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GATEBECK LOW GUNPOWDER WORKS AND THE WORKERS' SETTLEMENTS OF ENDMOOR AND GATEBECK, CUMBRIA

AN ARCHAEOLOGICAL AND ARCHITECTURAL SURVEY

SURVEY REPORT

Marcus Jecock, Christopher Dunn, Abby Hunt, Philip Sinton, Naomi Archer, Matthew Bentley, Tony Berry, Ian Goodall, Adam Menuge and Simon Taylor

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SUMMARY
In the first half of 2006, a multi-disciplinary team of archaeological and architectural investigators, illustrators and photographers from English Heritage's Research Department undertook survey and investigation of the disused Gatebeck Low Gunpowder Works and associated workers' settlements of Endmoor and Gatebeck. Together with a more rapid survey of the adjoining Gatebeck High Works (in reality part of the same site) which took place immediately afterwards, the survey was the last in a Departmental project investigating the seven gunpowder works that operated in the historic counties of Westmorland and Lancashire North of the Sands (modern-day Cumbria) between 1768 and 1936. The study has resulted in not just a detailed understanding of the history, form and power-supply arrangements of the surviving industrial structures (four pairs of incorporating mills, a glazing house, two corning houses, a stove house plus ancillary buildings and associated features) but an in-depth appreciation of how the factory and settlements developed over time, and how these changes relate to the gunpowder industry regionally and nationally.

CONTRIBUTORS
Archaeological fieldwork was undertaken by Marcus Jecock and Christopher Dunn aided by Abby Hunt and Philip Sinton, architectural fieldwork by Simon Taylor, the late Dr Ian Goodall, Dr Adam Menuge and Tony Berry aided by David Andrews, Naomi Archer and Matthew Bentley (the latter two, EPPIC placements in Architectural Investigation and Imaging, Graphics & Survey respectively). The report was researched and written by Marcus Jecock, Simon Taylor and Adam Menuge; Tony Berry, Phil Sinton, Naomi Archer and Matthew Bentley drew the illustrations. Bob Skingle spent a day on site taking the official archive photography, while Christopher Dunn, Simon Taylor, Tony Berry and Marcus Jecock took record shots during fieldwork. Ms Sanne Roberts, a Masters student in building recording at York University, and Crispin Edwards, formerly of EH's Heritage Protection Department, assisted with fieldwork for short periods, the latter as career and professional development

ACKNOWLEDGMENTS
English Heritage is extremely grateful to the directors of the Millbrook Caravan Park Co for permission to undertake the survey and view the site deeds, and to Dr Blackmore at Platt & Fishwick, Solicitors, for facilitating access to those deeds. Thanks are also due to the site warden, Geoff Vines, and his wife Jacqueline, for their friendly welcome, good humour, and willing assistance in the research. Alan and Glenys Crocker spent a day on site helping to unravel the intricacies of power supply to the incorporating mills. English Heritage would also like to thank Brian Gregg and David Willacy for allowing historic photographs in their possession to be copied, and Peter Cartwright, formerly of ICI's Nobel Enterprises at Ardeer, for supplying a copy of the 1923 factory plan.

ARCHIVE LOCATION
National Monuments Record, Swindon.

DATE OF SURVEY
Survey was undertaken between February and June 2006

CONTACT DETAILS
English Heritage, 37 Tanner Row, York, YO1 6WP
marcus.jecock@english-heritage.org.uk

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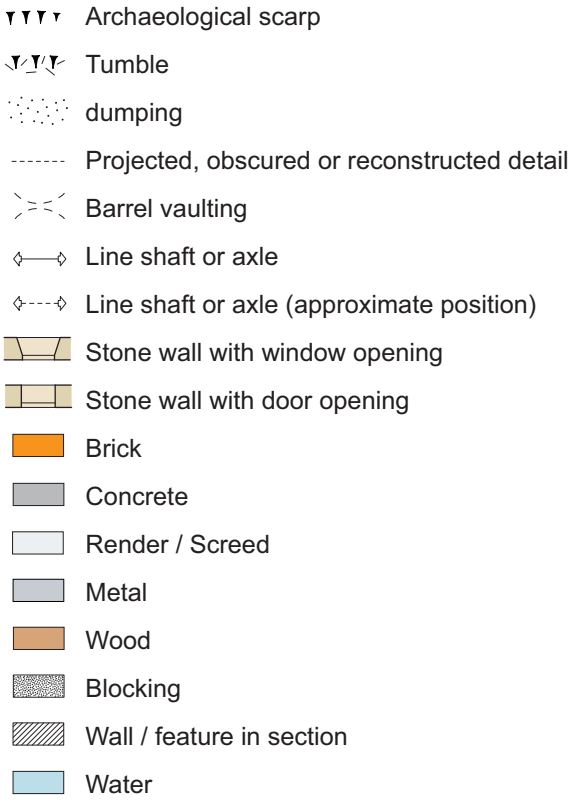

1. INTRODUCTION

During the first half of 2006, English Heritage carried out archaeological and architectural survey and investigation of the site of the former Gatebeck Gunpowder Works and nearby settlements of Endmoor and Gatebeck which is where the workforce in the main lived. The survey formed part of a wider thematic project investigating gunpowder manufactories across Cumbria, initiated in June 1999 (Dunn 2001; Jecock 2003) as the logical progression to the organisation's Monuments Protection Programme's (MPP) Step Reports for the gunpowder industry nationally (Gould 1993; Chitty 1996). Although there has been considerable interest and research into the Cumbrian works in recent years, directed at both the group as a whole and individual sites (*eg* Wilson 1964; Marshall & Davies-Shiel 1969, 75-88; Crocker 1988a, 36-41; Crocker and Crocker 1992; Patterson 1995; Palmer 1998; Tyler 2002; Vickers 2003), this has mostly concentrated on the documentary evidence with little formal examination or detailed recording of the physical remains. English Heritage's Cumbrian Gunpowder Industry Project is intended to rectify this omission, and will aid conservation management of those works which have been designated in whole or in part as protected monuments; the inclusion of all sites irrespective of their current level of designation will also enhance the overall understanding of what was an important regional industry.

The Gatebeck works is one of seven powder manufactories which operated in the historic county of Westmorland and the Furness area of Lancashire (since 1974 both amalgamated into modern day Cumbria) at various times between *c* 1764 and 1936. The factories were concentrated in three areas: Old Sedgwick, New Sedgwick, and Basingill lie in close proximity along the banks of the River Kent 5-6km south of Kendal, with Gatebeck (Low and High Works) situated about 4km to the south-east; Blackbeck and Lowwood occupy neighbouring valleys close to Haverthwaite; whilst Elterwater forms an outlier at the foot of Great Langdale (Fig 1). The seven factories were initially owned and operated by five companies, all producing gunpowder chiefly for the civilian, as opposed to military, market, but after World War I came under unified control.

The industry became established in Cumbria mainly in response to the increasing national demand for blasting powder from mines and quarries from the 18th century. The Lake District provided a very suitable environment for gunpowder manufacture: the numerous rivers could supply the power needed by the different stages of the manufacturing process, while the rural and wooded locations were sufficiently remote from populous areas to minimise the effects of any accidental explosions. Later on, as more regard began to be paid to the safety of the workforce as well, several mills even incorporated trees, natural rock outcrops and low hills into their layouts as barriers to dampen and help contain blasts. Timber was available locally both for charcoal manufacture and the making of barrels and packing crates, whilst proximity to the coast meant that other raw materials (sulphur and saltpetre) could be readily imported. As a result of these overseas contacts – mostly routed through Liverpool – the Cumbrian gunpowder industry was able to build up a healthy market for its products abroad, particularly in parts of the British Empire, as well as at home. After *c* 1860, alternative forms of explosive based on the nitration of a variety of organic compounds began to appear. Many English powder works diversified into producing the new explosives, but the Cumbrian mills stuck

with their traditional stock-in-trade, now re-named blackpowder to distinguish it from the newer forms. Despite this failure to diversify, the Cumbrian blackpowder industry continued to prosper until the end of World War I, when overcapacity in explosives manufacture, resulting from the gearing-up of production to meet wartime demand, led to the Cumbrian mill owners merging with many of their British competitors to form Explosives Trades Ltd and beginning a process of rationalisation of the industry. In 1920

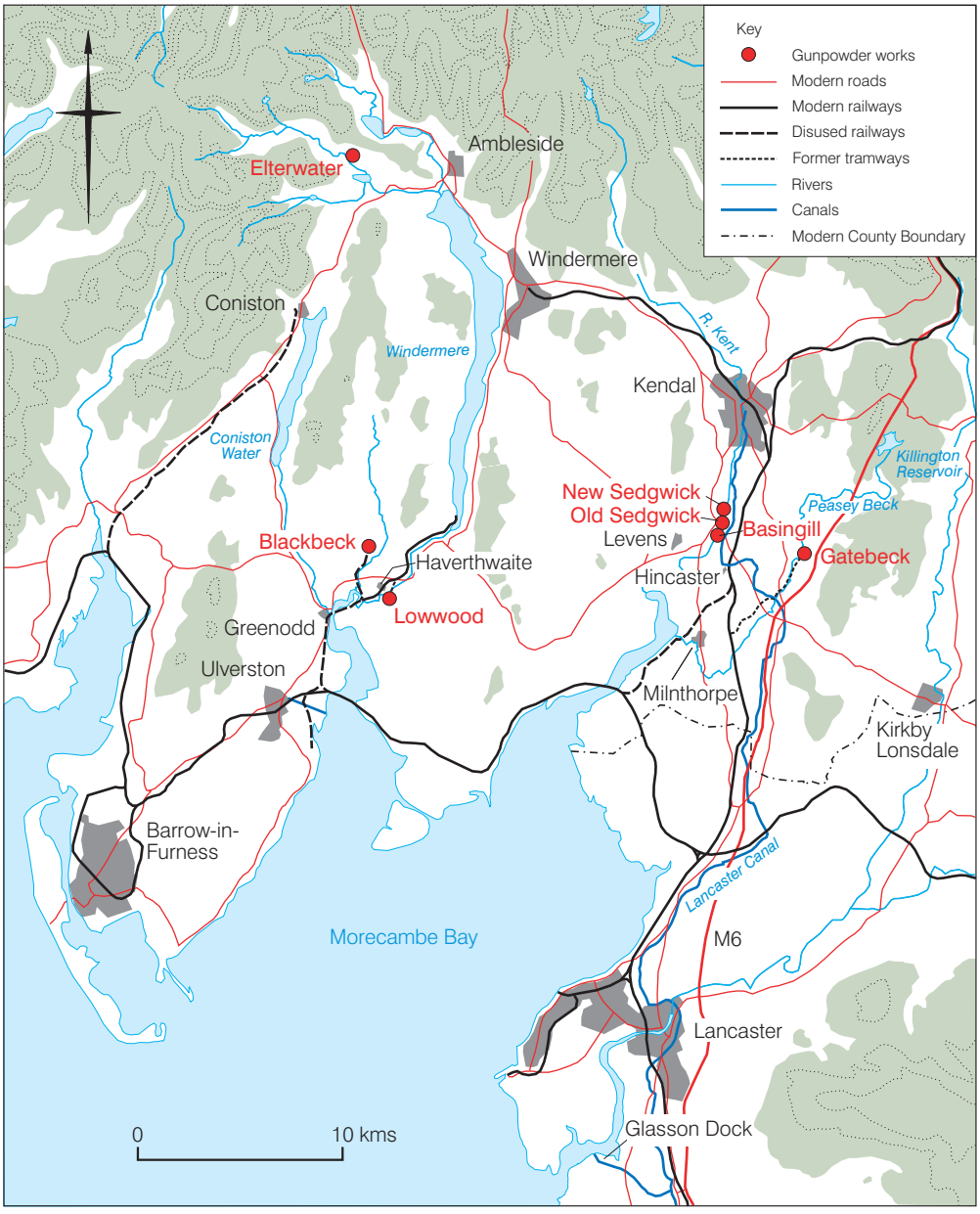

Figure 1: General location diagram (Drawn by Philip Sinton, © Crown copyright and database right 2009. All rights reserved. Ordnance Survey Licence no. 100019088)

Explosives Trades became Nobel Industries Ltd, in 1926 itself incorporated into Imperial Chemical Industries (ICI) Ltd. In 1928 ICI extended the programme of factory closures to Cumbria, and Gatebeck was the last of the Lakeland sites to shut in 1936. After this date all British blackpowder was produced at a single factory: Ardeer in Scotland (Cocroft and Tuck 2005, 231; Crocker 1988a, 1-2; Patterson 1995, *xi* and 44).

Gatebeck Gunpowder Works was owned and run by a family firm established by John Wakefield I. It replaced an earlier factory - Old Sedgwick - founded in 1768 but occupying a very cramped site, the lease of which expired in 1852. Wakefield's grandson, John III, applied for an operating licence to build new premises at Gatebeck in 1850. There is evidence that the water-power potential of the Gatebeck site had been harnessed previously, possibly to operate a bloomery forge, but the mill was probably long since disused and demolished. Construction work on the gunpowder works started in 1851 with the first powder made in 1852, although production did not transfer completely from Old Sedgwick until 1854. As built *circa* 1851-4, the works was confined to the east bank of the Peasey Beck between Gatebeck and Challon Hall Bridges, but soon expanded across the beck on to the west bank. In 1880 the company took over the site of a neighbouring mill (originally an iron foundry but latterly a bleachery) that stood on the east bank north of Gatebeck Bridge, and developed it as a Cooperage. In the mid-1890s, the company also acquired land on the west bank opposite this mill and erected facilities to manufacture a range of newly developed 'safety' powders. This latter site was run, at least initially, by a subsidiary company called Nitrate Explosives Ltd, and was the subject of a separate operating licence to the rest of the works. However, both parts of the factory were interlinked from the outset, and in later years seem to have been managed as a single enterprise. They were distinguished from each other as the Low and the High Works. The current report deals with the Low Works (and very briefly with the Cooperage) only; surviving remains at the High Works will be described elsewhere (Oswald *et al* in prep). At its greatest extent the Low Works covered *c* 19.6ha centred on National Grid Reference (NGR) SD 544 853, but the company also owned or leased other land in the area, and erected houses for their workforce in the neighbouring settlements of Endmoor and Gatebeck (Figs 1 and 2).

In 1882, Wakefield's took over one of their Lakeland rivals, the Lowwood Gunpowder Company, and in 1917 merged with the three other local manufacturers as part of the new conglomerate, Explosives Trades Ltd, which within a few years had become Nobel Industries Ltd and by 1926 was a division of ICI. Despite modernising the infrastructure, ICI closed the works in 1936 due to a general downturn in demand for blackpowder. At closure, all the so-called 'danger' buildings within the 'licensed' areas where powder had been processed or stored were set alight as required by Board-of-Trade regulations to prevent subsequent accidental ignition of powder residues, but non-danger buildings were simply abandoned. Some of the more modern machinery was shipped off to ICI's Ardeer factory for reuse there, the rest presumably sold for scrap.

Since closure, large parts of the factory have been put to other uses, many gunpowder buildings demolished and earthwork features erased; in addition, the workers' housing which the company erected in Endmoor and Gatebeck has been sold off. At the outbreak of World War II the factory was requisitioned by Army Engineers, but post-war the site was systematically subdivided and parts sold for a variety of residential, industrial and commercial uses: house plots and an industrial area were created along the factory frontage with the Endmoor to Gatebeck Road, the site of the Cooperage became an industrial estate, while after a short period as a Civil Defence Training Area during which time quantities of demolition debris from slum clearances in Kendal were dumped on site, much of the remainder of the Low Works was transformed into an industrial site and two caravan parks, the latter known as Gatebeck and Millbrook.

There are three areas of good archaeological survival within Millbrook Caravan Park, which is the only part of the former Low Works to have been investigated by English Heritage: the first is in the vicinity of the bridge on the short access road into the works/ caravan park where a number of ancillary buildings have been converted to residential use; the second, along the east bank of the beck at the very southern end of the former factory area where a range of features, including eight incorporating mills, two corning houses, a glazing house, stove and a sawmill latterly known as the mechanics' workshop survive in varying states of preservation; the third, a linear strip towards the eastern edge of the site where much of the main mill leat, albeit dry and in places infilled, together with elements of factory buildings arranged along it, also survives. Apart from the buildings around the bridge, these areas are neglected and overgrown. The second area adjacent to the east bank was designated a Scheduled Monument (RSM No. 27806) in 2000, as recommended by MPP; charcoal retorts used at the factory in its early years and which were subsequently reset as gateposts at the works entrance were also recommended for listing at Grade II, but the recommendation has so far not been enacted.

Gatebeck Low Works is the penultimate Cumbrian blackpowder site to appear in this English Heritage report series and its predecessors, after Old Sedgwick (Jecock and Dunn 2002), Basingill (Hunt and Goodall 2002), Elterwater (Jecock *et al* 2003), New Sedgwick (Dunn *et al* 2003), Blackbeck (Dunn *et al* 2005) and Lowwood (Jecock *et al* 2005). Archaeological and architectural survey of the scheduled area and of the southern end of the strip bordering the mill leat was carried out to level 3 standard (as defined most recently in English Heritage 2006, 13-14; 2007, 23-4), but a more rapid record was made of other parts of the factory and of the settlements of Endmoor and Gatebeck. Fieldwork was backed up by documentary research comprising a search for historical archive material and a reading of published sources, although the former was not exhaustive. A set of high-quality colour archive photographs was taken by English Heritage photographers as part of the recording process: many are reproduced in the present report. Further, non-professional, digital photography was undertaken on site during the investigation process, much of which is also reproduced in this report.

It must be emphasised that Millbrook Caravan Park is private property, with no automatic right of public access. In addition, the gunpowder remains are a risky environment with hazards of deep, unfenced wheel-pits, crumbling masonry, and falling trees. Unauthorised visits are therefore illegal and potentially dangerous.

2. GEOLOGY, TOPOGRAPHY AND LAND USE

Gatebeck Low Gunpowder Works lines the banks of the Peasey Beck between Gatebeck and Endmoor. The beck is the eastern of two tributaries of the River Bela, draining the eastern arm of the South Cumbria Low Fells south-westwards into Morecambe Bay via the lower drowned reaches of the River Kent which the Bela joins at Milnthorpe (Figs 1 and 2). The beck has a long history of mills sited along it - Kaker Mill south of Challon Hall

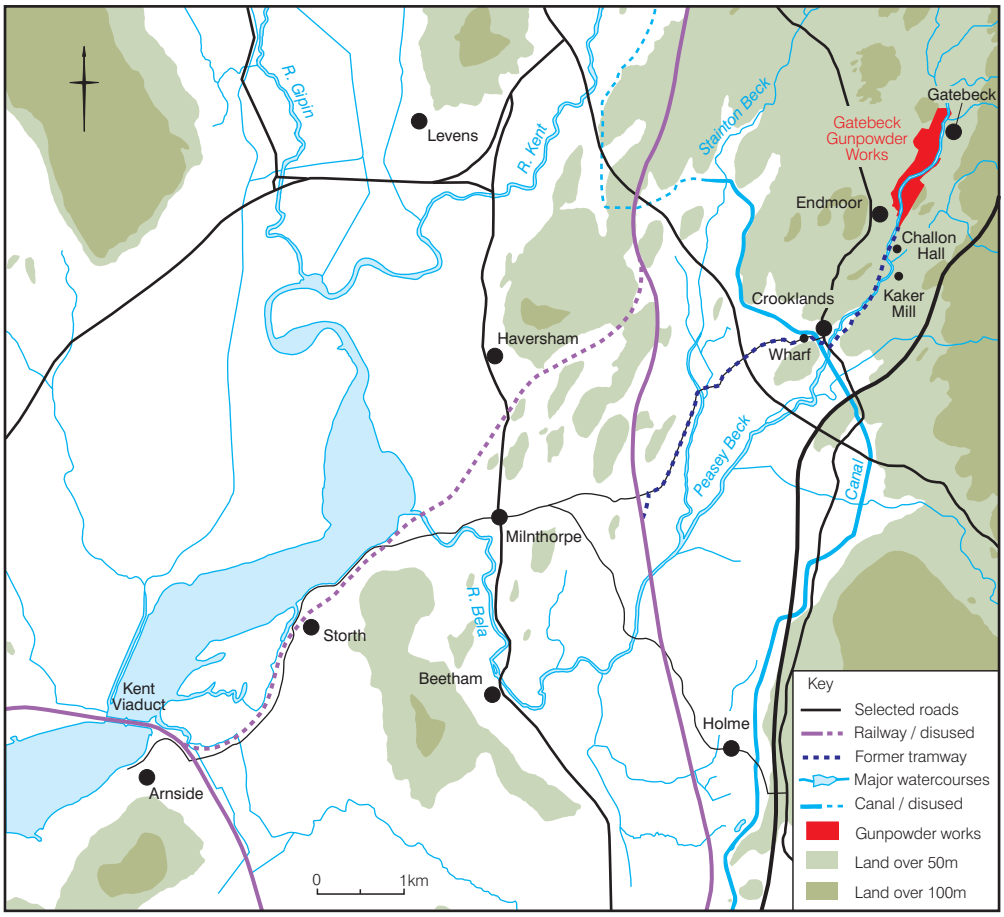

Figure 2: Local location diagram (Drawn by Philip Sinton, © Crown copyright and database right 2009. All rights reserved. Ordnance Survey Licence no. 100019088)

Bridge may date as early as 1119 for example, while a foundry was established opposite Gatebeck hamlet in 1781 (Somervell 1930, 78-9) - but became even more attractive as a source of water power after 1819 when chosen as a feeder for the northern section of the Kendal and Lancaster Canal, and the Killington Reservoir was constructed at its head to regulate water flows.

