Historic England

Industrial Sites

Scheduling Selection Guide

Summary

Historic England's scheduling selection guides help to define which archaeological sites are likely to meet the relevant tests for national designation and be included on the National Heritage List for England. For archaeological sites and monuments, they are divided into categories ranging from Agriculture to Utilities and complement the listing selection guides for buildings. Scheduling is applied only to sites of national importance, and even then only if it is the best means of protection. Only deliberately created structures, features and remains can be scheduled. The scheduling selection guides are supplemented by the Introductions to Heritage Assets which provide more detailed considerations of specific archaeological sites and monuments.

This selection guide offers a broad overview of the range of industrial sites which may be deemed to have national importance, and outlines the criteria used when assessing such for scheduling. It aims to do two things: to set these within their historical context, and to give an introduction to the designation approaches employed.

This document has been prepared by Listing Group. It is one is of a series of 18 documents. This edition published by Historic England July 2018.

Please refer to this document as:

Historic England 2018 Industrial Sites: Scheduling Selection Guide. Swindon. Historic England.

HistoricEngland.org.uk/listing/selection-criteria/scheduling-selection/

Front cover
The scheduled copper mine at Ecton, in the Staffordshire Peak District, visible top right.

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Introduction

This selection guide offers a broad overview of the range of industrial sites which may be deemed to have national importance, and outlines the criteria used when assessing such for scheduling. Only the principal industries are treated, although the approaches and criteria outlined are generally applicable. Reference should also be made to the separate Industrial Buildings listing selection guide. Other related selection guides include Transport listing and scheduling, Maritime and Naval listing and scheduling, and Military listing and scheduling Pre-1500 and Post-1500 selection guides.

The historic industrial environment is now recognised as being more than just the relics of the Industrial Revolution. The impact of early, even prehistoric, industry within the landscape may have softened and become less starkly obvious, but it nevertheless remains legible and can possess great archaeological potential for enhancing our understanding of past lives and industrial activity. Industrialisation was a key theme of social and economic history, above all in the last three centuries, and archaeology has a key role to play in its recovery. Many industrial sites and monuments are of national importance, and several are inscribed as World Heritage Sites because of their international significance.

Immense changes in industry and manufacturing in the second half of the twentieth century have had a significant impact on the survival of our industrial heritage. Traditional industry based on the extraction of metal ores and coal, the production and working of iron, steel and other metals, as well as the manufacture of textiles, has virtually disappeared. The landscapes that these industries and their infrastructures created have been subject to inevitable processes of clearance, decontamination and reclamation, and not always with the fullest regard to sites' heritage values.

Where industries have survived, they have often radically changed their processes, and hence their physical form within the landscape. The industries that came to typify the twentieth century – such as car manufacture, the petro-chemical industry, and power generation – have also witnessed wholesale reorganisation, contraction or concentration. The scale and thoroughness of industrial site-clearances in recent years has often left less evidence behind than is the case on older abandoned sites.

Some former industrial landscapes, especially in upland areas, have become recognised as positive assets, not least for the tourist industry. Many so-called 'natural' landscapes, as in Derbyshire or Cornwall, are the result of centuries of industrial exploitation, and their rugged terrain is admired, even if its origins are unappreciated by many visitors. The clay tips of Cornwall are known as the 'Cornish Alps' and have a significant landscape value, alongside the Cornish Mining World Heritage Site. Industry can contribute profoundly to the character of an area, and the identification and protection of its key components through designation plays a significant role in the safeguarding of these qualities.

1 Historical Summary

1.1 Prehistoric and Roman Periods

The earliest industries that have left evidence of substantial production for trade, rather than just for local domestic use, are flint mines and axe factories. Axes of special quality stone were highly-prized, being traded far and wide; often the sites of their origin are known. For example, stone from the Langdale Pikes in Cumbria was roughly fashioned on site, taken to settlements at some distance for finishing and polishing before being traded across the country (Fig 1). Flint mining occurred in many areas, but at Grimes Graves in Norfolk the Neolithic industry achieved a truly impressive scale – this scheduled site includes over 800 pits and 100 chipping floors (Fig 2).

Evidence of Bronze Age copper mining has now been recognised archaeologically at several locations (as at Ecton Hill near Wetton, Staffordshire), while the evidence for tin extraction in the south-west is largely from finds

Figure 1
Outcropping high in the mountains of the Lake District, a specific fine-grained volcanic stone was collected or quarried in the Neolithic period, and chipped into 'rough-out' axeheads. Massive amounts of debris, for instance as occurs here at Top Buttress and South Scree high on Pike O' Stickle, attest to the scale of this activity.

Figure 2
High-grade black flint for tool-making was mined – apparently intensively – at Grimes Graves near Brandon, Suffolk for some 200 years either side of 2500 BC. Some 433 shafts are known across the 20-hectare site, each up to 14 metres deep, driven down to reach the 'floorstone' flint seam (seen here) which was the miners' target.

and a small number of excavated sites, like Dean Moor, on Dartmoor (Devon). Metal ore extraction, with associated ore smelting sites, was greatly increased by the demands of Imperial Rome with lead being won (alongside silver if the ore was argentiferous) from the Mendips (Somerset), Shropshire, Derbyshire and the Yorkshire Pennines alongside tin from Cornwall. This is generally demonstrated via finds of stamped ingots rather than from identifying the extraction sites themselves, since rich mineral seams were generally exploited in later periods, removing evidence of earlier workings. Similarly, iron-working witnessed a change in scale from localised production in the Iron Age to large-scale production in areas such as the Weald of Kent and the Forest of Dean where the necessary charcoal fuel could be made in large quantities.

Prehistoric pottery production is generally thought to have been small in scale, using bonfires for firing. More industrial-scale production developed under the Romans, and some sites (a number of them scheduled, like those in Alice Holt Forest, Hampshire) are of a scale to suggest a large and well-organised industry manufacturing wares for distribution over a wide area. The ubiquity of this mass-produced pottery makes the modern analysis of trading patterns possible. The Romans also developed flourishing brick and tile industries, and remains of their production sites and products are widespread. Concrete formed a major Roman building material, and thus the lime-burning industry was also of importance although few sites have been positively identified. Stone for building projects (like Hadrian's Wall, where a quarry at Limestone Corner, Warden,

Figure 3
Evidence of Roman military quarrying can be seen at Limestone Corner, near Carrawbrough, Northumberland. Partially-quarried, and quarried but unused blocks, are visible in the ditch and sides of the unfinished Wall ditch in front of Hadrian's Wall.

Northumberland is scheduled; Fig 3) was generally quarried from existing natural outcrops, with workings sometimes enlarged if the stone proved to have special qualities.

