associated digital data.

HLC already forms a component of the approach developed here but one further area of work would be to investigate the relationship between archaeological sensitivity mapping and sensitivity assessment of the visible historic landscape, which is based on characterisation data (Herring 2022; see 9.2.1). Despite the evident relationship the two approaches to sensitivity differ in more than simply being about different landscape 'layers'; for example, landscape sensitivity assessment lacks the predictive element that is inherent in the archaeological approach and potentially offers more positive opportunities for strengthening landscape character in a way that is rarely possible for degraded archaeology.

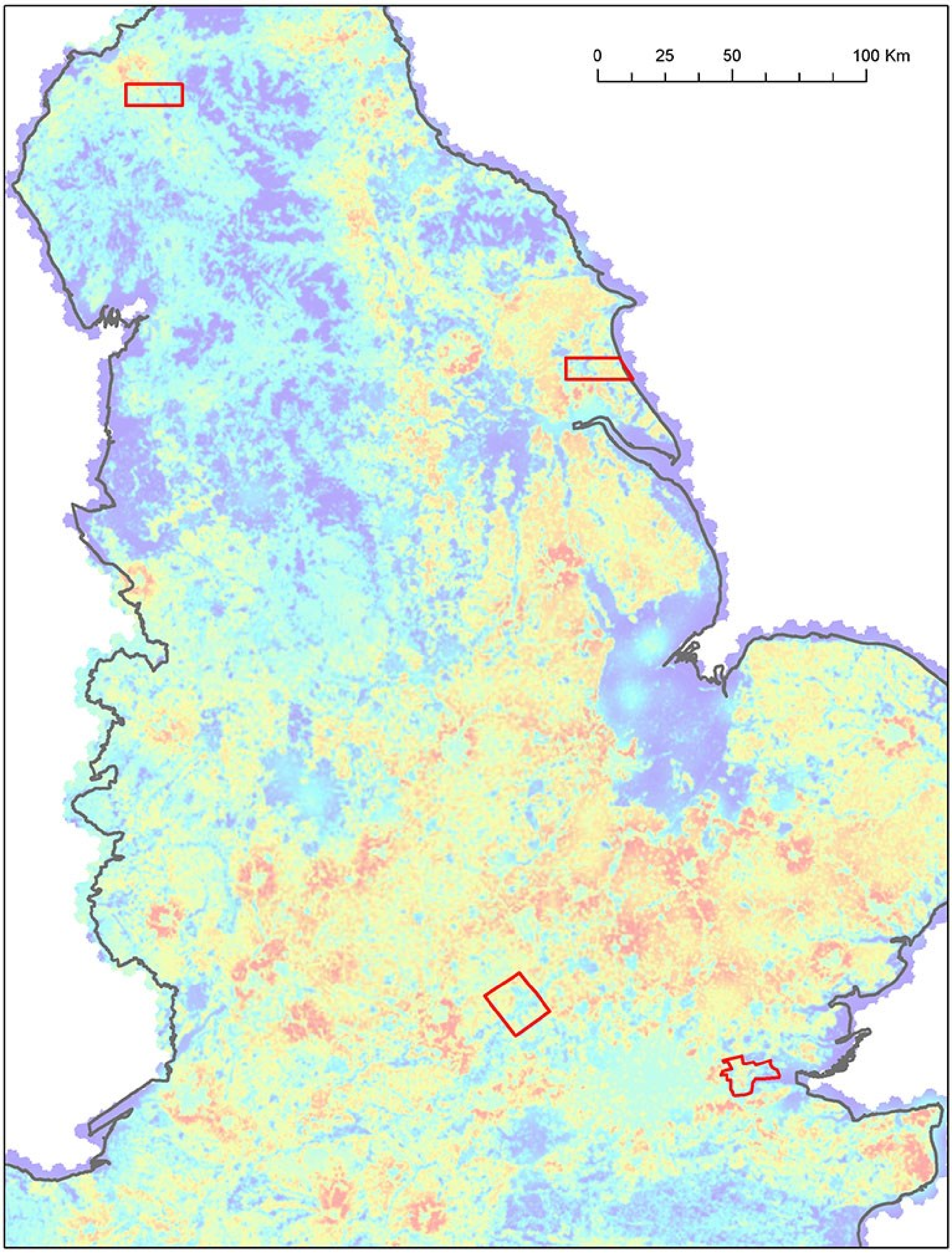

Figure 9.1: Pilot study areas (red outlines) in relation to the EngLaId monument affordance model

Recommendation 18: explore use of national datasets not routinely incorporated in HERs and provide recommendations on how they could be incorporated

Recommendation 19: consider whether/how to combine sensitivity assessments for historic landscape and archaeology

9.2.3 Using the model

Sensitivity modelling cannot simply be an academic exercise (interesting though it is in that respect, with obvious potential research contributions) but will only be of practical use if it can be embedded in planning (both the statutory planning process and that for other forms of landscape change). Therefore it needs to be comprehensible, useable and readily updatable. So far the emphasis has been on developing an evidence base rather than a model that can be used by non-specialists such as planners, environmental agencies or land owners. Building on Recommendation 1 above, work is required on how best to explain and present such models in a way that is useful to these audiences without losing the nuance that is essential when assessing sensitivity; their needs should be central to further model development. Consultation on sensitivity mapping needs to consider who the users are and what information they need, including the appropriate resolution or scale (e.g. for site allocations), when in the planning cycle it needs to be available, and how it is best communicated and presented. Specific points include whether there are geospatial techniques that would allow models to be used only at certain resolution levels e.g. for site allocations but not for individual planning applications, and if there is a stage in the plan-making process which should trigger sensitivity mapping exercises. Getting the scale and timing of models right will be central to their success.

- What are the lessons from other projects?

Following on from the SPARS project (2.2), there may be lessons to be learnt from understanding more about whether and how the outputs from other projects referred to in the review of previous work above (2.3) have been used in the development management process in these areas (if at all) and what benefits they have provided.

Recommendation 20: review the use of previous predictive modelling products in development management

- Is the model too complex for planners?
- How can we ensure sector buy-in?

There is a risk that these two questions are potentially in a zero-sum relationship, given what planners and curators respectively would like to see in a sensitivity model. While planners would prefer something like a traffic-light system that clearly distinguishes ‘proceed’, ‘proceed with caution’ and ‘no-go’ areas, that is unrealistic given the complexity and predictive element of the model, as well as the role of expert judgement. Conversely an issue of concern to many in the sector who are sceptical of the modelling approach is how we can be sure that zones characterised as ‘low probability’ or ‘low potential’ are really not interesting; for that reason such terms should be avoided (except for areas which are evidently massively damaged) as unexpected discoveries can come to light anywhere. Moreover, ‘off-site’ artefact distributions and even blank areas can be of great value in understanding the archaeological landscape but if not confirmed as such they will never be defined with any certainty. Incorporating biocultural heritage into models, such as areas of pasture or woodland (cf Fig. 2.11; and see Thomas and Darvill 2022, 10–11) may help with understanding and communicating the nature of the potential in ‘low probability’ areas.

Defining areas of low probability or sensitivity can therefore be a hostage to fortune and merely a means of reinforcing (untested) assumptions about the many sources of uncertainty inherent in these models, which include past behaviour, complex geomorphological processes, research biases and data quality. We could end up doing more of the same thing more of the time. The solution clearly lies in presenting products appropriately, perhaps, to borrow the Dutch phrase, as a means of improving the level of ‘knowledge for informed choices' in heritage management.

Recommendation 21: further consultation with potential users about communication and presentation of the models

- Can specific planning rules be attached to different sensitivity ‘tiers’?

Other things being equal, guiding developments towards locations likely to lie towards the lower end of the presence and condition ranges and away from those at the higher ends would seem desirable for archaeologists, planners and developers. However, there may be issues with being too dogmatic about the equation of rules with tiers or scales, especially if sensitivity is complex or fragmented. Such an approach also depends on the future of the planning system – the more it becomes rule-based and formulaic the less flexibility and scope there will be for site-based professional judgement.

Recommendation 22: explore the interface between sensitivity ‘tiers’ and planning rules

- How can the model be kept up-to-date or 'live'?

Unless automation becomes available (see 9.2.1) the models need to be adjustable as new data come in. HERs are inherently dynamic because they must be maintained so this will require a simple interface whereby a new HER entry can be compared with the model prediction and the relevant component(s) of the model adjusted accordingly on the map. Over time the baseline for the model will change so periodically more wholesale updates or verification will be required. This has some analogies with the use of OASIS data to update research frameworks[33], though that system is still being implemented and lacks a spatial framework at present.

Recommendation 23: explore processes for continual adjustment and model updates

- What is the business case/cost benefit for the sector?
- How will the work be funded?

The final point comes down to the bottom line – resources (not just money but also time). Sensitivity mapping would be an extra burden on curators and HERs, and certainly cannot be funded on a national basis by Historic England (covering the whole of England would cost perhaps £2 million, based on the time involved in preparing the pilot models). Fortunately the method could be rolled out according to need, as local plans are prepared or growth areas identified, while the possible advent of statutory HERs[34] could help with funding for such planning aids. In the end the business case will require some assessment of the value of the early models in cost-benefit terms, such as increased efficiency of the planning process for curators and/or developers. This may be possible initially in London, looking at how modernisation of the Archaeological Priority Area system has worked (Kidd 2017).

A cost-benefit approach could also be applied to the potential HER enhancements discussed above, such as polygonising event data or recording condition more systematically. Would such (relatively) minor enhancements have a disproportionate impact on the effectiveness of the models, for example allowing the development of more

[33] see https://historicengland.org.uk/research/support-and-collaboration/research-frameworks-typologies/research-frameworks/

[34] see https://www.archaeologists.net/news/statutory-hers-included-levelling-and-regeneration-bill-1652284835

quantitative approaches in the northern pilot areas, or testing and refining existing models in the southern pilot areas?

Recommendation 24: consider how to assess the efficiency of a model in avoiding unanticipated costs

9.2.4 Next steps

The above sections outline a large number of recommendations for further work. These can be grouped into priority, straightforward and longer-term objectives. Beginning with the key priorities, the next stage of work on sensitivity mapping will involve exploring how to implement each group.

Following consultation within Historic England, those recommendations seen as priorities are as follows:

- Recommendation 1: explain sensitivity mapping more widely
- Recommendation 4: further discussion with specialists to assess potential for mapping survival patterns beyond wet versus dry
- Recommendation 11: develop pilots and guidelines for assessing and utilising undated and unclassified records
- Recommendation 21: further consultation with potential users about communication and presentation of the models
- Recommendation 22: explore the interface between sensitivity 'tiers' and planning rules.

Other relatively straightforward next steps include:

- Recommendation 3: develop protocols for filtering assets where alert maps/SHINE datasets are not available
- Recommendation 6: work through specific model change scenarios for one or more of the pilot studies
- Recommendation 9: test the Lower Thames Crossing for London Gateway and Carlisle Southern Link Road for the Eden Valley
- Recommendation 12: trial a programme of HER enhancement akin to SHINE in a suitable area
- Recommendation 13: incorporate sensitivity mapping into an AIM project, including condition assessment

- Recommendation 14: building on the LCCP, undertake further work to understand the character, representativeness and variability of the NHLE (SMs).

Technical work that may also be reasonably achievable includes:

- Recommendation 2: explore different approaches to the presentation of models
- Recommendation 8: explore the spatial limits of rules identified for the pilot study areas
- Recommendation 10: explore statistical methods of correcting for sampling bias
- Recommendation 17: develop a method of summing multiple sensitivities
- Recommendation 20: review the use of previous predictive modelling products in development management
- Recommendation 23: explore processes for continual adjustment and model updates
- Recommendation 24: consider how to assess the efficiency of a model in avoiding unanticipated costs.

More lateral, exploratory work includes:

- Recommendation 15: experiment with mapping cultural heritage capital and/or community values for archaeology
- Recommendation 18: explore use of national datasets not routinely incorporated in HERs and provide recommendations on how they could be incorporated
- Recommendation 19: consider whether/how to combine sensitivity assessments for historic landscape and archaeology.

Longer-term aspirations include the following:

- Recommendation 5: encourage archaeologists to adopt more objective assessments and descriptions of condition so judgements can be made relative to a norm and condition data fed into HERs and/or HLC
- Recommendation 7: scope potential applications of machine learning/artificial intelligence approaches

- Recommendation 16: consider how research frameworks can inform significance, especially in spatialised form.

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Appendices

Appendix 1: Vale of Aylesbury case studies

Fourteen case studies have been used to assess the nature of archaeological remains revealed by evaluation and recording investigation in order to compare new discoveries against pre-existing knowledge (Table A1.1). The case studies were selected primarily from large greenfield developments (over 20 ha) known to the author and where reports were readily available. Eleven studies fell into this category whilst a further three examined much smaller investigations carried out in historic settlement cores. The fieldwork on greenfield sites was conducted over the last thirty years but that in the historic cores was done between the 1970s and mid-1990s. Of the eleven greenfield sites, five have published mitigation reports but the other six rely on evaluation results alone – it must be acknowledged that the latter may not entirely accurately characterise the archaeological resource but as this is the data available at the decision-making point it seems reasonable to include it with caveats. Due to the patterns of development and archaeological investigation all bar one of the case studies were located in the north-east quadrant of the study area around Aylesbury (Fig. A1.1). This skews the results both in terms of locality and indicators that can be assessed – for example the sites are predominantly on gravel or mudstone geologies.

Table A1.1: List of Vale of Aylesbury case studies

Case study	***Site name***	***Area (ha)***	***Type***	***Description***
1	Aston Clinton Bypass	31.9	Greenfield excavation	Evaluation and strip, map and sample/open-area excavations on rural trunk road scheme
2	Arla Dairy	54.7	Greenfield excavation	Evaluation and open-area excavation of industrial development
3	Weedon Hill	33.3	Greenfield excavation	Evaluation and open-area excavation of housing development
4	Aylesbury Old Town	0.6	Historic core	Excavation on town centre infill site
5	Fleet Marston	176	Greenfield evaluation	Geophysics and trial trenching of proposed housing development.
6	Berryfields	222.9	Greenfield excavation	Evaluation and strip, map and sample/open-area excavations on housing development

7	Park Mill Farm	21	Greenfield evaluation	Geophysics and trial trenching of proposed housing development. The only site not in NE quadrant.
8	Aston Clinton MDA	31.3	Greenfield evaluation	Earthwork survey, geophysics and trial trenching of proposed mixed-use development
9	Quarrendon Fields	80	Greenfield evaluation	Fieldwalking, geophysics and trial trenching of proposed housing development
10	Coldharbour Farm	40	Greenfield excavation	Evaluation and open-area excavation of housing development
11	Hampden Fields	220	Greenfield evaluation	Geophysics and trial trenching of proposed housing development
12	Aylesbury Woodlands	218	Greenfield evaluation	Geophysics and trial trenching of proposed housing development
13	Walton Village	0.8	Historic core	Multiple excavations on infill sites
14	Bierton Village	0.9	Historic core	Two excavations on infill sites

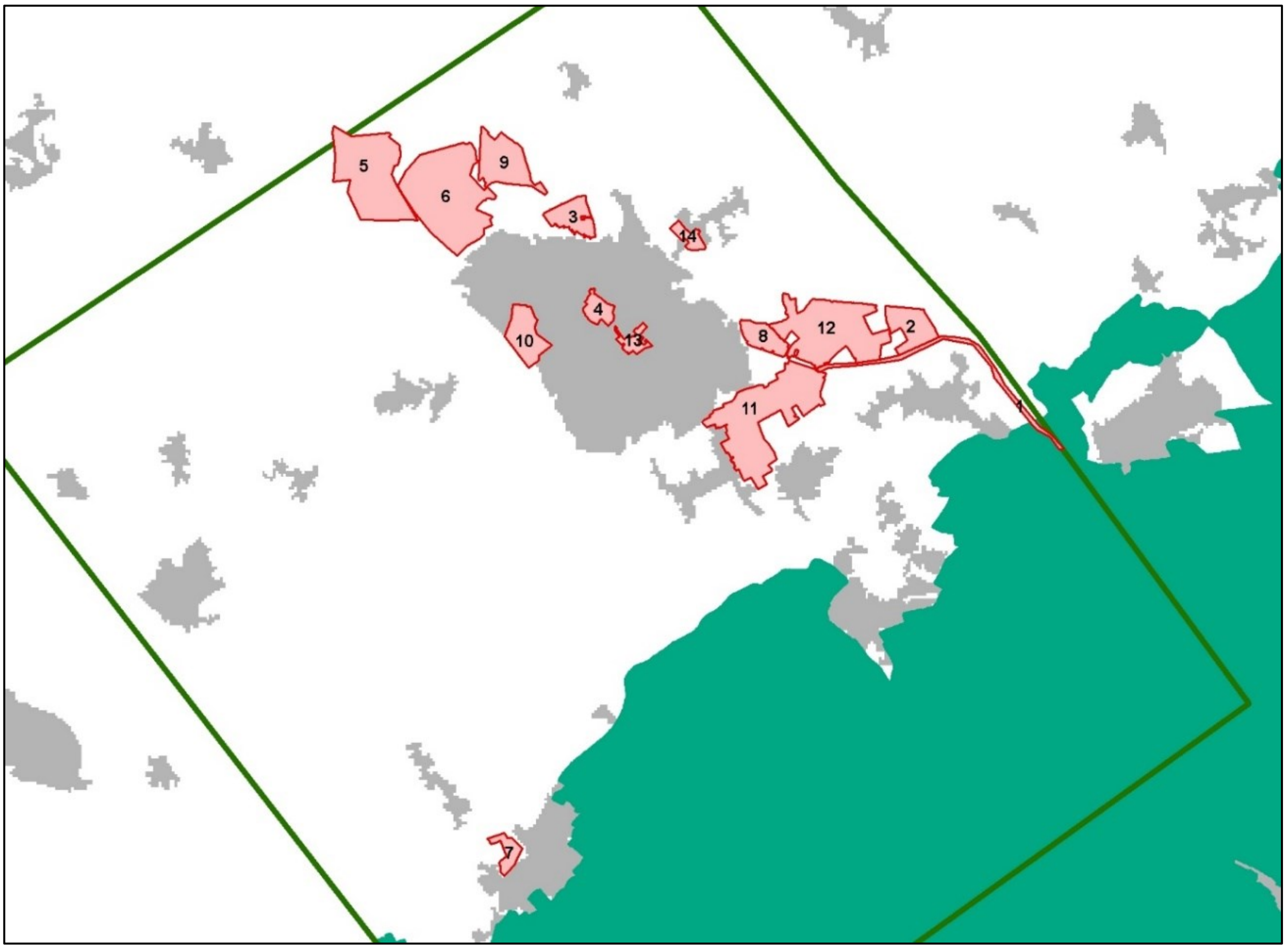

Figure A1.1: Location of Vale of Aylesbury case studies

For each site the areas covered by heritage assets were mapped and compared to possible indicators of archaeological potential (such as geology, proximity to Roman roads or SMs etc). The archaeology encountered was classified in terms of general period and type with particularly significant assets highlighted. This data is summarised in Table A1.2. The condition of assets was also recorded (Fig. A1.2).