For much of its course, the beck occupies a narrow valley cutting through glaciated, rolling hills of carboniferous limestone (Institute of Geological Sciences 1980), but between Gatebeck and Endmoor the valley broadens out and the river runs down the western edge of the valley floor, creating a terrace up to 125m wide on the east bank. It was this terrace that was chosen as the location for the gunpowder works, on land that at the time was part of the Wakefield family's Challon Hall estate, although the works

subsequently expanded onto the west bank also. There is little evidence for what the area was used for before this time, although the first edition 25-inch OS map (Fig 137), surveyed in 1858 only a few years after the first buildings had been erected, shows the eastern side of the valley as an essentially open landscape parcelled up into a grid of rectangular fields suggestive of parliamentary enclosure, and the west bank as wooded with fields beyond. The factory was evidently not the first water-powered establishment on the estate, for the map portrays a weir and associated system of mill leats at the southern end of the terrace: this cannot have powered the gunpowder works, although it subsequently acted as the works tailrace (sections 4.2 and 6.1.2 below). Later maps (Figs 138 and 139) depict the factory as surrounded by woodland called Gatebeck Plantation: presumably a deliberate creation to provide zones of blast protection within the factory and shield adjoining properties should outlying danger buildings blow up.

Figure 3: Collapsed stream revetment opposite the northern charge house (building 6) (Photograph: Christopher Dunn 2006, © English Heritage)

Following closure and sale of the gunpowder factory in 1936-7, the site was requisitioned by Army Engineers for wartime training purposes. After 1945, however, the land was sold off in lots, and parts used variously for residential or industrial development, Civil Defence Training, and, most recently, for two caravan parks in different ownership, one on each side of the beck. During the time that the eastern part of the disused factory was used for Civil Defence Training, building material from slum clearances in Kendal was reportedly brought onto site and dumped (Millbrook Caravan Park 1975, 5-6): it is presumably this material, bulldozed flat, that accounts for much of the broad fan of

dumping that visibly overlies the valley floor - and probably obscures archaeological detail - between the extant mechanics' shop and small corning house at the southern end of Millbrook Caravan Park (Fig 143).

Gatebeck Plantation is now much reduced in size, and consists of unmanaged, unvisited woodland, largely confined to parts of the valley floor and steep eastern valley side. It is precisely for this reason, however, that gunpowder buildings (incorporating mills, corning houses, a glazing house, stove and various ancillary structures) survive at the southern end of the former factory area, albeit now threatened by weed trees rooted into the masonry and others that have sown close-by. Tree-felling and clearance of undergrowth was undertaken around the incorporating mills in the early winter of 2006 prior to English Heritage fieldwork, partly for reasons of health and safety but also to aid the accessibility and visibility of standing structures during investigation and recording and

Figure 4: The 'power house' (building 13a) north of the large corning house, destroyed by a wind-blown tree
(Photograph: Christopher Dunn 2006, © English Heritage)

to improve their long-term conservation management by reducing the threat of root damage and wind-throw. It is hoped that continued regular management will prevent re-seeding, but many of the remaining trees are old and/or poorly rooted, and wind-throws will continue to cause damage: for example, fallen trees by the beck had already, before survey commenced, destroyed sections of the stone walling revetting the river bank in front of the large corning house, glazing house, incorporating mills and charge houses (Fig 3), thereby exposing these buildings to eventual erosion by the beck, and more have fallen since. Prior to survey a tree had also fallen onto the brick-built 'power house' to the mark II large corning house (Fig 4), flattening what photographic evidence (Tyler 2002, 58 bottom) shows had, until recently, been a well preserved, upstanding building.

3. PREVIOUS RESEARCH

All published studies of the Gatebeck Low Works prior to the present investigation have been primarily concerned with the documentary evidence.

The earliest historical account is an anonymous article published in the Imperial Chemical Industries (ICI) in-house magazine whilst the factory was still operational. This is best described as a potted history of the five independent Lakeland blackpowder manufacturers which came together as part of Explosives Trades Ltd in 1917, and which after 1926 constituted ICI's North of England Gunpowder Group (Imperial Chemical Industries 1929). The article is brief, but nonetheless informative, outlining principal milestones in the history of each of the constituent companies. It is not clear what records the ICI historian had access to, but his statements have been accepted uncritically by most subsequent researchers. A few additional facts were given shortly afterwards in a review of South Westmorland water mills compiled by a local historian (Somervell 1930, 78), but a general history of ICI and its founding companies published at the end of the 1930s after Gatebeck had closed, contained no new data (Imperial Chemical Industries 1938).

Academic research into the south Lakeland blackpowder industry commenced in 1964 with the publication of Paul Wilson's seminal article. Wilson treated Gatebeck in less than two full pages (Wilson 1964, 55-7), and strangely made almost no reference to the work of the ICI historian, preferring instead to give a generalised overview of how the site was powered based to large degree on correspondence with Messrs Bush and Towell, former employees of the company. The article was quickly followed by a detailed overview of the industry by Mike Davies-Shiel which appeared as a chapter in a book on the industrial archaeology of the Lake District (Marshall and Davies-Shiel 1969, 75-88), but while this overview draws on Davies-Shiel's personal fieldwork and research into several Lakeland gunpowder works, it contains little that is new or specific to Gatebeck. Subsequent short notes (Crocker 1988a, 38-9; Crocker and Crocker 1992, 11-14) simply reprise facts presented by these studies.

The next work to present substantive new information on Gatebeck appeared in 1995. This was written by Edward Patterson, a former employee of ICI at their Ardeer site which, following Gatebeck's closure, became the sole producer of blackpowder in the United Kingdom. Patterson had access to documents whose existence was unknown to earlier researchers, namely an annotated factory plan produced in 1898, and a copy of the Manufacturing Method Book (MMB) dating to 1931 or shortly after. However, his published commentary contains errors and misunderstandings, and the nature of his source material means that discussion is very much limited to how the factory operated towards the end of its life (Patterson 1995, 24-32).

More recently, two further accounts of Gatebeck have appeared. The first, a chapter in a book describing the history of all seven of the Lakeland gunpowder factories (Tyler 2002, 44-96) takes a straightforward chronological approach, but the omission of detailed references from the text makes many of the statements difficult to verify. The second, a thoroughly researched academic PhD thesis, tackles the subject from the fresh perspective of trade and economic and commercial history (Vickers 2003, *passim*).

4. HISTORY AND DOCUMENTARY SOURCES

The main purpose of this chapter is to review in some detail both the history of the Gatebeck Low Works and the extent and nature of the documentary sources.

Almost no primary documentation survives. Many company records were reportedly destroyed at, or shortly after, the factory's closure in 1936; more were probably lost in 1940 when the Wakefield family's main residence, Sedgwick House, was requisitioned for war service (Marshall and Davies-Shiel 1969, 86; Tyler 2002, 81-2). A few, however, have survived by circuitous means. These comprise a copy of a factory plan of 1923 preserved at the Ardeer headquarters of Nobel Enterprises (but presumably now lost following ICI's recent sale of the business) and a copy of ICI's (post-1931) Manufacturing Method Book (MMB) plus other assorted minor documentation acquired by an ex-Ardeer worker, Edward Patterson (preserved at the NMRC in Swindon). Other principal sources of unpublished primary information are: the 1851 bill of tender to build the factory and copies of an annotated factory plan surveyed in 1898 by the Land Agents, A Hoggarth & Son, all deposited at the Cumbria Records Office in Kendal (CRO(K)); the title deeds to the site held by the current owners of the Millbrook Caravan Park; and the records of the turbine manufacturer, Gilkes of Kendal. A number of photographs also exist in private collections, some of which have been reproduced commercially. Published primary sources comprise: the three editions of Ordnance Survey (OS) mapping surveyed in 1858, 1896 and 1911; local newspaper accounts of fatal accidents and other notable events at the works; and the official report by HM Explosives Inspectorate into the death of two press-house workers in 1881. Major published secondary sources comprise the works of Mike Davies-Shiel, the ICI historian, Ian Tyler, Dr Robert Vickers and Paul Wilson (chapter 3 above); Paul Wilson got some of his information from Alfred Bush, a retired Gatebeck employee who later became manager at New Sedgwick and also subsequently held positions of authority at Ardeer.

As the Wakefield company who owned and ran the Gatebeck works for much of its life, originally operated out of a factory at Larkrigg or Lakerigg Mill (more frequently but inaccurately now referred to as Old Sedgwick), the following account of the factory's development is prefaced by a brief review of the company's early history and the reasons and events influencing their decision to relocate. The company also operated a small outstation at Basingill, situated close to Old Sedgwick, which remained open following the physical transfer of the main business to Gatebeck. Both Old Sedgwick and Basingill have been the subject of previous reports in this English Heritage series (Jecock and Dunn 2002; Hunt and Goodall, 2002). However, additional information which has come to light in the interim and builds on, and in some cases, corrects, information in those two reports, is reviewed briefly in Appendix 3 at the end of the present volume.

4.1 The circumstances surrounding the Company's relocation to Gatebeck

Under the terms of the 1772 Gunpowder Act, any premises where gunpowder was milled had to be licensed and conform to certain regulations governing the form of construction and siting of specified buildings. On 18 October 1850, John Wakefield III received licence from Justices of the Peace sitting at Kendal 'to erect Buildings for the manufacture of Gunpowder … upon an estate called Challon Hall, in the township of

Preston Patrick in the County of Westmorland, and upon that part of it which abuts upon, and is near to the river, situate between the Bridges called Gatebeck Bridge and Challon Hall Bridge … known by the name of Tommy Levens Brow and Dove Holme' (CRO(K) WQ/O/15). The area specified can be equated with what, following the expansion of the factory onto the west bank of the Peasey Beck north of Gatebeck Bridge in 1898 (see below), was thereafter referred to as the Gatebeck Low Works to distinguish it from the newly opened High Works. To all intents and purposes, however, and certainly in later years, both parts of the site were run very much as a single enterprise.

By 1850, when John Wakefield III made his licence application to construct the Low Works, the Wakefield family had already been successfully engaged locally in the manufacture of blackpowder for over 80 years. Wakefield's grandfather - the first John - had entered into partnership with four other Westmorland entrepreneurs to manufacture gunpowder as far back as 1764, although seemingly it was not until 1768 that the partnership leased its first premises at Larkrigg Mill/Old Sedgwick. They traded in the first instance as Wakefield, Strickland & Co. However, as the Old Sedgwick site was cramped and had limited waterpower potential, when the company wanted to expand in 1790 it was obliged to do so by opening a small outstation at Basingill some 0.5km distant. Both these early factories lay on the east bank of the River Kent on the outskirts of Sedgwick village, 4km north-west of Gatebeck (Jecock and Dunn 2002, 8 and 12).

Probably because it is how later members of the Wakefield family referred to it (*Westmorland Gazette*, 10 Sep 1864), the original partnership has been described by most modern commentators (eg Wilson 1964, 55) as a tontine agreement under whose terms the longest-surviving partner stood to inherit everything. Vickers (2003, 37), however, has recently pointed out that *stricto sensu* the description is inaccurate: although each of the partners had the option to buy up a retiring or deceased partner's shares, the shares were not forfeited automatically. Nevertheless, by exercising his pre-emptive right to buy, John Wakefield I had, by 1795, acquired sole ownership of the company, which for many years thereafter traded as John Wakefield & Sons. When John died in 1811, the business passed to his son, John II; by 1826 it was controlled by his grandson, John III. Sometime in the 1830s one William Bainbridge was admitted as partner, and for the next twenty or so years the company changed its style to Wakefield and Bainbridge (Vickers 2003, 39 and 105-6).

The lease of the Old Sedgwick site - which the original partners had signed in May 1768 - was for a maximum of four 21-year terms (Jecock and Dunn 2002, 8): it thus expired in 1852. Although John Wakefield III entered into early renewal negotiations with the site owners, the Strickland family of Sizergh Castle, it seems that by gaining the necessary permissions to erect a new factory at Gatebeck (on land owned by his uncle, Jacob) he was, at the very least, preparing a fall-back position should those negotiations fail. Discussions with the Sizergh estate dragged on and eventually collapsed. At expiry, therefore, the Wakefield & Bainbridge company continued to occupy Old Sedgwick as sitting yearly tenants under the terms of the expired lease, paying only a small nominal increase in rent (Vickers 2003, 106; CRO(K) WDB/35/SP271). However, the two business partners were already taking forward their plans for a new factory at Gatebeck, advertising in November 1851 for tenders to undertake the construction

of 'Two Corning and Glazing Houses; one Refining House, Boiling and Cooling House; Saltpetre, Charcoal, and Brimstone Houses; Retort House, Preparing House, Magazine, Packing House &c, together with a Saw Mill, Stave and Store Sheds, and other requisite Buildings, including Four Water-Wheel Cases [wheel-pits] to designs drawn up by Mr M Thompson, Architect, of Kendal' (CRO(K) WD/K/300). Low-level production of powder reportedly commenced in 1852 (Imperial Chemical Industries 1929, 338), but was progressively scaled up and early in 1854 the company quit the Old Sedgwick factory completely. It may not be without coincidence that Wakefield and Bainbridge parted company at or shortly after the time of the move (Vickers 2003, 107).

4.2 Gatebeck Low Works, 1851-1936

English Heritage has found very little documentary information which sheds light on the development of the Low Works. The principal source for tracing the stages in the expansion of the factory is the series of Ordnance Survey (OS) maps with survey dates of 1858, 1896 and 1911 plus two unpublished factory plans dated 1898 and 1923 (see below and Figs 5 and 137-140). Only the two latter plans contain information on the function of individual buildings, but by comparing and contrasting all documents an outline chronology of the date range of particular buildings and of the overall development of the site can be constructed. Limited additional information comes from secondary and other sources, but is often contradictory and/or open to interpretation.

The site was first surveyed by the OS in 1858. Although the survey was undertaken at a scale of 1:2500, the maps were only ever published at the smaller scale of 1:10560 (Ordnance Survey 1862). The 1:2500 survey was engraved, however, and an unpublished paper copy of the northern of the two sheets covering the area of the works survives at the OS map library in Southampton (the map was actually produced as two sheets depicting separate parishes: Ordnance Survey nd [1858] a; nd [1858] b). From these unpublished 1:2500 sheets (Fig 137) and the published small-scale mapping of the wider area, it may be seen that in its early years, the Gatebeck factory was confined solely to the east bank of the Peasey Beck. The maps depict a cluster of thirteen buildings of varying size arranged near, alongside, and in one case astride, a mill leat leaving the beck at a weir just upstream of Gatebeck Farm, with two other buildings situated adjacent to the leat but a little removed from the main cluster, one to the north and one to the south; a scatter of other buildings occupies the open ground between the main cluster and beck. A short track from what is now Gatebeck Road on the west bank of the beck formed the principal means of access into the works (replacing an earlier track leading from Gatebeck Farm which seems to have been severed by the leat) although there was also pedestrian access from Endmoor village to the south via a path and footbridge. The maps portray a second weir about 500m downstream of that adjacent to Gatebeck Farm plus what appears to be a short race leading from it, suggesting that a water-powered mill of some kind existed on the Challon Hall estate prior to the establishment of the gunpowder works. However, no documentary evidence identifying when it operated or what it processed has been traced.

There is no direct evidence for what function individual buildings served at this time, but structures in close proximity will either have been ancillary buildings or those used in the preparation and storage of raw materials, while those in relative isolation

are likely to have been 'danger' buildings (that is those used in the various stages of manufacture and to store the final product) due to the risk of accidental explosions and fires communicating between them. On this basis and by checking against the function of buildings recorded on the 1898 factory plan, we can be reasonably sanguine that buildings in the central cluster included the 'Refining House, Boiling and Cooling House; Saltpetre, Charcoal and Brimstone Houses [*ie* stores]; Retort House, Preparing House … [and] Saw Mill, Stave and Store Sheds' mentioned in the 1851 bill of tender, while the 'Magazine' is probably the isolated building to the north, and the 'Two Corning and Glazing Houses' the isolated building to the south and another secluded building adjacent to the beck due west of the main cluster. It is not possible to be certain of the location of the 'Packing House' referred to by the bill because in 1898 packing was undertaken in a building which did not exist 40 years earlier, but it will have been another of the more isolated mapped structures. Although not itemised in the 1851 bill, the three buildings depicted closest to the bridge at the end of the main access road are likely to have had an administrative function (these buildings were in use as offices and as a house for the works' foreman in 1898).

The 1851 bill mentions four wheel-cases (that is, wheel-pits). Extrapolating from the named buildings, it would seem logical that these earliest waterwheels were sited at the two corning and glazing houses, the preparing house and sawmill - the only buildings amongst those listed with any requirement for mechanical drive. The wording in the bill suggests that the corning and glazing houses were 'combined' houses at this time, that is to say both processes were undertaken within the same building. This ties in with the evidence of the ICI historian (Imperial Chemical Industries 1929, 338), who states that 'granulating [that is, corning] and glazing of the powders was then [in 1852] carried on, certainly in different compartments, but under one roof.' He goes on to say, however, that 'This state of affairs did not last long, as a great demand for gunpowder arose, stimulated largely by the rapid growth of the export trade, and in the expansion which followed, opportunity was taken to separate the buildings.' This spatial separation would seem to have been well in hand by the early 1860s, for in 1865 a workman was killed in a blast of accumulated powder which he accidentally ignited whilst converting an old corning house disused since 1863 (*Westmorland Gazette*, 13 May 1865). Tyler (2002, 50) adds the building was being converted into an engine house, but gives no authority for the statement. The probability must be that both of the combined houses were re-fitted as dedicated corning houses at this time; certainly building complexes existed already in 1858 on the sites of both corning houses named on the 1898 factory plan (Figs 137 and 5). As that later plan names only a single glazing house, it is likely that the business of glazing was brought within one, new, purpose-designed building at the same time as the former combined houses were reconstructed.

The ICI historian states that pressing was also initially carried on within the combined houses (Imperial Chemical Industries 1929, 338). He adds that uncertainty over the reliability of the factory's water supply 'led to the installation of steam engines as supplementary power', with the first engine, nicknamed 'Garibaldi', purchased in 1863. Although the historian does not specify what this engine drove, Tyler (2002, 49) claims that it generated hydraulic power to operate the presses. Two dedicated press houses existed by 1881, for one blew up in July of that year; a passing comment contained in

the official report into the accident to the effect that Benjamin Hitchen, one of the men killed, had 'spent no less than about 22 years in this press house', suggests that the new press houses were erected in 1859 (Explosives Inspectorate 1881, 6n).

The creation of separate, dedicated, pressing, corning and glazing houses between *circa* 1859 and 1863 can probably be ascribed, at least in part, to the passage in 1860 of a new Gunpowder Act which placed tighter restrictions on the quantity of powder that could be present in individual process buildings at any time (Public Statutes General 1860, 616). The same Act also stipulated that what were termed 'expense magazines' had to be provided at least 40 yards (36.56m) distant from any process building for the temporary storage of powder undergoing manufacture, and 'store magazines' had to be provided at least 140 yards (127.96m) 'distant from the Mill or Mills and every Presshouse and other House or Place used for or in the making of Gunpowder', to which finished powder was to be removed as soon as practicable. It must be at or around this time, therefore, that the expense magazine and magazine recorded on the factory plans (Figs 5 and 140) were constructed, both in previously undeveloped parts of the works on the west bank of the beck: the former between the two new press houses, the latter just south of the west-east road leading to Gatebeck Bridge.

It is interesting to note that the 1851 bill makes no mention of incorporating mills. Their omission was presumably because Wakefield and Bainbridge's initial intention was to use the existing mills at Basingill to incorporate green charges prepared at and transported thither from Gatebeck, with ripe charges returned to Gatebeck for onward processing. However, the 1896 OS map and the 1898 factory plan (Figs 138 and 5) demonstrate that four pairs of mills existed at Low Gatebeck by 1896.