Larger-scale workings include Bath stone (perhaps quarried at Combe Down above the city); Ham Hill stone (Somerset); and Beer stone (Devon), thought to have been quarried underground. Most stone appears to have had a relatively limited distribution, although there are exceptions: the second-century barge found near Blackfriars Bridge (London) had a cargo of Kentish ragstone, believed to have been brought by water from Maidstone (Kent), and which was used for the wall and public buildings of *Londinium*.

The expansion of settlements and towns under Roman control led to an increase in scale of domestic and agricultural industries such as corn milling and tanning, as well as a wide range of craft and small-scale manufacturing industries. These are typically identified as components of settlements, rather than as isolated sites and are thus normally considered for designation as components of larger sites, for instance the scheduled *Cataractonium* (Catterick, North Yorkshire).

Salt, because of its preservative qualities, had been produced on a small scale since prehistoric times; during the Roman period it became a major coastal industry as evidenced by sites in Lincolnshire, Somerset, Kent and Essex, where a number of red-hills (waste heaps) are scheduled; areas of Roman saltworking at Droitwich (Worcestershire), are also scheduled (see Pre-Industrial Salterns IHA).

1.2 Anglo-Saxon and Viking

Industrial production generally seems to have continued on a much-diminished scale – if at all – following the formal severance of links with the Roman Empire in the early fifth century, and sometimes for many centuries thereafter. In the archaeological record this is seen most dramatically with pottery, where industrial-scale production only began again on a limited scale in the mid-seventh century with Ipswich ware (made on a slow turntable), and more widely in the ninth century when industries, like that producing Stamford ware, re-introduced the potter's wheel.

Most manufacturing in this period falls more under the heading of 'craft' rather than 'industry', although that is not to underplay, for instance, the immense skills which some metalworkers possessed, or the overall scale of textile production on home looms. It must also be remembered how important wood was to Anglo-Saxon society, and how skilled carpenters were: six sets of carpenters' tools (the fullest from Flixborough, Lincolnshire) demonstrate the woodworking tasks that could be undertaken, whether to build houses, boats, furniture or musical instruments.

Few buildings – mainly major ecclesiastical structures – were constructed of stone until the spate of church building in the tenth century. Roman stone buildings were widely scavenged for these projects, although by the late Saxon period some new quarries were open, and a few at least were relatively deep as evidenced by the good quality of stone found in some churches. Domesday Book (1086) notes seven quarries, though the fact that it omits mention of such at Barnack (Cambridgeshire; Fig 4), a known

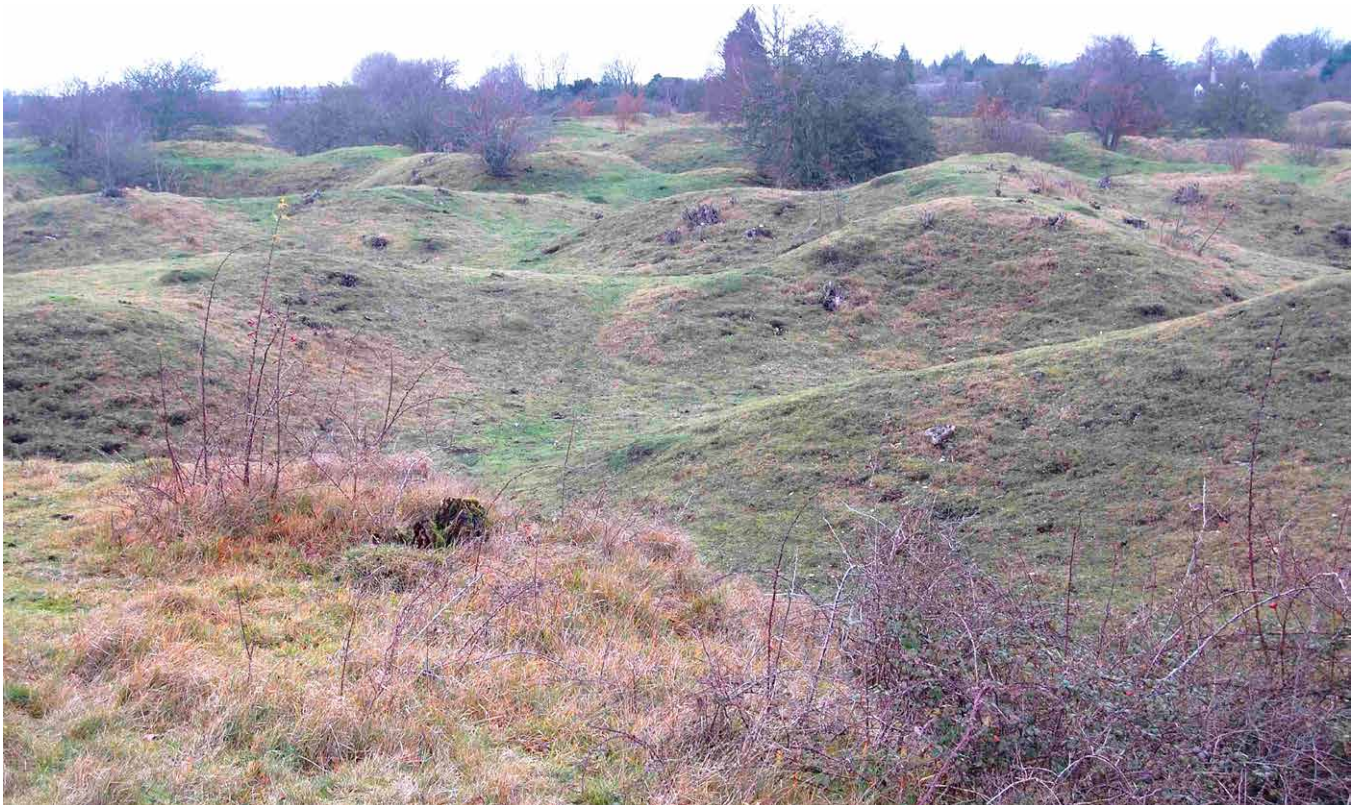

Figure 4
Some of medieval England's finest building stone was quarried at Barnack, Cambridgeshire, the Jurassic limestone being used, for instance, for Peterborough Cathedral and many buildings in Cambridge. Some 24 hectares of abandoned quarries and waste heaps, known locally as 'hills and holes', attest to this activity. This is a Site of Special Scientific Interest for the significance of its grassland and wild flowers.

production site at that time, shows that its coverage cannot be seen as comprehensive.