Table A1.2: All assets encountered on case study sites

Vale of Aylesbury Case Studies Asset Periods and Types	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	1	0	1
Post-medieval	2	4	0	1	1	2	1	0	11
Late medieval	7	10	1	2	2	0	0	1	23
Early medieval	2	0	0	0	2	0	0	2	6
Roman	13	17	3	13	4	0	0	0	50
Later prehistoric (MBA/IA)	11	11	0	4	5	1	0	2	34
Earlier prehistoric (Neo/EBA)	1	0	0	0	1	0	0	5	7
Mesolithic	0	0	0	0	0	0	0	1	1
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	2	0	0	0	0	0	0	2	4
Total	38	42	4	20	15	3	2	13	137

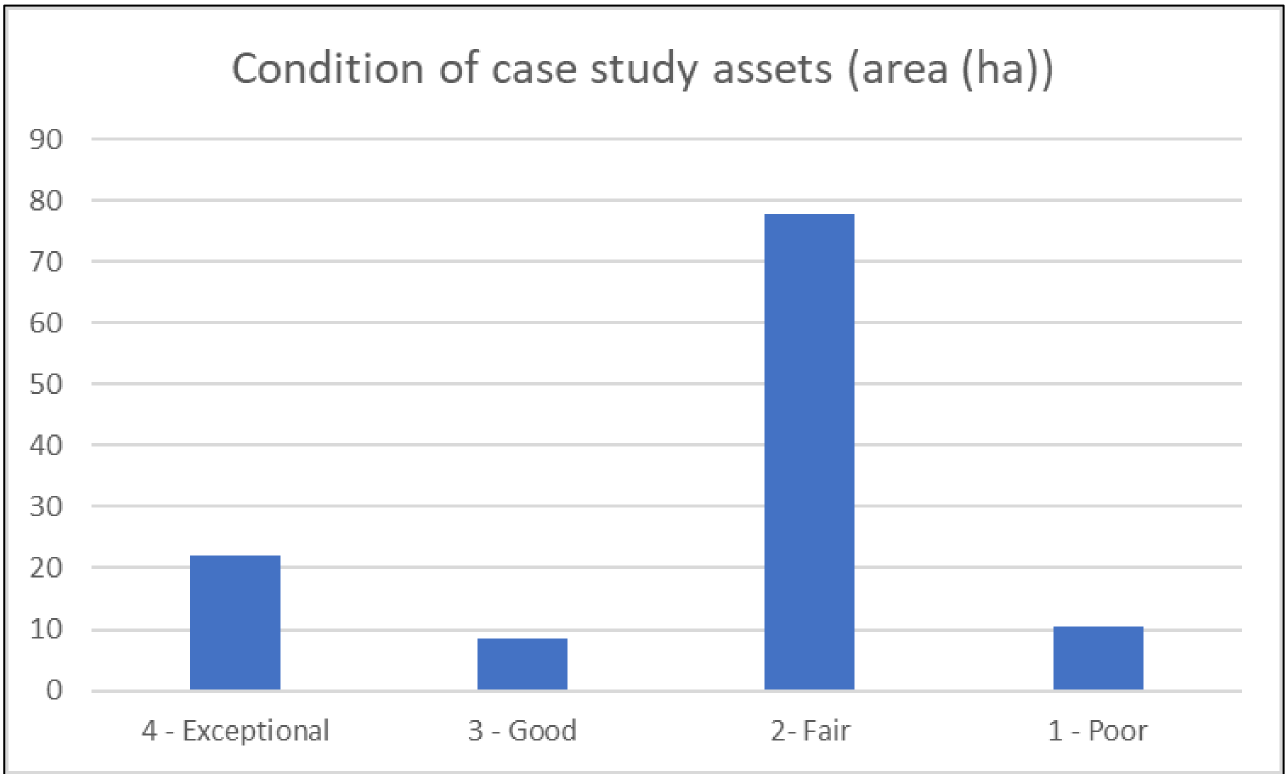

Figure A1.2: Condition of case study assets (ha per category)

All large greenfield case studies contained heritage assets of archaeological interest. This is believed to be representative and it is considered that few such sites over about 10 ha would be devoid of archaeological remains in this part of the country. The study showed that, overall, the proportion of each site covered by significant archaeology averaged 13.6%, varying from just below 5% to about 35%, with most cases falling between 5 and 20% (Fig. A1.3).

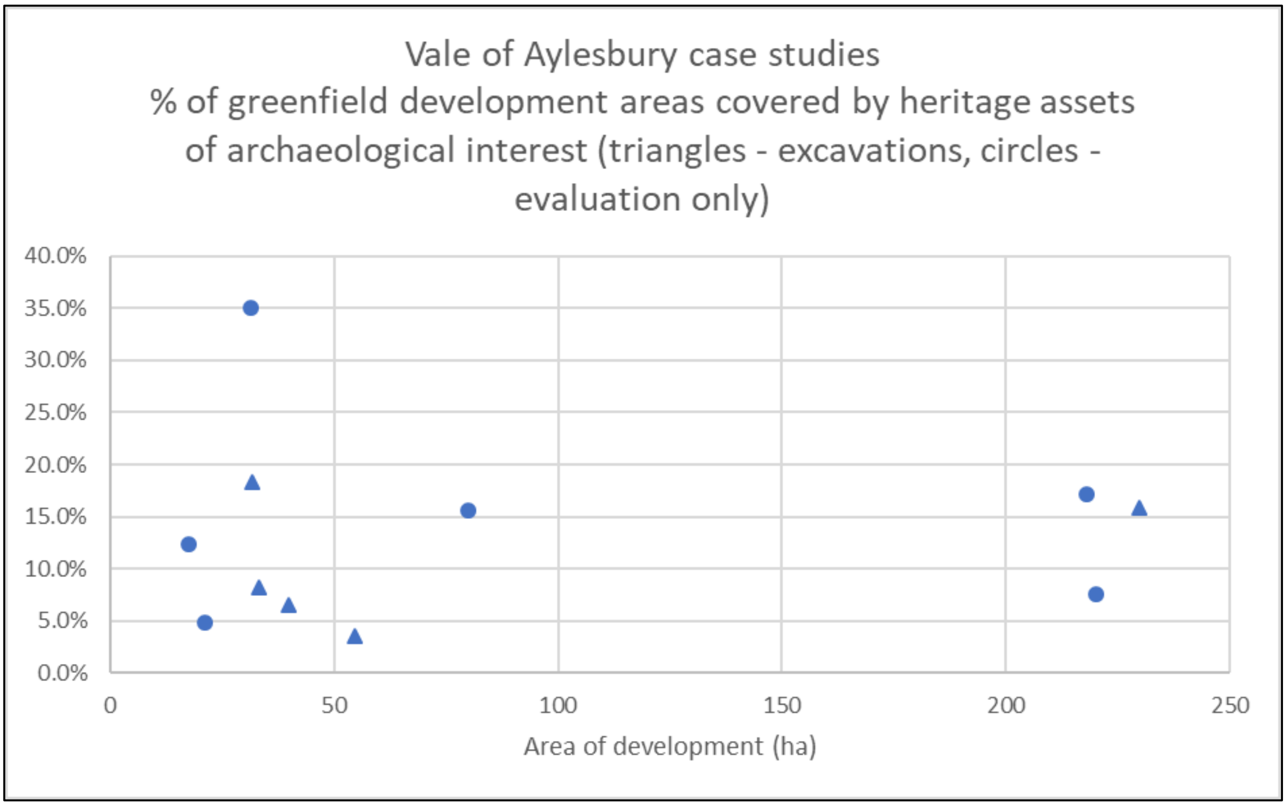

Figure A1.3: Percentage of development areas covered by heritage assets

Study of potential indicators has identified some which appear to correlate with a high incidence of archaeological remains in the case studies (Fig. A1.4). It can be seen that in the case study areas, location within archaeological notification areas (ANAs) and proximity to local high points, medieval churches and SMs all show strong positive correlations with archaeology, whilst proximity to Roman roads and listed buildings show more modest positive correlation. Alluvial deposits show a negative correlation but the other geologies represented, and proximity to watercourses, do not appear influential.

Other things being equal, guiding developments towards sites likely to lie towards the lower end of the presence and condition ranges and away from those at the higher ends would seem desirable for archaeologists, planners and developers.

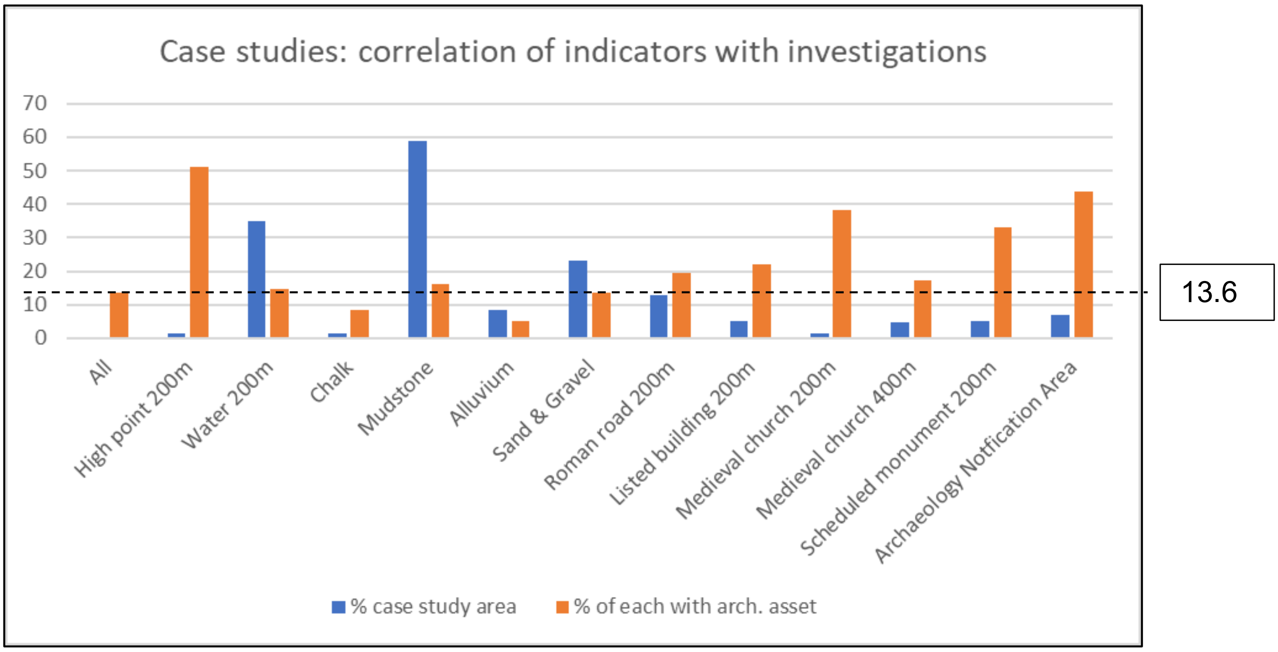

Figure A1.4: Correlation of archaeological remains with potential indicators (dotted line shows the average proportion of each site covered by archaeology)

Case Study 1: Aston Clinton Bypass

Development: 5.6 km road built 2001–2

Total area of impact: 31.9 ha

Physiographic indicators: 24.5 ha (76.8%) lie on Gault Mudstone and 7.4 ha (23.2%) on chalk – 6.5 ha (20.4%) on Lower Chalk and 0.9 ha (2.8%) on Sussex White Chalk. 9 ha (28.2%) lie within 200 m of a watercourse – a shallow spread of alluvium was noted in part of this area. There are no 'steep slopes' or mapped local high points although the southern end reaches the Chiltern scarp.

Cultural indicators: 4 ha (12.5%) lie within 200 m of Roman Akeman Street. None of the route lies within a conservation area (although one is adjacent for 360 m) or within 200 m of a listed building, but 2.4 ha lie within 200 m of a SM (a medieval moat) though this had no archaeology. The route came close to several ANAs but did not directly affect any.

Archaeological strategy: evaluation by geophysics, fieldwalking and targeted trial trenching followed by mitigation by excavation and watching brief. The results have been published (Masefield 2008). Overall the evaluation identified areas of interest but underestimated the periods and diversity of remains. Notably it failed to identify the late prehistoric shrine at Site A and early medieval cemetery at Site D.

Archaeological outcome (Table A1.3): three main sites (named A, B and D) were identified covering 5.8 ha (18.2%) of the route. Site A comprised the Roman road and a Late Bronze Age/Early Iron Age 'shrine'. Site B was a later prehistoric, Roman and post-Roman settlement alongside a trackway. Site D was a pagan Saxon cemetery. Each site had other remains of secondary significance ('background signature').

Table A1.3: Aston Clinton Bypass assets by period and type

Aston Clinton Bypass Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive	Uncertain or Other	Total
Modern	0	0	0	0	0	0	0	0
Post-medieval	0	0	0	1	0	0	0	1
Late medieval	0	2	1	1	0	0	0	4
Early medieval	0	0	0	0	1	0	1	2
Roman	1	1	1	2	0	0	0	5
Later prehistoric (MBA/IA)	1	2	0	1	2	0	0	6
Earlier prehistoric (Neo/EBA	0	0	0	0	0	0	0	0
Mesolithic	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0
Total	2	5	2	5	3	0	1	

All three sites were plough-truncated and in a broadly similar state of preservation, although Site D was probably more truncated, with graves and a few posthole structures surviving. Site B had localised stratigraphy surviving within a holloway and waterlogged material within a Roman waterhole. All three had fair to good survival of pottery, metalwork, bone and charred remains. This equates to Condition Code SB covering sites with shallow cut features and on basic soils but with limited survival of vertical stratigraphy and no more than localised anoxic deposits. For assessment purposes they all equate to Condition Level 2 (3.2.2).

Sites A (0.6 ha) and B (4.5 ha) were on Gault which had archaeology on 21.2% of its area. In reality both locations were more complex geologically as Site A lay on a thin spread of gravelly head while Site B lay at the interface of clay and chalk. Site D was on Sussex Chalk which had archaeology on 8.1% of its area.

Sites A and D were within 200 m of the Roman road; overall 32.5% of the development within 200 m of the road had archaeology. Site A was within 200 m of a historic watercourse, meaning that 6.7% of the development within 200 m of a watercourse had archaeology.

Most of the route lay within land classified by HLC as enclosed from open fields; furrows were observed on Sites A and B. In Site C, which lay within anciently enclosed land where there were no furrows, the cross-tree foundation of a windmill was found.

Most of the route, including sites A and D, lay within HLC types classified as having medium archaeological potential. Site D straddled four polygons categorised as low, low-medium, medium and medium-high potential. About half of the site lay within 'prairie fields' categorised as low potential but which actually contained the Roman waterhole.