The date and order of construction of these mills is uncertain. The relevant part of the published 1858 OS map (Ordnance Survey 1862) is blank as if the detail was not surveyed or, less plausibly, never engraved. At least one pair of mills seems to have been operational by 1859, however, for a 'mill-keeper' (the official job title of someone who loaded and unloaded – 'charged' and 'discharged' – an incorporating mill) died on 3 May of that year after being dragged into a wheel-pit (*Westmorland Gazette*, 5 March and 7 May 1859). The newspaper states that the man fell into 'Number Four low wheel-case'. Tyler (2002, 46) has read this as referring to the wheel-pit in 'No. 4 [incorporating] mill', but the wording can be interpreted in other ways. For example, the term mill-keeper may not be being used in its strict sense but more loosely to refer to someone who supervised water-powered machinery generally; again, it is unknown if the numbering of the 'mills' relates solely to incorporating mills or includes all buildings that contained water-powered machinery. Even if mill-keeper is being used in its strict sense and the numbering refers only to incorporating mills, it is unclear if the incorporating mills were numbered individually at this time (as they were at Lowwood after 1863 for example (Jecock *et al* 2005, 83)), or in pairs (as definitely was the case at Gatebeck by 1898). The choice of phrasing might be thought to favour the latter interpretation, suggesting all eight mills existed by 1859. However, against this is a passing comment in the official report into the 1881 explosion in the press house (Explosives Inspectorate 1881, 2) that Gatebeck then had twelve mills – a figure which must include the eight mills located at the Basingill outstation – plus a note by one Bob Dickie written on the back of a

photocopy of CRO(K) WDB/35/680f now deposited in the Patterson Collection, to the effect that Low Gatebeck had four mills (that is, two pairs) in 1856, with another two (one pair) added by 1881, and the final pair by 1898.

The source of Dickie's information is uncertain. His calculations are flawed, however. His note indicates that he believed that there were six mills at Basingill in 1881, whereas it had at least seven - and more likely eight - mills in operation by 1857 and certainly possessed eight mills by 1883 (Hunt and Goodall 2002, 9-10). This means that in 1881 when the Inspector of Explosives stated that the Wakefield company possessed twelve incorporating mills, there were only four at Low Gatebeck, not the six Dickie claims. It follows, therefore, that the remaining four mills at Low Gatebeck must all have been added – quite possibly as a single development – *after* 1881. This argument receives support from a remark made by the ICI historian who refers to 'twelve more incorporating mills' being built at Gatebeck sometime after 1852 (Imperial Chemical Industries 1929, 338). Since on map and other evidence, the total number of mills at Gatebeck (Low and High Works, but excluding Basingill) in 1898 when the High Works opened is known to have been sixteen, the implication is that only four existed at the Low Works in the early years. Other commentators have given different figures for the factory's incorporating capacity: for example Wilson (1964, 56) says that there were twelve mills, while Tyler (2002, 49) states there were twenty by 1863. Whilst it is probable that Tyler's figure has been inflated by inclusion of the Basingill contingent, both men are clearly mistaken.

The ICI historian reports that a replacement saltpetre refinery was constructed in the mid-1860s (Imperial Chemical Industries 1929, 338). This refinery utilised a new procedure for turning inferior sodium nitrate saltpetre (referred to in the business as N/S saltpetre) into the more valuable potassium nitrate form (N/P) by the addition of potassium chloride; previously the only way of doing this had been by boiling N/S saltpetre with wood ash (Vickers 2003, 148). In time, the new procedure became known as 'the Wakefield Process', and by 1896 the company was exporting saltpetre (*Westmorland Gazette*, 11 Nov 1911). It seems likely that the replacement refinery opened in the summer of 1864, for a newspaper report (*Westmorland Gazette*, 4 February 1865) of the death of a saltpetre refiner who fell into a boiler in December 1864, includes the statement that the 'boilers were erected and have only been at work since last summer'.

Although the company carried on making saltpetre and purifying sulphur at the refinery for many years after 1864, they switched from producing cylinder charcoal in-house to buying it from specialist external suppliers around this time. The ICI historian dates this change to 'about 1860', but Vickers and Tyler are more precise citing dates of 1865 and 1866 respectively (Imperial Chemical Industries 1929, 338; Tyler 2002, 50; Vickers 2003, 149).

The company celebrated the centenary of its founding partnership on 2 September 1864 by holding a party at the works for all the men plus their families and invited guests (*Westmorland Gazette*, 10 Sep 1864). John Wakefield III died in 1866, and the company passed to his son, William Henry (Tyler 2002, 50). The ICI historian (Imperial Chemical Industries 1929, 339) states that the name of the company was changed in 1868 to W H Wakefield & Co, but newspaper reports (*Westmorland Gazette*, 10 September 1864 and

4 February 1865) indicate that William Henry Wakefield and Alfred Keightley had been partners in the business since at least 1864, and that the firm was already styling itself W H Wakefield & Co by 1865. Tyler (2002, 49) adds that Keightley, a Liverpool solicitor, had become a director as far back as 1855 and had married into the Wakefield family in 1861.

At some point between the survey dates of the first two OS map editions (that is, 1858 and 1896), the factory expanded beyond its original confines on the east bank of the Peasey Beck, and ranges of additional buildings were constructed downstream of the core area and on the opposite bank; some demolition is also evidenced (compare Figs 137 and 138). The expansion was undoubtedly not a single event but happened in stages over a number of years. Unfortunately the evidence is insufficient to trace the process in great detail, although it has been argued (above) that four pairs of incorporating mills were built at the southern end of the factory, probably in two campaigns, in the mid- to late 1850s and again between 1881 and 1896, that two press houses, an expense magazine and new store magazine were erected on the west bank *circa* 1859-60, and that the glazing house shown on the 1898 factory plan (Fig 5, and see below) just north of the incorporating mills dates to around 1863. Other developments are less securely dated, or can only be dated by inference. For instance, a new stove complex existed on the west bank by 1896 but its date of construction is unknown. During 1875 a 6.5km-long horse-drawn tramway (termed 'Gatebeck Tramway' on later OS maps) was constructed connecting the works with the main rail line at Milnthorpe, finally opening in January 1876. This ran from the southern end of the factory alongside the Peasey Beck to Crooklands (where a branch led to the company's wharf on the Lancaster Canal) and continued on along the sides of roads and through fields to the station yard at Milnthorpe (Imperial Chemical Industries 1929, 339; Tyler 2002, 64-5). However, it is unclear if a tram system existed within the works before 1875, or if the internal network of lines depicted on the 1896 OS map was laid at the same time as the line to the station. An indication that the internal network may have been earlier is given by the possibility, discussed by Tyler, that the two parts of the system were constructed to different gauges - 1 foot 9 inches (533mm) and 3 feet 6 inches (1067mm) respectively (Tyler 2002, 65-6) - although close examination of the photographs which Tyler (*ibid*, 62-3) reproduces suggests that the latter gauge was probably employed throughout, and historic maps give no evidence of the transfer sidings that would have been needed if the two parts of the system were built to different gauges.

In 1872, John Wakefield Weston, William Henry's nephew, started work at the factory in order to learn the family business. He joined his other uncle, Alfred Keightley, as one of the managing partners sometime between 1874 and 1877 (*Westmorland Gazette*, 1 August 1874 and 7 July 1877), although by 1881 the partners in the company are given as Wakefield, Weston and a certain R Crooke (Explosives Inspectorate 1881, 1). Around 1873 Weston purchased a 2 acre plot of land on the outskirts of Endmoor opposite the works and built himself a house, *Enyeat*, complete with landscaped gardens. The house has since been demolished and the gardens developed for bungalows (Tyler 2002, 52 and 81).

In 1875 Parliament passed a new Explosives Act. This placed fresh restrictions and legal controls to the factory, but also generated business opportunities. The Act, which came into force at the beginning of 1876, replaced the system of legal controls on gunpowder

factories administered at county level by local Justices of the Peace that had existed since 1772, with a national licensing régime overseen by a newly created Explosives Inspectorate lodged within the Home Office. Under the Act, Gatebeck had to apply for a Continuing Certificate in order to carry on operating. This involved submitting large-scale plans of the factory to the Inspectorate for them to examine the layout of the works and ensure, for example, that danger buildings were a safe distance apart; Gatebeck duly received certificate no. 19, on 18 April 1876, although a number of unspecified buildings were proscribed (Explosives Inspectorate 1881, 1). Explosives factories were also henceforward subject to periodic checks by the Inspectors, who had to authorise all construction work and changes to the layout and use of buildings by the issuing of what were termed Amending Licences; the inspectors were also required to produce reports into workplace accidents if they resulted in fatalities. The flip side of the Act was that by requiring all places where explosives were manufactured to be licensed, it put an end to the traditional practice of miners producing their own blasting cartridges at home (Marshall and Davies-Shiel 1969, 84). Most gunpowder manufacturers saw this as a business opportunity, and experimented with the production of compressed cartridges. Gatebeck started commercial production of such cartridges in 1880 (Imperial Chemical Industries 1929, 339), and it is probably at this time that the disused Magazine was converted into a 'Cartridge [Packing] House and Changing Room' and two new 'Cartridge Press Houses' erected, as recorded by the 1898 factory plan (Fig 5, and see below). The cartridge press and packing houses all stood towards the top (north) end of the works on a narrow neck of land between the mill leat and beck.

Also in 1880, Wakefield's leased the site of an old bleachery on the east side of Peasey Beck north of Gatebeck Bridge (Tyler 2002, 67), and converted the standing buildings into a cooperage; power for the sawmill came from an existing network of weirs and mill leats created when the site was home to a foundry operated by Messrs Winder between 1781 and 1826/41 (CRO(K) WD/W/6.3; Somervell 1931, 78). The bleachery is labelled as 'Bleachworks' on first edition Ordnance Survey mapping (nd [1858] b; 1862), but since it is likely to have been an establishment where cloth was bleached rather than where bleach was made, bleachery is the more correct term for it. The opening of the new Cooperage enabled the Wakefield company not just to satisfy its own demand for barrels and boxes in which to package gunpowder and cartridges, but also to produce a surplus which could be sold on the open market to a range of customers, including other gunpowder manufacturers. According to the ICI historian (Imperial Chemical Industries 1929, 339), what was in effect now a subsidiary business employed at its peak as many as 40 coopers, twelve hoopers and 40 sawyers, machinists and labourers, although in 1896 the number of hands engaged by it was reportedly only 63 (*Westmorland Gazette*, 11 Nov 1911); Wilson's (1964, 56) figure of 45 employees probably relates to sometime in the 20th century. Vickers (2003, 208) states that the Cooperage closed in 1916, but a newspaper report suggests that the business was still operational in 1923 (*Westmorland Gazette* 19 May 1923). Timber was grown locally. The complex was connected to the rest of the works by extending one of the tram lines leading to the new magazine on the west bank of the beck on under the road to Gatebeck Bridge in a tunnel and back across the beck via an iron bridge (eg Fig 138).

Tyler (2002, 67) infers that it was around this time that the company invested heavily in providing local housing for their expanding workforce, putting up a terrace of six houses

at Gatebeck, and constructing a further 45 terraced dwellings at Endmoor. In fact the Gatebeck terrace could have been built at any time between 1858 and 1896, although a date of after 1880 is most likely, while of the six terraces that eventually existed at Endmoor, parts of two had been erected as early as 1858. The latter had been extended and three new terraces built by 1896; the sixth terrace was probably added between 1911 and 1914.

On 21 July 1881, two workers were killed when building 16 exploded. The building can be identified as the northern of two press houses which the 1898 factory plan (Fig 5, and see below) shows stood in line on the west bank of the beck, either side of an expense magazine which is also mentioned in the official report into the explosion (Explosives Inspectorate 1881, 4).

In 1882 Wakefield's expanded by buying up their near neighbour, the Lowwood Gunpowder Company, based just over 19km away at Low Wood, near Haverthwaite close to the southern end of Windermere. Although the Lowwood factory continued trading under its old name, it was now managed from Gatebeck (Jecock *et al* 2005, 29). A letter dated 26 December 1888 written by the Lowwood works manager, James Collinson, mentions that the Gatebeck factory had electric lighting by that date (preserved in the Heritage First! archive in Ulverston: LW/959/346). W H Wakefield died in 1889 (Tyler 2002, 73), after which the company was managed by John Weston although he may have been in effective control for sometime already (Imperial Chemical Industries 1928, 339).

In 1895 permission was gained to construct a dam across the Fall Beck some 1.5km east of the Cooperage. This dam lay some 300 feet (*c* 90m) higher than the works, and enabled water to be piped down to the factory under pressure where it was used to operate some of the press houses; it also served as the main domestic water supply to the factory and both Gatebeck and Endmoor villages. According to Wilson (1964, 56) and Tyler (2002, 73-4), the supply also later powered three Pelton wheels, purchased from the firm of Gilkes of Kendal, which drove the glazing and reeling house at the High Works, the fan for a coal gas plant, and an electricity generator. However, Gilkes's own records only document the sale of two Pelton wheels to Gatebeck (units no. 2063 in 1909 and no. 2178 in 1911, with respective outputs of 6kW and 0.7kW) although the Wakefield company did purchase a Trent turbine outputting 14.9kW (unit no. 2120) in 1910 (information from Sharon Bianchi, Gilbert Gilkes & Gordon Ltd). Other data confirm that the Pelton wheels were indeed driven from Fall Beck - both are recorded by Gilkes as powered by a 'Nett head' (that is, fall of water) of '325 feet' – but also suggest that they were not sited within the Low Works for a later plan of the High Works shows that the pipe from the reservoir led to the Cooperage (Oswald *et al*, in prep). In contrast, the Trent turbine - designed for a head of only '12 feet' (3.66m) – must have been powered from a mill leat, although there is no information to show whether it was located at the Low or High Works.

By 1896 the company was busy erecting new plant on a virgin site on the west bank of the Peasey Beck opposite the Cooperage, as shown by the 1896 OS map (Fig 138). In 1898 the company received an operating licence, no. 126, to run the site, which was termed Gatebeck High Works. The reason for seeking a separate licence for the new part of

the factory seems to have been because it was intended that a subsidiary company called Nitrate Explosives Company Ltd would manufacture specialist safety powders here. These powders, named Virite, Aphosite and Titanite, contained substances such as ammonium oxalate, ammonium nitrate, aniline nitrate and trinitrophenol in addition to the saltpetre, sulphur and charcoal of conventional blackpowder, and were designed for use in coal mines where there was a risk of firedamp. The powders appear to have been developed specifically for the Wakefield company by two European scientists, Guttman and Condenlove, working in an on-site laboratory (Vickers 2003, 209).

It is the need for a plan of the new High Works to submit to the Explosives Inspectorate which provides the probable context for the 1898 factory plan (Fig 5) already referred to. This is the earliest plan of the works marked up with the function of individual buildings that is known to survive. It actually exists in three versions, two of which would appear to be working copies based on divorced surveys with buildings numbered and identified on accompanying draft keys (CRO(K) WDB/35/680c-h); the third, presumably derived from them, is a marked-up copy of the 1896 OS map (WDB/35/680a and b). The plans and keys differ slightly in how they number and describe some of the buildings - most probably reflecting changes to the numbering system introduced just prior to 1898 because a partial listing of building numbers preserved in an appendix to the official report into the 1881 press-house explosion (Explosives Inspectorate 1881, 10) matches some of the otherwise 'incorrect' numbers/identifications which appear on the drafts. Both working copies of the plan are dated 13 February 1898. All the documents were produced by A Hoggarth & Son (a Kendal firm of Land Agents), in whose possession they remained until deposition in the Records Office.

In 1903 Wakefield's converted to limited liability status with nominal capital of £75,000. In 1917, the company merged with many of its national competitors to form Explosives Trades, which became Nobel Industries Ltd in 1920, and finally ICI in 1926 (Imperial Chemical Industries 1929, 339; 1938, 177).

According to Tyler (2002, 78), electric lighting was extended to the eight incorporating mills at the Low Works in 1913. In addition, he states that six of the mills had been converted from waterwheel to water-turbine operation by this time; the remaining two were powered by electric motor. In 1923, the company purchased another turbine from Gilkes of Kendal: this was a Vortex unit, manufacturer's no. 3049, generating 8.9kW from a head of 22 feet or 6.71m (information from Sharon Bianchi, Gilbert Gilkes & Gordon Ltd). The occasion for the purchase may have been the need for a replacement power unit following the destruction of one of the corning houses at the Low Works in an explosion on 17 May of that year which killed two men. It is not known if the Explosives Inspectorate produced a special report on the incident: English Heritage has been unable to locate a copy in any public library or other repository, and has been forced to rely instead on the local newspaper report for information (*Westmorland Gazette*, 19 May 1923). According to Patterson (1995, 42), the incident was covered on pages 10-12 of the Inspectorate's 1923 Annual Report. Once again English Heritage has been unable to source a copy of that document at first-hand, but the limited information reproduced by Patterson makes it clear that the corning house in question was building 12 adjacent to the main mill leat, and not no. 17 adjacent to the beck.

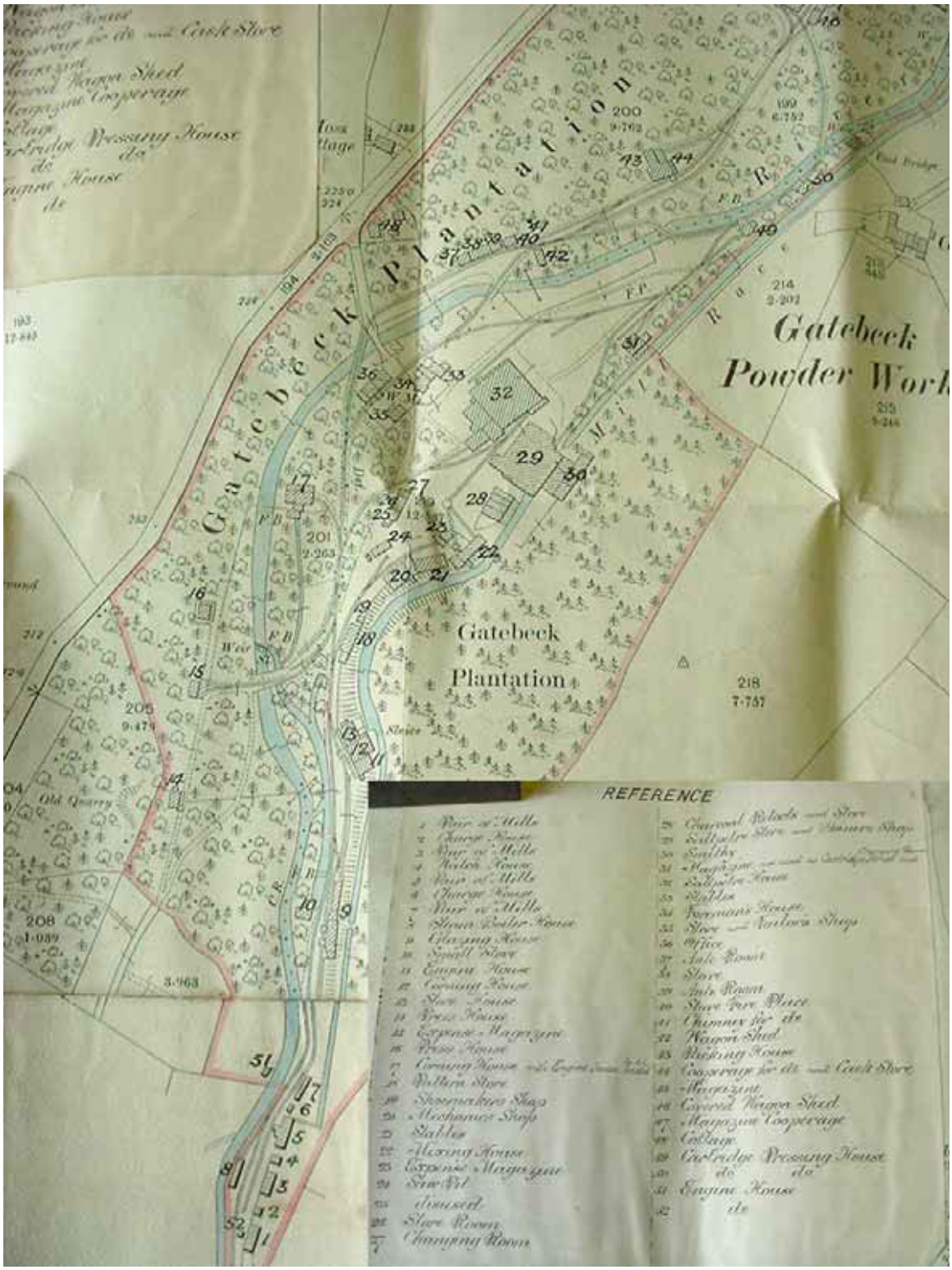

Figure 5: Detail of the 1898 factory plan with key shown at inset (Photograph: Abby Hunt 2002. Extract from CRO(K) WDB/35/680a, copyright reserved)

The latest plan of the works located by English Heritage is the 1923 factory plan, reproduced here as Fig 140. Its existence seems to have been unknown to Ted Patterson, even though it survived until recently in the possession of ICI at their Ardeer site in Scotland. Information written on the plan reveals that it was originally produced as the basis for Amending Licence no. 2851 on 22 August 1923, and signed off by Lt

Col R A Thomas, HM Inspector of Explosives, on 25 September. Following on from the suggestion above that the company was forced to purchase a new turbine in 1923 as a replacement power unit for the destroyed corning house 12, it is tempting to speculate that the 1923 factory plan was produced in support of the application to license that house's replacement. The plan gives the function of buildings at the High Works in addition to those at the Low Works, but there is no key for the buildings which comprised the Cooperage - presumably because this area was not directly involved in the production of gunpowder and therefore did not require government licence.