Assessment of industrial activity in a period with only limited documentation is almost wholly reliant on archaeological evidence. The increasing number of finds from metal detecting is providing a much expanded data-set, but more important is information from the still relatively small number of identified sites where raw materials were won, or goods made. In some hands, iron working was a highly skilled and technical business, with smiths (whom written sources indicate had close links with kings and lords because of what appeared to be their near-magical abilities) making steel-edged and pattern-welded blades as well as more mundane agricultural and domestic ironwork. Workshops seem to have been essentially one-man operations, typically in settlements close to patrons and customers. Just one set of smithing tools has been found, in a seventh-century grave at Tattershall Thorpe (Lincolnshire).

The working of non-ferrous metals, principally bronze, seems again to have been small-scale, with scrap being melted and recast into buckles and brooches, just as waste glass was reworked into a limited number of beads and vessel types. Renowned finds of highly prestigious metalwork, as at Sutton Hoo's early seventh-century ship burial in Suffolk, show the height of attainment of such craftsmen, as well as how international the trade was in materials and objects of high prestige.

1.3 Medieval

The traditional, and still probably broadly correct, view is that industrial activity increased with the arrival from the Continent of the reforming monastic orders in the twelfth century. The Cistercians, for example, exploited lead ores where these were found within their grants and were also skilled in the iron industry (Fig 5). Monastic bloomeries (small, low-temperature furnaces for producing non-molten iron from ore) are known from documentary sources to have been abundant and spread across the country but physical remains of such are comparatively rare, and generally identified from their slag (see Pre-Industrial Ironworks IHA).

Blast furnaces (higher temperature furnaces producing molten iron) were introduced from the Continent in the last years of the fifteenth century, and after the Dissolution of the Monasteries (1536-1541) the secular owners of former monastic estates were to take full advantage of this leap in technology. Monastic sites also display evidence for some larger-scale use of water power for grinding corn and other processes such as fulling (the beating of woven wool to clean and thicken it), as at Halesowen Abbey (West Midlands) (see Mills IHA). There were also many secular mills, generally associated with manorial sites such as the example at Kirkby Knowle (North Yorkshire). Mills were typically rebuilt on the same or adjacent sites many times over the centuries, and many mills used for industrial processes in the eighteenth and nineteenth centuries stood on the sites of medieval predecessors, the remains of which were thereby often built over. Throughout history, the repeated use of rivers and even streams for industrial production means that many industrial landscapes are strongly linear.

Though there is evidence for the use of coal from outcrops from Roman times there would seem to be a hiatus in its use until perhaps the twelfth century, when it began to be used for lime-burning, salt-making and other industrial processes (see Pre-Industrial Mines and Quarries IHA). Until recently it was assumed that the mining was primitive throughout the period, as evidenced by irregularly-spaced bell pits lacking underground connections. However, discoveries in Leicestershire during recent open-cast mining have shown that by the mid-fifteenth century there were underground pillar and stall workings reached by wood-lined vertical shafts around 30m deep. It should also be noted that coal extraction via shaft-mounds (that is, individual bell pits) persisted in some areas into the nineteenth century.

There is archaeological evidence for the resumption of tin streaming (a practice known from the prehistoric period of using water to

Figure 5
Near Bentley Grange, Emley, West Yorkshire, is an extensive area of scheduled ironstone mining remains, with a grid-pattern of doughnut-like mounds of spoil marking where shafts were driven for access or ventilation. Although originally thought medieval – it is known Byland Abbey had mines here – a sixteenth-century date now seems more probable.

extract and concentrate metal ore deposits) on Dartmoor by the twelfth century. Similarly there is documentary evidence for lead and silver mining from this date, but sites are difficult to identify on the ground because of extensive later re-workings: it should not be assumed that surface workings (termed rakes in northern England) are medieval. Early ore processing is similarly difficult to positively identify, although small numbers of smelting sites have been located (generally via spreads of waste slag) such as hillside-sited lead boles (where the wind was used to increase firing temperatures), although smelters with water-powered bellows are also known from the twelfth century.

The quarrying of stone for building also greatly increased from the twelfth century, and was soon on a far greater scale than during the Roman period. Although most quarried stone was used locally, high quality stone could be transported over considerable distances, as much as possible by water, for the construction of prestigious buildings such as castles, abbeys and cathedrals (much stone was shipped across the Channel for Norman buildings such as the White Tower (at the Tower of London), for instance). There is evidence that the underground quarries in the Bath and Corsham (Wiltshire) areas were exploited at this time, but their great period of expansion was to be later and has continued to the present day.

Lime, whether for building or for agriculture, was probably burnt locally normally in simple clamps which are difficult to identify archaeologically because of the lack of a built structure (see Pre-Industrial Lime Kilns IHA). Brick and tile making was quite widely distributed by the

fourteenth century but relatively few production sites are known due to the temporary nature of most works (see Roman and Medieval Pottery and Tile Production IHA). From the twelfth century pottery production seems to have shifted away from towns, where it had been concentrated since the late Saxon period, to more rural locations. Archaeology has identified many production centres and some are scheduled such as Brill (Buckinghamshire).

There is very little evidence for the production of glass in England before the Norman Conquest and even afterwards much was imported. Glass was being produced in the forests of the Weald of Kent from the thirteenth century and Staffordshire from the fourteenth century. Little is known of the technology of glass production in the early part of this period, although several excavated sites have yielded valuable technical information (see Medieval and Early Post-Medieval Glassworks IHA). The salt industry continued from Roman times at both inland and coastal locations; the Domesday Book (1086) records over 1,195 *salinas*, mostly coastal, and also the three Cheshire 'wich' (meaning brine spring or well) towns of Middlewich, Northwich and Nantwich. In the late Middle Ages cheap foreign imports are said to have reduced home production, especially at coastal locations, although the demands of the fishing industry buoyed production on the north-east and north-west coasts.

1.4 1550-1700

This period can be seen as the prelude to the Industrial Revolution, with many industries expanding dramatically in scale. The later sixteenth century witnessed profound changes in the organisation of industry. The Dissolution of the Monasteries led to a hiatus in many industrial concerns, but also led to a release of wealth that prompted the expansion of various secular-owned businesses, some benefiting from monopolies and privileges granted by the Crown. For example the Chartered Companies – the Society of Mines Royal and the Company of Mineral and Battery Works – had privileges covering large areas of land, processing and manufacturing techniques and trade covering a range of non-ferrous metals. These joint-stock companies, funded by the private investment of shareholders, imported mining, smelting and manufacturing expertise from central Europe and introduced larger scale industrial enterprises based on the extensive use of water power for dressing (that is, ore processing) and smelting.