Observations: the bypass route avoided known sites (both SMs and ANAs) and inhabited historic settlements. HLC potential was varied (mostly medium) and its historic period results based on historic mapping were consistent with this. Middle Bronze Age to early medieval remains were found at three sites, two of which lay within 200 m of Roman Akeman Street, but the third (and largest) did not lie in a location currently identified as 'favoured' by cultural or topographical indicators. However, it did lie on an historic parish boundary which has elsewhere been considered a significant indicator. The Gault mudstone produced a noticeably higher density of archaeology than the chalk. No significant early prehistoric remains were found.

Case Study 2: Arla Dairy

Development: industrial plant built on greenfield land from 2012. Arla Dairy lies alongside the Aston Clinton Bypass (case study 1).

Total area of impact: 54.7 ha

Physiographic indicators: 100% lies on Gault mudstone and 25.8 ha (47.2%) lie within 200 m of a watercourse .The site is generally flat and low-lying with no 'steep slopes' or local high points. It lay on a narrow ridge between infilled Pleistocene and Holocene channels indicative of at least seasonally swampy conditions.

Cultural indicators: none of the route lies within a conservation area or SM. In the north-east corner 3.6 ha (6.6%) lie within 200 m of a listed canal bridge (the canal forms the northern site boundary). The site does not include any ANA nor does it lie within 200 m of a Roman road. An historic parish boundary passes through the site.

Archaeological strategy: evaluation by geophysics and trial trenching followed by mitigation excavation the results of which have been published (Simmonds 2020). The evaluation successfully identified one area of interest with the remainder blank.

Archaeological outcome (Table A1.4): the excavation covered 1.9 ha (3.5%) of the development site. It comprised a Romano-British farmstead preceded by Late Iron Age agriculture and accompanied by a trackway and small burial ground. There was no later occupation but medieval ridge and furrow and a parish boundary were recorded.

Table A1.4: Arla Dairy assets by period and type

Arla Dairy Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive	Uncertain or Other	Total
Modern	0	0	0	0	0	0	0	0
Post-medieval	0	0	0	0	0	0	0	0
Late medieval	0	0	0	0	0	0	1	1
Early medieval	0	0	0	0	0	0	0	0
Roman	1	1	0	1	1	0	0	4
Later prehistoric (MBA/IA)	0	1	0	0	0	0	0	1
Earlier prehistoric (Neo/EBA	0	0	0	0	0	0	0	0
Mesolithic	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0
Total	1	2	0	1	1	0	1	

The site was not badly plough-truncated with structural remains well preserved beneath ‘dark earth’ midden or occupation deposits. It had fair to good survival of pottery, metalwork, bone and charred remains but poor land snail preservation. Despite the damp low-lying location no waterlogged remains were encountered. This equates to Condition Code VB, covering sites with vertical stratigraphy protecting shallow and surface features on basic soils and no more than localised anoxic deposits. For assessment purposes they all equate to Condition Level 3 (3.2.2).

Although the development site lay on Gault, in reality the location was more complex geologically due to superficial deposits. The entire development site lay within land classified by HLC as enclosed from open fields, and ridge and furrow is visible on aerial photographs across most of it but not the actual archaeological site, where the parish boundary bank followed the natural topography of the early Holocene channels. The entire site lay within HLC types classified as having medium archaeological potential.

Observations: the Arla Dairy site avoided known sites (both SMs and ANAs) and inhabited historic settlements. HLC potential mapping was medium and its historic-period results based on historic mapping were consistent with this. A fairly well-preserved Roman rural settlement was found in a location not currently identified as ‘favoured’ by cultural or topographical indicators. However, it did lie on an historic parish boundary which has elsewhere been considered a significant indicator. No significant early prehistoric remains were found. The overall density of archaeology seems rather low at only 3.5% of the site area compared to 21.2% on the Gault geology of the adjacent bypass. The only site may have occupied a locally preferable location within an otherwise unfavourable (boggy) landscape and its better than usual preservation may also reflect such micro-topographic factors.

Case Study 3: Weedon Hill

Development: residential build on greenfield land from 2004

Total area of impact: 33.3 ha

Physiographic indicators: 100% lies on Kimmeridge and Ampthill Clay with 8.9 ha (27.0%) within 200 m of a watercourse. The site is on a south-facing slope overlooking the River Thame with a local high point in its north-west corner – 3 ha (9%) lies within 200 m of this. It includes a shallow colluvial-filled coombe.

Cultural indicators: none of the route lies within a conservation area or within 200 m of a listed building. A scheduled DMV and post-medieval designed landscape lie immediately to the north-west: 3 ha (9%) of the site lie within 200 m of it. Prior to the site evaluation it lay adjacent to but not within the ANA covering the SM and some associated land. An historic parish boundary forms the western site boundary.

Archaeological strategy: evaluation by fieldwalking, metal-detecting, geophysics and trial trenching followed by mitigation excavation and metal-detecting. The results have been published (Wakeham and Bradley 2013). The evaluation successfully identified one area of interest, with the remainder producing a sparse scatter of 17th-century military equipment associated with a skirmish known as the ‘Battle of Aylesbury’.

Archaeological outcome (Table A1.5): the archaeological excavation covered 3 ha (9%) of the development site but only 2.7 ha (8.1%) contained archaeological features (excluding the low-density 17th-century artefact scatter). This comprised a small open Late Bronze Age/Early Iron Age settlement and field system and a Romano-British rural settlement with field system and malting. This site is known from geophysics to extend along an east-west ridge-line just to the north of the development site. There was no later occupation, but medieval ridge and furrow was recorded. The Romano-British malting was the most significant discovery.

Most of the site was badly plough-truncated but in a shallow infilled coombe structural remains of the malting were well preserved beneath colluvial deposits. It had fair to good survival of pottery, metalwork, bone and charred remains but poor land snail preservation. No waterlogged remains were encountered. The malting equates to Condition Code VB, covering sites with vertical stratigraphy protecting shallow and surface features on basic soils and no more than localised anoxic deposits whilst the rest of the site had been heavily truncated by medieval and modern ploughing, fitting Code = DFB for sites where only deeper cut features survive. For assessment purposes most of the site equates to Condition Level 1 (3.2.2) but protected within the coombe the RB malting was raised to Condition Level 3.

Table A1.5: Weedon Hill assets by period and type

Weedon Hill Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Uncertain or Other	Total
Modern	0	0	0	0	0	0	0	0
Post-medieval	0	0	0	0	0	1	0	1
Late medieval	0	1	0	0	0	0	0	1
Early medieval	0	0	0	0	0	0	0	0
Roman	1	1	1	0	0	0	0	3
Later prehistoric (MBA/IA)	1	1	0	0	0	0	0	2
Earlier prehistoric (Neo/EBA	0	0	0	0	0	0	0	0
Mesolithic	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0
Total	2	3	1	0	0	1	0	

The entire development site lay within land classified by HLC as enclosed from open fields and having medium archaeological potential, and ridge and furrow was found across the site.

Observations: the Weedon Hill site sat adjacent to known sites (both SMs and ANA) and avoided inhabited historic settlements. HLC potential was mapped as medium and its historic-period results based on historic mapping were consistent with this. A poorly preserved Roman rural settlement was found in a location identified as ‘favoured’ by cultural or topographical indicators. Part of the site (the malting) had better than usual preservation because of micro-topographic factors. No significant early prehistoric remains were found. A locally significant historical artefact scatter covered essentially the whole site at low density and presumably extends beyond its boundaries.

Case Study 4: Aylesbury Old Town

Development: piecemeal urban redevelopment in historic core; evidence principally from Prebendal site excavated in 1985 supplemented by a few other smaller investigations.

Total area of impact: 0.6 ha (multiple sites in town centre)

Physiographic indicators: 100% lies on Portlandian Limestone. The site is on a hilltop not within 200 m of a watercourse.

Cultural indicators: the site lies entirely within a conservation area and within 200 m of numerous medieval and post-medieval listed buildings, including the parish church. There are no SMs but the Old Town is an ANA flagged as of national significance due to the discoveries at Prebendal.

Archaeological strategy: Prebendal was a pre-PPG 16 ‘rescue’ excavation which is now published (Farley and Jones 2012).

Archaeological outcome (Table A1.6): the Prebendal excavation itself covered only 0.1 ha but contained a dense concentration of archaeological features. These comprised an unusual ritual bone deposit of Middle Iron Age date, a hillfort ditch with Anglo-Saxon recut, a Civil War defensive ditch and medieval/post-medieval domestic occupation. Further Iron Age occupation and Anglo-Saxon burials associated with the minster church are known across the Old Town. There are also slight traces of Early Bronze Age and Roman activity, and Akeman Street passes just to the east of the hilltop.

Table A1.6: Aylesbury Old Town assets by period and type

Aylesbury Old Town Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Uncertain or Other	Total
Modern	0	0	0	0	0	0	0	0
Post-medieval	1	0	0	0	1	1	1	4
Late medieval	1	0	0	0	1	0	0	2
Early medieval	0	0	0	0	1	0	0	1
Roman	0	0	0	0	0	0	0	0
Later prehistoric (MBA/IA)	1	0	0	0	1	1	0	3
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	1	1
Mesolithic	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0
Total	3	0	0	0	4	2	2	11

The site displayed a fairly typical ‘shallow urban’ character with extensive fragmentation of earlier periods by ‘intrusive’ later cut features. It had fair to good survival of pottery, metalwork, bone and charred remains but no waterlogged remains were encountered. Overall this equates to Condition Code VBF, covering sites with vertical stratigraphy protecting shallow and surface features on basic soils and no more than localised anoxic deposits but with extensive fragmentation by later intrusions. For assessment purposes the site therefore equates to Condition Level 2 (3.2.2).

The entire development site lay within land classified by HLC as historic settlement, which was confirmed by the presence of extensive medieval and post-medieval settlement features. Historic settlement is classified as high archaeological potential.

Observations: this is a different type of case study which provides a useful contrast to the large greenfield developments. Aylesbury Old Town is a well-defined complex of multi-period heritage assets occupying a local high point on an outcrop of permeable Portlandian Limestone. HLC potential mapping would identify this as a high-potential location which is consistent with the results. The hillfort, associated ritual bone deposit and early medieval re-use as a minster church (and documented sub-Roman British stronghold) elevates the location to national significance.

Case Study 5: Fleet Marston

Development: proposed residential development on greenfield land evaluated 2010–11.

Total area of impact: 176 ha

Physiographic indicators: the site has a small stream along its eastern boundary so 32.3 ha (18.4%) lie within 200 m of a watercourse. The site is on generally flat land but contains a pronounced knoll in its south-east corner on which sits the now isolated St. Mary's Church.

Cultural indicators: prior to the evaluation two ANAs covered the deserted village of Fleet Marston (25.6 ha) and the Roman 'small town' along Akeman Street (16.7 ha within the development area). None of the site lies with a conservation area or within 200 m of a SM.

Archaeological strategy: evaluation by geophysics, metal-detecting and trial trenching by Oxford Archaeology and PCA. Planning consent was not forthcoming and the results are only available in grey literature.

Archaeological outcome (Table A1.7): the archaeological evaluation covered the whole site identifying six areas of substantive remains plus a 'background signature' of Late Iron Age/Romano-British and medieval agriculture:

1. Fleet Marston Church (a grade II* standing medieval building and churchyard) and a surrounding outer enclosure covered 1.5 ha. The church and churchyard were identified for preservation so not trial-trenched; after evaluation the newly discovered outer enclosure was also identified for preservation as part of the church's setting.
2. A large Romano-British agricultural enclosure (animal pen?) covered 2.4 ha south of the church.

3 Fragmentary remains of the medieval village east of the church covering 2.6 ha.

4 Fragmentary remains of the medieval village south of Fleet Marston Farm (west of the A41) covering 1.4 ha.

5 A Romano-British roadside settlement stretched along Akeman Street and up a side road to Thornborough covering 7.3 ha within the development site and extending beyond it; this is the other end of the nucleated settlement investigated at Berryfields (case study 6). This site was identified for preservation so not trial-trenched.

6 Roman secondary road to Thornborough temple (1.9 ha).

Table A1.7: Fleet Marston assets by period and type

Fleet Marston Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	1	0	0	0	0	0	0	1
Late medieval	1	1	0	0	1	0	0	0	3
Early medieval	0	0	0	0	0	0	0	0	0
Roman	1	4	0	2	0	0	0	0	7
Later prehistoric (MBA/IA)	0	1	0	0	0	0	0	0	1
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	0	0
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	0
Total	2	7	0	2	1	0	0	0	12

Overall 11.8 ha (12.4%) of the proposed development area contained substantive archaeological assets. Most of the site was badly plough-truncated but better preservation was encountered around the churchyard. There was good survival of pottery, metalwork and bone but few charred plant remains. No waterlogged remains were encountered. The medieval church and churchyard itself equates to Condition Code = UB and Condition Level 4 (3.2.2). The outer medieval enclosure around the church equates to Code = VB and Condition Level 3. The Akeman Street roadside settlement was not evaluated so its condition was not established. The medieval village and Roman animal pen both appeared heavily plough-truncated so are assigned to Code = DB and Condition Level 1.

The north and west of the development site lay within land classified by HLC as prairie fields and most had formerly been land enclosed from open fields with ploughed-down ridge and furrow found across much of this area. The church field and that to the north of it was classified as irregular (ancient) enclosure without ridge and furrow. The north and west of the development site lay within HLC types classified as low archaeological potential whilst the south-east was medium-high.

Observations: as Fleet Marston has only been subject to evaluation conclusions must be provisional. The two ANAs did successfully identify the two main focal points – the Roman roadside settlement and the church – and just over 30% of their areas contained substantive remains – that is 64.3% of the archaeology on the site lay within the 24% identified as an ANA. Moreover, the HLC potential correctly identified the church field as having better preservation than elsewhere. The local high point and listed building predictors also highlighted this location whilst the Roman road buffer picked up that the roadside settlement might extend further along Akeman Street. The model also aligns with significance as association with the grade II* church enhances its outer enclosure. Both the church enclosure and roadside settlement engage with the national importance/significance issue. Flagging these issues early encouraged evaluation and sensitive mitigation measures which (had the development proceeded) would have provided significant heritage benefits to offset harm. Overall, an encouraging result!

Case Study 6: Berryfields Major Development Area

Development: residential development and related infrastructure built on greenfield land 2007–16

Total area of impact: 229.9 ha

Physiographic indicators: the southern and eastern site boundaries are defined by the River Thame and a tributary stream respectively: 79 ha (10.4%) of the development site lies within 200 m of a watercourse. The topography slopes gently upwards to local high points on its south-west side and a ridge along the northern boundary.

Cultural indicators: 24.5 ha (10.7%) lie within 200 m of Roman Akeman Street or a supposed secondary road (Margary 173a). The western side of Quarrendon SM (a DMV) abuts the eastern site boundary – 19.6 ha (8.5%) of the site lie within 200 m of the SM. By 2004 the part of the site south of the A41 was mostly covered by an ANA for Roman roadside settlement (19.8 ha) whilst a small area adjacent to the SM (3.5 ha) was in the Quarrendon ANA. The Quarrendon ANA was identified by Bucks HER as potentially of national importance because the county archaeologist had requested scheduling of ‘Fleet Marston Roman town’ in the 1990s but this had been declined on the basis of insufficient information. None of the site lies within a conservation area although it does contain a listed post-medieval farmhouse.

Archaeological strategy: evaluation by geophysics, fieldwalking (south of A41 only) and targeted trial trenching followed by mitigation by preservation in situ, excavation and watching brief. The results have been published by Oxford Archaeology (Biddulph *et al.* 2019). The evaluation proved broadly accurate although the Roman field systems were somewhat more extensive than anticipated as were isolated pits and graves. The Quarrendon SM and associated land was transferred to the Buckinghamshire Conservation Trust.

Archaeological outcome: five main sites (A to E) were identified plus more extensive field systems. In all archaeological interest was identified over about 36.3 ha (15.8%) of the development site.

Site A comprised Roman Akeman Street and a nucleated roadside settlement alongside it, including a few burials and a malting with waterlogged preservation. Roman bridge timbers were recovered from the river at the south-east end of the site. The road and settlement are known to extend further north-west as far as the HS2 route. Site A had a total area within the development of 9.8 ha and was mainly preserved in situ (7.2 ha) but part was excavated (2.6 ha).

Site B was detected by geophysics but remains undated as it lay on the northern fringe of the development site where it could be preserved in situ. It covered 9.9 ha and is probably either a Late Iron Age/Romano-British or medieval settlement.

Site C was a Romano-British ‘ladder settlement’ lining a side road that may extend north-west as far as Watling Street and Magiovinium (Fenny Stratford). It covered 2.7 ha of which 2.3 ha were preserved in situ.