At first glance, differences between the 1898 and 1923 factory plans (Figs 5 and 140) appear few and minor. However, a close comparison of the two documents reveals that a considerable proportion of buildings had been added, altered or undergone a change of use in the intervening 25 years. Other than the new building 12, the principal differences comprise: the demolition of the northern end of the 'Glazing House', building 9, and its replacement by a new building 11 identified on the 1923 plan as the 'Graphite Store'; the addition of a small freestanding building behind the glazing house which, although unnumbered, should presumably be equated with the accompanying 'Power and Motor House' mentioned in the key; the replacement of a store (building 13) attached to the northern side of the old corning house (building 12) by a new free-standing power house; the addition of a dedicated 'Power House' to the Mixing House (building 22); the conversion of building 24, described as 'Saw Pit' in 1898, into an 'Engineering Store' by 1923; the adaptation of building 25, disused in 1898, into the 'Foreman's Office', and the conversion of buildings 34 and 35, which in 1898 served as the 'Foreman's House' and 'Store and Tailor's Shop', into extra 'Office' accommodation; the addition of a new building 27a at the northern end of buildings 25-27 for use as the 'Fire Engine House'; the conversion of building 42, in use as a 'Wagon Shed' in 1898, into a 'Stove Reserve'; the erection of a new building adjacent to the northernmost cartridge-pressing houses (building 50); and the erection of three brand new structures all on the periphery of the works, namely a new 'Charcoal Store' (building 53) just outside the southern limit of the licensed area, and a new 'General Store' and 'Cycle Shed' (buildings 54 and 55) at either end of the bridge giving access to the works. The 1911 OS map (Fig 139) cannot be compared with the two factory plans in quite the same way since it does not contain information on what individual buildings were used for. However, it does indicate that most, if not all, the structural changes post-date 1911.

There are very few sources of information which shed light on developments at Gatebeck between 1923 and closure in 1936. Limited information is contained in a short account of the works published by a local historian in 1930, who states that the factory was then powered 'by two waterwheels generating 15 or 20 hp, and 9 turbines varying from 6 to 15 hp' (Somervell 1930, 78). Which of these power units were sited at the Low Works and which at the High Works is not known. A more informative document is the Manufacturing Method Book (MMB) preserved in the Edward Patterson Collection at the NMRC. This document can be dated on internal evidence to sometime after April 1931 (MMB, 4), and provides fairly detailed descriptions of the machinery and processes employed at the factory in its final years, but almost nothing on the history or form of the buildings or how long any piece of equipment had been in use. There is also remarkably little on the power arrangements, although the general impression is that

many of the processes normally driven by water (wheel and turbine), had electrical back-up systems which could be brought on line when water levels in the beck ran low: these included the corning houses, the glazing house and the pumps for the presses.

In 1935, ICI announced that Gatebeck would remain open for a further three years (Vickers 2003, 273-4). However, production of gunpowder was halted prematurely in September 1936 (Patterson 1995, 44), and by February 1937 the factory had been decommissioned and stripped of anything saleable or salvageable (Tyler 2002, 81; Vickers 2003, 275). Some of the machinery seems to have been sent north to ICI's factory at Ardeer for reuse, as evidenced by technical drawings donated to the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) by Ted Patterson in the late 1980s (eg, http:// canmore.rcahms.gov.uk, Site NS24SE47.3, item DC 22114). Subsequently in March 1939, the land and buildings were sold to one Oscar Louis Spedding for £3,500. At the outbreak of World War II the site was requisitioned for use by Army Engineers, but between 1939 and 1950 Spedding progressively re-sold his purchase in a succession of small lots. Areas of the Low Works adjacent to the road frontage west of the beck went for piecemeal housing development, while the Cooperage north of Gatebeck Bridge was redeveloped as an industrial estate. The bulk of the Low Works was sold in 1950; in 1956, the purchaser leased the east-bank portion of it to Westmorland County Council for 21 years as a Civil Defence Training Ground, and in 1959 and 1962 sold the west-bank in two lots for development as an industrial site and caravan park. Meanwhile, in 1958 Westmorland Council constructed toilet facilities on their leased part of the site, and also 'adapted' one of the surviving buildings - the mechanics' shop - for the training of Rescue Services; in 1965 the south-west gable wall of this building was found to be in a dangerous condition and was rebuilt in brick. With the running down of Civil Defence by government in 1968, the Council terminated its lease, and thereafter this part of the site, too, was developed as a caravan park (Millbrook Caravan Park Company Collection; Millbrook Caravan Park 1975, 5-6).

5. THE PROCESS OF GUNPOWDER MANUFACTURE

The method of gunpowder manufacture has been described in detail elsewhere (*eg* Cocroft 2000; Crocker 1999; Patterson 1995) and only a brief outline will be given here in order to provide the reader with a general overview of the processes and structures described in section 6.2 below. Details of the precise method followed at Gatebeck in its final years are known from the factory Manufacturing Method Book (MMB), a copy of which survives in the Patterson Collection in the NMRC in Swindon. Internal evidence shows that this document was produced in 1931 or later. Only very sparse details on the specifics of processes used at earlier times survive. Stages of manufacture also varied slightly according to the type and intended use of the powder.

The three ingredients of gunpowder are saltpetre, charcoal and sulphur in the approximate ratio 75:15:10, although the precise mix varied according to the quality of powder desired. These constituents do not react chemically, but are simply blended together. The manufacturing process was therefore designed to create a thoroughly combined mixture of the correct density, in an evenly-granulated form. Saltpetre has two chemical forms: potassium nitrate (nitrate of potash) and sodium nitrate (nitrate of soda). The former is stable under ordinary climatic conditions and was always the saltpetre of choice. Sodium nitrate absorbs water from the air, but was less expensive; it was normally used for the cheaper blasting powders, but had to be kept dry or it lost its efficacy. Blackpowder made from the two forms was distinguished as N/P or N/S powder (Patterson 1995, 10-11). In the 1860s the Wakefield company pioneered a simple method for converting sodium nitrate into potassium nitrate, and built a new refinery at the Gatebeck Low Works in which to carry out the process.

The first stage of gunpowder manufacture was the preparation of the three raw ingredients. In the early years at Gatebeck, potassium nitrate saltpetre was imported from abroad in its 'grough' or raw state, and had to be refined by a cycle of washes followed by gentle boiling and re-crystallisation, which produced fine crystals of almost pure saltpetre, but from 1864 the works was producing its own supplies using a newly patented method as mentioned above. Sulphur (brimstone) was also imported and could contain impurities. Refining of sulphur and the production of saltpetre were undertaken at the refinery. Charcoal was initially made on site in sealed retorts, but by from the mid-1860s was being bought in from external suppliers instead. At gunpowder works, the raw ingredients were normally kept in separate stores, known appropriately as the saltpetre store, sulphur store and charcoal store. However, for most of the time at the Low Works there is no evidence for a dedicated sulphur store, and sulphur was probably kept alongside the charcoal or saltpetre.

In the preparing or mixing house, charcoal and sulphur were ground to a fine powder in an edge-runner mill and sieved to remove lumps or grit; saltpetre from the refinery was already of sufficient fineness and purity. All three ingredients were weighed out in the correct proportions to produce a single 'charge' (anything between 40 and 75lb (18.16-34.05kg) depending on the legislation in force at the time), and mixed in a drum containing rotating arms. At the Low Works, grinding and mixing seem always to have been water-powered, initially by wheel and later by turbine. Each mixed charge, called a green charge, was transferred to the nearby green-charge house for storage, before transfer to special charge houses adjacent to the incorporating mills immediately prior to the unloading of the charge then under incorporation.

At the incorporating mills, mill keepers fed individual green charges into edge-runner mills that mixed and compacted each one into a denser mass known as mill cake or ripe charge. Incorporation was a dangerous procedure which the mill keepers supervised from the comparative safety of the watch house. The northernmost pair of incorporating mills at the Low Works may initially have been powered by a waterwheel, but by 1913 it and two of its three neighbours were driven by water turbine and the other pair by an electric motor. There was also an earlier phase when some or all of the mills were powered by steam engine, although this may only have been brought on line when water levels were too low or conditions were too frosty to operate the turbines. All the milling machinery was over-driven (that is, the drive shaft was mounted above the edge runners). Once incorporated, ripe charges were removed to the nearby charge houses before onward transfer to press houses - or if the press houses were too busy to handle the charges straightaway - to the expense magazine. Expense magazines were for the storage of powder between the various stages of manufacture; they were made a legal requirement at all gunpowder works by a series of Acts of Parliament from 1772 which placed strict limits on the quantities of powder that could be present in individual process buildings at any one time.

After incorporation, the powder had to be compressed at the press house in order to turn mill cake into slabs of high density called press cake. The MMB (pages 16-18) provides an exact account of this process at the Low Works as performed in 1931; details would have varied slightly over time, but the description is no doubt valid in its essentials for earlier periods too. For a short period before 1860, pressing was co-located with corning and glazing (that is, all three processes were performed within the same building albeit in separate compartments), but after that date the factory had two, dedicated, press houses. The pumps that produced the hydraulic pressure seem always to have been located at the corning houses, driven at different times by waterwheels, steam-engines, water-turbines and electric motors.

By this stage the powder had reached a satisfactory mix and density. It now needed to be formed into rounded and evenly-sized grains. The first part of this process was carried out in the corning house, which reduced the press cake to angular grains of approximately the correct size. There were always two corning houses at the Low Works. By 1931 both corning machines were of the toothed-roller, 'Nobel', type; the design of machinery at earlier times is unknown. The grains were then shaken through a stack of sieves of different meshes in order to separate out grains of the required size from those too big (stops) or too small (dust); stops went back through the rollers a second time. The available evidence suggests that the corning houses were initially powered by waterwheels (perhaps with reserve power provided by steam engines), and later by water-turbines with electrical back-up.

From the corning houses, the angular grains went to the glazing house where they were tumbled in wooden barrels for a number of hours in order to smooth them, with graphite added for part of the time. The frictional energy of the grains helped to dry the powder; but the process also rendered the grains less hygroscopic (prone to absorb water), increased their density and smoothed them thereby helping the powder to keep its structure. The amount of graphite added depended on the 'brightness' required. Particularly fine powders requiring an extra 'polish' or to be freed of dust were subsequently put into reels – similar to glazing barrels but with the sides formed of a particular type of linen called 'Irish Crash'. At Gatebeck, reeling seems to have been confined to the High Works. At the Low Works, the glazing barrels were initially powered by a waterwheel - again perhaps augmented when necessary by a steam engine - but later by a water-turbine with electrical back-up.

Before 1880, all glazed powder went straight to the stoves to remove residual moisture. In that year, however, Gatebeck started selling powder pre-formed into blasting cartridges as well as loose in barrels, and powder destined for cartridge manufacture travelled first to the packing and cartridge houses. The stoves seem always to have been heated by steam or hot air ducted in pipes around the building; the steam/hot air was produced in boiler houses detached from the stove house itself to reduce the risk of sparks igniting the powder. By 1931 the MMB (page 36) states that powder was stoved for 12-15 hours and then left under residual heat overnight as the stove house cooled down.

After stoving, loose powder went to the dust house (at the Low Works, seemingly co-located with the packing house) for removal of fine dust and final sizing of the grains. In 1931, the dusting machinery comprised a nest of two sieves of different mesh sizes; when the nest was agitated, over-sized grains were retained in the top sieve, grains of the right size in the lower sieve, and under-sized grains passed into a box on the floor. The dusting machinery was operated by hand crank.

After dusting, loose powder went to the packing house to be weighed and packed into barrels or boxes, which were then transferred to the factory or store magazine to await despatch to customers, or, if the powder was to be used for blasting cartridges, despatch to the cartridge houses.

At the cartridge houses, the powder was poured into moulds and compressed into solid pellets, often with a central hole to take a fuse. As with the powder presses, the cartridge presses were hydraulically powered. Once formed, the cartridges were individually wrapped before being packed into boxes at the cartridge-packing house. As was normal in gunpowder works, the wrapping and packing of cartridges was carried out by women. Boxed cartridges were returned to the magazine until despatched to customers.

Batches of powder were no doubt checked for quality and reliability. There is no evidence that Gatebeck ever possessed a proofing range as existed at Lowwood, Elterwater and New Sedgwick, and it is likely that proofing was carried out by less spectacular means in a laboratory. A laboratory is recorded at the works in the 19th century, although its function is unclear and it might have been for testing the quality of saltpetre instead of (or perhaps as well as) proving the powder; it may even have been a research laboratory. The location of any laboratory in the 20th century is not recorded.

Other buildings known to have existed at the Low Works at various times include a sawmill, mechanics' shop, cooperage, joiners' shop, stables, fire-engine house, office, shoemaker's shop, tailors' shop, privies, and miscellaneous stores. Horses were needed to pull carts, and after 1875 also to propel bogies (trucks) around the tramway system within the works; the function of the other buildings listed is otherwise self-explanatory. At the Low Works, changing - the donning by the workforce of special clothing (manufactured on site by the shoemaker and tailors) before they commenced their daily tasks - was carried out in a special changing-room, later also used as the mess room; female workers, however, got changed in the cartridge-packing house. There is no mention of a specific search house - where the workers were examined to ensure they carried no matches or other incendiary devices - suggesting this was carried out in the buildings where the workforce changed.

6. FEATURE CATALOGUE AND DESCRIPTION

The following catalogue of features is divided into three sections: the first and last (sections 6.1 and 6.3) deal with features which pre- and post-date the gunpowder works; the central, much longer and more detailed, part (section 6.2) describes structures which make up the gunpowder works itself (and also buildings within the nearby settlements of Endmoor and Gatebeck). The English Heritage survey plan (Fig 143) of the southern part of the factory area, is reproduced here at a scale of 1:2000 although recording was carried out at a variety of scales in the field; more detailed plans of selected structures are also included within the text.

The first and third sections are broken down into sub-sections ordered as far as possible by phase. However, section 6.2 describing the gunpowder works is arranged by process rather than date order, with sub-sections detailing each building and structure according to function. This creates problems, for inevitably many buildings changed function over time. Where this is the case, cross-references will guide the reader to other relevant sections of the catalogue. Section 6.2.1 summarises evidence for how the factory was powered, whilst section 6.2.2 discusses structures related to the preparation and storage of raw materials used in the manufacture of gunpowder (in the main, charcoal, sulphur and saltpetre); section 6.2.3 follows the steps in gunpowder production from grinding and mixing of ingredients through to the packing and storing of the finished product, while section 6.2.4 deals with buildings specific to cartridge manufacture (a process only introduced to Gatebeck in 1880); section 6.2.5 reviews the evidence for the testing of gunpowder. Ancillary buildings are detailed in section 6.2.6, and buildings of uncertain purpose in section 6.2.7. The next two sections deal with different aspects of transport: section 6.2.8 with the movement of goods to and from the works, section 6.2.9 with how powder was transported between process buildings during manufacture (a number of transport-related buildings such as stables are also described in this section). Section 6.2.10 forms a catch-all for a miscellany of other features at the works; a final section, 6.2.11, describes the development of, and particularly the workers' housing in, the nearby settlements of Endmoor and Gatebeck.

Every gunpowder structure for which there is cartographic, documentary or physical evidence is included in the catalogue; buildings for which there is cartographic or physical evidence (that is, those for which there is precise locational information) have also been allocated a unique number. The numbering scheme adopted is largely based on that recorded on the 1898 and 1923 factory plans (Figs 5 and 140), and does not bear any relation to the order in which buildings were constructed or how the site developed over time. Indeed, comparison of the two plans shows that numbers were periodically reallocated as buildings were destroyed or replaced. Some renumbering of buildings has therefore been necessary in the present report to allow for this, mostly by use of a letter suffix to help distinguish between buildings sharing the same number. The 1923 plan identifies a total of 55 buildings or building groups at the Low Works. However, it also shows – but does not include a key for - buildings at the Cooperage in Gatebeck hamlet numbered as 53-75. The slight overlap between the two sequences of numbers suggests that the plan is based on an earlier, combined plan of the Low Works and Cooperage, redrawn to include the sites of three recent additions to the Low Works building stock (nos. 53-55) to bring it up to date for submission to the Explosives Inspectorate. The

fact that the Cooperage buildings lay outside the licensed factory area of concern to the Inspectorate explains the absence of any key explaining the function of that part of the works. Although it is unlikely that the identity of buildings 53-75 at the Cooperage will ever now come to light, buildings marked on the 1858 map which had been demolished/ replaced before the 1898 factory plan was drawn up and whose original factory number is not known, are here numbered from 100 to minimise any potential confusion from duplication of numbers and to make clear that the run of numbers has no historical validity.

Numbered buildings will all be found on a series of phase diagrams (Figs 130-136) reproduced in chapter 7 of this report, which attempts a chronological overview of the site's development combining the documentary, archaeological and architectural evidence detailed in chapters 4 and 6. The reader may find it useful to read the following text in conjunction with those diagrams.

6.1 Phase 1. Structures Pre-dating the Gunpowder Works

6.1.1 Field boundaries and other structures

By 1896 much of the steep hillside immediately east of the Low Works was wooded and formed part of the wider 'Gatebeck Plantation' (Fig 138) planted around the factory as blast protection. But in 1858 (Fig 137), this area was still open fields, labelled by the OS as land parcels 212 and 263. The present survey has identified two lynchets running down the hillside within the plantation: one, a strong lynchet, *circa* 1m high, above the large corning house (building 12), corresponds to the position of the boundary between fields 212 and 263 as mapped in 1858; the other, a slighter example above the sawmill/ mechanics' workshop (building 20), indicates that field 212 was at one time subdivided. This second lynchet is only traceable on the less steep parts of the hillside and consequently survives in two sections: a straight section running west from the drystone wall that forms the plantation boundary, and a curving section indicating the field's former north-west corner at the base of the hill. Immediately south of the eastern (uphill) section, low, stony banks adjacent to the plantation wall are suggestive of two small buildings or structures. They are of unknown date and purpose, although both appear to be cut by, and therefore to pre-date, the wall.

6.1.2 Pre-gunpowder mill site

It has been suggested (section 4.2 above) that the depiction on the 1858 OS map (Fig 137) of a weir and associated leat system 500m downstream of the Wakefield company's weir above Gatebeck Farm, is evidence that a water-powered mill existed on the Challon Hall estate prior to the construction of the gunpowder works. No documentary reference for the date or output of this early mill has been found, suggesting it was redundant and perhaps even demolished by the time the gunpowder works was built, although for reasons not immediately apparent, the weir plus the start of the leat leading from it seem to have been maintained by the Wakefield company: traces of the stone-built weir survive in either river bank and the first few metres of the leat are lined in concrete (Fig 6). Since this leat rapidly broadens out into a feature akin to a small millpond (Fig 7), the pre-gunpowder mill most probably stood at the southern end of the latter feature at *circa*

Figure 6: The pre-gunpowder weir (far side shown in detail at inset) and start of the headrace (Photograph: Christopher Dunn 2006, © English Heritage)

Figure 7: The pre-gunpowder millpond looking north (Photograph: Christopher Dunn 2006, © English Heritage)

SD 5432 8507, in the vicinity later occupied by the small stove house. The course of the tailrace from the early mill is uncertain since leat and millpond subsequently became part of the gunpowder works tailrace: map evidence (Ordnance Survey 1862) shows that in 1858 the latter continued parallel to the beck for almost 0.5km below the millpond and connected into the headrace to Kaker Mill which left the beck a little upstream of Challon Hall (Fig 2), but a narrow, shallow earthwork channel that runs away south from the small stove house towards a short length of stone walling at a skew angle to the river bank may mark the position of the early mill's tailrace (Fig 142). Because it is difficult to know how much the surviving form of the early leat system is original and how much 19th- and 20th-century modification, the various parts are described in more detail in section 6.2.1 below.

6.2 Phase 2. Low Gatebeck Works

6.2.1 The Power Systems

In common with most other Lakeland blackpowder factories, water was always the main source of power at Gatebeck. It was used in the main to generate mechanical power to operate machinery, initially by means of waterwheels, but very soon via the medium of water-turbines also; probably right from the start it was also used to generate hydraulic power to operate powder presses (and, from 1880, cartridge presses) and by 1913 was being used to generate electricity (via water-turbines or Pelton wheels) to provide lighting and run motors at some of the incorporating mills and corning and glazing houses. However, unlike other Lakeland gunpowder manufacturers (with the notable exception of Blackbeck), for a time Gatebeck also made limited use of steam engines between *circa* 1863 and the 1920s, probably primarily as back-up power when water levels were too low to operate the waterwheels and turbines or when there was a severe frost, but seemingly also to run pumps providing hydraulic power for the press houses. A general overview of the system of weirs and leats and the use of hydraulic, steam and electrical power at the works is given below, with more detailed information included in sections 6.2.3, 6.2.4 and 6.2.6 under the descriptions of the individual buildings which the waterwheels, turbines, pumps, steam engines and electric motors served.