Underground blasting with gun powder was in use by the late seventeenth century, as evidenced at the copper and lead mines at Ecton (Staffordshire). The production of copper and, at the very end of the period, its alloy brass, also greatly increased. Similarly, monopolies were sold by the Crown to cover the production of products such as alum and copperas, which were used to process wool and were to become the foundation of the early chemical industry.

The iron industry also saw significant development with the late medieval introduction of charcoal-fired blast furnaces in the Weald leading to a rapid take up of this technology throughout the country with some 70 furnaces in blast by 1580. A number of early blast furnaces are scheduled, of which Rockley Old Furnace (South Yorkshire), built about 1700, is one of the finest surviving examples; Charlcott (Shropshire; Fig 6) is another.

Blast furnaces did not completely supplant the use of bloomeries, as the former produced a brittle cast-iron which required conversion in a forge to become as malleable as the wrought iron produced in bloomeries. Later bloomeries typically employed water-powered bellows, initially developed in the fourteenth century. Though forges on bloomery sites had produced limited quantities of steel for centuries, the introduction of the cementation furnace (where iron was reheated mixed with charcoal) from 1614 resulted in a great increase in production of steel for the edge-tool industry.

The coal industry was very small in scale in the medieval period, being far less significant than other mining industries. By the sixteenth century

Figure 6
Much industry was rural, or at least it was until a workforce arrived. The ironworks at Charlcott, in south-east Shropshire where there were local ironstone reserves, remained relatively small-scale over a century of operation from about 1725.

there was a proliferation of small pits in most coalfields, but in the seventeenth century the domestic and industrial market for coal started to expand rapidly, helped by improvements in the transport system with the introduction of tramways, improved river navigations, estuarine staithes and other new facilities for coastal colliers. By 1690 national output was approaching 3 million tons, nearly half being produced in the north-east, much being shipped to London by sea. Technologically the industry was also developing, for instance with longwall working starting to replace pillar-and- stall in Shropshire and the widespread adoption of horse whims (or windlass) for winding. The increase in output also stimulated the expansion of other industries such as salt-making and glass production, allowing them to compete with continental suppliers.

In the 1560s the arrival in England of continental glassmakers led to the introduction of new techniques which allowed the production of glass which was higher in lime and lower in alkali, and which appears to have been of higher quality. At the same time, the English manufacture of *cristallo* glass, a very high quality clear glass used in expensive tableware, started on a small scale. But the main technical development in glassmaking came in the second decade of the seventeenth century when glassmaking with wood was effectively prohibited in England in order to conserve woodland. Coal was used thereafter, and the way in which the technical problems involved were overcome is still not clearly understood. One significant development, possibly around 1700, was that of the large cone. These cones became a distinctive landscape feature of glassmaking

districts in the eighteenth century, such as Stourbridge (West Midlands).

Somewhat earlier, the gunpowder industry developed from a peripatetic activity associated with war campaigns to a permanently-located industry based on waterpower producing larger volumes of higher-quality powder which could be stored. The earliest mills date from the mid-sixteenth century and were initially clustered around London, and then around the south-east, still serving an essentially military and naval need. By the late seventeenth century gunpowder was also being used for blasting in mining and its production spread to the Bristol area in the 1720s.

1.5 1700-1840

The eighteenth century witnessed the transformation of Britain's economy. Although the timing and origins of the Industrial Revolution are complex and the subject of debate – it is now seen as a longer, less dramatic process than was formerly thought – the effects are clear. During the period England's population more than doubled, and its distribution had started to shift north. The Industrial Revolution was stimulated by the expansion of trade in the eighteenth century and by a series of discoveries, inventions and developments that were to transform industry and the landscape over the next hundred years.

Notable amongst these are the smelting of iron by coke, the puddling of iron (an improved method of converting cast into wrought iron), the development of the steam engine, and the invention of textile machinery, initially powered by water. This was accompanied by significant advances in ways of working, such as the emergence of the factory system: the systematised approach to production bringing together multiple processes on the same site. Coupled with this was the ongoing transport revolution with the development of commercial docks, an extensive turnpike road network and the canal system. It is important to bear in mind that traditional, craft and domestic industries prospered alongside, and indeed were symbiotic with, the new power-driven industries of the Industrial Revolution: factory scale production did not command a monopoly of industrial output, and only started to dominate at the end of the period.

In 1709 Abraham Darby successfully smelted iron without charcoal, using coke instead (coal processed to remove impurities). This first coke-fuelled blast furnace survives in Coalbrookdale, a valley spur off the Ironbridge Gorge (Shropshire) and is scheduled: the first marker of the freeing of iron production from the limitations of charcoal supply. Although clusters of charcoal blast furnaces in areas like Cumbria continued to produce high quality iron, the use of coke allowed a great expansion, with numbers of furnaces expanding to over 170 by 1800, with pig-iron output rising from 30,000 tons to almost 250,000 tons.

By the end of the period, England had become an exporter of iron for the first time. Ironically, the main survivals from this period are charcoal furnaces as most of the early generation of coke furnaces were obliterated by later developments on their sites, an exception being the scheduled Bedlam furnaces in the Ironbridge Gorge itself. The final break in the industry's dependence on woodlands occurred in 1783-1784: Henry Cort discovered how to convert cast pig-iron into wrought iron without the use of charcoal by using a reverberatory furnace where burning coal was kept separate from the iron. In this process, known as puddling, melting pig-iron was stirred to produce malleable iron that could then be rolled into sheets.

The eighteenth century also saw an expansion in steel production with cementation furnaces (where iron bars were reheated packed in charcoal dust) such as the scheduled example at Derwentcote (Tyne and Wear), and the perfection of Benjamin Huntsman's Process in 1740 (producing high quality cast steel using crucible furnaces). The latter sparked the development of Sheffield's steel and edge tool industries; although crucible furnaces of this period are only thought to survive archaeologically, scheduled standing examples are later in date.

The eighteenth century saw many experiments and refinements of metallurgical processes: a number being poorly documented because they were closely guarded secrets. Where such sites are identified, the archaeological deposits can retain valuable technological information that can justify designation, even if associated structures have been largely lost. Surviving furnaces of all types dating to the period are rare and generally already designated.

Fed by the expansion of iron and steel production was an expansion of forges and foundries converting the raw metal into an ever-increasing range of products for both domestic and export markets. Although some were closely associated with blast furnaces such as Coalbrookdale, others, such as the forges and rolling mills at Wortley near Sheffield, were separate concerns. By the closing years of the eighteenth century specialist foundries producing steam engines and other machinery were being established. Notable amongst these were Boulton and Watt's Soho Foundry at Smethwick in the West Midlands and Mathew Murray's Round Foundry in Leeds (West Yorkshire). Within a few years, numerous other foundries followed with Peel William's Phoenix and Soho Foundries in Manchester, while in Cornwall the Perran and partly scheduled Hayle Foundries achieved international renown. Despite wholesale clearance of most of these sites, the archaeological investigation of surviving buildings and surrounding of the Round Foundry in Leeds, of Boulton and Watt's Soho Foundry, and of the Perran Foundry is demonstrating their archaeological potential.