Site D was a Middle Iron Age open settlement with a small enclosure, ditches, pit alignment and Late Iron Age/Romano-British. It covered 1.6 ha and was fully excavated.

Site E was detected by geophysics but remains undated as it lay in the western corner of the development site adjacent to Quarrenden SM where it could be preserved in situ. It covered 1.5 ha and is probably part of the adjacent medieval settlement.

A small area of extant ridge and furrow (1.8 out of 10.9 ha) adjacent to the SM was preserved in public open space.

Elsewhere on the site strip, map and sample and watching briefs recovered generally low-density RB field systems and trackways as well as ploughed-down ridge and furrow and a small post-medieval agricultural enclosure close to the SM.

Overall, substantive archaeological assets were found over about 36.3 ha, or 15.8% of the development site. Of this archaeology, 22.7 ha (62.5%) was preserved in situ and 13.6 ha (37.5%) recorded prior to loss.

All three sites that were investigated (A, C and D) were plough-damaged. Sites A and C had localised stratigraphy surviving associated with the road surfaces and Site A had good waterlogged survival with organic artefacts (including a basket of eggs!) and environmental data (insects etc) within a Roman pond. All three had generally fair survival of pottery, metalwork, bone and charred plant remains.

Site A had variable survival with shallow stratigraphy surviving from the road surface coded VB (Level 3) and exceptional anoxic survival in the pond coded VA (Level 4) but elsewhere plough truncation gives code SB (Level 2). Overall the site is probably towards the lower end of Condition Level 3 (3.2.2).

Site C had only limited investigation suggesting Condition Code = SB and Condition Level 2.

Site D was plough-truncated to the extent that few shallow features such as postholes survived. It is allocated to Condition Code = DB and Condition Level 1.

The ridge and furrow would be classified as Condition Code = UFB and Condition Level 3. The F rating records likely impact on buried remains.

Apart from a thin fringe of meadow alongside the Thame, the rest of the site lay on land classified by HLC as enclosed from open fields. Furrows were observed in most of the excavation areas but possible medieval settlement was located by geophysics adjacent to the SM (Site E) and (with less confidence on dating) at Site B. The HLC classification rated the meadow land as high potential, the land south of the A41 as medium archaeological potential (modern enclosure) and most of that north of the A41 as medium-high (historic irregular enclosure) except for a small area of medium potential across part of site B.

Observations: this is the most interesting case study which arguably presents a rare example of something like ‘archaeology net gain’ from development. Early identification of known assets through scheduling and a local ANA flagged high archaeological sensitively and triggered field evaluation early enough to influence design and achieve substantial preservation in situ for both previously known and newly discovered sites. Preserved sites were taken out of cultivation reducing long-term risk. In addition an entire adjacent SM and its immediate surroundings (c 100 ha) was brought into public management.

There are clear favoured locations on the local high ground, along the Roman roads and around the SM; notably the road to Magiovinium can now be relocated, improving its predictive power in future. Interestingly the arbitrary 20 m buffer around SMs compares fairly well with the actual site-specific sensitivity assessment and outcome. The arbitrary 200 m buffer around 'high points' needs refining but the concept appears useful in this location. By contrast geology is not such a good predictor of site location here. The waterlogged malting pond was found within 200 m of a watercourse but not under alluvium, suggesting that in some cases proximity to historic watercourses might be a useful way of picking up this potential.

Case Study 7: Park Mill Farm, Princes Risborough

Development: evaluation only of proposed greenfield residential development that did not gain consent.

Total area of impact: 21 ha

Physiographic indicators: the site is generally flat and low-lying with no 'steep slopes' or local high points. It lies just below the Chiltern scarp spring line with 5.2 ha (24.8%) within 200 m of a watercourse.

Cultural indicators: none of the site lies with a conservation area, listed building or SM. It does not include any ANA nor does it lie within 200 m of a Roman road.

Archaeological strategy: evaluation by geophysics and trial trenching; Wessex grey literature report only. The evaluation successfully identified one area of interest with the remainder apparently blank or very sparse background.

Archaeological outcome (Table A1.8): the evaluation identified a single Early/Middle Iron Age settlement covering c 1 ha (4.8%) of the development site. The southern part of the site was thought to have lain within a medieval park and royal stud farm for which there was no direct archaeological evidence but it might explain the apparent absence of ridge and furrow.

The site was not badly plough-truncated. Postholes, pits and stakeholes survived and there was fair to good survival of pottery, metalwork, bone and charred remains. No waterlogged remains were encountered. This equates to Condition Code = SB and Condition Level 2 (3.2.2).

The southern and central parts of the development site lay within land classified by HLC as prairie field and before that as irregular ancient enclosure enclosed from open fields. Prairie fields were considered to have low archaeological potential. The northernmost development field lay within land classified as sinuous enclosure created from open fields and assessed as having medium archaeological potential.

Table A1.8: Park Mill Farm assets by period and type

Park Mill Farm Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	0	0	0	0	0	0	0	0
Late medieval	0	0	0	0	0	0	0	0	0
Early medieval	0	0	0	0	0	0	0	0	0
Roman	0	0	0	0	0	0	0	0	0
Later prehistoric (MBA/IA)	1	0	0	0	0	0	0	0	1
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	0	0
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	1	1
Total	1	0	0	0	0	0	0	0	2

Observations: a rare example of a large greenfield case study away from Aylesbury. The evaluation identified a relatively low density of archaeology (4.8%) that was broadly as predicted by the DBA and geophysics. The attribution of low potential to prairie fields is problematic here as the site does not appear badly plough-damaged.

Case Study 8: Aston Clinton MDA

Development: evaluation only of proposed greenfield mixed-use development that began c 2019

Total area of impact: 31.3 ha

Physiographic indicators: the site is generally flat and low-lying with no ‘steep slopes’ or local high points. 22.5 ha (71.9%) lie within 200 m of the stream that marks the northern site boundary.

Cultural indicators: the site includes a scheduled medieval moat and 22.2 ha (70.9%) of the site either lie in the scheduled area or within 200 m of it. The north-west part of the site (31.3%, including the SM) is covered by a 9.8 ha ANA whilst 6.5 ha (20.8%) lie within 200 m of listed buildings (including a medieval barn) located outside the site. Akeman Street Roman road forms the southern site boundary, placing 11.7 ha (37.4%) of the site within 200 m of it.

Archaeological strategy: evaluation by earthwork survey, geophysics and targeted trial trenching. Archaeological Solutions grey literature report only.

Archaeological outcome (Table A1.9): the evaluation mapped earthworks of the moat, ridge and furrow, meadow channels and closes across the APA and confirmed medieval settlement along Boughton Lane, the western site boundary. The remainder of the site was apparently blank or sparse background. Overall, significant archaeology was present over 11 ha (35.1% of the site). The APA and SM were removed from the development area.

Table A1.9: Aston Clinton MDA assets by period and type

Aston Clinton MDA Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	0	0	0	0	0	0	0	0
Late medieval	2	1	0	0	0	0	0	0	3
Early medieval	0	0	0	0	0	0	0	0	0
Roman	0	0	0	0	0	0	0	0	0
Later prehistoric (MBA/IA)	0	0	0	0	0	0	0	0	0
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	0	0
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	0
Total	2	1	0	0	0	0	0	0	3

The APA in the north-western part of the site had extant earthworks and proximity to water indicating potential for waterlogged remains in deeper features (such as the moats). It is therefore assessed as Condition Code = either UA or UB and Condition Level 4 (3.2.2).

HLC records the whole site as parliamentary enclosure from open field, assessed as medium archaeological potential.

Observations: a site with multiple overlapping indicators proved to have a high incidence of significant archaeology flagged early by the SM and APA, enabling preservation in situ with development on the rest of the site. A 200 m buffer around the SM proves a good approximation for the sensitive area and almost all the archaeology lies within 200 m of a watercourse.

Case Study 9: Quarrendon Fields

Development: evaluation only of proposed greenfield residential development refused at appeal on archaeological grounds. The site was not allocated for development in the local Plan.

Total area of impact: 80 ha

Physiographic indicators: the site has a stream on its western side and rises gently to a ridge line to the north with no 'steep slopes' or mapped local high points. 21 ha (26.3%) lie within 200 m of the stream.

Cultural indicators: the site lies about 200 m north of a scheduled DMV and Tudor garden but only 2 ha (2.5%) of the site lie within 200 m of either. It is not in a conservation area and there are no listed buildings nearby, nor was there an ANA prior to evaluation. A secondary Roman road was thought to run further west but actually now appears to pass through the site.

Archaeological strategy: evaluation by fieldwalking survey, geophysics and targeted trial trenching. Albion and Stratascan grey literature reports only.

Archaeological outcome (Table A1.10): the evaluation discovered four linked archaeological areas (AZ2–5): two Late Iron Age/early Roman settlements, a banjo enclosure, agricultural/stock enclosures and a trackway. There was no earlier activity and only ploughed-down ridge and furrow and field boundaries for historic periods. Overall, significant archaeology was present over 15.6 ha (19.5% of the site).

Table A1.10: Quarrendon Fields assets by period and type

Quarrendon Fields Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	1	0	0	0	0	0	0	1
Late medieval	0	1	0	0	0	0	0	0	1
Early medieval	0	0	0	0	0	0	0	0	0
Roman	2	0	0	1	0	0	0	0	3
Later prehistoric (MBA/IA)	0	1	0	0	0	0	0	0	1
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	0	0
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	0
Total	2	3	0	1	0	0	0	0	6

Planning permission was refused due to setting impact on the SM to the south and harm to non-designated buried archaeology.

The site was under arable with trenches identifying differential preservation. Despite this the evaluation concluded that 'the sub-surface remains investigated by trial trenching are considered to be well preserved. However, given the shallow depths of the majority of remains, future ploughing will continue to cause damage.' Overall preservation was broadly Condition Code = SB and Condition Level 2 (3.2.2).

HLC records the whole site as irregular (pre-parliamentary) enclosure from open field, assessed as having medium-high archaeological potential.

Observations: a site with few indicators proved to have a fairly high incidence of significant archaeology representing one brief but intense episode. The evaluation noted dry ground in close proximity to water as an apparent attraction. The Roman road identified here indicates a likely error in the county Roman road dataset – had this road been identified elsewhere its projected alignment could have been a successful predictor.

Case Study 10: Coldharbour Farm

Development: excavation on a greenfield residential development in 1996 after fieldwalking and trial trenching (pre-PPG16 consent)

Total area of impact: 40 ha

Physiographic indicators: the site is low-lying between two streams on river gravel covered by a thin (<0.5 m) skim of alluvium. It has no 'steep slopes' or mapped local high points. All 40 ha lie within 200 m of a stream.

Cultural indicators: the site has no cultural indicators. It is not in a conservation area nor are there are any listed buildings, SMs or Roman roads nearby. The preserved part of the archaeological site (see below) was made an ANA after the investigation.

Archaeological strategy: limited pre-PPG16 evaluation by fieldwalking and targeted trial trenching followed by area excavation which is published (Parkhouse and Bonner 1997).

Archaeological outcome (Table A1.11): the evaluation discovered Iron Age and Early Saxon pottery but the subsequent investigation found no trace of the latter period. There is slight aerial photographic evidence for ridge and furrow. Open-area excavation (1.8 ha) uncovered a single Neolithic pit and tree-throws, an Early/Middle Iron Age open settlement, linear boundary ditch, enclosures and droveway. There was also a single Late Iron Age roundhouse and field system. Another part of the site (0.8 ha) was preserved in situ. However, remains extended beyond both these areas, indicating that the 2.6 ha (6.5%) of identified archaeology is an underestimate.

The site had been under arable but was partly protected by alluvium. No surfaces were found but shallow cut features (gullies and postholes) survived. Despite the promising location no waterlogged remains were encountered giving an overall Condition Code = SB and Condition Level 2 (3.2.2).

Table A1.11: Coldharbour Farm assets by period and type

Coldharbour Farm Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	0	0	0	0	0	0	0	0
Late medieval	0	1	0	0	0	0	0	0	1
Early medieval	0	0	0	0	0	0	0	1	1
Roman	0	1	0	0	0	0	0	0	1
Later prehistoric (MBA/IA)	2	2	0	1	0	0	0	0	5
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	1	1
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	0
Total	2	4	0	1	0	0	0	2	9

HLC records the whole site as within a larger area of modern settlement of mixed origin with low archaeological potential.

Observations: a site with few indicators proved to have a moderate (and probably underestimated) incidence of significant later prehistoric archaeology. The only indicators were proximity to a watercourse and gravel geology. HLC was completed a decade after the site's development so would not be expected to identify potential. However, the preserved area acts as a reminder that even 'low' potential HLC types can retain 'islands' of significant archaeology.

Case Study 11: Hampden Fields

Development: evaluation of a large proposed greenfield residential development.

Total area of impact: 220 ha

Physiographic indicators: the site is on nearly flat land traversed by a stream – 78.5 ha (35.7%) of the development lie within 200 m of a watercourse. It has no 'steep slopes' or mapped local high points.

Cultural indicators: the site has few cultural indicators. It is not in a conservation area nor are there are any listed buildings or SMs within 200 m. Roman Akeman Street forms the north-eastern site boundary and 19.3 ha (8.8%) of the site lie within its 200 m corridor.

Archaeological strategy: evaluation by geophysical survey and targeted trial trenching. Grey literature reports only, no further investigation yet.

Archaeological outcome (Table A1.12): the evaluation found four previously unknown substantive assets interpreted as a Romanised farm (7.4 ha), an Iron Age banjo enclosure

(0.9 ha) and two areas of Iron Age/Roman enclosures (probably agricultural and settlement covering 5.6 and 2.6 ha). Overall the evaluation indicated that substantive archaeology covered 16.5 ha (7.5%) of the site. The Romanised farm was identified for preservation in situ under a school playing field. Ploughed-down ridge and furrow covered most of the site.

Table A1.12: Hampden Fields assets by period and type

Hampden Fields Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	0	0	0	0	0	0	0	0
Late medieval	0	1	0	0	0	0	0	0	1
Early medieval	0	0	0	0	0	0	0	0	0
Roman	1	2	0	1	0	0	0	0	4
Later prehistoric (MBA/IA)	1	1	0	1	0	0	0	0	3
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	0	0
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	0
Total	2	4	0	2	0	0	0	0	8

No waterlogged remains were encountered giving an overall Condition Code = SB and Condition Level 2 (3.2.2).

HLC records most of the site as parliamentary enclosure from open fields of medium archaeological potential.

<u>Observations</u>: the standout asset is an enclosed Romanised farm with stone buildings and a ‘fort-like’ plan-form. Lack of evidence for hypocaust or mosaics precluded positive identification as a villa, although a simple cottage villa is possible. Notably it occupied an outcrop of gravelly head deposit. A question arises as to whether such a site can be considered equivalent to a SM.

Case Study 12: Aylesbury Woodlands

<u>Development</u>: evaluation of a large proposed greenfield residential development.

<u>Total area of impact</u>: 218 ha

<u>Physiographic indicators</u>: the site is flat and low-lying, traversed and bounded by streams. 77.1 ha (35.4%) of the site lie within 200 m of a watercourse. The geology is mapped as Gault mudstone but in reality proved more complex (see below).

<u>Cultural indicators</u>: the site has few cultural indicators. It is not in a conservation area nor are there are any listed buildings or SMs within 200 m. It lies just north of Roman Akeman

Street with 19.3 ha (8.9%) of the site within its 200 m corridor. Prior to evaluation the site only contained one small ANA of 0.6 ha adjacent to the Woodlands Roundabout site covered by the Aston Clinton Bypass case study.

Archaeological strategy: MOLA evaluation by geophysical survey and targeted trial trenching. Grey literature reports only (Simmonds 2016), no further investigation yet.

Archaeological outcome (Table A1.13): the evaluation found four previously unknown substantive assets interpreted as a Romano-British farmstead with agricultural enclosures and trackway plus Late Bronze Age/Early Iron Age finds (Site B: 4.6 ha), another Romano-British farmstead (Site C: 9.1 ha), a Romanised farm/villa and field system (Site D 17.7 ha), and a Roman mortuary enclosure and field system (Site F: 5.8 ha). Overall the evaluation indicated that substantive archaeology covered 37.2 ha (17.1%) of the site. Ploughed-out ridge and furrow was recorded across most of the site.

Table A1.13: Aylesbury Woodlands assets by period and type

Aylesbury Woodlands Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	1	0	0	0	0	0	0	1
Late medieval	0	1	0	0	0	0	0	0	1
Early medieval	0	0	0	0	0	0	0	0	0
Roman	3	4	0	1	1	0	0	0	9
Later prehistoric (MBA/IA)	1	1	0	0	0	0	0	1	3
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	0	0
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	0
Total	4	7	0	1	1	0	0	1	14

The site is under arable. No waterlogged remains were encountered. Whilst a substantial quantity of animal bone was recovered (1567 fragments), its condition was mostly poor. Only low densities of charred plant remains were found. Sites B, C and F had suffered shallow plough truncation giving an overall Condition Code = SB and Condition Level 2 (3.2.2). Outlying parts of site D were in similar condition but the settlement core (4.5 ha) had surface deposits covering cut features so would be classified as Condition Code = VB and Condition Level 3.