Weirs, Leats and Waterwheels

The Low Works was powered by its own mill leat. As initially constructed (in 1851-2), this ran from a weir on the Peasey Beck north of Gatebeck Farm to a point approximately 70m south of the large corning house (building 12) where map evidence (Fig 137) suggests it dropped down the hillside and entered a (?new) tailrace running south from the pre-gunpowder millpond (section 6.1.2 above). Apart from a short stretch immediately after the millpond, culverted to allow access across it (Fig 8), this tailrace seems to have been an open channel in 1858 (part of its course was never surveyed by the OS; see section 4.2 above), but had been largely covered over by 1896 (compare Fig 138). It ran for over 500m parallel to the beck and joined the headrace to Kaker Mill near Challon Hall (Fig 2).

The stone-built gunpowder weir survives in reasonable condition, although the wooden sluice gate controlling the flow of water into the mill leat is now ruinous (Fig 9). As the

Figure 8: Entrance portal to the high-level culverted leat at the south end of the pre-gunpowder millpond (Photograph: Christopher Dunn 2006, © English Heritage)

Figure 9: The sluicegate at the head of the gunpowder mill leat (Photograph: Christopher Dunn 2006, © English Heritage)

crow flies, the original length of the leat was just over 650m, but because it followed the valley side the actual length was closer to 700m. The level of water was controlled by an overflow (labelled 'Weir' on OS maps) just north of Gatebeck Farm which took excess water back to the beck. Field evidence shows that the main channel was stone-lined (although sections were later refaced or rebuilt in concrete, presumably by ICI) and measured *circa* 5-6m wide by up to 1.3m deep, but narrowed down to half this width after the large corning house.

According to the 1851 bill of tender the mill leat initially drove just four waterwheels - most likely located at the sawmill, the preparing house and the two combined press, corning and glazing houses (sections 4.1 and 4.2 above). Although the sites of all four buildings are known, the 1858 OS map (Fig 137) is not particularly informative as to the positions of the headraces and pentroughs that supplied them, and, apart from a short length of channel (perhaps leading from the sawmill) emptying into the pre-gunpowder mill leat, shows no tailraces suggesting that the latter were for the most part culverted. This is particularly problematical in the case of the more northerly of the two combined houses (later the small corning house (building 17)) which lies some distance from the mill leat but has no visible connection to it. Whilst it is possible that the corning machinery here was initially hand-operated, given the evidence of the bill of tender the most likely scenario is that the house was powered by an undershot wheel driven by waste water conduited underground from the preparing house and/or sawmill/mechanics' shop: later OS maps (Figs 138 and 139) both depict an open channel running away south from the building suggesting it was water-powered, and the omission of this feature from the 1858 map may be a simple error.

By 1896 also (Fig 138), the mill leat had been extended by some 115m to the south in order to bring power to four pairs of incorporating mills plus a new glazing house, the latter constructed where the leat formerly descended the hillside. The extended leat now discharged into the tailrace leading from the pre-gunpowder millpond via a sloping culvert (Figs 10 and 11) that passed between the two northernmost pairs of incorporating mills (buildings 7 and 5), while the tailrace itself had also been mostly culverted – it re-emerged into the open air for a short length immediately north of incorporating mill pair 7 (Figs 12, 23 and 30) - to a point 115m north of Challon Hall (Fig 13) to allow unimpeded access to the new glazing house and incorporating mills and, after 1875, to enable the riverbank in front of them to be used as the course of the Gatebeck Tramway. The date the mill leat was extended and the tailrace culverted is uncertain, but because there is evidence that the northernmost two pairs of incorporating mills (pairs 5 and 7) were operational by early 1859 (section 4.2 above), the work may have been carried out the previous year.

The tailrace (hereafter referred to in this report as the culverted leat) lies at two levels, higher in the north than the south, the division between the two sections seemingly coinciding with the waterwheel house in mill pair 7, suggesting it had to be dug deeper at this point when the incorporating mills were built in order to prevent waste water backing up and so impeding the waterwheels or turbines in those buildings (this also no doubt accounts for why the tailrace had to be so long). In theory the extended mill leat on the hillside above could have delivered water directly onto a waterwheel at incorporating mill pair 7, but as no headrace or pentrough is shown leading to the

Figure 10: The south end of the mill leat and start of the sloping culvert (Photograph: Christopher Dunn 2006, © English Heritage)

Figure 11: The sloping culvert looking west (downhill) (Photograph: Christopher Dunn 2006, © English Heritage)

building on the 1896 map (Fig 138) and it is very hard to see how the leat could ever have delivered water directly onto wheels at the other three mill-pairs, by that date mill-pair 7 must have been powered by water-turbine instead and the other three pairs (mills 5, 3 and 1) were probably powered by water-turbines from the outset (although there is a possibility that mills 1 and 3 were initially powered by steam engines). The turbine at mill pair 7 may have been fed directly from the northern (higher level) section of the culverted leat (the drop in level effectively providing the head of water necessary to drive the turbine), the others by water taken from it (or from the main mill leat above) passing in front of the mills in a penstock. However, the exact arrangement is uncertain, and the power systems to the incorporating mills are examined in more detail in section 6.2.3 below. The glazing house and large corning house were also probably powered initially by a waterwheel and later by water-turbine.

Later map evidence is not particularly informative as to developments in water power generally, although documentary evidence (section 4.2 above) backed up by observations in the field suggests that by the 1930s water-turbines had replaced most of the waterwheels.

The leat survives in reasonable condition. The central section between the smithy (building 30) and mechanics' shop (building 22) is infilled (Fig 14) and part of the western side bulldozed to create ramped access up to it. Very little of the lining is visible in this section, perhaps destroyed during the infilling (which presumably dates from the time when the site was used for Civil Defence Training or immediately after), but from the large corning house southwards where the channel narrows (Fig 15), the original stone-lining is much better preserved albeit collapsing in places. South of the corning house much of the west side of the leat is rendered or rebuilt in concrete, suggesting a period of probably 20th-century repair.

Turbine Power

Confirmation that, by the end of its working life, Gatebeck generated most of its water power from turbines rather than waterwheels, comes from the mention in 1930 by a local historian that there were then nine turbines but only two waterwheels at the works (Somervell 1930, 78). Apart from one Trent and one Vortex unit and two Pelton wheels purchased from the local firm of Gilkes of Kendal between 1909 and 1923, the manufacturer(s) of these turbines is(are) unknown. Technical data on the Pelton wheels shows that they were both situated at the Cooperage or High Works and so need not concern us here (section 4.2 above). There is no evidence for where the Trent turbine was installed, but the Vortex unit, bought in 1923, was undoubtedly intended for the large corning house mark II built that year following an explosion that destroyed the mark I house: a 'Power House' was constructed north of the new corning house to accommodate it (identified as building 13a in the present report: Large Corning House, section 6.2.3 below). Field evidence suggests that the small corning house mark II, built sometime between 1923 and 1931, also had its own, detached, turbine house, as, at least towards the end of its life, did the glazing house (section 6.2.3 below). According to Tyler (2002, 78), three of the four pairs of incorporating mills had all been converted to turbine-operation by 1913, too, although it is possible that they had always been so powered (see Weirs, Leats and Waterwheels, this section above). The mention on the

Figure 12: The short open-air section of the high-level culverted leat north of incorporating mill 7 (Photograph: Christopher Dunn 2006, © English Heritage)

Figure 13: The exit portal of the low-level culverted leat north of Challon Hall (Photograph: Christopher Dunn 2006, © English Heritage)

1923 factory plan of a 'Power House' in association with the mixing house suggests that the latter building was similarly turbine-powered by that date (section 6.2.3 below).

Hydraulic Power

Hydraulic power was needed to operate powder presses and, after 1880, the new cartridge-presses. Before *circa* 1860, the powder presses were located within the two combined corning and glazing houses. Although it is possible that these early presses were screwed down by hand (as the press was at the nearby Elterwater gunpowder works until *circa* 1840 (Jecock *et al* 2003, 64-5)), by the 1850s they are more likely to have been hydraulically operated; if so, the pumps producing the hydraulic pressure were probably driven by the waterwheel within each combined house (the press pumps at the Lowwood gunpowder works are known to have been powered by waterwheel in the 1860s (Jecock *et al* 2005, 102)). This situation no doubt persisted when, *circa* 1859-60, the powder presses were relocated to new, dedicated buildings, with hydraulic power piped across the river from one or both of the corning houses into which the old combined houses were converted. By 1863 or shortly thereafter, however, the pumps at the large corning house seem to have been powered by steam engine, as, after *circa* 1875, were those at the small corning house. In the 1920s with the modernisation of both corning houses, power for the pumps was supplied by water-turbine with electric motor back-up (Press and Corning Houses, section 6.2.3 below).

The factory started manufacturing blasting cartridges in 1880. Although the cartridge presses are known to have been hydraulically operated by 1931 – and probably always had been – there is no information on where or how the hydraulic pressure was generated (section 6.2.4 below). It is worthwhile noting, however, that after 1895 the company had its own supply of pressurised water generated from their newly constructed reservoir at Fall Beck 325 feet above the works (section 4.2 above), and it may be that this water supply operated the presses directly.

Steam Power

According to the ICI historian, the company acquired its first steam engine in 1863, nicknamed 'Garibaldi' (section 4.2 above), but Tyler's statement that this was located next to the large corning house is debateable given that by 1898 steam engines also existed at the incorporating mills, small corning house and glazing house. All were most likely held in reserve for periods when frost or low water levels in the leat made it impossible to use waterwheels or turbines to power these process buildings, although the two corning-house engines may well have run continually operating pumps generating hydraulic pressure for the press houses, and it is just conceivable that incorporating mills 1 and 3 were initially steam-powered rather than driven by water-turbine. All the engines seem to have been disused and/or replaced by electric motors by 1923. After this date the only use of steam was to heat the stove house(s) (section 6.2.3 below). Field evidence (discussed under Unidentified Features, section 6.2.10 below) suggests that a boiler and/or engine house may once have stood adjacent to the mill leat north of the incorporating mills, but no documentary or cartographic evidence has been found that corroborates or dates this suggestion.

Figure 14: The infilled mill leat looking south from the near the joiners' shop (building 29) (Photograph: Christopher Dunn 2006, © English Heritage)

Figure 15: The narrow mill leat looking south from near the glazing house (building 9) (Photograph: Christopher Dunn 2006, © English Heritage)

Electrical Power

The Gatebeck factory had electric lighting by 1888 (section 4.2 above), although there is no indication of where or how power was generated, or of how extensive the lighting was at this time. Later, around 1909-11, electricity was generated by a Pelton wheel that the company purchased from Gilkes of Kendal, although this was located somewhere within the High Works or Cooperage. Tyler claims that an electric motor was powering one of the pairs of incorporating mills at the Low Works by 1913 (section 4.2 above). This motor certainly existed by 1923, as did others by 1931 providing back-up power to the glazing and both corning houses (section 6.2.3 below). An historic photograph reproduced by Tyler (discussed in detail under Stove and Stove Reserve, section 6.2.3 below) indicates that by the 1920s power was distributed around the Low Works by cables attached to a system of timber rails and posts. Short lengths of metal ducting that survive in association with some of the incorporating mills confirms that they were, at least latterly, lit by electricity.

6.2.2 The Preparation and Storage of Raw Materials

Cylinder Houses, Charcoal Stores and Coppice Barns (buildings 28 and 53 and unlocated)

For the first 10 to 15 years of operation, the Low Works manufactured its own charcoal on site using the cylinder or retort method. From the mid-1860s, however, in-house production ceased and charcoal was bought in from external suppliers (section 4.2 above). In its early years, therefore, the works would have possessed sheds and barns for sheltering the retorts and for storing supplies of coppice wood as well as actual charcoal stores. The siting of charcoal stores within gunpowder works was regulated by the 1772 Gunpowder Act, one of the clauses of which stipulated that no such store could lie within 20 yards (18.3m) of any mill or magazine in case the charcoal self-combusted (Cocroft 2000, 28) – as happened at the nearby New Sedgwick factory for example in 1884 (Dunn *et al* 2003, 38).

A 'Retort House' and 'Charcoal House' (that is, store) are both named in the 1851 bill of tender to build the works. The earliest evidence for the position of either building, however, is the 1898 factory plan (Fig 5), which names one of the central cluster of buildings adjacent to the main mill leat (no. 28) as 'Charcoal Retorts and Store'. Since it is extremely unlikely that charcoal would have been stored in the building if the retorts were in use, the retort element of the name presumably represents an historical legacy recording the building's original function. This ties in with the documentary evidence that the factory outsourced its charcoal production in the mid-1860s. By the same argument charcoal manufactured on-site must have been stored away from the retorts prior to the mid-1860s. There must also have been a separate coppice barn nearby at this time for storing the wood to be made into charcoal. No evidence for the location of either of these early buildings has been found, but candidates comprise buildings 100, 101 and 104 on Figs 131 and 132 - all depicted on the 1858 OS map as of timber or iron construction, and demolished before 1896 (compare Figs 137 and 138).

The disused retorts may well have still been still *in situ* within building 28 in 1898, but if so they were no doubt dismounted sometime thereafter for the 1923 factory plan

(Fig 140) identifies the building simply as 'Charcoal Store'. Both factory plans depict the building in identical fashion as divided into four compartments arranged side by side, connected at the rear by a single, longitudinal range backing directly onto the mill leat; OS map evidence shows that the latter range was added between 1858 and 1896. Much of this area is now covered by static caravans and no sign of the four compartments survives above ground. However, a long, narrow, shallow earthwork platform visible in the top of the leat embankment (shown on Fig 91) corresponds with the site of the rear, longitudinal range, and traces of walls and concrete buttresses protruding out of the embankment scarp must be the remnants of internal structural elements of the larger building. According to Tyler (2002, 44), the retort house accommodated 36 retorts, of which four survive upended and set into the ground as gateposts: two at either end of the access road to the works (Figs 16 and 100). Until recently, two more retorts stood at the entrance into what was the Cooperage north of Gatebeck Bridge, but one of these was relocated *circa* 2005 to the site of the former Elterwater Gunpowder Works.

The 1923 factory plan indicates that a second charcoal store (building 53) existed by that date, located at the very southern edge of the factory just beyond the licensed area. It was then relatively new for it does not feature on the 1911 Ordnance Survey map (compare Figs 139 and 140). It is shown serviced by a short loop from the Gatebeck Tramway which enters the works from the south along the bank of the Peasey Beck; the loop runs beneath a covered awning.

The concrete base and retaining walls of the platform on which the building was located survive terraced into the hillside, although heavily overgrown and masked by soil build-up (Fig 17). There is no field evidence for the actual charcoal store, however, suggesting that it was of timber or metal construction. The concrete base was accessed from the north-west and south-west by ramps adjacent to the tram loop; several, mostly paired, metal bolts in the stone face of the base adjacent to the tram loop must mark the positions of timber uprights supporting the covered awning.

Saltpetre Stores (buildings ?105 and 29)

There were at least two saltpetre stores at the Low Works. According to the factory plans (Figs 5 and 140), by 1898 and from then probably until the factory closed in 1936, the 'Saltpetre Store' was located in building 29, one of the cluster of buildings which stood in the centre of the works adjacent to the mill leat. This building also doubled up as a 'Joiners' Shop'. The cartographic sources show that it was a large, almost rectangular building a maximum of *circa* 35m north-east to south-west by 28m transversely with a small projection or wing at the western corner; it was also connected to building 30 (a smithy) to the south-east by an intervening block. It is unclear which parts of the building were used for which purpose, but on logistical grounds it is likely that saltpetre was stored at the south-west end of the building for ease of receipt of saltpetre from the refinery and onward transmission of the same to the mixing house as needed, and that the joiners' shop comprised the more northerly elements of the complex, including the intervening block connecting it to building 30. Saltpetre from the refinery was probably taken into the store through the western wing, which maps show fronted onto a tramline running between refinery and mixing house (the 1911 OS map (Fig 139) shows a small covered loading bay projecting over the tramline), and was taken out through a doorway

close to the southern corner of the building for the 1911 OS map also shows that the store was (at least then if not earlier) connected to the mixing house by a second tramline parallel to the main mill leat.

Building 29 cannot be the saltpetre store mentioned in the 1851 bill of tender, however, since map evidence shows that building 29 was not constructed until after 1858 (compare Figs 137 and 138). There is no documentary evidence for the location of the earlier store, but the logistical requirement for it to be close to both refinery and mixing house suggests that it most likely occupied much the same location as its successor. On this argument the early store was probably part of the suite of buildings (numbered 105 on Figs 130 and 131) that building 29 replaced.

Aerial photographic evidence indicates that building 29 was demolished between 1950 and 1970 (NMRC AP library nos. 1073 and 10051). The area is now occupied by static caravans, and little is visible of the building apart from fragments of stone and brick walling at the foot of the leat embankment, which must represent elements of various internal dividing and supporting walls. These and other remains that seem more relevant to use of the building as a joiners' shop are discussed further in section 6.2.6 below.

Sulphur Stores (unlocated)

A 'Brimstone House' (that is, sulphur store) is mentioned in the 1851 bill of tender as one of the buildings to be erected at the works. Since the building is not named by either the 1898 or 1923 factory plans (Figs 5 and 140), its location is unknown, but it was probably one of the buildings that the 1858 OS map (Fig 137) shows stood toward the centre of the site (perhaps buildings 103 and 104 on Fig 130), subsequently demolished. After demolition, stocks of sulphur may have been kept at either the charcoal or saltpetre store (buildings 28 and 29).

Saltpetre Refineries (buildings ?105 and 32)

There were two so-called saltpetre refineries at the Low Works. (The title is a slight misnomer as saltpetre refineries also frequently purified sulphur by a simple process of heating and skimming). The earliest refinery (the 'Refining House, Boiling and Cooling House' mentioned in the 1851 bill of tender) must have been of the traditional design in which potassium nitrate saltpetre imported from Bengal was purified by dissolving it in water, boiling the solution, scooping out the crystals that formed as the hot solution cooled and finally re-washing these in fresh water (see Jecock *et al* 2005, 67-76 for a more detailed explanation of the process and variations thereof, plus the infrastructure it entailed). There is no documentary evidence for the early refinery's location, but the most likely candidate is part of the complex of buildings which, for the purposes of this report, has been numbered building 105 (Fig 130).

In 1864, the company constructed and fitted out a replacement refinery in which to carry out a new technique (the 'Wakefield process') that manufactured pure potassium nitrate saltpetre from the cheaper, inferior, sodium nitrate form (section 4.2 above). This second 'Saltpetre Refinery' is named by both factory plans (Figs 5 and 140) as building 32. It was the largest, single building erected at the Low Works, consisting of a main block measuring *circa* 30m square, around and against which were arranged a multitude of

Figure 16: Charcoal retorts reused as gateposts at the junction of the access road with Gatebeck Road (Photograph: Christopher Dunn 2008, © English Heritage)

Figure 17: The platform for the charcoal store (building 53) from the north-west (Photograph: Christopher Dunn 2006, © English Heritage)

smaller ranges. Comparison with the 1858 OS map (Fig 137) shows that it was erected on a largely virgin site towards the centre of the works, although one existing building (numbered 106 on Fig 130) - of unknown function, but possibly the early packing house (section 6.2.3 below) - had to be demolished to make space for it.

If correctly identified, the first refinery (building 105) had been demolished by 1896 for later maps and plans depict building 29 in its stead. Although not a danger building, the new refinery was also demolished at or shortly after closure of the factory in 1936, for aerial photographic evidence shows that its site was already mostly levelled before the end of World War II (NMRC AP library no. 3864). There are no known ground photographs specifically of the new refinery, but something of the scale and complexity of the building can be gauged from one corner that is just visible in the background of a photograph of the Gatebeck 'management team' taken from in front of building 34 in the 1920s or 1930s (NMR AA035283).

No surface trace of either refinery was recognised during English Heritage's investigation.

Graphite Store (buildings ?9 and 11a)

Graphite (also known as blacklead) was needed to glaze gunpowder. The only evidence for a dedicated 'Graphite Store' is the 1923 factory plan (Fig 140) which records a small building (no. 11) immediately north of the then glazing house (building 9) as in use for this purpose. In all likelihood, however, the store had only very recently been constructed, for the 1898 factory plan (Fig 5) shows that the same building number allocated to an engine house attached to the southern end of building 12 (the large corning house) - buildings destroyed in an explosion only five months prior to the date of the 1923 plan. Although the new graphite store assumed the number of the destroyed engine house, it will here be called building 11a to help make the distinction between it and its predecessor. It is not clear where graphite was stored prior to the construction of building 11a, but it was most probably within the various glazing houses (buildings 9, 11/12/13 and 17).

No field evidence that can be attributed to building 11a was found during survey.