As with the glass industry earlier, the pottery industries witnessed a similar revolution in technology and scale. At the beginning of the eighteenth century most English pottery production was of relatively coarse earthenware, but the introduction of improved salt glazing had encouraged a much finer cream ware to develop by the mid-eighteenth century. Further developments by the Wedgwood family from the 1760s, and then William Cookworthy's discovery of the use of Cornish china clay in 1768, led to the production of porcelain for which the Staffordshire industry especially became so renowned, though other centres developed in London, Worcester, Derbyshire and at Coalport (Shropshire), all areas with better access to coal than Cornwall. Designated sites of this date are typically standing structures which are listed, although the earthware kiln at Dunster (Somerset) is scheduled. The scheduled Wheal Martyn china clay works (Cornwall) developed from the 1820s.

The glass industry maintained its progress with the adoption of the distinctive glass cones (brick built covers over reverberatory and annealing furnaces) which became distinctive elements of the skyline of Bristol, Bridgwater (Somerset) and around Sheffield and Newcastle. Dudley in the West Midlands was also important for glass where the archaeological remains of a group of works are scheduled. The partial survival of Chandos Glass Cone, Bridgwater, built 1725 is scheduled. Catcliffe, Rotherham (South Yorkshire), is also scheduled: dated 1740, it is thought to be the oldest largely intact surviving example in Europe.

The salt industry shifted its focus at this time. Coastal salt-making became relatively less important as firstly inland brine reserves were exploited and then, somewhat later, rock salt. Both these required fuel to raise and/or process, favouring those reserves close to coal-fields or good transport.

All this activity and the revolution in transport caused a huge increase in the demand for bricks nationally, not just in the traditional brick-making areas of the south and east. Ironmasters for example claimed to be using a million bricks a year when faced with the Brick Tax in 1784. The building boom encouraged the establishment of permanent brickyards and the development of substantial, albeit intermittent, kilns which at this date were generally open-topped. A rare surviving eighteenth-century example is scheduled on Ebernoe Common, West Sussex.

Large-scale quarrying was also a feature of this period, with growing quantities being dispatched from the Isle of Portland, from Bath (especially following the completion of the Kennet and

Avon Canal in 1810), from the slate mines of Cornwall and Westmoreland, from the granite quarries of Devon and Cornwall, the carboniferous sandstones of Yorkshire (and from elsewhere besides). The role of the canal system in transporting this heavy material was fundamental, and it had a major impact on the appearance of England's towns.

In some places coal was coming to have a price advantage over wood in the early post-medieval period, as in Bristol from the 1570s, and soon after it was taken up as a fuel in brewing, distilling and cloth-finishing; in the manufacture of glass and pottery; and in the processing of non-ferrous metals. A dramatic increase in the demand from the coalfields also came from the furnace-based industries discussed above which consumed coal, or its processed form of coke. Demand was further compounded by the development of the steam engine. Thomas Newcomen's engine of 1712 was quickly adopted for pumping water out of mines, but it was not until James Watt's 1769 patent and other subsequent improvements (mainly by Cornish engineers such as Richard Trevithick) that the steam engine was widely adopted away from the coalfields.

By 1800, at least 1,000 steam engines are thought to have been in use. Annual coal production in Britain rose to some 10 million tons by this date, with extraction starting to extend into concealed coalfields requiring deeper workings. However the classic mining pithead with a concentration of buildings around a shaft was really a feature of the later nineteenth century: coalmines of this earlier period are more typically characterized by areas of scattered, dispersed, shaft-mounds with few or even no permanent structures. Instead archaeology has revealed a range of more temporary facilities such as horse gins, which could be relocated as workings progressed. Scheduled examples of such mining landscapes include Goyt Moss (Derbyshire) and Dewley Pits, Woolsingham (Tyneside). Consequently, rare eighteenth-century pithead buildings are strong candidates for designation even when ruinous, such as the scheduled Saltom Pit on the Cumbrian coast.

The eighteenth century also saw a great expansion of metal-ore mining, which continued into the nineteenth century, often obscuring earlier evidence. For much of the eighteenth century, Cornwall became the world's main source of copper, its industry peaking in the mid-nineteenth century, although there were mines elsewhere such as Ecton, Staffordshire (see cover), and Coniston, Cumbria (both scheduled). Other minerals, particularly lead, were also extensively exploited, although the great expansion of tin mining in the south-west occurred later. Where possible, drainage adits (or soughs) were used to drain workings (being a particular feature of the Pennine orefields), although steam pumping was also used, with Cornish mines leading the way to increased efficiency because of the high cost of shipping-in fuel. Ore-dressing (separating the ore from waste minerals before smelting into metal) normally took place close to the extraction sites and was generally water-powered, leaving archaeologically rich sites which can provide much information about early technology and techniques. These sites are often highly vulnerable and the best can be good candidates for protection via scheduling. Smelting sites were sometimes located at mines, but were often at some remove. Some were short lived such as the Marrick Cupola smeltmill, Swaledale, North Yorkshire (1700-1723). Others, such as at Allendale (Northumberland) remained in use for considerable periods (1692-1896) undergoing many modifications (both being for lead and are now scheduled ruins). Copper smelting was more complex because of its chemistry: fewer sites survive so that even those where just slag heaps remain may warrant designation. The related brass industry expanded around Bristol in the eighteenth century, including William Champion's brass works at Warmley (established 1743 and now scheduled).

The textile industry has fared somewhat better in terms of surviving structures, the designation of which is discussed in the Industrial Buildings listing selection guide. The landscape settings of the mills and especially their water management systems are of archaeological interest, while the buried remains of early water supply systems

and steam-driven mills are of considerable archaeological potential. The recent excavation, for example, of several such sites in the Ancoats area of Manchester has greatly added to our understanding of the transition from water to steam power. Sites are known in the Pennines where steam and water power worked together to drive machinery, or where steam was used to pump water up to mill ponds. Haarlem Mill, Wirksworth (Derbyshire) is the earliest mill known in England designed from the outset to house a steam engine, probably to pump water.

Bristol and its environs was also a focus of an increase in the gunpowder industry with a new group of mills established by the 1720s including the scheduled Littleton Works (North Somerset). Previously the industry had served a purely military market with mills clustered in and around London from the mid-sixteenth century, but from the late seventeenth century gunpowder found a new use in mining. The combination of good charcoal supplies and a ready market for explosives saw the industry spread to the Lake District in the 1760s where a number of sites are now scheduled.