In relation to site location the evaluation report observed that: 'The natural substrate broadly fell into two types; the free-draining coarse flint gravels with sands and the heavy clays more likely to hold water. Interspersed with these were areas of alluvial channel deposits, notably in the central part of the site… The major sites were Sites B, C and D and all were located on sands and gravels as opposed to the unforgiving glacial clays around Site F and on land to the east of College Road North.'

HLC records most of the site as parliamentary enclosure from open fields of medium archaeological potential.

Observations: the MOLA evaluation report is commendably well structured and helpful in considering site location and preservation conditions – microtopography is again flagged as a significant factor but this detail could not be identified from the 1:50,000 geology maps. Three of the four sites are close to historic watercourses. Neither proximity to the SM nor the small ANA proved useful predictors. The geophysical survey provided a good indication of the main sites confirmed by evaluation. Prehistoric activity was limited with nothing pre-Late Bronze Age whilst post-Roman land use was purely agricultural. The standout asset is a probable villa with robbed-out stone buildings, tesserae, painted wall plaster and CBM. The condition of the core area is fairly good so the question arises as to whether the site can be considered equivalent to a SM.

Case Study 13: Walton Village

Development: piecemeal urban redevelopment in historic core, evidence from excavations from 1970s on.

Total area of impact: 0.8 ha (open area excavation of multiple sites)

Physiographic indicators: the site is low-lying alongside the Bear Brook stream – 50% of the excavated areas are within 200 m of this watercourse.

Cultural indicators: Walton has a conservation area but the excavated areas are outside it, though all of them lie within 200 m of it and post-medieval listed buildings. There are no SMs but Walton was an ANA (now much reduced due to extensive archaeological clearance).

Archaeological strategy: mainly pre-PPG 16 excavations, some unpublished but summarised in Ford (2004) and Dalwood *et al*. (1989).

Archaeological outcome (Table A1.14): the main findings have been a Middle-Late Bronze Age open settlement of post-built roundhouses and a Middle Saxon settlement of mainly post-built halls and SFBs. The Mesolithic and Early Bronze Age are represented by a few unstratified finds. Roman field boundaries and 11th-12th century stone structures are also present.

Table A1.14: Walton Village assets by period and type

Walton Village Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	0	0	0	0	0	0	0	0
Late medieval	1	0	0	0	0	0	0	0	1
Early medieval	1	0	0	0	0	0	0	0	1
Roman	0	1	0	0	0	0	0	0	1
Later prehistoric (MBA/IA)	1	0	0	0	1	0	0	0	2
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	1	1
Mesolithic	0	0	0	0	0	0	0	1	1
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	
Total	3	1	0	0	1	0	0	2	7

The sites displayed a fairly typical ‘shallow urban’ character but without much fragmentation by ‘intrusive’ later cut features. The Walton Lodge site had ‘dark earth’ deposits and stone structures over cut features. There is fair to good survival of pottery, metalwork, bone and charred remains but no waterlogged remains were encountered. Overall this equates to Condition Code VB, covering sites with vertical stratigraphy protecting shallow and surface features on basic soils and no more than localised anoxic deposits. The Orchard site lacked this vertical stratigraphy so would fit Condition Code = SB.

For assessment purposes Walton displays both Condition Level 2 and Level 3 (3.2.2). Most of the Walton sites lie within land classified by HLC as historic settlement and high archaeological potential. One site lies within land classified by HLC as modern settlement and low archaeological potential since its redevelopment.

Observations: Walton is another historic settlement-core case study demonstrating unexpectedly deep time-depth. Like Aylesbury Old Town, Walton lies on permeable Portlandian Limestone.

Case Study 14: Bierton Village

Development: infill development in historic village core.

Total area of impact: 0.9 ha (evaluation and open-area excavation of two sites)

Physiographic indicators: the site is on a Portlandian Limestone ridge but the local high point is 500 m to the north-north-west.

Cultural indicators: Bierton has a conservation area but the excavated areas are outside it though all of them lie within 200 m of the listed medieval church. There is also a scheduled moat within 200 m. Bierton ANA (now reduced due to archaeological clearance) is flagged as potentially of national importance.

Archaeological strategy: trial trenching and subsequent excavation, the latter carried out at Church Farm by Tempus Reparatum in 1996 (unpublished). Earlier small-scale investigation in the vicarage garden (Allen 1986).

Archaeological outcome (Table A1.15): settlement remains of Bronze Age, Iron Age, Saxon and medieval date and remains of a Late Neolithic/Early Bronze Age barrow were found during the Church Farm excavation. The vicarage garden produced a possible Roman villa with high status Late Iron Age and subsequent Saxon occupation.

Table A1.15: Bierton Village assets by period and type

Bierton Village Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	1	0	0	0	0	0	0	0	1
Late medieval	1	0	0	0	0	0	0	0	1
Early medieval	1	0	0	0	0	0	0	0	1
Roman	1	0	0	0	0	0	0	0	1
Later prehistoric (MBA/IA)	1	0	0	0	0	0	0	0	1
Earlier prehistoric (Neo/EBA)	1	0	0	0	1	0	0	1	3
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	
Total	6	0	0	0	1	0	0	1	8

The sites displayed a fairly typical 'shallow urban' character but without much fragmentation by 'intrusive' later cut features. For assessment purposes Bierton displays both Condition Level 2 and (for the vicarage gardens, which had intact stratigraphy and good material preservation) Level 3 (3.2.2).

Bierton vicarage lies within land classified by HLC as historic settlement and high archaeological potential, whereas the larger Church Farm site lies within land now classified by HLC as modern settlement and low archaeological potential since its redevelopment.

Observations: Bierton is another historic settlement-core case study demonstrating unexpectedly deep time-depth, including (unusually) a Neolithic/Early Bronze Age burial monument. Like Aylesbury Old Town and Walton it lies on permeable Portlandian

Limestone and has other indicators, notably proximity to the medieval church and a SM. The area has clear potential for nationally important archaeology, most obviously a villa, but there would not be sufficient information to designate anything more than the medieval moat at present.

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Appendix 2: Condition coding steps and rules (Vale of Aylesbury)

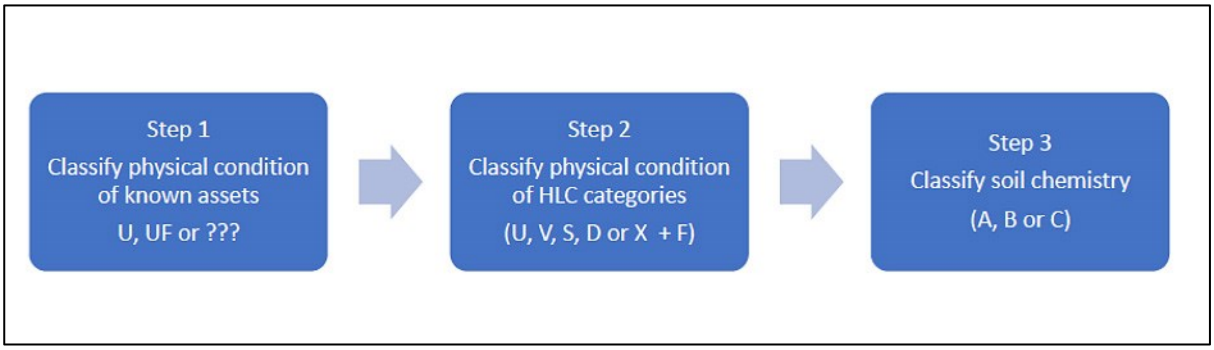

Figure A2.1: The three steps of the condition coding process

Step 1a: For known assets physical condition can be derived from or added to alert and SM maps (Table A2.1; Fig. A2.2)

Table A2.1: Classification of known assets (for steps see Fig. A2.1)

Classification of form of known assets from ANA alert maps with equivalent physical condition code	
built	Built-up area with buildings and structures of archaeological interest as well as below-ground deposits Code = U move to step 3
land	Landscapes with upstanding structures, landforms or managed vegetation of archaeological interest as well as below-ground deposits Code = U move to step 3
ewk	Visible earthworks, occasionally with ruined structures Code = U move to step 3
flat	Buried remains with minimal or no visual component Code depends on HLC move to step 2
finds	Findspot(s) only Code depends on HLC move to step 2
doc	Documentary reference only Code depends on HLC move to step 2

Step 1b: For extant ridge and furrow (mapped from APs for Turning the Plough in 1997) Code = UF (F indicating fragmentation of earlier remains) then move to step 3 (note that land cover and modern mapping and aerial photographs could be used to remove ridge

and furrow lost since the early 1990s but would require manual adjustment so was not done for this study).

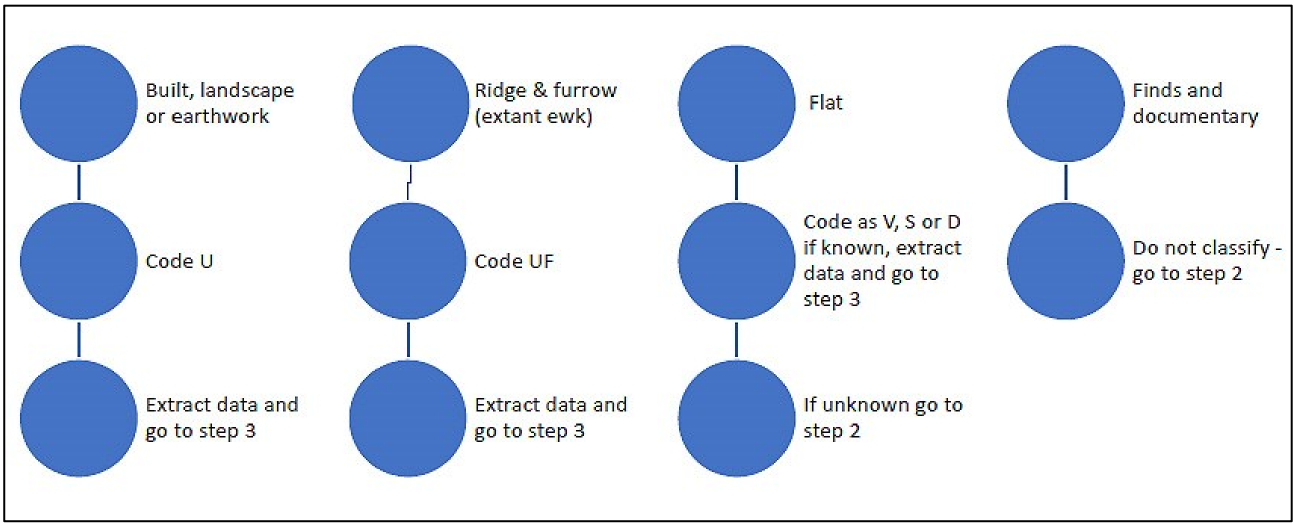

Figure A2.2: Step 1 – classify physical condition of known assets

Step 2: Coding physical condition of HLC Broad and Type categories (Fig. A2.3)

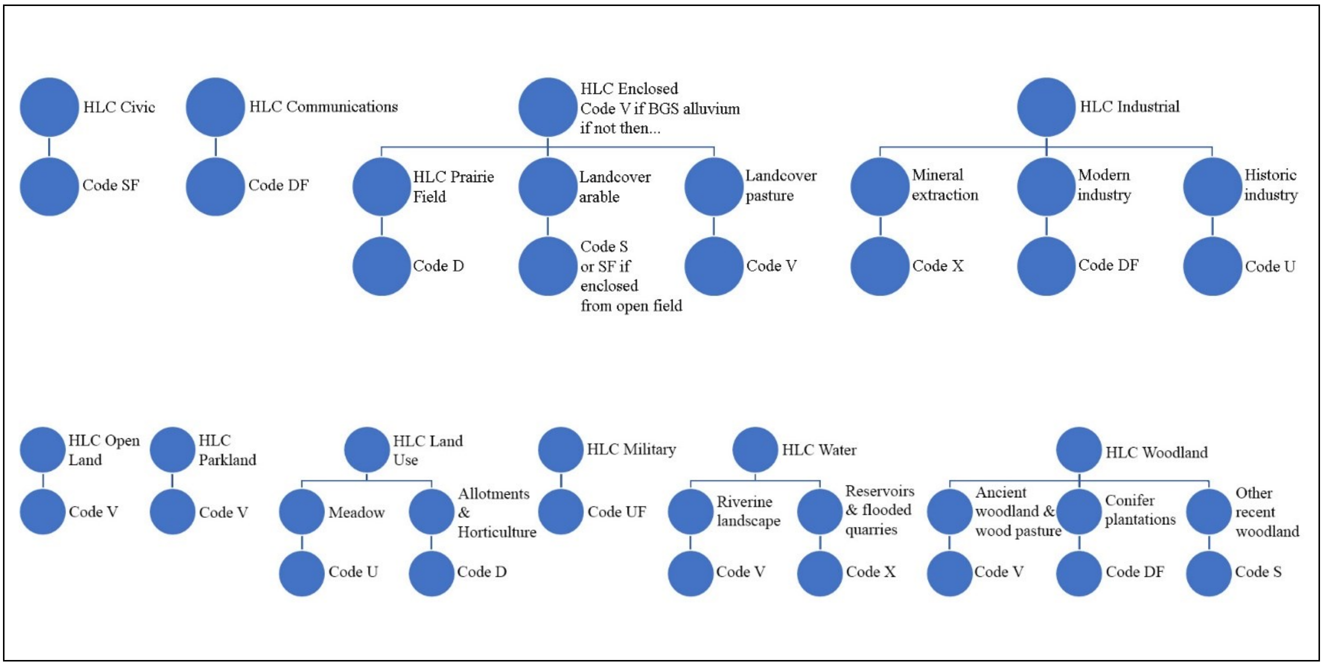

Figure A2.3: Step 2 – classify physical condition of HLC categories

CIVIC (CIV): code as SF

COMMUNICATIONS (COM): code as DF due to expected extensive construction disturbance.

ENCLOSED LAND (ENC):

- Enclosure (Prairie Fields) (ep): indicative of intensively destructive mechanised agriculture so code as D
- All other enclosed land: classify as V if shown as pasture on land cover map or alluvium on BGS, otherwise as S due to plough truncation or SF if Enclosed from Open Field.

INDUSTRIAL:

- Industrial (post 1885) (in), Industrial (disused) (id): code as DF due to expected extensive construction disturbance. Earlier industrial areas (not present in Vale of Aylesbury) would have a different code.
- Mineral Extraction and Disused Mineral Extraction (de): code as X (destroyed).

LAND USE (LAN):

- Meadow (mw): Code as U because of likely surviving water channels etc
- Allotments (ag), Nursery with Glasshouses, Watercress Farming (fw): code as D due to likely deep digging

MILITARY (MIL): code as UF reflecting potential for military built/below-ground archaeology but fragmentation of earlier remains

OPEN LAND (OPN) – Commons & Greens (cm), Heaths (ht) and Downland (dw): code as V because uncultivated

PARKLAND (PAR): code as U because of designed landscape/structures and often uncultivated land

RECREATION (REC): code as S because modern recreation is often subject to surface landscaping

SETTLEMENT (SET)

- Settlement (Post 1885) (st): code as DF due to likely truncation and fragmentation
- Settlement (Pre 1885) (se): code as UF if containing listed buildings or VF if not.

WATER (WAT)

- Riverine Landscape (rl): code as V
- Water Reservoir (rw), Flooded Restored Mineral Extraction: Gravel Pits (mf): code as X.

WOODLAND (WOO)

- Woodland (Ancient Semi Natural) (wa) & Woodland Pasture (wp): code as V because of relative protection given by long-term tree cover.
- Woodland Coniferous Plantation (wc): classify as DF due to likely disturbance during plantation
- All other woodland: code as S because of likely surface disturbance.

Step 3: Coding chemical composition (Fig. A2.4)

The primary source for wetlands mapping coded as A (anoxic) is the Peat dataset viewed on the UK Soil Observatory website and derived from the Soil Parent Material Model developed by the British Geological Survey (BGS). Potential for anoxic conditions could also be anticipated along watercourses, under alluvial spreads or associated with 'wet' monuments such as bridges, moats and mills. One option would be to identify selected known monuments, alluvial spreads and/or a buffer alongside streams as having anoxic potential in addition to mapped wetlands. For this 'proof of concept' study a W code has been applied to alluvium, peat and moated sites adjacent to watercourses. Localised anoxic contexts are rare but can be found almost anywhere so are not modelled here.