6.2.3 The Manufacture of Gunpowder

Mixing Houses

The mixing house (also sometimes called the preparing house) was where the three raw ingredients of gunpowder – charcoal, saltpetre and sulphur - were first brought together, ground to fine powder, and mixed in the correct ratios to produce a green or unripe charge ready for the incorporating mills. It thus performed two separate tasks: grinding (preparing) and mixing. Indeed documents occasionally refer to preparing and mixing houses as if they were separate buildings, but the evidence suggests that at Gatebeck both processes were carried out under the same roof. Mixing houses required access to power in order to grind and mix the ingredients, usually undertaken using small edge-runner mills and rotating drums or reels.

Mixing House (building 22)

A 'Preparing House' is mentioned in the bill of tender as one of the buildings to be erected at the Low Works in 1851. It was presumably in this house that an explosion killed two men in 1859 (Patterson 1995, 24), although the building itself may not have been badly damaged. There is no certain evidence for the location of the preparing house at this early date, but the likelihood must be that it is the same as the 'Mixing House' (building 22) that the 1898 factory plan (Fig 5) records in close proximity to the charcoal retorts (later charcoal store (building 28)), saltpetre refinery and saltpetre store (buildings 32 and 29), thus making for easy delivery of raw ingredients into it.

According to the MMB, the mixing house was a two-storeyed construction with grinding undertaken on the ground floor and mixing above. Map evidence (Fig 138) suggests that by 1896 saltpetre (and possibly sulphur too) arrived by tram bogie at the northern end of the building. No tram connection is depicted between the mixing house and adjacent charcoal store (building 28) at this time, but later maps show that by 1911 a line ran from the rear of the store to the southern corner of the house (Figs 139 and 140), indicating that charcoal was then taken in and processed at the opposite end of the building; perhaps it always had been. According to the MMB only sulphur and charcoal were ground because saltpetre was already of sufficient fineness having been sieved in the refinery. Grinding operations were carried out using a water-powered edge-runner mill equipped with 6-feet diameter iron runners weighing *circa* 4 tons. After milling each ingredient was rotated in a sloping reel fitted with 16-mesh copper wire cloth; matter of sufficient fineness passed through the mesh but 'stops' (oversize particles) were returned for further milling. Ground sulphur and charcoal were weighed out and taken in wooden tubs to the mixing floor above via a small belt-driven lift; saltpetre was measured out on the mixing floor. The weighed amounts were tipped into three hexagonal mixing drums powered by belts from a shaft connected to the grinding mill, and the mixed charges then emptied into bags (MMB, 7-12; Patterson 1995, 24). Cartographic evidence (Figs 5 and 138-140) suggests that the resulting, prepared (green) charges emerged from near the west corner of the building for transfer, again by tram bogie, into a nearby expense magazine (building 23), with the bogies running on to a turntable to return to the saltpetre store, although the MMB records that in the 1930s transfer was by wheelbarrow. The MMB states that in the 1930s both N/P and N/S charges were prepared here: the former for incorporation at the Low Works mills, the latter for incorporation at the mills at the High Works, although in the latter case the charges consisted of charcoal and sulphur only, with nitrate of soda added at the High Works mixing house.

English Heritage located no field evidence for building 22 during survey: its site appears to lie beneath a modern ramp giving access up onto the central, infilled, section of the mill leat. Neither does any obvious physical evidence survive for how the house was provided with waterpower. There is some suggestion on the 1858 OS map (Fig 137) that a waterwheel stood against the outside of the building's south-west gable wall, but no tailrace is shown; water must, therefore, have returned to the river in a culverted leat, possibly by way of the small corning house (Weirs, Leats and Waterwheels, section 6.2.1 above). The 1923 factory plan (Fig 140) labels the building as 'Mixing House and Power House', suggesting that a water-turbine had replaced the waterwheel by that date.

Green-Charge Houses

The 1772 Gunpowder Act placed limits on the amount of powder that could be present within particular process buildings at any one time. Because of these limits, after 1772 all gunpowder works needed expense magazines or similar structures for the temporary storage of powder as it progressed between the various stages of manufacture. The Act stipulated that such temporary magazines and storehouses had to be constructed in brick or stone, and could not be erected closer than 50 yards (45.7m) to any mill building (Cocroft 2000, 28). However, green charge fresh from the preparing house was considerably less explosive than ripe charge (the name given to powder which had passed through the incorporating mills) and may have been considered exempt from these legal controls.

Green-Charge House (building 23)

The 1898 and 1923 factory plans (Figs 5 and 140) both record the presence of expense magazines and what are termed charge houses at the Low Works. The two named charge houses (buildings 2 and 6) stood in line with and between the incorporating mills at the southern end of the site. However, they seem to have been for the temporary storage of green and ripe charges just prior to, and immediately after, 'charging' and 'discharging' the incorporating mills in order to avoid more than a single charge being present within a mill chamber at any one time: they are accordingly described in detail elsewhere (charge houses, this section below). The two expense magazines marked on the plans on the other hand, were more centrally located. Of these, building 15 in between the two press houses on the west bank of the Peasey Beck was clearly chiefly intended for the storage of powder *en route* to, and unloaded from, the presses, but building 23's proximity to the mixing house and many non-process buildings means that it is unlikely to have been authorised for anything other than the temporary storage of green charges. Indeed, in the 1930s building 23 was known specifically as 'the Green Charge House' (MMB, 10 and 13).

Although building 23 is not identified as an expense magazine/green-charge house before 1898, it undoubtedly represents one of the original factory buildings erected in 1851-2 for a structure with an identical footprint stood on the site as early as 1858 (Fig 137). Its position in relation to other structures is strong evidence that it always functioned as a green-charge house. It has already been suggested (Mixing House, this section above) that charges were taken into it through a door in the north-east wall; map evidence indicates that by 1896 (Fig 138) they were being taken out through a door in the opposite, south-west wall and conveyed to the incorporating mills by tram bogie. In the 1930s (and probably earlier) the bogies were horse-drawn (MMB, 13).

English Heritage located no above-ground evidence for building 23 during survey: the mapped site now lies under tarmac and/or part of the static-caravan park.

Incorporating Mills and associated buildings

Once mixed, green charges had to be incorporated (incorporation was also sometimes called amalgamation). This process was designed to ensure that the powder was thoroughly combined and of the correct density. A little water was normally added at this stage to make the charge hold together better; this also had the effect of dissolving some of the saltpetre which aided its absorption by the charcoal.

Incorporation was carried out using a particular form of edge-runner mill. Early designs consisted of a large bedstone and two vertical rollers or edge-runners, all manufactured out of limestone. The green charge was placed on top of the bedstone - around the edge of which a deep, angled, retaining curb was fitted - and mixed by the edge-runners which turned and rotated in the 'pan' so formed. Turning motion was imparted via a vertical spindle (which could be powered either from above or below: termed over-drive and under-drive), but rotational movement relied on friction between the edge-runners and charge laid within the pan. A later, safety modification entailed suspending the edge-runners about 6-9mm above the pan to eliminate frictional heat which could be generated if they momentarily came into contact with, and skidded on, the pan surface (that is, the bedstone). Another (relatively late) design innovation involved the substitution of hollowed iron wheels and a totally iron bed plate in place of the limestone traditionally used (Patterson 1986, 15-24). Iron runners were in use at the Low Works by the 1930s, although they were not of the suspended type (see below).

In later years incorporating mills were also very often fitted with drenchers: tanks of water balanced on a common shaft above the edge-runner mills, designed to empty onto the charge and extinguish the flames if one mill in a pair blew up, at the same time as dampening the charge in the adjoining mill to prevent the explosion communicating to it (Patterson 1986, 20). However, only one of the four pairs of incorporating mills at the Low Works was reportedly so fitted.

In common parlance, the phrase incorporating mill can refer to either the edge-runner mill or the building in which the process was accommodated. To avoid possible confusion, the present report will always use the term to mean the mill building, with the machinery referred to as an edge-runner mill.

By 1896 and from then until the factory closed in 1936, there were eight incorporating mills at the Low Works. All the mills were constructed as pairs, that is a mill chamber situated either side of what appears to be a central waterwheel house but might more accurately be described as a drive chamber (see below). The four pairs, interspersed with two charge houses and a watch house (described elsewhere: this section above, and section 6.2.6 below), were arranged in line almost due north-south at the foot of the east side of the valley close to the factory's southern limit. It has previously been argued (section 4.2 above) that the incorporating mills were constructed in two campaigns, with the northernmost two pairs the first to be erected in the mid- to late 1850s (they almost certainly existed by 1859) and the southern two pairs added between 1881 and 1896. Both the 1898 and 1923 factory plans (Figs 5 and 140) identify the mill pairs as buildings 1, 3, 5 and 7 numbered south to north. These numbers do not reflect the order in which the mills were constructed but will nevertheless be retained for the purposes of the present report, with individual mill chambers within pairings distinguished as north and south (*contra* Ponsford 2007, 331-3). A different numbering system was evidently in use towards the end of the factory's life, for the MMB (page 12) refers to one pairing as mills 7 and 8; it is unclear, however, whether this later numbering system ran south to north or *vice versa*.

The only written description we have of the milling plant is that contained in the MMB, which dates to 1931 or later (section 4.2 above). This states that all eight incorporating mills then housed two edge runners of 4.5-5 tons (4.57-5.08 tonnes) each, that these

runners were made of iron and had a diameter of 7 feet (2.13m) and a face of 18-19 inches (457-483mm), that they were over-driven and that the edge-runner mills turned at 9 rpm. Only one pair of edge-runner mills was fitted with drenchers and in these the runners were staggered. Six of the edge-runner mills were driven by water-turbine – one turbine for each pairing; the other pair was driven by electric motor (MMB, 12-13). The MMB, however, describes the incorporating mills as they were during their final phase after takeover and, presumably, substantial modernisation of the works by ICI. Although the mill buildings survive, they are in a ruinous state. Weed trees have taken root in and around the walls, and although much of this was cut down immediately prior to investigation in the winter/spring of 2006 (compare Figs 18 and 19), not all the stools could be killed with the result that some are now (re-)coppicing, while the opening up of the tree canopy has allowed other vegetation to colonise the area. Much of the evidence for earlier plant layouts and power arrangements has consequently been lost, is obscured beneath tumbled masonry or is once more obscured by vegetation, but it seems likely that all the edge-runner mills were originally powered by conventional waterwheels or water-turbines, supplemented (possibly only during times of severe frost or drought) by one or more small steam engines located in attached engine houses (although it is possible, if unlikely, that, as built, incorporating mill pairs 1 and 3 were steam-powered and only later were converted to turbine and/or electric motor operation).

Two 'Engine House[s]' are named on the 1898 factory plan (Fig 5): one, numbered 51, on the west bank of the beck opposite mill pair 7; the other, numbered 52, on the east bank of the beck immediately in front of mill pair 1. The 1923 factory plan (Fig 140), however, states that engine house 51 was never built (indeed neither the 1896 nor 1911 OS maps (Figs 138 and 139) portrays it), while the 1896 map depicts additional small structures omitted and/or not named by the factory plans: one just south of mill pair 3 and the other immediately in front of mill pair 5; only the latter is depicted on the 1911 OS map. For the purposes of the present report these additional structures are numbered below and on Figs 131-136 as buildings 3a and 5a respectively. Building 3a is of unknown function, building 5a is probably an engine house. The later factory plan indicates that building 52 had been converted into an 'Electric Motor House' by 1923, but field investigation has identified an additional structure, not shown on the plan, situated immediately north of it, which may be the true site of the motor house, a late replacement for it or a separate (late) generator house; this building is numbered 52a in the present report.

Incorporating mills (buildings 1, 3, 5 and 7), power houses, boiler houses and chimneys (buildings 5a, 8, 8a, 8b, 51, 52 and 52a) and other buildings (building 3a)

Although ruinous, it is clear that each of the four pairs of incorporating mills at the Low Works consists of what appears to be a central waterwheel house (but see below) flanked by chambers for edge-runner mills (Figs 20-23). Each pair is connected to its neighbour(s) by a revetment wall which is pierced by (in turn) a charge house, a watch house and a second charge house (Figs 45, 78 and 46). Within each pairing the mill chambers face westwards, are rectangular in plan and are thickly walled on three sides with roughly coursed stone rubble, 0.72m thick, intended to contain the force of any accidental explosion. There is evidence at some of the pairs of a second wall behind the rear wall, presumably to help revet the hillside. The west (front) walls and roofs of the chambers were probably made of light timber and metal, designed, unlike the thick stone side and rear walls, to blow out easily in the case of explosion, and are now missing.

Figure 18: Incorporating mill 1 before tree clearance
(Photograph: Christopher Dunn 2005, © English Heritage)

Figure 19: The south chamber of incorporating mill 1 following tree clearance
(Photograph: Bob Skingle 2006, DP028056 © English Heritage.NMR)

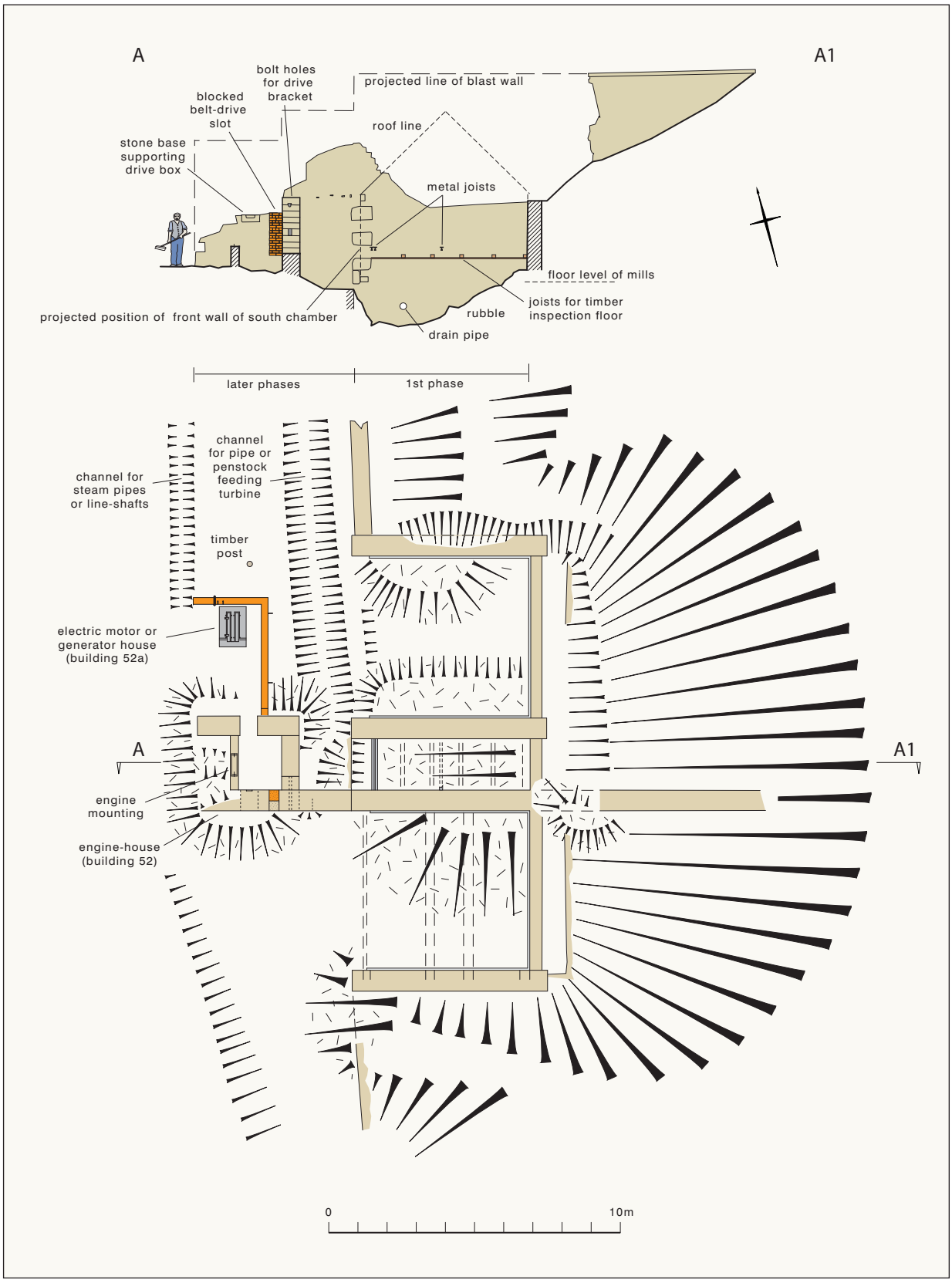

Figure 20: Plan of incorporating mill 1.
(Drawn by Tony Berry and Philip Sinton, © English Heritage)

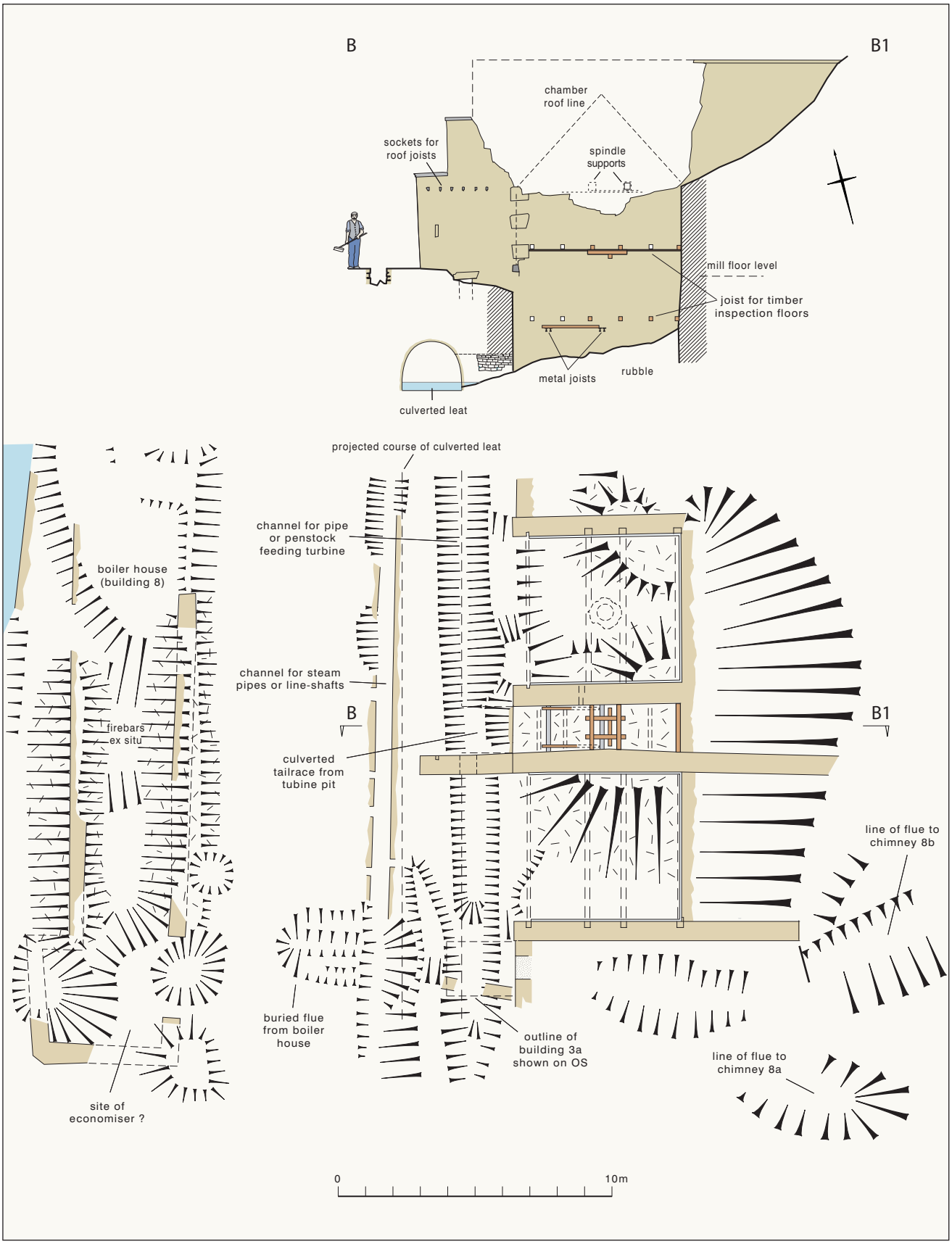

Figure 21: Plan of incorporating mill 3.
(Drawn by Tony Berry and Philip Sinton, © English Heritage)