1.6 1840-1914

For much of this period Britain was the 'workshop of the world'. There was a spectacular increase in production in all sectors: some in terms of scale (such as larger blast furnaces (Fig 7) and factories with greatly increased outputs), but also in terms of range (with a great multiplication of small scale specialist workshops and businesses). Cheap steel, an ever-expanding range of machine tools facilitating mechanical engineering (notably the machinery installed 1803-1805 at the Block Mills,

Figure 7
The scheduled Blists Hill ironworks, within the Ironbridge Gorge World Heritage Site in Shropshire. Its blast furnaces of the 1830s and 1840s had blast provided by two steam engines. Although superseded by the 1870s by works with hot blast furnaces several times bigger, they closed only in 1912. The works typifies many built during the early nineteenth century throughout the West Midlands.

Portsmouth), mass production and the extension of the factory system to consumer goods such as clothing and shoes, all played their part.

The significant improvements in transport (for which see the Infrastucture: Transport listing selection guide), particularly the development of the railways, fuelled this increase in production by opening up new markets and reducing the transport costs of raw materials. Improved transport also allowed the spread of industrialisation into new areas of the country, completing the transformation of the nation's former agrarian economy into one based on industry (Fig 8). And, as first recorded in the 1851 census, this was the period when Britain became an urban nation.

Most of this expansion of industry was based on coal. Coal production rose from around 15 million tons in 1815 to 170 million tons when the industry peaked in 1913. Some of this expansion was due to newly developed or much expanded coalfields (such as Somerset, including the scheduled Vobster Breach colliery) but most was the result of increased capital investment in long established coalfields like the north-east, seeing the rise of the classic colliery pithead with suites of buildings housing steam engines for pumping and winding, workshops and other facilities, as can be seen at the scheduled Woodhorn Colliery, Northumberland (opened 1894), and Caphouse, West Yorkshire (developed 1870s), both now being museums, as well as at Chatterley Whitfield, Staffordshire (Fig 9). Structures such as ventilation fan houses were typically installed late in the period as a result of changing legislation prompted by pit disasters. The free availability of unsalable small coal meant that the efficiency of steam engines was of little concern at collieries.

Figure 8
In the 1860s a Dundee firm built large-scale lime kilns on Holy Island (Northumberland) to burn quarried limestone. They stood next to a jetty, convenient for the importation of coal to burn the lime and for the export of quicklime, used in building and agriculture. Within a generation railways made mainland lime cheaper, and burning here fell away.

Figure 9
Chatterley Whitfield colliery, Stoke-on-Trent, Staffordshire, was one of England's most productive in the later nineteenth and earlier twentieth century, finally closing in 1977. A period as a museum meant, unlike most mines, it survived clearance, and in 1993 its importance was recognised by scheduling; various individual structures are listed.

For instance, in 1795 at Elsecar (South Yorkshire) a steam engine of essentially Newcomen's 1712 design was installed and pumped mine workings until 1923 (Fig 10). This engine remains in its engine house and is scheduled. Investment in electric power, mechanised coal-cutting, and in miner's welfare (for instance, pithead baths) did not generally take place until after the First World War.

The economics of ore mining was volatile, prompting particularly careful investment in permanent facilities (Fig 11). New techniques spread from Cornwall to other ore fields, and American machines such as vanners (which concentrated ore) were introduced. Water power was still employed wherever possible, such as the waterwheel-powered compressors for pneumatic drills used at Gunnerside Gill, in the Yorkshire Dales, in the 1870s (the water-powered lead ore works here being scheduled) and at the scheduled Eylesbarrow tin mine and smelt mill on Dartmoor. Where steam engines were used (such as the large numbers of iconic beam pumping engine houses mainly built during the mid-nineteenth century copper boom and now designated in Cornwall) efficiency, reducing fuel costs, was a primary concern.

Evolving economics and techniques also saw changes in the patterns of exploitation such as the great expansion in tin mining later in the century, overlaying earlier remains of copper extraction. Improved technology also allowed the reprocessing of old slag heaps, although tin streaming continued in Cornwall into this period, processing the waste ore from large mines. The reprocessing of old slag heaps was practiced at Snailbeach New Smeltmill (Shropshire), built in 1862, and although largely demolished in 1895 it is now scheduled as one of the best

preserved lead smeltmill complexes nationally. New discoveries saw rapid expansions of new industrial centres, such as the extensive deposits of ironstone in the Cleveland Hills in the 1850s leading to the dramatic growth of a hamlet into the town of Middlesbrough. In Cornwall, the production of arsenic, essential in a number of agricultural and industrial processes, became an important by-product of the tin and copper mines in the nineteenth century; half the world's arsenic came from the county in the 1870s.

With the coming of the railways, markets for good building stone expanded enormously. There were over 50 quarries working on Portland by 1850, while those around Bath and Corsham (Wiltshire) achieved an enormous extent. Many nineteenth-century and earlier quarries are now abandoned, but where they survive, they may preserve archaeological evidence of how they were worked, such as the currently unscheduled areas of granite quarrying on Kilmar Tor, on Bodmin Moor (Cornwall).

Brick production similarly increased in the nineteenth century, not least following the repeal of the Brick Tax in 1850 which stimulated the introduction of mechanised techniques. Brick production soared, and many new types of kiln were introduced on the continuous working principle invented by Hoffman in 1858, such as the scheduled example in Sheffield, built in 1879. Though intermittent kilns continued in use at construction sites and for specialised products (and indeed survived in use until the later twentieth century), kilns on the Hoffman principle, with many refinements of arrangement and firing, became the dominant type.

Figure 10
The Newcomen Beam Engine at Elsecar, South Yorkshire is the only Newcomen-type engine in the world to have remained in its original location. The engine pumped water from the coal mine beneath it from 1795 until 1923.

Figure 11 (top)
Magpie Mine, near Bakewell, Derbyshire, is the Peak District's best-preserved lead mine. Active by 1740, the heaviest investment – not least in pumping and a deep sough for drainage – was in the nineteenth century. Most of the buildings are mid-nineteenth-century, although the steel headgear is of the 1950s. The mine closed in 1958.

Figure 12 (bottom)
The Lion Salt Works, Marston, Cheshire is England's last surviving inland open-pan salt works. It evidences the full range of processes involved in twentieth-century salt production, from mining and brine-evaporation, to the drying, storing and transportation of the refined product.

Figure 13
Royal Gunpowder Factory, Waltham Abbey, Essex. A unique mid-nineteenth century gunpowder hydraulic press house with a surviving waterwheel, pump and press, probably manufactured by William Fairbairn and Sons of Manchester. In the foreground are the earthwork remains of the canal which was used by the powder barges and which provided the motive power for the waterwheel.