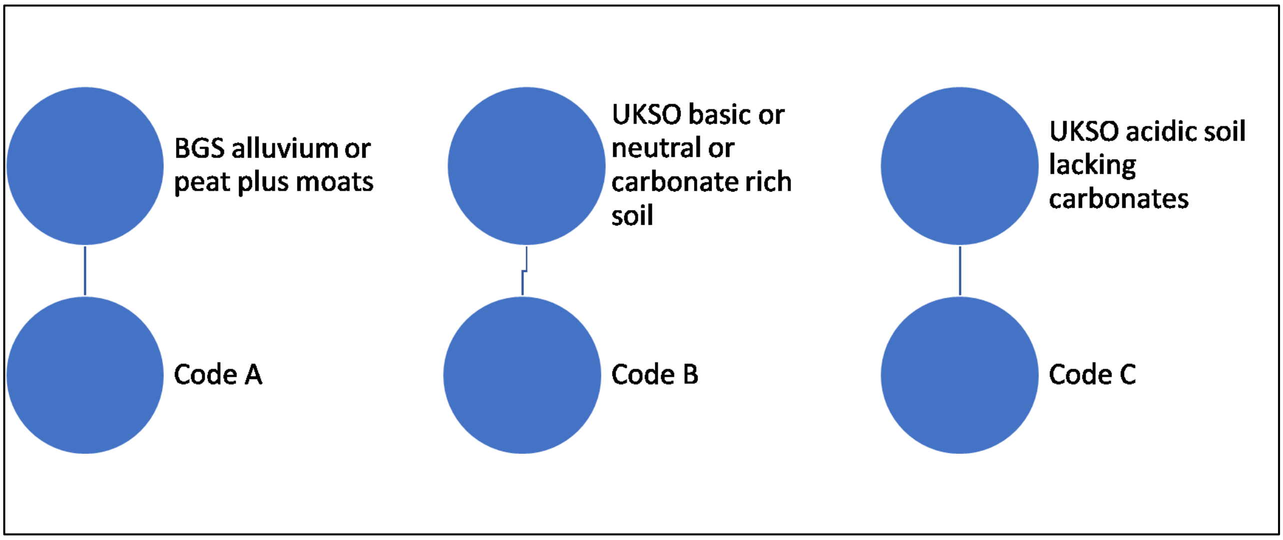

Figure A2.4: Step 3 – classify chemical composition

The UK Soil Observatory soil pH and carbonate content maps can be used to check for acidic soils and sense-checked against excavation results, especially bone and metalwork survival. In practice the Vale of Aylesbury dryland areas will all be coded B (basic).

Appendix 3: London Gateway case studies

Six case studies covering 829.6 ha (5.1% of the study area) have been used to assess the nature of archaeological remains revealed by evaluation and recording investigations in order to compare new discoveries against pre-existing knowledge (Table A3.1). The case studies sought were primarily large greenfield developments where reports were readily available. Five studies fell into this category whilst the sixth (DP Ports World) covered a mix of brownfield and greenfield land. This last site was very much larger than the others so rather skews the statistics. No case studies could be found in historic settlement cores.

Table A3.1: List of London Gateway case studies

Case study	***Site name***	***Area (ha)***	***Type***	***Description***
1	Stanford Wharf Nature Reserve	44	Greenfield excavation	Evaluation, open-area excavations, watching brief and geoarchaeological investigation on an ecological compensation area for London Gateway Port. Shallow groundworks meant that deeper buried prehistoric deposits were not disturbed.
2	Mucking	18	Greenfield excavation	Iconic rescue excavation of a landfill site carried out incrementally between 1965 and 1978
3	Walton Hall Farm	46	Greenfield evaluation	DBA, geophysical survey and trial trenching of proposed mineral site
4	Mill House Farm, Chadwell St Mary	7.9	Greenfield excavation	Cropmark site subject to strip, map and sample excavation ahead of gravel extraction
5	East Tilbury	13.7	Greenfield excavation	Geophysical survey, trial trenching and targeted excavation in advance of residential development.
6	DP Ports World London Gateway	c 700	Mixed brown/green evaluation and mitigation	Complex zoned assessment and mitigation of large infrastructure project (NSIP).

The fieldwork on five projects was conducted over the last twenty years but the ground-breaking Mucking excavations took place in the 1960s and 1970s. Only one of the sites (Walton Hall Farm) is an evaluation with only a grey literature report; the others have published reports on the complete investigation.Due to the local patterns of development and investigation all of these case studies were located in the south-east part of the study area between Grays, Stanford-le-Hope and Coryton (Fig. A3.1). This skews the results both in terms of locality and indicators that can be assessed – for example the sites are predominantly on gravel and coastal geologies and mostly away from potential indicators such as conservation areas or local high points.

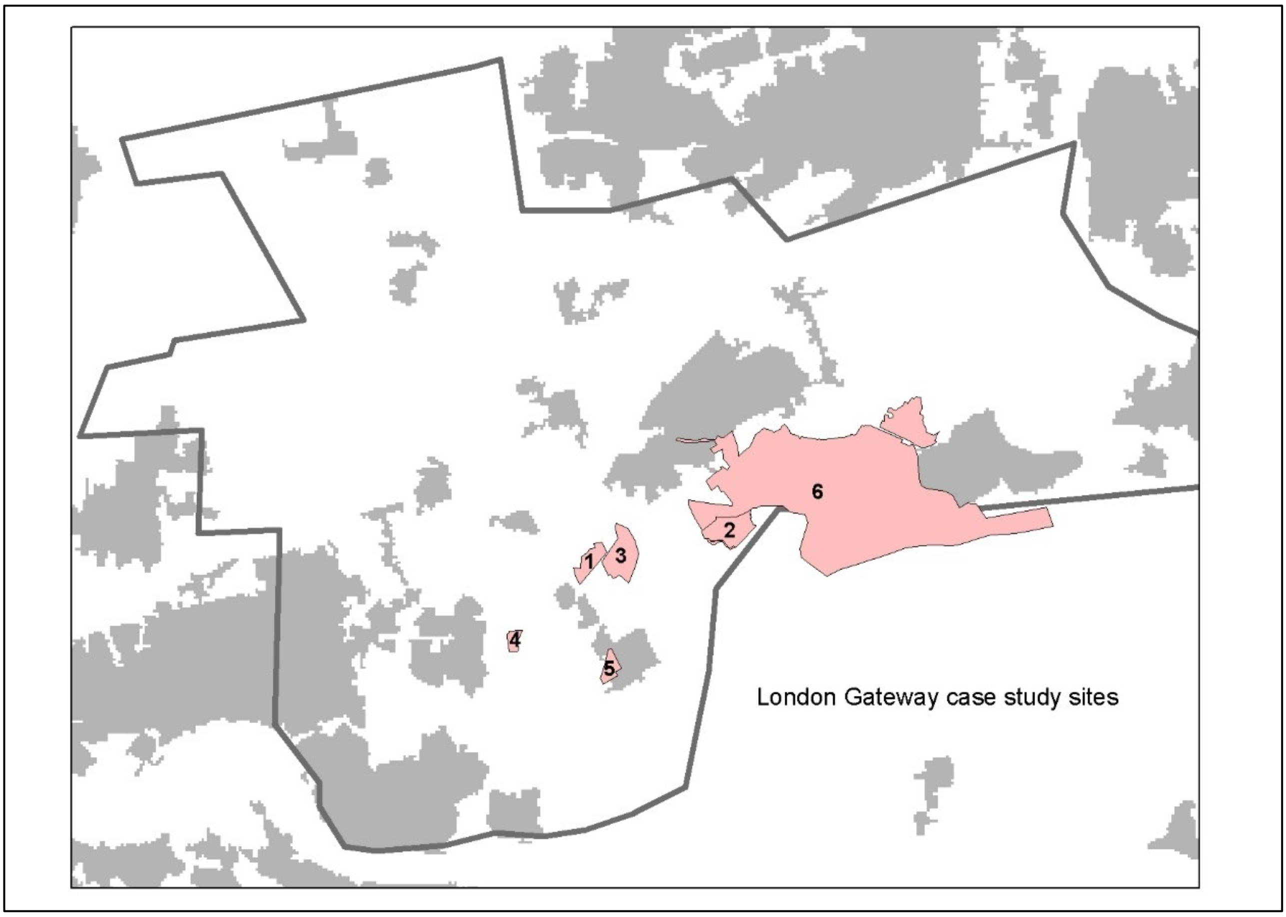

Figure A3.1: Map of London Gateway case studies

For each site the areas covered by heritage assets were estimated and compared to possible indicators of archaeological potential (such as geology, proximity to Roman roads or SMs etc). The archaeology encountered was classified in terms of general period and type with particularly significant assets highlighted. This data is summarised in Table A3.2.

The grid reflects a strong emphasis on later prehistoric archaeology, primarily Middle-Late Bronze Age, on the Thames gravels with secondary but still significant Neolithic/Early Bronze Age, Roman and early medieval components. Other periods are notably rare reflecting locations largely away from known settlements.

Incredibly, more than half of these 'assets' (77) are recorded from one site (Mucking) which accounts for just 2.2% of the total case study area (in reality the disparity would likely be even greater if feature numbers rather than subjectively assigned 'assets' were the unit of analysis). The inclusion of this exceptional site and also the partly brownfield DP Ports World site means the case study data ought to be treated with caution. This point is illustrated by the wide variation in the proportion of sites covered by substantive archaeological remains and correlations with potential indicators (Fig. A3.2).

Table A3.2: All assets encountered on case study sites

London Gateway Case Studies Asset Periods and Types	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive/Military	Recreation	Unclassified	Total
Modern	0	0	0	0	0	1	0	0	1
Post-medieval	0	3	0	1	0	0	0	1	5
Late medieval	1	2	1	0	0	0	0	0	4
Early medieval	11	0	0	0	2	0	0	1	14
Roman	5	0	3	4	5	0	0	0	17
Later prehistoric (MBA/IA)	25	5	4	5	9	2	0	1	51
Earlier prehistoric (Neo/EBA)	9	0	0	0	9	0	0	3	21
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	1	1
Undated	0	0	0	0	0	0	0	0	0
Total	51	10	8	10	25	3	0	7	114

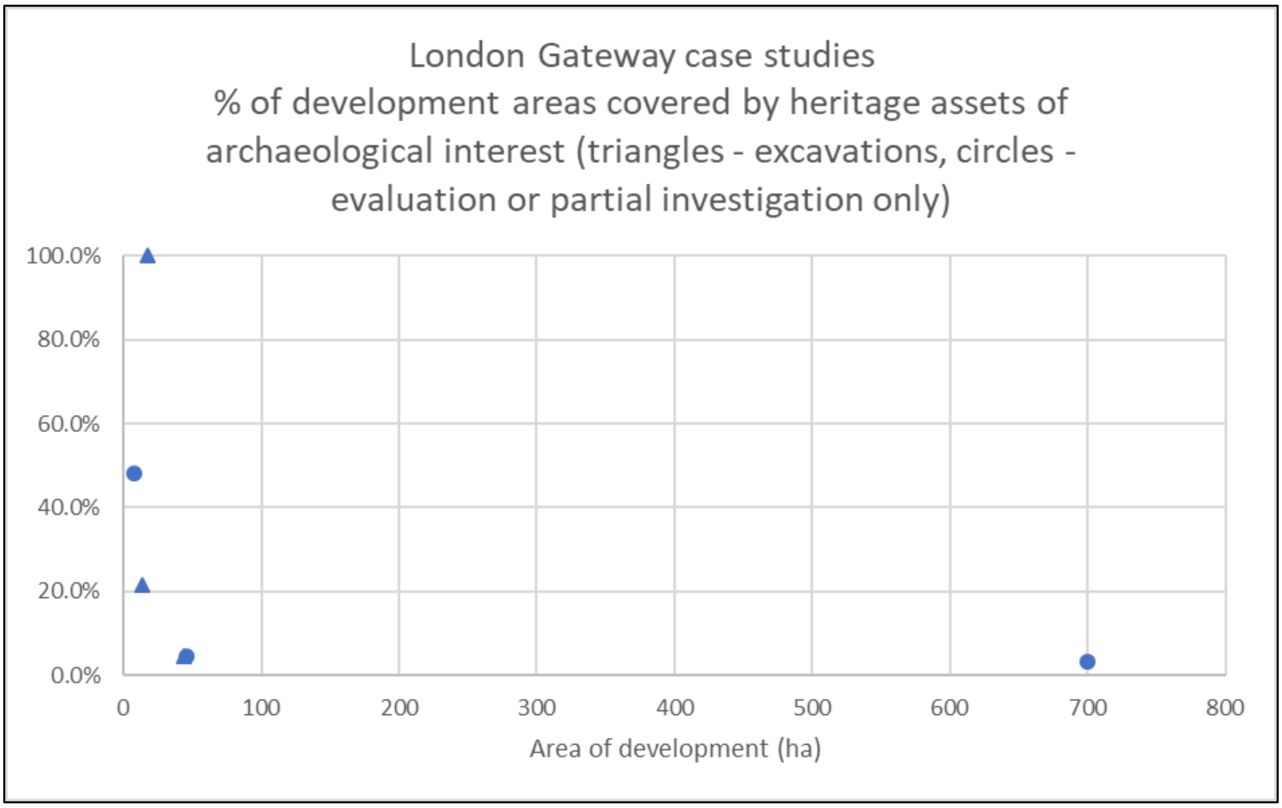

Figure A3.2: Percentage of development areas covered by heritage assets

Overall only 6.2% of the case study area lay on an asset, but by site this varied from under 5% (3 cases) to 100% (Mucking). Sand and gravel geology shows a strongly positive correlation with 38% asset coverage – over six times the average (Fig. A3.3). Alluvial and coastal deposits show strongly negative correlation and drive down the overall average, leading alluvium (4.3% coverage), head (10.3%) and mudstone (9.7%) to look 'better' indicators than they really are. The very small areas in proximity to water, Roman roads and listed buildings are not a sufficient sample to draw any conclusions.

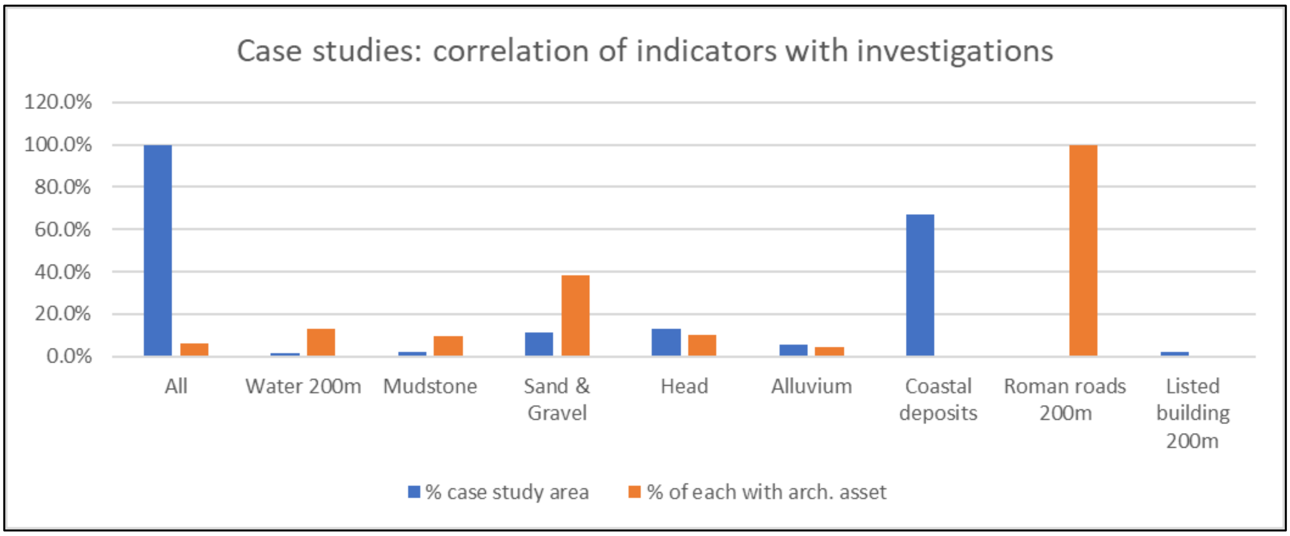

Figure A3.3: Correlation of archaeological remains with potential indicators

Case Study 1: Stanford Wharf Nature Reserve

Development: ecological compensation area for port development constructed in 2009

Total area of impact: 44 ha

Physiographic indicators: Stanford Wharf lies entirely on alluvium with Mucking Creek forming its south-western boundary

Cultural indicators: there are no Roman roads, medieval churches or other indicators close to the site.

Archaeological strategy: evaluation by aerial/lidar and geophysics (gradiometry and electrical resistivity) to create a deposit model then targeted trial trenching followed by mitigation by excavation (7.35 ha), strip, map and sample (8.4 ha), and watching brief (13 ha). The results have been published (Biddulph *et al.* 2012). Construction involved only a shallow site strip of about 0.5–1.0 m which left more deeply buried archaeology undisturbed. Some of the remains identified were preserved in situ and there is likely to be other more deeply buried archaeology as yet undiscovered.