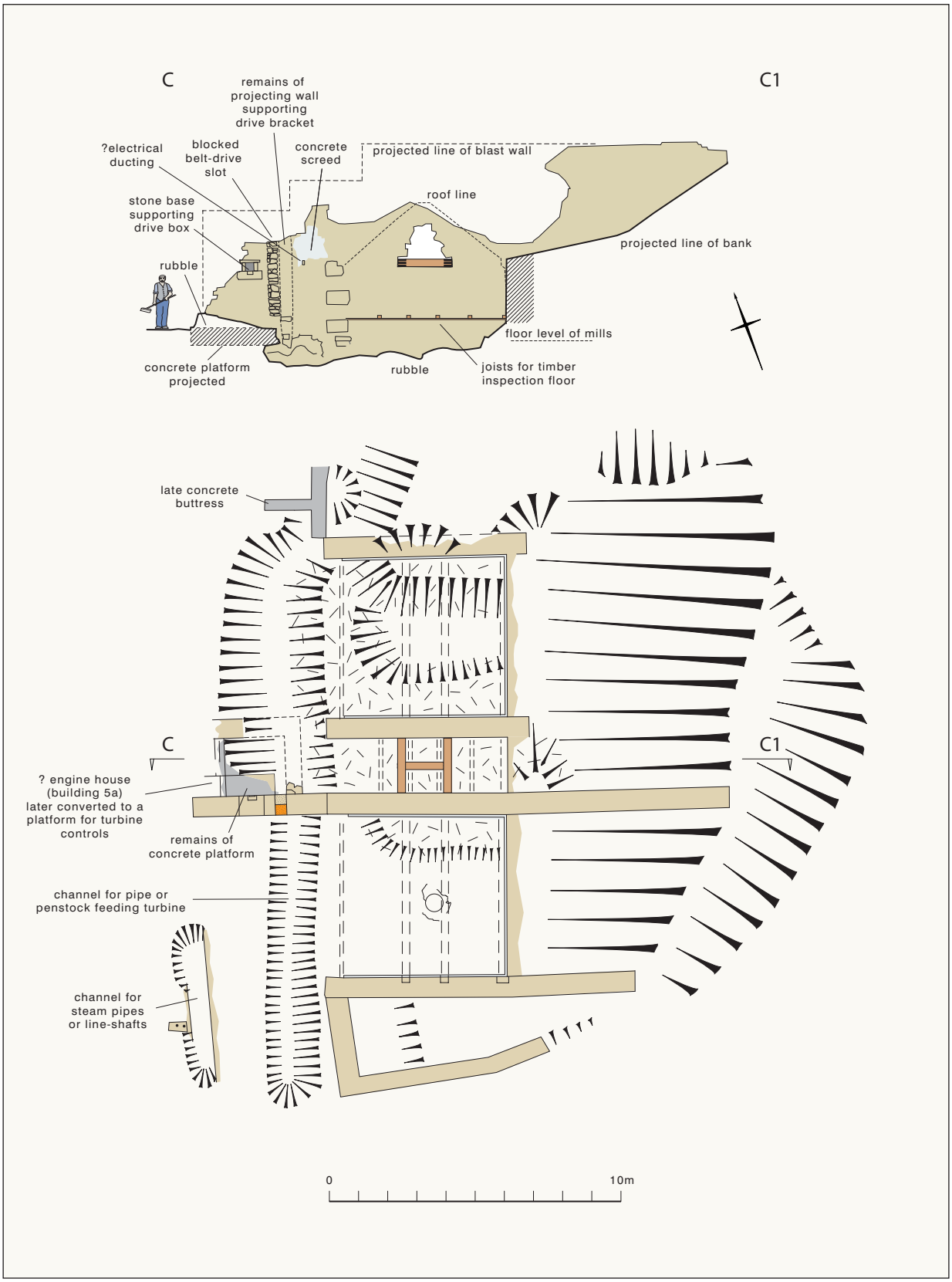

Figure 22: Plan of incorporating mill 5.
(Drawn by Tony Berry and Philip Sinton, © English Heritage)

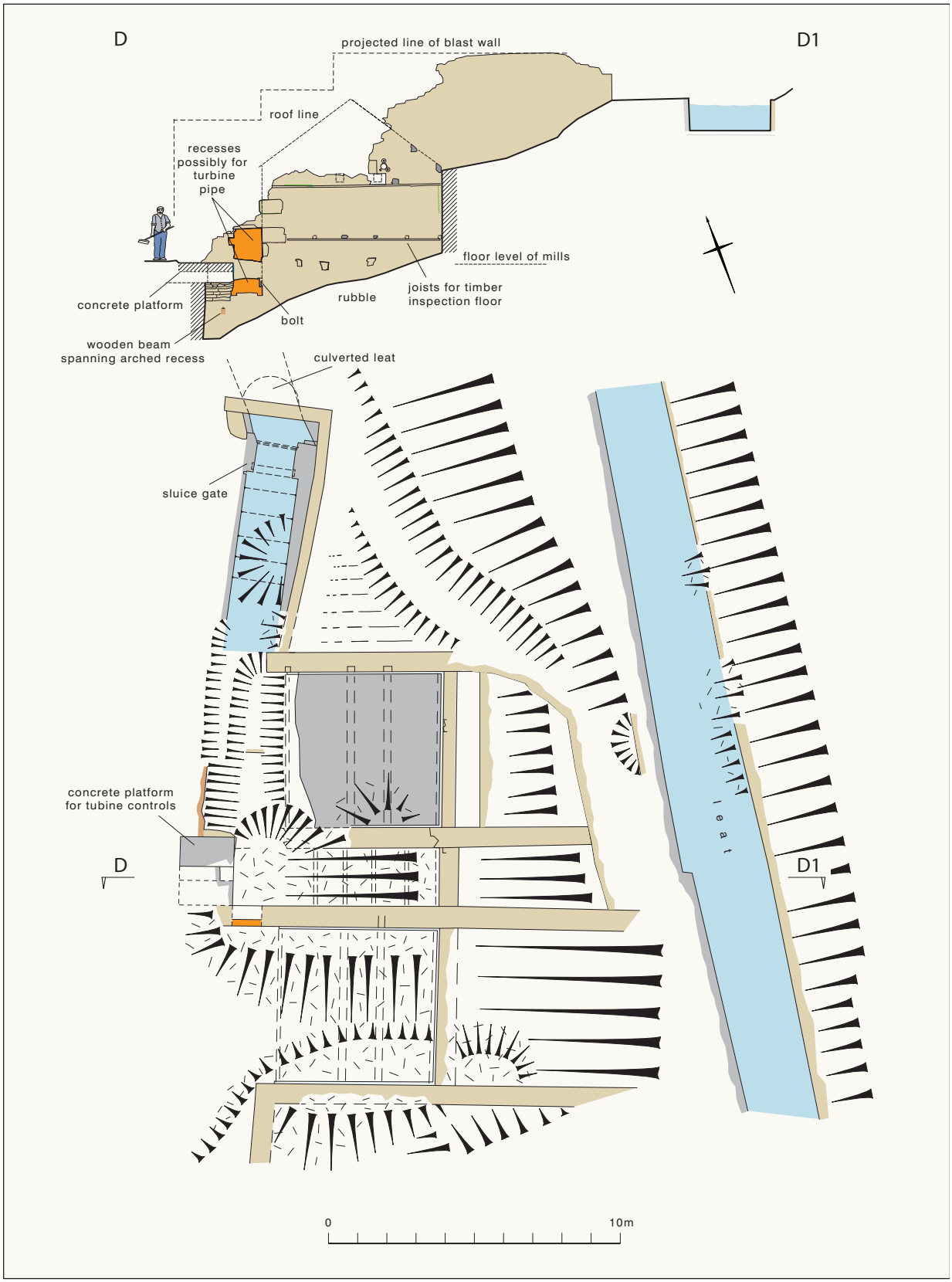

Figure 23: Plan of incorporating mill 7.
(Drawn by Tony Berry and Philip Sinton, © English Heritage)

The side walls of each chamber originally terminated as evenly-sloped gables with stone-flagged copings (Fig 24), in several cases continuing as blast-proof parapets above the roof lines (Fig 25). The stone side walls projected beyond the front (screen) walls and were finished with shallow marginally dressed rock-faced stone quoins. Their inner faces, except where they projected above the rooflines and beyond the screen walls, were thickly coated with smooth cement to exclude any irregularities or ledges where dangerous gunpowder dust might have accumulated. The roofs and fronts of the incorporating mills have been lost, presumably purposely destroyed by fire when the works closed, but their positions can be identified as lines without cement in the side walls and in the case of the latter by opposing sockets for the front wall plates in each side wall.

Figure 24: The north chamber of incorporating mill 3 and retaining wall to the north
Photograph: Bob Skingle 2006, DP028069 © English Heritage.NMR)

Evidence from the south chambers of mill pairs 3 and 5 (Figs 25 and 26) suggests that, at least in their final form, the roofs were covered in metal sheets (Fig 27), similar to that recorded at Basingill (Hunt and Goodall 2002, 12-13 and 41). There would have been two square sockets with smooth stone linings in the side walls of each chamber for timber beams bracing the tops of the edge-runner mill spindles (Fig 30), but these are now only evident in chambers 1 south, 3 south and north, 5 south and north and 7 north because of masonry collapses. Although the mill floors appear to have been replaced during the final production phase, it must be assumed that the edge-runner mills were always over-driven since there is no evidence for the basements necessary to house the drive shafts, gearing and the spindle bases if the edge-runner mills had ever been under-driven. Over-drive requires each chamber to have an aperture for a horizontal drive-shaft bearing in the side wall adjacent to the waterwheel house.

Figure 25: The south wall of the south chamber of incorporating mill 5 (Photograph: Bob Skingle 2006, DP028072 © English Heritage.NMR)

The only definite such feature is to be found in the south wall of the wheel house at incorporating mill 7 (Figs 28 and 29), but is probably a late example since it is comparable to drive-shaft apertures in the final phase adaptation of incorporating mills 25/26 and the mark IV large corning house at Lowwood (Jecock *et al* 2005, 84-9 and 109-12), both of which date to after ICI's acquisition of that site. Evidence for earlier

Figure 26: Detail of metal roof panels surviving in the rear wall of the south chamber of incorporating mill 3 (Photograph: Christopher Dunn 2006, © English Heritage)

examples has been lost through gable collapses, although a ragged hole in the inner gable of mill pair 5 south might denote the general position of an early drive slot.

Since waterwheels were the preferred source of motive power for incorporating machinery at most gunpowder works in Cumbria - including four of the incorporating mills built at the turn of the 19th century at the Gatebeck High Works (Oswald *et al*, in prep) - the inclusion of what, at first glance, appear to be conventional waterwheel houses between the pairs of mill chambers should indicate that waterwheels were likewise the primary driving mechanism for the Low Works edge-runner mills when first built. However, against this proposition, none of the apparent waterwheel houses retains any indication of wheel positions; nor is there any provision for the inspection and maintenance chambers that would have been needed for conventional axled wheels. Furthermore, it is not at all clear how water from the main leat could ever have been dispersed to turn wheels between all four pairs of mills: the leat turns to flow down the hillside after mill pair 7 (Fig 30) and joins the culverted leat (the former tailrace from the pre-gunpowder mill; Weirs, Leats and Waterwheels, section 6.2.1 above), and there is no evidence in the landscape to suggest that it ever continued beyond the turn, no map or field evidence for pentroughs, flumes or subsidiary leats by which water could have been conducted to wheels at the more southerly mills and little conclusive evidence (apart from a slight unconformity in the concrete-lined, and therefore rebuilt, side of the mill leat above the waterwheel house to pair 7 (Fig 31) where a sluice and take-off might once have been) that it powered even this pair. The position and height of the culverted leat in front of the mills, which drops in level where it intersects the waterwheel house of mill pair 7 (Weirs, Leats

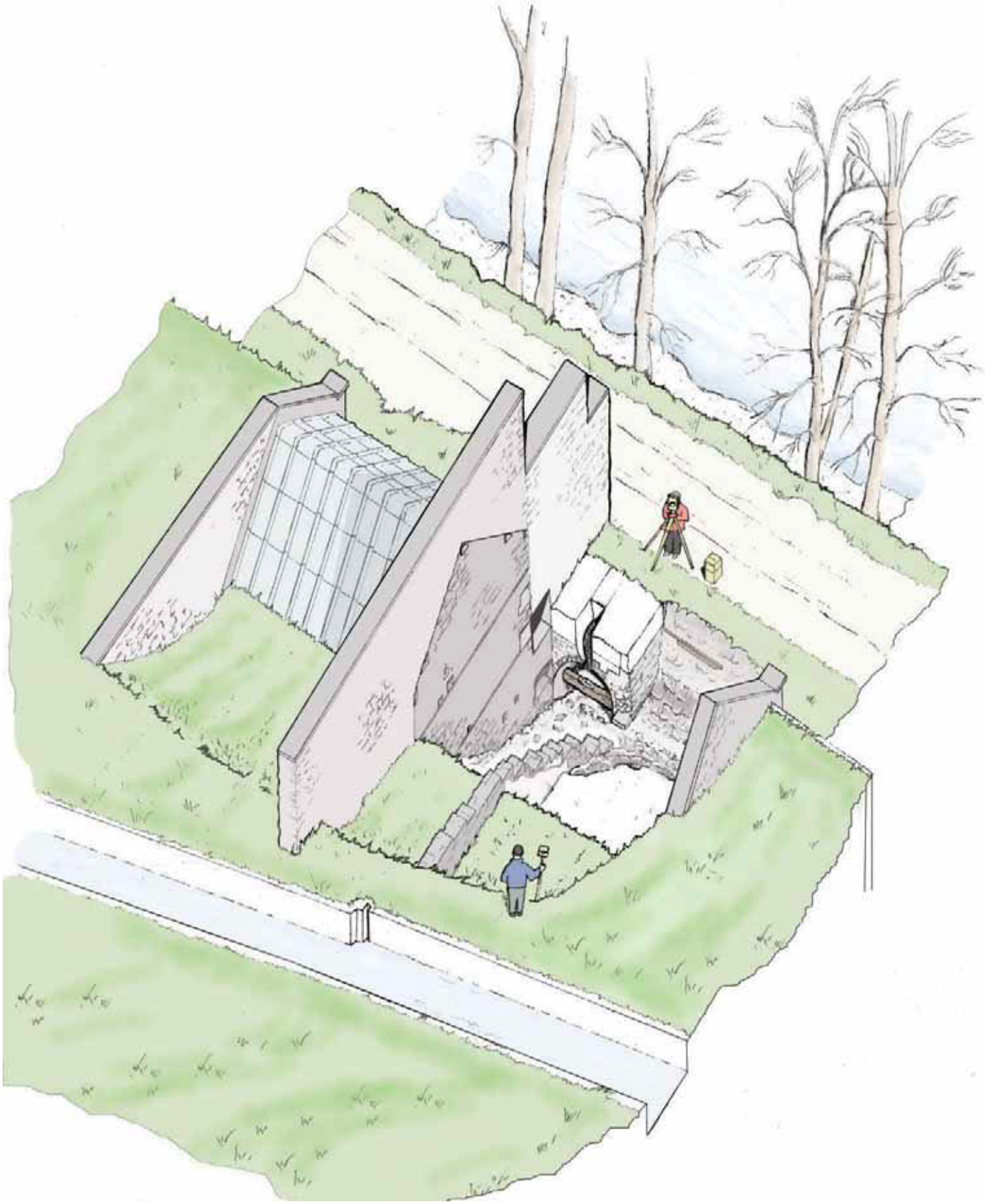

Figure 27: Isometric partial reconstruction drawing of incorporating mill 7 (Drawn by Matthew Bentley, © English Heritage)

Figure 28: The waterwheel house and drive-shaft aperture at incorporating mill 7 (Photograph: Bob Skingle 2006, DP028080 © English Heritage.NMR)

Figure 29: The drive-shaft aperture in the south chamber of incorporating mill 7 from the south (Photograph: Bob Skingle 2006, DP028078 © English Heritage.NMR)

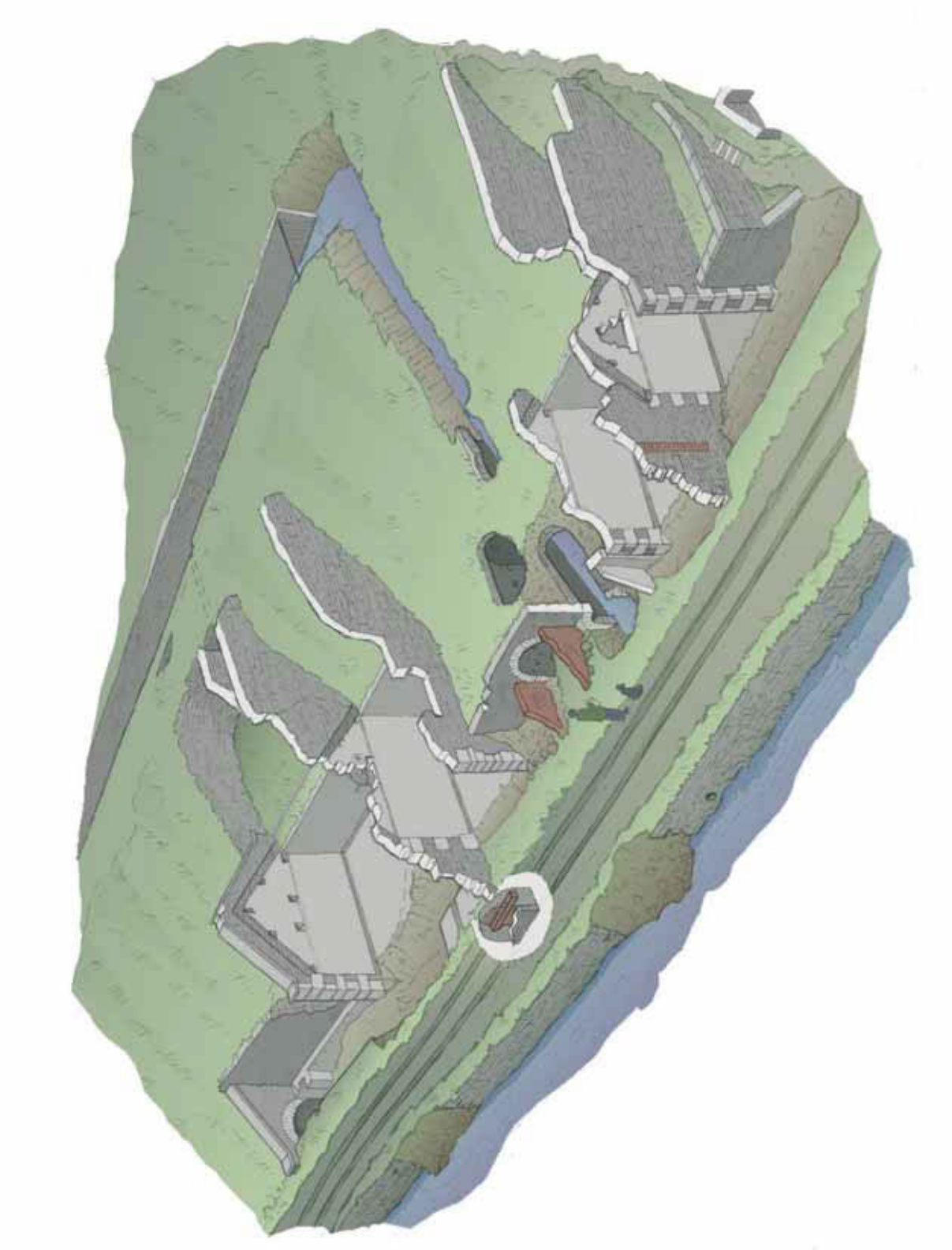

Figure 30. Isometric drawing of incorporating mills 5 and 7
(Drawn by Tony Berry, © English Heritage)

Figure 31: Unconformity in the side of the mill leat above incorporating mill 7 (Photograph: Christopher Dunn 2006, © English Heritage)

and Waterwheels, section 6.2.1 above), also means that the latter cannot have efficiently supplemented the flow of water from the mill leat and helped to turn waterwheels.

The explanation might be that only the northernmost pair of incorporating mills was originally powered from above by water from the main leat, the disturbance in the leat side marking the position of the take-off point for a short headrace removed before 1896. This putative headrace may have powered a conventional waterwheel but, since there is no evidence (Fig 20) for the position of axle bearings, etc, in the extant southern side of the waterwheel house (the northern side has largely collapsed down to the floor level of the adjoining chamber (Fig 28)) more likely led to a turbine positioned low down towards the centre or rear of the wheel-pit, the supports for which are now obscured by rubble. Since the waterwheel house corresponds to a drop in the level of the culverted leat, the tailrace by which waste water exited the pit into the southern, lower, level of the culverted leat is also now obscured by debris (compare Figs 21 and 33). A blind, stone arch (Fig 32) in the pit's front (west) wall may mark the blocked entrance to an original tailrace at high level, but is more likely to be simply the support for a platform (largely destroyed) on which the turning-handle controlling the gate for starting and stopping the turbine, was situated; bolts for some kind of fitting survive at the centre of a timber beam that spans the width of the arch. The original platform was presumably, like the arch beneath, built in stone, but the

Figure 32: Blind arch in waterwheel house in incorporating mill 7 (Photograph: Bob Skingle 2006, DP028081 © English Heritage.NMR)

Figure 33: The tailrace from incorporating mill 3, showing its junction with the low-level culverted leat (Photograph: Marcus Jecock 2008, © English Heritage)

extant, mutilated, example is concrete suggesting it is a late (probably ICI-period) replacement, no doubt smashed in 1936 when the turbine and its controls were salvaged. A similar, mutilated, concrete platform plus traces of stone supporting walls exists at the front edge of the wheel-pit at the next mill pair to the south (pair 5), too, but may represent a late adaptation of an earlier feature, possibly a steam-engine house (see building 5a, below).