The pottery industry, building on the technological achievements of the eighteenth century, now became the largest supplier of ceramics in the world. Much of the industry was concentrated around Stoke-on-Trent which became famous for its distinctive landscape of pot-works with thousands of bottle-shaped kilns, although this did not entirely supplant many smaller local potteries such as the steam-powered Wetheriggs Pottery (Cumbria), opened in 1860 and now partially scheduled but still operating. The period also saw the expansion of the architectural ceramics industry pioneered in London by Eleanor Coade from 1769, which culminated in the Doulton works in Lambeth. There were also major centres of glass and ceramic production in the north-east, in Yorkshire and in Lancashire.

The shift in salt production to inland sites was accentuated by this time and the salt reserves around Northwich (Cheshire) became the main focus of the industry (Fig 12). Gunpowder production became concentrated into larger units with the Royal Gunpowder Works at Waltham Abbey (Essex; Fig 13) leading the way in technology, but towards the end of the period other explosives were being preferred for both mining and military use. Many of these new explosives were manufactured on existing gunpowder sites where isolated working and stringent safety procedures were already in operation.

Many industries of the period, and for that after 1914, are well represented by standing buildings which are now generally designated via listing rather than scheduling. Consequently the Industrial Buildings listing selection guide should be referred to for nineteenth-century and later textile mills, breweries and other structures of the food and drink industry such as corn mills, as well as for many manufacturing industries based in workshops and factories. However, scheduling may remain appropriate in some cases, particularly where vulnerable archaeological deposits remain.

2 Overarching Considerations

2.1 Scheduling and protection

Archaeological sites and monuments vary greatly in character, and can be protected in many ways: through positive management by owners, through policy, and through designation. In terms of our designation system, this consists of several separate approaches which operate alongside each other, and our aim is to recommend the most appropriate sort of protection for each asset. Our approach towards designation will vary, depending on the asset in question: our selection guides aim to indicate our broad approaches, but are subordinate to Department for Digital, Culture, Media and Sport (DCMS) policy.

Scheduling, through triggering careful control and the involvement of Historic England, ensures that the long-term interests of a site are placed first. It is warranted for sites with real claims to national importance which are the most significant remains in terms of their key place in telling our national story, and the need for close management of their archaeological potential. Scheduled monuments possess a high order of significance: they derive this from their archaeological and historic interest. Our selection guides aim to indicate some of the grounds of importance which may be relevant. Unlike listed buildings, scheduled sites are not generally suited to adaptive re-use.

Scheduling is discretionary: the Secretary of State has a choice as to whether to add a site to the Schedule or not. Scheduling is deliberately selective: given the ever-increasing numbers of archaeological remains which continue to be identified and interpreted, this is unavoidable. The Schedule aims to capture a representative sample of nationally important sites, rather than be an inclusive compendium of all such assets.

Given that archaeological sensitivity is all around us, it is important that all means of protecting archaeological remains are recognised. Other designations such as listing can play an important part here. Other sites may be identified as being of national importance, but not scheduled. Government policy affords them protection through the planning system, and local authorities play a key part in managing them through their archaeological services and Historic Environment Records (HERs).

The Schedule has evolved since it began in 1882, and some entries fall far short of modern standards. We are striving to upgrade these older records as part of our programme of upgrading the National Heritage List for England. Historic England continues to revise and upgrade these entries, which can be consulted on the Historic England website.

2.2 Heritage assets and national importance

Paragraph 194 and footnote 63 of the National Planning Policy Framework (July 2018) states that any harm to, or loss of, the significance of a designated heritage asset should require clear and convincing justification and for assets of the highest significance should be wholly exceptional; 'non-designated heritage assets of archaeological interest that are demonstrably of equivalent significance to scheduled monuments, should be considered subject to the policies for designated heritage assets'. These assets are defined as having National Importance (NI). This is the latest articulation of a principle first raised in PPG16 (1990-2010) and later in PPS5 (2010-2012).

2.3 Selection criteria

The particular considerations used by the Secretary of State when determining whether sites of all types are suitable for statutory designation through scheduling are set out in their Scheduled Monuments Policy Statement.

3 Specific Considerations

There are several particular issues to address when considering industrial sites for designation, alongside the non-statutory criteria. All sites must be judged on their own merits, but some recurrent themes are explored in more detail below.

3.1 Listing or scheduling

Industrial remains have historically been the subject of complementary approaches to designation. Thus listing has been applied to buildings in use: scheduling to those monuments where general re-use is inappropriate, or which are in ruinous condition. There are, however, many exceptions to this old rule of thumb: in practice, there are listed inert buildings in ruinous condition, and scheduled monuments in active use. The important thing is to identify buildings and sites deserving designation at a national level, and then apply the most appropriate designation regime. Given the very high order of significance demanded for scheduling, and the particular controls it brings, listing may often be the more appropriate approach for most other assets: especially when their significance can be upheld through the planning system. Some other designation regimes may also be appropriate, such as the creation of conservation areas by local planning authorities.

One approach, which has been used successfully on a number of industrial and modern military sites, is to combine the protection outcomes offered by both listing and scheduling. An example is Stublick Colliery (Northumberland) where the standing buildings are used as part of a farm and are listed Grade II*, whereas the surrounding and underlying earthworks and archaeological deposits are scheduled. In such instances grading is an important consideration: where warranted, listing in a higher grade (indicative of 'more than special interest') will ensure that the site is managed comparably and more seamlessly, regardless of the use of two designation Acts.

3.2 Modern industrial sites

Modern industrial sites can sometimes have strong claims to acknowledgment and may be considered for scheduling. However, generic and standard modern industrial structures lend themselves to listing first and foremost, if they are designatable at all. Innovation and historic interest may be key. For the more extraordinary, non-standard, structures listing will also be the more valid approach, and scheduling should only be considered in exceptional cases where it is wholly appropriate. For the most contentious modern sites, it would be expected that a discussion on various options is had with owners. Heritage management agreements should be considered. Long-term monumentalisation of whole sites is seldom feasible, and selectivity is essential. Preservation by record can be the most appropriate response: securing a vivid coverage before closure is desirable. Regeneration of 'brown-field' sites covers many former industrial locations: where

important structures remain, our designation response is generally through selective listing.

3.3 Scheduling below-ground sites

While it is legally possible to schedule industrial workings below the surface of the earth, in practice very few have been designated in the past. Considerable challenges arise over their long-term management. Mining played a fundamental part in the Industrial Revolution, but only in carefully selected instances will below-ground scheduling be appropriate.