Archaeological outcome (Table A3.3): two main sites (Areas A and B) were identified, covering 1.9 ha (4.3% of the site).

Area A (1.4 ha) contained Middle Iron Age remains, Roman saltworkings and a Roman boathouse. Area B (0.5ha) was a Roman saltworks. The rest of the site had other remains of secondary significance ('background signature') including a lithic scatter, undated horticultural trenches and a handful of Saxon, medieval and modern features. The site was crossed by a palaeochannel and had a complex alluvial sequence providing significant palaeo-environmental evidence.

The archaeology was well preserved beneath and within alluvium with vertical (dry) stratigraphy surviving, waterlogged structural timbers and anoxic preservation of environmental evidence. This equates to Condition Code VA and Condition Level 4 (3.2.2).

Table A3.3: Stanford Wharf assets by period and type

Stanford Wharf Nature Reserve Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive	Recreation	Unclassified	Total
Modern	0	0	0	0	0	1	0	0	1
Post-medieval	0	0	0	0	0	0	0	0	0
Late medieval	0	1	0	0	0	0	0	0	1
Early medieval	0	0	0	0	0	0	0	1	1
Roman	0	0	1	1	0	0	0	0	2
Later prehistoric (MBA/IA)	0	0	1	0	0	0	0	0	1
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	1	1
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	0
Total	0	1	2	1	0	1	0	2	7

The site lay within HLC Drained Reclaimed Land so the predicted preservation code VA accords with the observed condition.

Observations: the coastal alluvial location makes Stanford Wharf something of a special case that can only be compared to other similar locations, not to dryland sites. The relatively low occurrence but good preservation of assets is expected to be a feature of alluvial landscapes, although prehistoric archaeology (and therefore overall presence of archaeological assets) is likely to be under-represented here because of the shallow investigation profile. The site's palaeoenvironmental significance is not captured by an asset-based model.

Case Study 2: Mucking

Development: an iconic rescue excavation carried out in advance of mineral extraction and landfill between 1965 and 1978

Total area of impact: 18 ha

Physiographic indicators: Mucking lies entirely on alluvium with Mucking Creek forming its south-western boundary. It clearly occupies a favoured location – what has been described as a 'gateway' commanding long views down the Thames estuary – but that is not captured by the simple indicators used in this study.

Cultural indicators: there are no Roman roads, medieval churches or other indicators close to the site.

Archaeological strategy: rescue investigation on a cropmark complex without prior evaluation using an early form of 'strip and map' but with an aspiration of total excavation giving a much higher sample of all features (c 75%) than modern commercial excavations. Archaeology was encountered over the entire area with intense multi-period activity across much of the site. The results have been published in a number of volumes – this analysis has been based on the site-wide overviews in Evans *et al.* (2016), primarily chapter 6. The sheer quantity and complexity of the excavated evidence has made it challenging to summarise in the format used in this study and the table below necessarily gives no more than an impression of the periods and types of remains.

The Mucking excavation revealed archaeology of national significance (Table A3.4). Most notable in that respect are the Anglo-Saxon settlements and cemeteries and the Late Bronze Age 'South Rings' defended settlement. The Late Iron Age 'Plaza' ritual site and associated burials could also make a claim to national significance whilst the Iron Age and Roman settlements are at least regionally significant. That the Neolithic/Early Bronze Age activity and barrows seem less prominent is more a testament to the importance of the rest rather than their lack of interest.

Table A3.4: Mucking assets by period and type

Mucking Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/funerary	Defensive	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	1	0	0	0	0	0	0	1
Late medieval	0	1	1	0	0	0	0	0	2
Early medieval	10	0	0	0	2	0	0	0	12
Roman	5	0	1	3	5	0	0	0	14
Later prehistoric (MBA/IA)	22	1	2	0	5	1	0	0	31
Earlier prehistoric (Neo/EBA)	9	0	0	0	8	0	0	0	17
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	0
Total	46	3	4	3	20	1	0	0	77

Note: South Ring classified as Defensive. 'The Plaza' is combined with LIA funerary. Settlement derived from Evans et al, 2016, table 6.1

The archaeology survived as cut features without evidence of widespread vertical stratigraphy or severe plough truncation. This equates to Condition Code S and Condition Level 2 (3.2.2). Environmental archaeology was at an early developmental stage at the time of investigation so sampling was much more limited than would now be expected. No waterlogged deposits were reported and bone was poorly preserved – only c 10,000 fragments of animal bone were recovered and human burials were mostly sand stains. This is worse preservation than would be predicted by soil pH.

The Site lay within HLC Twentieth Century Enclosure (TEF) having previously been ancient 'Dengie-form' enclosure. That combined with arable land cover prior to landfill would have given a predicted physical preservation code D – worse than that actually observed, but the Mucking excavation took place fifty years ago, not long after modern heavy mechanised agriculture began, so does not invalidate the suggestion that such a site would now be more truncated if it had remained under such an agricultural regime.

Observations: Mucking stands out as an intensively occupied palimpsest landscape which extended beyond the limits of excavation. Whilst each individual asset or cluster of assets was of more modest scale the accretion of these assets over nearly five millennia combined with shifting foci of activity eventually covered the whole terrace.

Whole landscape coverage is a feature of other river valley gravel sites and raises the question of whether a pragmatic distinction might be made between continuous archaeological landscapes and landscapes of discrete assets.

Case Study 3: Walton Hall Farm, Linford

Development: proposed mineral extraction site

Total area of impact: 46 ha

Physiographic indicators: Walton Hall Farm occupies a south-east facing slope on geologies mapped as London Clay, head, and sand and gravel. There are no watercourses nearby.

Cultural indicators: a large site just to the east of the Mucking excavation area but there are no Roman roads, medieval churches or other indicators close to the site.

Archaeological strategy: desk-based assessment, geophysical survey and c 1% trial-trench evaluation (latter by Archaeological Solutions in 2014). The evaluation report is succinct and essentially descriptive.

The evaluation found one ring-ditch and a trackway, both tentatively dated to the later Bronze Age, and remarkably little else (Table A3.5). Together they covered about 2 ha (4.3% of the site).

Table A3.5: Walton Hall Farm assets by period and type

Walton Hall Farm Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	0	0	0	0	0	0	0	0
Late medieval	0	0	0	0	0	0	0	0	0
Early medieval	0	0	0	0	0	0	0	0	0
Roman	0	0	0	0	0	0	0	0	0
Later prehistoric (MBA/IA)	0	0	0	1	1	0	0	0	2
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	0	0
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	0
Total	0	0	0	1	1	0	0	0	2

The archaeology survived as cut features including postholes equating to Condition Code S and Condition Level 2 (3.2.2). Environmental archaeology potential was poor with no bone reported and poor charred plant remains.

The Site lies within HLC Twentieth Century Enclosure (TEF) which, combined with arable landcover, gives a predicted physical preservation code D – worse than that inferred from the evaluation.

Observations: it is surprising to see such a low density of archaeology adjacent to Mucking with virtually no evidence for activity other than in the later Bronze Age – a complete contrast to discoveries only 100 m or so away. The trial-trench sample was noticeably low by present standards, although the results were consistent with the geophysics, which also indicated low-density archaeology.

Structural survival was a bit better than predicted but environmental preservation worse, meaning the overall balance of both would come out at level 1, both in the model and evaluation.

There appears to be a disparity between the mapped and actual geology which unfortunately the evaluation report does not clarify.

Case Study 4: Mill House Farm, Chadwell St Mary

Development: mineral extraction

Total area of impact: 7.9 ha

Physiographic indicators: the Mill House Farm site lies on a flat gravel terrace overlooking the Thames valley to the south and east, a location comparable to the Mucking case study. There are no watercourses nearby.

Cultural indicators: the site lies within a triangle of minor Roman roads but none are within 200 m. There are no medieval churches or other indicators close to the site.

Archaeological strategy: desk-based assessment, aerial photography and c 2.7% trial-trench evaluation followed by strip, map and sample excavation by Archaeological Solutions. Full excavation report published (Newton 2010).

The excavation revealed over 1000 features, dominated by Late Bronze Age remains comprising one large ring-ditch, interpreted as a ringwork, an extensive ditched field system and numerous posthole clusters apparently representing a diffuse open settlement (Table A3.6). Six SFBs and a post-built structure defined a dispersed Anglo-Saxon settlement. Other periods were very sparse although Lower Palaeolithic lithics/Pleistocene geology were notable. Whilst features were found across most of the site the main concentration of Late Bronze Age and Anglo-Saxon remains covered about 3.8 ha (48.1% of the site).

Table A3.6: Mill House Farm assets by period and type

Mill House Farm Chadwell St Mary Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	0	0	0	0	0	0	0	0
Late medieval	0	0	0	0	0	0	0	0	0
Early medieval	1	0	0	0	0	0	0	0	1
Roman	0	0	0	0	0	0	0	0	0
Later prehistoric (MBA/IA)	1	1	0	0	0	1	0	0	3
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	0	0
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	1	1
Undated	0	0	0	0	0	0	0	0	0
Total	2	1	0	0	0	1	0	1	5

The archaeology survived as cut features including postholes, equating to Condition Code S and Condition Level 2 (3.2.2).

Environmental archaeology comprised carbonised plant remains of regional significance; potential was poor but only cremated bone survived and no waterlogged deposits were encountered.

The site lay within land which would have had a predicted physical preservation code D prior to mineral extraction – that is worse than that observed from the excavation.

Observations: Mill House Farm supports the extensive occupation of the terrace gravels, albeit with less intensity than seen at Mucking. The main archaeological focus correlated well with the area identifiable from cropmarks, i.e. prediction from known assets would have identified most of the archaeology. Structural survival was a bit better than predicted (level 2) but environmental preservation was overall poor so arguably the overall balance could still come out as Level 1.

Case Study 5: Bata Fields, East Tilbury

Development: housing

Total area of impact: 13.7 ha

Physiographic indicators: Bara Fields lies on a flat gravel terrace overlooking the Thames valley to the east. There are no watercourses nearby.

Cultural indicators: there are no cultural indicators close to the site.

Archaeological strategy: geophysical survey and targeted trial trenching followed by two open-area excavations totalling 2.92 ha, by Oxford Archaeology. Grey literature report (Bush 2016).

The excavation revealed a Late Neolithic/Early Bronze Age 'double enclosure' (possibly a funerary monument), three small Middle Bronze Age barrows, droveways, enclosures, and pit and posthole groups. Other periods were very sparse or absent. Features were found at a generally low density across most of the stripped area of 2.92 ha (21.3% of the site), with some extending beyond it. The archaeology survived as cut features but with considerable truncation reported and very sparse degraded environmental evidence (charred plant and animal bone) and no waterlogged deposits. Overall this equated to Condition Code DC and Condition Level 1 (3.2.2).

Observations: Bata Fields East Tilbury offers further support for prehistoric occupation of the terrace gravels, albeit with much less intensity and a shorter time-frame than seen at Mucking. The assets were unknown prior to evaluation - prediction from known assets would not have identified the archaeology but prediction from geology would highlight the potential. Structural and environmental condition was poor as predicted.

Case Study 6: DP Ports World, London Gateway

Development: the DP Ports World London Gateway was a complex multi-faceted port development partly adjacent to a pre-existing oil refinery. Stanford Wharf Nature Reserve (case study 1) was associated and lies adjacent to this site.

Total area of impact: c 700 ha (approximate area for whole site taken from Essex HER excluding estuary itself and Stanford Wharf Nature Reserve)

Physiographic indicators: London Gateway lies mainly over coastal estuarine deposits but the road access where most of the archaeological investigations took place crosses gravel terrace and head deposits.

Cultural indicators: there are two listed buildings on the gravel terrace within the site.

Archaeological strategy: this was a complex multi-faceted development on a site with variable modern land use history and therefore preservation potential. A zoned approach to mitigation was adopted comprising monitoring, targeted trenching and limited strip, map and sample excavations, rather than large-scale open-area excavation. Due to the thick layer of alluvium deposited throughout the intertidal zone, few of the individual sites within the development area exposed extensive archaeological remains. The results have been published in Oxford Archaeology Monograph 31 (Biddulph *et al*. 2021).

The excavation revealed a few small lithic scatters, two areas of Bronze Age field systems, traces of Bronze Age and Roman saltworkings, parts of a medieval hamlet and a post-medieval wharf (Table A3.7). Earthworks of post-medieval sea defences were recorded whilst aerial photographs showed a pattern of WW2 anti-glider trenches. Features were found at a low density across about 23.2 ha (2.3% of the site) with most occurring on the gravel or edge of the estuarine deposits. A deposit model and landscape time-slice environmental reconstruction were also created from borehole and geophysical evidence. Other as yet undiscovered prehistoric assets could survive within these deep deposits.

The archaeology mainly survived as dry cut features, although the post-medieval sea defences were upstanding earthworks and the post-medieval wharf had waterlogged timbers. Good environmental evidence was also recovered from the boreholes. Overall survival within the estuarine deposits was either Condition Code UA or VA equating to Level 4 (3.2.2). On the other hand the dryland areas appeared truncated with little environmental survival, equating to Condition Code DC and Condition Level 1.

Table A3.7: London Gateway assets by period and type

DP Ports World London Gateway Asset Periods and Types (with more significant discoveries outlined)	Settlement	Agriculture	Industry	Transport	Religious/Funerary	Defensive	Recreation	Unclassified	Total
Modern	0	0	0	0	0	0	0	0	0
Post-medieval	0	1	0	1	0	0	0	1	3
Late medieval	1	0	0	0	0	0	0	0	1
Early medieval	0	0	0	0	0	0	0	0	0
Roman	0	0	1	0	0	0	0	0	1
Later prehistoric (MBA/IA)	0	2	1	0	0	0	0	1	4
Earlier prehistoric (Neo/EBA)	0	0	0	0	0	0	0	2	2
Mesolithic	0	0	0	0	0	0	0	0	0
Palaeolithic	0	0	0	0	0	0	0	0	0
Undated	0	0	0	0	0	0	0	0	0
Total	1	3	2	1	0	0	0	4	11

Observations: London Gateway is a complex site with multiple fragmented interventions not ideally suited to this form of assessment. The dryland element conforms to the general pattern of prehistoric focus on the gravel but with less intensity than seen elsewhere, and a shorter time-frame than at Mucking. Taken at face value the estuarine deposits have revealed a much lower density of archaeology but the deposit model has demonstrated potential for well-preserved deeply buried assets and some historic features are still visible, although the extent of such survival is not clear from the published report. The limited scale of investigations (in proportion to the very large site) means that the calculated 2.3% coverage of assets is surely a significant underestimate of the true resource.

Comparison of the published zoned mitigation strategy (Fig. A3.4) with this project's condition model (Fig. A3.5) indicates a good general correlation although the latter underestimates the potential for deeply buried archaeology under the former refinery, whilst the former may have somewhat overemphasised the potential of the 'gravel terrace' bearing in mind the likely condition of plough-truncated features.