3.4 Mineral rights ownership and outstanding mineral permissions

A particular consideration for industrial archaeological cases is that of mineral rights. Generally minerals are held in private ownership and often independently from the landowner, and in some instances, mineral permissions to work or rework mines and mine tips may be valid, but held in abeyance, for considerable periods of time. In addition, some sites may have other extant planning permissions which remain valid. It is not necessary for an owner of minerals to register his rights if these are separate from the surface of the land. In such instances, a decision to schedule may incur valid claims for compensation if the owner's ability to exercise their valid permits are revoked or made subject to additional costs or conditions; a recommendation to schedule will, therefore, be exceptional. Some information may be available from the Land Registry but these rights are registered on a voluntary basis.

3.5 Period

Sites of all periods may be considered for scheduling. Those which predate the Industrial Revolution may be rare examples of a particular industry. They are thereby likely to have national importance and be strong candidates for scheduling either in their own right, or as part of a wider site such as a larger settlement which includes industrial features. However, period is far from the only consideration, and even with relatively early industrial sites, some are sufficiently common that only selected examples will be proposed for designation. Many sites, say where ores were extracted at different times, will be multi-period. While this can lead to complexity, and perhaps a lesser immediate legibility, in general such sites may have added interest and potential where evidence of early works still survives; where later works have obliterated the early ones, this will not be the case.

3.6 Rarity, representativity and selectivity

Being a rare survival of a site-type may strengthen the case for scheduling. This will include sites where technological experimentation took place (see below under Documentation). Equally, it is important that the schedule is broadly representative of all kinds of sites, and not just the extraordinary or unusual ones. A range of industrial site-types of different periods should be considered for inclusion, although the relative significance of the particular industry in national terms is also a factor - not every specialised niche industry will justify a designated example of its own.

Selection also requires that the national spread of an industry is represented, for instance so that it is not forgotten that coal was mined in Kent and Somerset, not just in the great coalfields of the north. Selection of sites for designation should also aim to capture important regional specialisms, such the steel-working sites of Sheffield, as these will often have strong claims to note on a national level. However, it should be noted that our approach is not to designate every survival within these localised clusters. We must be selective, and designation can only be warranted by the survival of substantial interest, not simply by the fact of survival. With frequently encountered site-types or structures, whether or not with a national distribution, a selection of the best and most representative examples will be sought.

3.7 Documentation

Where a site has good documentation, either contemporary (such as historic plans or descriptions), or recent (such as archaeological surveys or excavations), this may enhance its claims to national importance. However in many industries, particularly metallurgical ones, techniques used during the industrial revolution were often closely-guarded secrets that were not documented. Archaeological analysis of deposits can play an important role in understanding these poorly documented processes (see Potential). This will seldom be the case when a full documentary record survives of processes, particularly on more modern sites, however.

3.8 Historic importance

Where a site is associated with a famous and especially an innovative industrialist, engineer or company, or saw new processes pioneered, this may add to its significance. That will be especially so where innovation has impacted on, and can be read in, the form of the asset.

3.9 Group value

Industrial sites function by taking in raw materials, subjecting them to one or more processes to produce a product (normally along with waste products), with the output then transported off-site to market or to form a raw material for another industry. Sites where this sequence of activities or 'process flow' is still recognizable are often of greater importance than sites where only part of the industrial process can be identified. Thus a spoil heap can provide additional group value, complementing the survival of the site of the primary industrial process by showing its by-products. That said, some industrial features are so significant even in isolation that they may justify designation when other elements of the site have been lost. With some sites such as those served by long leat or transport systems, especially where documented on maps, it is appropriate to only include sample lengths of what would otherwise represent repetitive archaeological information. Appropriate boundaries are always drawn to ensure that the key part of a dispersed site is identified.

Another form of group value occurs where there are a number of different industrial concerns clustered together, especially where there were historical linkages. An example is the scheduled Dark Hill ironworks and brickworks and the Titanic steelworks at Coleford (Gloucestershire).

3.10 Survival and condition

In designation assessments, a high level of alteration and reconstruction is sometimes the basis for a decision not to designate. With industrial structures and buildings, however, partial rebuilding and repair is often related to the industrial process. This may provide archaeological evidence for technological change that can itself be of sufficient significance to warrant protection: alteration can thus have a positive value. Where deterioration and loss have affected the significance of a site, however, judgment is needed as to whether national importance is still present: remains of buildings, sites and structures are eligible for scheduling, but outright loss can undermine the claims. A site's condition can be a determinant too: given that the aim of scheduling is to secure the long-term preservation of a monument for the benefit of future generations, where the condition of a site is *proven* to be unsustainable, questions must be asked about the appropriateness of scheduling.

3.11 Potential

Industrial sites sometimes have the potential of yielding historic information which can only be gained through the use of the scientific investigative techniques of archaeology. Analysis of waste artefacts and process residues can elucidate industrial techniques unrecorded elsewhere, for instance. Potential, when demonstrably present, can add to the case for scheduling as the preferred designation option.

4 Select Bibliography

As part of English Heritage's Monuments Protection Programme, surveys of major historic industries were undertaken in the years after 1990, and a series of 'step reports' compiled. The step 1 reports contain overviews of particular industries, while the step 3 reports include a list of identified sites that are potentially of national importance: validation of these assessments may be needed, but as general indicators of significance their findings still hold true. For industries treated in this selection guide MPP step 1 reports have been completed for the following: alum, arsenic, brass, chemicals, clay, coal, copper, glass, gunpowder, iron/steel, lead, lime, minor metals, oil, salt, stone, tin, zinc.

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http://www.gracesguide.co.uk/ - Historical information on industry and manufacturing in Britain.

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http://hist-met.org/ The Historical Metallurgy Society: journal and occasional papers.

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https://www.spab.org.uk/spab-mills-section/ The mills section of the Society for the Protection of Ancient Buildings for traditional water and wind mills.

4.2 Regional studies

Between 1965 and 1980 a series of regional guides was published by David and Charles and then Batsford, generally with titles in the format of *The Industrial Archaeology of …* These remain useful as starting points and for context.

The Association for Industrial Archaeology has produced regional and county gazetteers in connection with its annual conference each year for over 20 years. Many are out of print but some are available at http://industrial-archaeology.org/publications/sales/

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5 Where to Get Advice

If you would like to contact the Listing Team in one of our regional offices, please email: customers@HistoricEngland.org.uk noting the subject of your query, or call or write to the local team at:

North Region
37 Tanner Row
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Acknowledgments

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HEAG246
Publication date: March 2013 © English Heritage
Reissue date: July 2018 © Historic England
Design: Historic England