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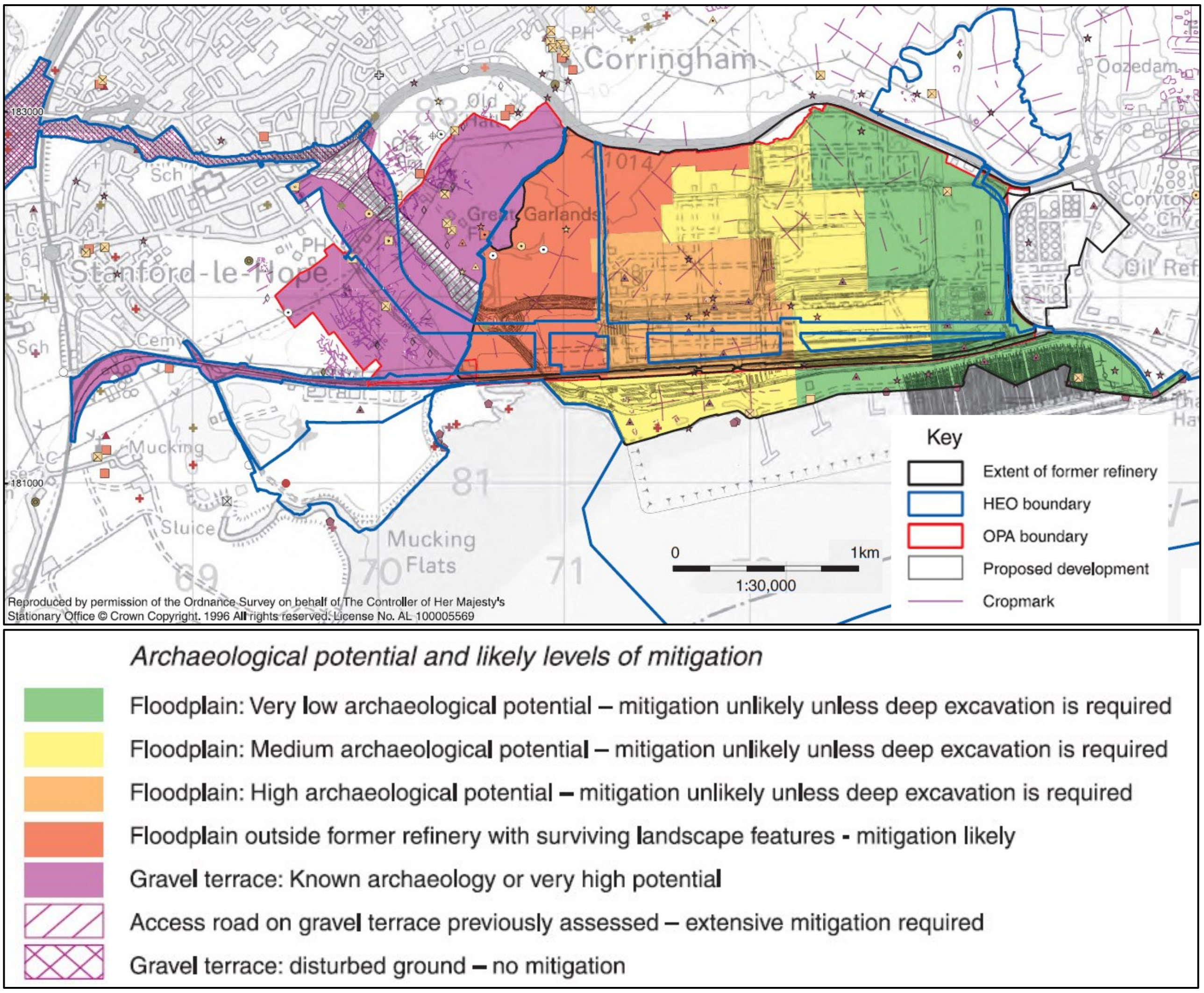

Figure A3.4: London Gateway mitigation zones (adapted from Biddulph *et al*. 2021, fig 2.1; © Oxford Archaeology)

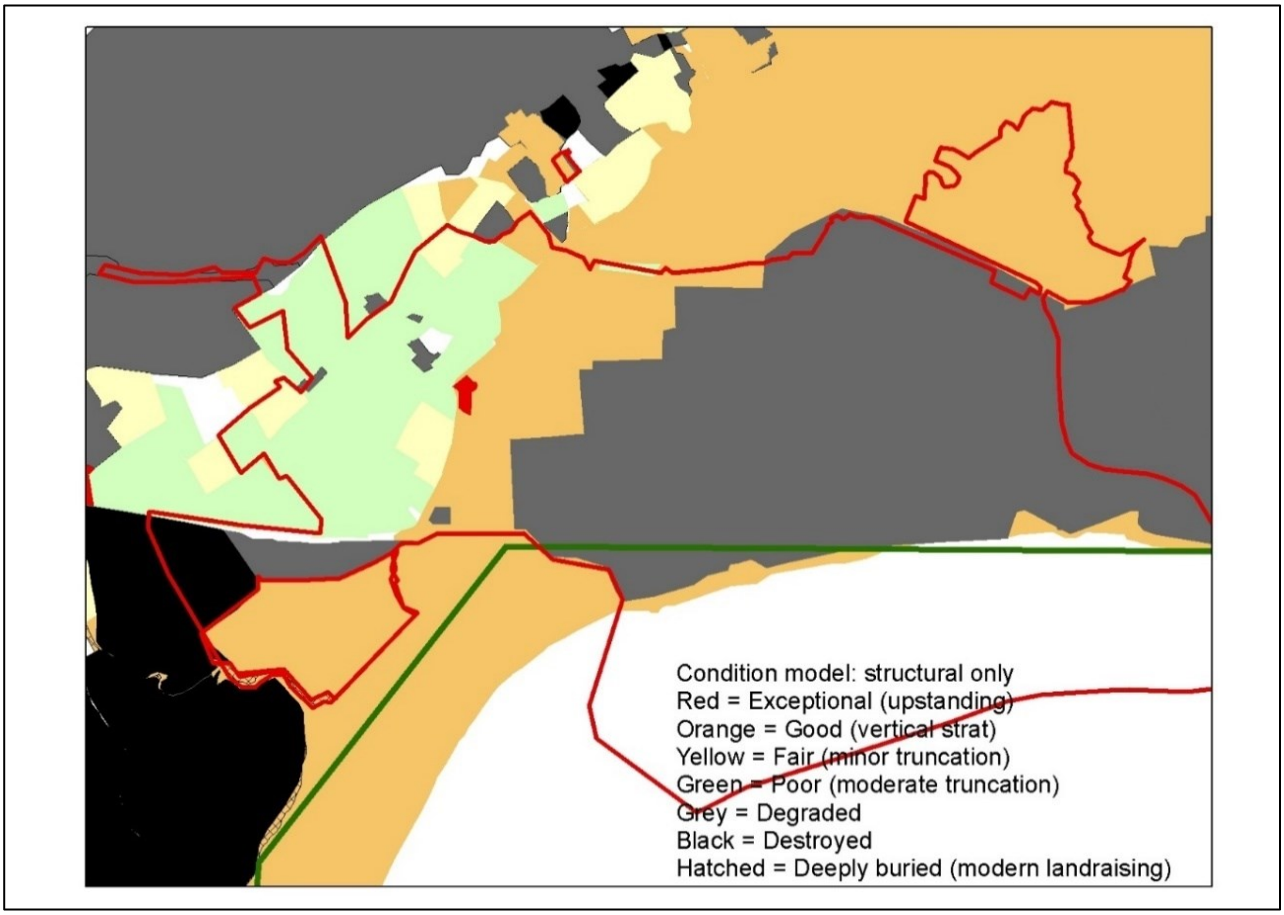

Figure A3.5: Condition model for London Gateway

Appendix 4: Condition coding steps and rules (London Gateway)

Step 1: For known assets physical condition can be derived from or added to alert and SM maps (Table A4.1; Fig. A4.1)

Table A4.1: Classification of known assets (for steps see Fig. A2.1)

Classification of form of known assets from SM data with equivalent physical condition code	
built	Built-up area with buildings and structures of archaeological interest as well as below-ground deposits Code = U move to step 3
ewk	Visible earthworks, occasionally with ruined structures Code = U move to step 3
flat	Buried remains with minimal or no visual component Code depends on HLC move to step 2

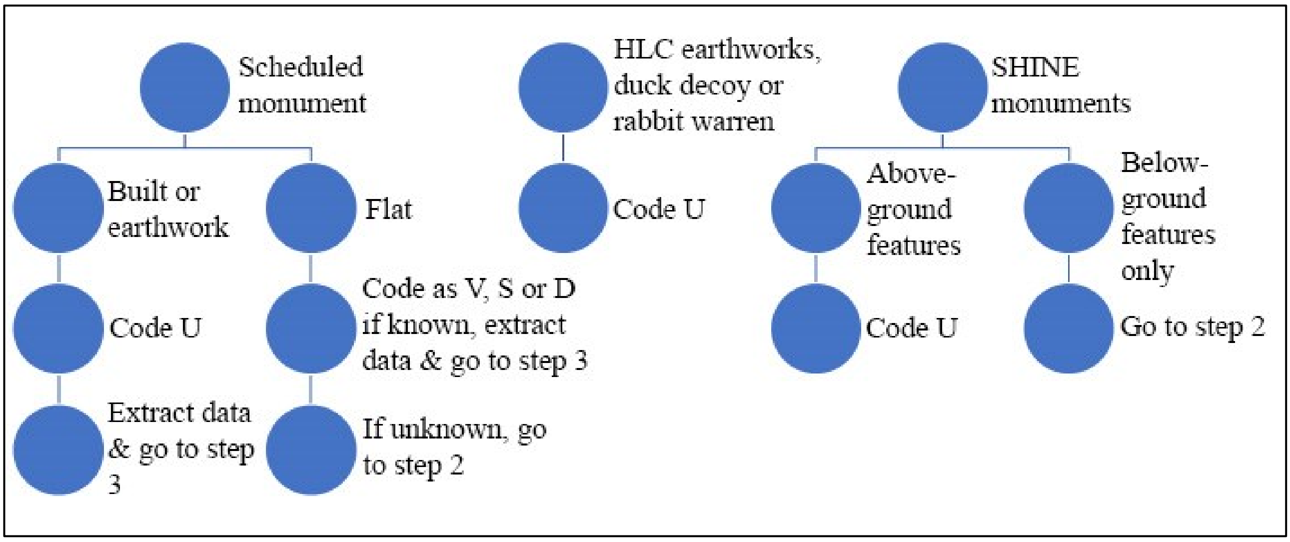

Figure A4.1: Step 1 – classify physical condition of known assets

Step 1b: Essex HLC identifies a few upstanding assets – earthworks, duck decoys and rabbit warrens which can be coded U.

SHINE can also be used to identify monuments with upstanding features recorded in the shine_form field.

Step 2: Coding physical condition of HLC Broad and Type categories (Fig. A4.2; see Bennett 2011b, 7–8)

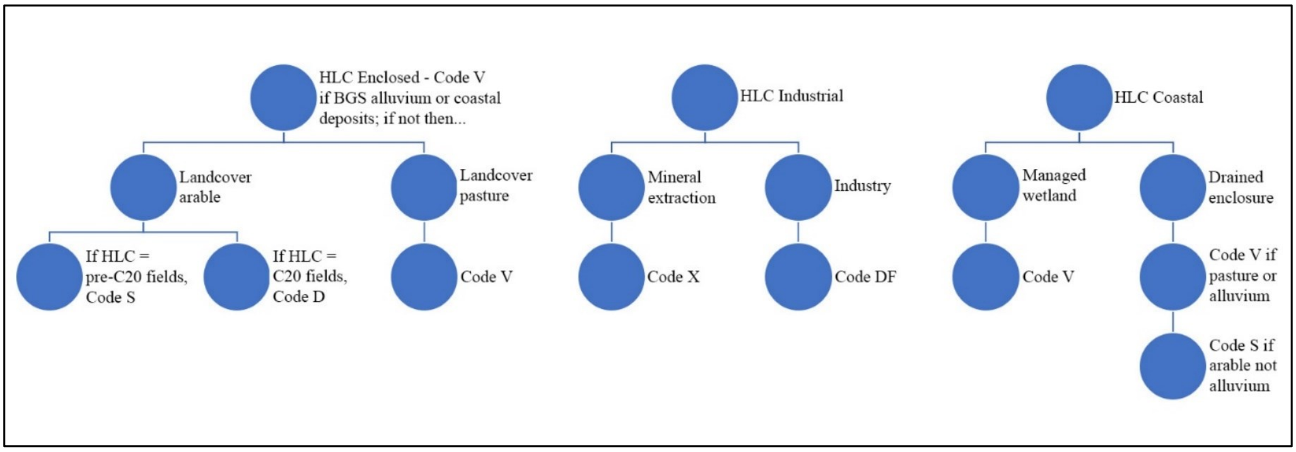

Figure A4.2: Step 2 – classify physical condition of HLC categories (selected examples)

ENCLOSED LAND

- Pre-18th century enclosure (AEF): code as V if shown as pasture on land cover map or alluvium on BGS, otherwise as S due to plough truncation.
- 18th–19th century enclosure (LEF): code as V if shown as pasture on land cover map or alluvium on BGS, otherwise as S due to plough truncation.
- 20th century agriculture (TEF): indicative of intensively destructive mechanised agriculture so code as D unless on alluvium when code as V.
- Inland managed wetland (IMW); meadow and watercress beds: code as U because of likely surviving water channels etc.
- Marginal (MAR): unenclosed rough pasture so classify as V.

OPEN LAND (CWH) – Commons, wastes, heaths: code as V because uncultivated land.

WOODLAND (WDS)

- Ancient woodland (aw): code as V because of relative protection given by long-term tree cover.
- Woodland plantation (wp): code as SF because of likely surface disturbance and fragmentation.

PARKLAND (PGR)

- Informal parkland (ip): code as U because of designed landscape/structures and often uncultivated land.
- Leisure/recreation (tl): code as S because modern recreation often subject to surface landscaping.

COASTAL

- Coastal managed wetland (CMW): code as VA
- Coastal drained enclosure (CDF): code as V – but ?A
- Water features (WAT); sea defences (sd): code as UF reflecting intrinsic significance and fragmentation of earlier remains.

SETTLEMENT

Built-up areas – modern (BUM)

- Urban development (ba): code as DF due to likely truncation and fragmentation.
- Hospitals, schools, universities (hs) and plotlands (pl): code as SF.

Built up areas – historic (BUH):

- Settlement (bh): code as UF if containing listed buildings or VF if not. Unfortunately, the Essex HLC did not actually use the bh code in the study area so instead the Chris Blandford Associates urban_1858_1873 layer and the conservation area layer have been used (which has probably missed the smallest historic settlements). And as all these areas include listed buildings each was coded UF.
- Religious institutions – historic (ri): code as U.

INDUSTRIAL

- Industrial and disused Industrial (IND): code as DF due to expected extensive construction disturbance. Pre-20th century industrial areas could have a different code.
- Mineral Extraction (MIN): code as X (destroyed).

HORTICULTURE (HOR)

- Code allotments (ag) and nurseries (ng) as D to reflect deep digging.
- Code orchards (at) as VF.

MILITARY (MIL): code as UF reflecting potential for military built/below-ground archaeology but fragmentation of earlier remains.

LAND USE

- Historic earthwork (EAR-dd): code as U
- Water features (WAT-wr): code as X (reservoirs)
- Communications (COM): code as DF due to expected extensive construction disturbance.
- Miscellaneous (MIS) – duck decoy (dd) and rabbit warren (rw): classify as U; stud farm (st): code as V.

Step 3: Coding chemical composition (Fig. A4.3)

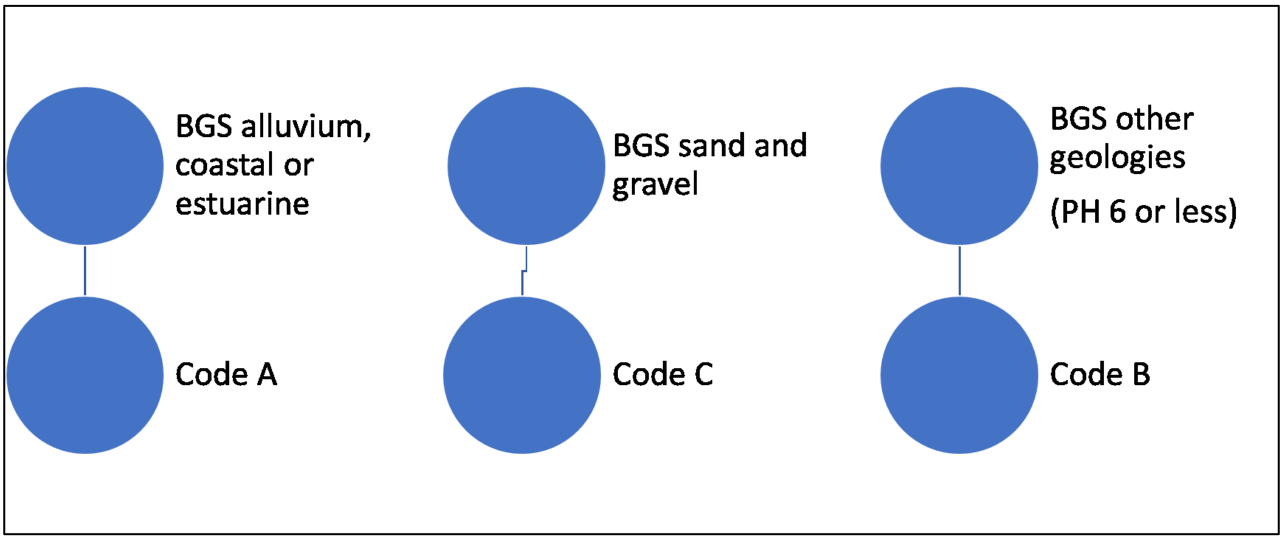

Figure A4.3: Step 3 – coding chemical composition

The primary source for wetlands mapping is the Peat dataset viewed on the UK Soil Observatory website and derived from the Soil Parent Material Model developed by the British Geological Survey (BGS). Potential for anoxic conditions could also be anticipated along watercourses, under alluvial spreads or associated with 'wet' monuments such as bridges, moats and mills. One option would be to identify selected known monuments, alluvial spreads and/or a buffer alongside streams as having anoxic potential in addition to mapped wetlands. For this 'proof of concept' study an A (Anoxic) code has been applied to alluvium, coastal and estuarine deposits. Localised anoxic contexts are rare but can be found almost anywhere so are not modelled here.

The dry sand and gravel deposits were identified as having generally poor geochemical survival conditions so were coded C (acidic) and the rest of the dryland areas were coded B (basic).

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