Incorporating mills 5, 3 and 1 were presumably equipped with turbines from the outset (although see comments below over the possibility of the primacy of steam power at mills 1 and 3), powered by water somehow taken from the main leat and flowing at low level past their fronts in a pipe or penstock: water presumably fell onto the turbines positioned between the paired mill chambers via side flumes in series, with the exhaust water returning to the culverted leat via short culverted subsidiary tailraces, although since most of the wheel-pits are filled with collapsed masonry only that in incorporating mill pair 3 (Fig 33) is now visible. A linear depression in the ground which passes directly in front of incorporating mill pairs 5, 3 and 1, from the point at which the sloping culvert at the end of the main leat passes between the northern charge house and mill pair 5 (Fig 30), might be the remains of the channel in which the pipe or penstock feeding the turbines was situated. This arrangement would mean that each waterwheel house was in fact a drive chamber designed to accommodate a turbine and associated drive shafts, gearing and probably drive belts. The supposition is supported by evidence for access and inspection floors within the drive chambers to incorporating mill pairs 1, 3 and 5 as indicated by the positions of joist holes on thin wooden stabilising beds within the rubble walling, and by timber frameworks carried on two heavy timber cross beams that might have supported and braced the vertical drive shaft from the turbines, which survive at the latter two incorporating mill pairs (Fig 34). At incorporating mill pair 3 the remains of a lower framework of timber beams and iron I-section joists (Fig 35), probably the remains of a further floor and/or supports for the base of the flume and turbine, are also visible towards the bottom of the pit. At incorporating mill pair 1, metal joists occur in association with the upper inspection floor, indicating that the arrangements for mounting the turbines and drive shafts varied.

The 1898 factory plan (Fig 5) identifies two '[Steam-] Engine House[s]' (buildings 51 and 52) and a long, narrow boiler house (building 8) in association with the incorporating mills. The boiler house is shown standing opposite mill pair 3, building 52 directly in front of the southernmost mills (pair 1) and building 51 in front of the northernmost mills (pair 7) but on the opposite side of the beck. The engines presumably powered the edge-runner mills when there was insufficient water in the mill leat to operate the turbines. Since Gatebeck did not acquire its first steam engine until 1863 (section 4.2 above), they were presumably secondary additions although in the case of mill pairs 1 and 3, which were not erected until after 1881, there is the possibility that an engine was the original prime mover, later replaced by turbines and/or electric motor (see below). Building 51, however, does not appear on any OS map, and the 1923 factory plan (Fig 140) specifically states it was never built, suggesting that although in or before 1898 the intention was for mill pair 1 to be powered by a dedicated steam engine, the idea was never taken forward. The 1898 factory plan also shows an unnamed and unnumbered structure very similar in size and relative location to building 52 attached to the front of mill pair 5, which it is tempting to suggest is another engine house. The structure existed by 1896 and

Figure 34. Timber framework supporting the drive shaft from the turbine in incorporating mill 3 (Photograph: Christopher Dunn 2008, © English Heritage)

Figure 35: Timber and iron framework to support the base of a flume and turbine in incorporating mill 3 (Photograph: Christopher Dunn 2008, © English Heritage)

Figure 36: The southern chamber and extended blast wall of incorporating mill 3 (Photograph: Bob Skingle 2006, DP028065 © English Heritage.NMR)

Figure 37: Detail of the wall of incorporating mill 3 extended over the turbine race (Photograph: Christopher Dunn 2006, © English Heritage)

Figure 38: The extended wall of incorporating mill 5
(Photograph: Bob Skingle 2006, DP028075 © English Heritage.NMR)

appears on the 1911 OS map as well (Figs 138 and 139); it is here numbered building 5a. The factory plan's failure to differentiate and name it in the same manner as building 52 suggests that it was erected without the need for an Amending Licence - that is before the requirements of the 1875 Explosives Act came into force. All the mill pairs appear to have been extended westwards (Fig 36) to accommodate line shafting transmitting power from the new engine houses (which is an argument against the primacy of steam power at mills 1 and 3). Large stone lintels carry these extensions over the posited turbine race (Fig 37) in front of incorporating mill pairs 3 and 5: in each case the north side wall of the south chamber was extended forward, the later builds clearly butting against the quoins which marked the original wall ends (Figs 34 and 38).

Engine house 52 in front of incorporating mill pair 1 has lost its machinery and roof and most of its walls have been reduced to stubs (Figs 20 and 39). It was built against the extended north wall of the south mill chamber, in which there is a deep slot for rope or belt drive, latterly infilled with brick (presumably when the engines were retired), and a north-facing socket, just above head height, with a mount for line-shaft bearing boxes. It retains a central engine mounting and had an entrance on the east side. A similar arrangement appears to have been in place in building 5a (Fig 22). Although this (presumed) engine house has been almost completely destroyed, the extended north wall of the south mill chamber exhibits a similar deep slot for rope or belt drive, latterly infilled with rubble and red brick, and a north-facing socket above head height with a mount for line-shaft bearing boxes (Figs 38 and 40). The arrangement suggests that the engine in front of mill pair 1 was capable of driving that pair and pair 3 while the engine in front of mill pair 5 was capable of driving that pair and pair 7. A shallow, stone-lined channel in the ground, which extends from engine house 52 as far as mill pair 5, might have accommodated steam pipes from the boiler house or further line shafting related to this.

The walls of the boiler house (building 8) have been reduced to low stubs and few structural details are now discernible (Figs 21 and 41). However, the visible plan of the building matches the depiction that appears on the 1896 and 1911 OS maps (Figs 138 and 139), that is a long, narrow structure, roughly rectangular but with a slightly wider south end. The walls are of stone rubble with some ashlar quoins surviving. The remains of a buried, stone-lined flue pass from the wider, southern end of the building, under the tramway, up the hillside immediately south of incorporating mill pair 3 and lead to

Figure 39: Engine house 52 in front of incorporating mill 1
(Photograph: Bob Skingle 2006, DP028058 © English Heritage.NMR)

Figure 40: The south chamber of incorporating mill 5, showing later extension westward (Photograph: Bob Skingle 2006, DP028071 © English Heritage.NMR

Figure 41: The steam-boiler house (building 8) from the north (Photograph: Christopher Dunn 2006, © English Heritage)

a detached chimney located on a field boundary some distance beyond the limit of the works. The latter is shown on all historic, post-1896 mapping of the site (Figs 5, 139 and 140); although unnumbered by the factory plans, for the purposes of the present report it is identified as building 8b. Earthwork evidence, however, suggests that this chimney - which survives as a grassy mound (Fig 42) - is secondary, and that a predecessor (identified as building 8a on Fig 131) - the site of which survives as a flat earthen platform - stood at the top of the steepest part of the valley slope between incorporating mill pairs 1 and 3, just inside the works perimeter wall (platform and complete line of the sunken flue are shown on Fig 45). The chimney must have been re-sited for reasons of safety to reduce the risk of sparks causing explosions in the adjacent mills. Although the date when this happened is unknown, perhaps the most likely scenario is that when the boiler house was built, mill pairs 1 and 3 did not exist, and chimney 8a had to be moved when they were added. It could be argued that removal of the chimney to a safer distance away from those mills might have been a condition laid down by the Explosives Inspectorate in 1876 in order for them to grant the works a continuing licence as required under the 1875 Explosives Act, but this may be discounted given that other evidence suggests that mill pairs 1 and 3 date to after 1881 (section 4.2 above). The 1896 OS map (Fig 138) shows a small structure immediately south of incorporating mill pair 3, not included or named on later cartography but numbered building 3a for purposes of the present report. Its function is unknown, but it may not be without significance that it lies on the line of the boiler house flue; only the base of its southern (stone) wall survives (Fig 21).

The narrowness of the boiler house indicates that it was designed to accommodate a single boiler. (If so, the engines it powered may only ever have been intended as auxiliary power, otherwise there would presumably have been a second boiler to allow for periods of downtime on the first for repair and maintenance; however, the question cannot be satisfactorily resolved on the evidence available). From the 1840s boilers were often equipped with an economiser (a device that improved fuel efficiency by pre-heating water passing into the boiler using the hot exhaust gases from the fire box). Since this was most conveniently located directly between the boiler and its chimney (Giles and Goodall 1992, 149-50), it is likely that the boiler stood towards the middle of the building (indeed a number of fire bars lie scattered on the ground in this part of the interior) and was stoked from the north (a shallow, rectangular depression a few metres beyond the position of the northern wall may be the position of a coal store) while the wider, southern end of the building opposite the chimney flue housed the economiser. A water tank might also have been accommodated on the boiler-house roof, replenished by water pumped up from the beck, although there is no evidence for this. South of the boiler house, a low bank composed of very black matter, lying between the beck and incorporating mill pair 1, is probably the remains of the ash dump from the boiler's fire box.

At some point, new blast walls were built on top of the existing north side walls of each of the south chambers in each pair of incorporating mills, except pair 7. These new blast walls also extended back from the incorporating mills and may have helped to stabilise and laterally revet the hillside. At incorporating mill pair 7 the inner side walls of both mill chambers were built over, the new walls also extending backwards. By 1896 (Fig 138), the north chamber also had a stone revetment behind it and parallel to its rear wall. This curved to meet the outer side wall of the incorporating mill (whose gable and coping

Figure 42: Boiler-house chimney (building 8b) from the west (Photograph: Christopher Dunn 2006, © English Heritage)

stones it abuts and partly overlies (Fig 30)) thus forming an enclosure immediately above and behind it; its purpose is unknown although it may simply have been added to help retain the hillside and the main leat above. The stone revetment wall between charge house 6 and incorporating mill pair 5, at the point where the sloping culvert descends the hillside, has been replaced or reinforced with a T-shaped section of concrete wall (Figs 22, 43 and 46); the use of concrete suggests that the feature is late, and was probably a remedial intervention by Nobel Industries or ICI.

By the 1930s the group of incorporating mills had been modernised (probably by ICI), a process which involved the removal of the original edge-runner mills and the installation of new over-driven ones with iron runners and pans. At some point the original chamber floors were replaced with deep concrete ones, probably as part of the modernisation although this cannot be verified; roughly circular impressions, indicating the positions of the pans and edge-runner mill spindles, can be seen in the floors of the north chamber of incorporating mill pair 3 and the south chamber of pair 5. It is likely that during this phase of modernisation the existing turbines were replaced with more modern ones (as happened at other Cumbrian gunpowder works following takeover by ICI, where waterwheels were replaced by turbines). In each case, power from the turbines appears to have been transmitted to a drive shaft which passed into the incorporating mills through ribbed cement-lined holes (presumably originally fitted with bearings). The steam engines were evidently taken out of service or, in the case of building 52, converted into an electric motor house, later replaced or augmented by a new motor or generator house (building 52a) immediately to the north, suggesting that the edge-runner mills in mill pair 1

were those described in the MMB as being driven by electric motor. Building 52a (Figs 20 and 44) is rectangular in plan, and has north and east walls built of red brick rendered in concrete; there is no indication of a west wall suggesting it was open-fronted. It has lost its roof and its machinery has been removed, although a rectangular stone engine- or generator-bed, with eight upwardly projecting mounting bolts or pins (four on each side), remains *in situ*.

Charge Houses

As already explained (Green-Charge House, this section above), the provision of expense magazines or similar buildings for the temporary storage of powder as it passed between the various stages of manufacture (including ripe charge emanating from the incorporating mills), was a requirement of the Gunpowder Act 1772. The Act placed limits on the quantities of powder which could be present within particular process buildings at any one time, and stipulated that magazines for the temporary storage of powder had to be built in stone or brick, and be situated at least 50 yards (45.7m) from any mill building (Cocroft 2000, 28). This minimum distance was amended by a subsequent Act of 1860, which defined such buildings as expense magazines, and laid down that they had to be at least 40 yards (36.56m) distant from any process building. But the same Act also formalised the concept of charge houses. Although their exact purpose is not specified, they seem to have been for the storage of green and ripe charges immediately prior to 'charging' and 'discharging' the incorporating mills. The Act did not set any minimum safe distance such houses had to be from other buildings, merely stipulating that they must be 'a safe and suitable Distance from each Incorporating Mill or Group of Incorporating Mills' (Public Statutes General 1860, 616).

According to the 1898 and 1923 factory plans (Figs 5 and 140), there were two charge houses (buildings 2 and 6) at the Low Works. These stood between, and in line with, the four pairs of incorporating mills at the southern end of the site: charge house 2 was sited between mill pairs 1 and 3 and charge house 6 between mill pairs 5 and 7, indicating that each serviced the four mill chambers closest to it. It has been argued elsewhere in this report (section 4.2 above) that the mills were constructed in two phases, and that what became known as mills 5 and 7 were actually earlier than mills 1 and 3; charge house 6, therefore, must date to the late 1850s and charge house 2 to sometime between 1881 and 1896. Although the factory plans name each building simply as 'Charge House', one of the draft keys for the 1898 plan (CRO WDB/35/680d) describes them in more detail as 'Bomb Proof Charge House[s]' reflecting the fact that they were not just stone buildings but barrel-vaulted chambers constructed at the foot of the valley side and buried beneath earth held in place by a 1.8m high stone revetment (Fig 47). Indeed, neither charge house could legally have been built after 1860 or continued operating in the positions occupied without some such 'proofing' against the consequences of an accidental explosion in an incorporating mill communicating to the houses' contents, or *vice versa*. Although not known as such during their lifetimes, for the purposes of the present report the two structures will here be distinguished as the 'northern' and 'southern' charge house. A third charge house of similar design which existed at the High Works after 1898 is described elsewhere (Oswald *et al* in prep).

Figure 43: Concrete buttress north of incorporating mill 5
(Photograph: Bob Skingle 2006, DP028074 © English Heritage.NMR)

Figure 44: The electric-motor house (building 52a) from the west
(Photograph: Christopher Dunn 2006, © English Heritage)

'Northern' and 'Southern' Charge Houses (buildings 2 and 6)

Both Low Works charge houses are rectangular in plan and barrel-vaulted in stone (Figs 45 and 46). They are flanked at the front by stone revetment walls which in turn butt against the ends of the outer walls of the flanking incorporating mills. The incorporating mills and charge houses thus present a continuous frontage to the tramway along the beck. Both charge houses have round-arched entrances, but that to the (later) southern house has well-formed voussoirs, imposts and key-block with rock-faced rustication with marginal tooling, bearing the remains of light cement rendering with traces of a red-coloured wash (Fig 47), while that to the (earlier) northern house has much plainer, simply dressed voussoirs, formerly rendered, and lacks imposts (Fig 48). The inner walls of the southern house retain traces of cement render, also originally covered with red wash, in which a deeply recessed door position is evident; a single timber stub survives. The southern charge house appears to have had shelving at a single low level on three sides and there is also an L-shaped ceramic ventilation pipe at the rear of the interior at the apex of the vault. There is no visible evidence for the position of the door in the northern charge house and no visible trace of red wash, but there are rows of timber lugs at two levels in the north wall indicating the former position of shelving. Both charge houses are in reasonable condition, although the vaults are holed and part of the southern side wall of the northern house has collapsed.

Both charge houses subsequently had rectangular, walled holding areas built up against them; map evidence (Fig 138) shows these existed by 1896. These are now ruinous and the interiors obscured by debris. The southern holding area is slightly offset in relation to the charge house behind, the stubs of its thick, stone-rubble side walls coming off from the outer revetment wall 0.69m north and 0.38m south of the entrance, possibly to allow for the accommodation of a brick base of unknown function up against the inside of the north wall. The northern holding area has similar stubs of stone-rubble walls on either side of its entrance but spaced much further (4.75m) apart. At a later date a smaller holding enclosure, very similar in size to that which exists outside the southern charge house, was built of red brick in English garden-wall bond within the stone enclosure; the stubs of the side walls remain flanking the entrance. OS map evidence (Figs 138 and 139) shows that a branch of the internal tramway system passed in front of both charge houses; in addition, the 1896 map depicts what appear to be turntables in front of each house. This supports the evidence of the MMB that fresh charges were brought from the green-charge house (this section above) by bogie; no doubt ripe charges were removed to the expense magazine by the same method. It also suggests that the primary function of the holding areas was as glorified covered loading bays in which the bogies could be loaded and unloaded in the dry.

Press Houses

After incorporation, ripe charges had to be pressed in order to turn them into hard dense slabs ('press cake') which could subsequently be broken down ('corned') into grains of the required size.

The surviving factory plans (Figs 5 and 140) and MMB all agree that by the end of the 19th century until closure, two press houses existed at the Low Works (buildings 14 and 16). For ease of reference they will be called here the 'southern' and 'northern' houses, although there is no evidence that either building was known as such during use.

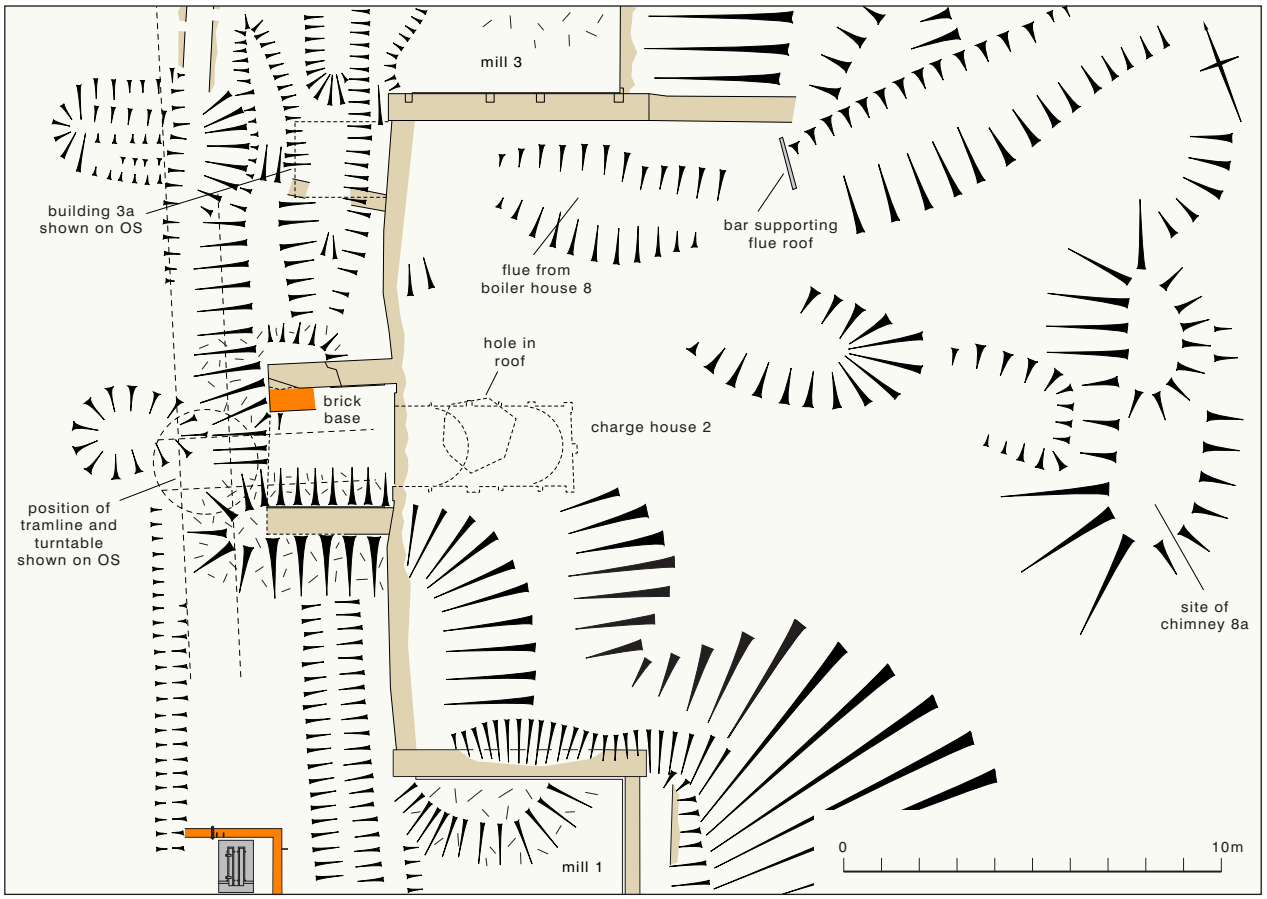

Figure 45: Plan of southern charge house (building 2)
(Drawn by Tony Berry and Philip Sinton. © English Heritage)

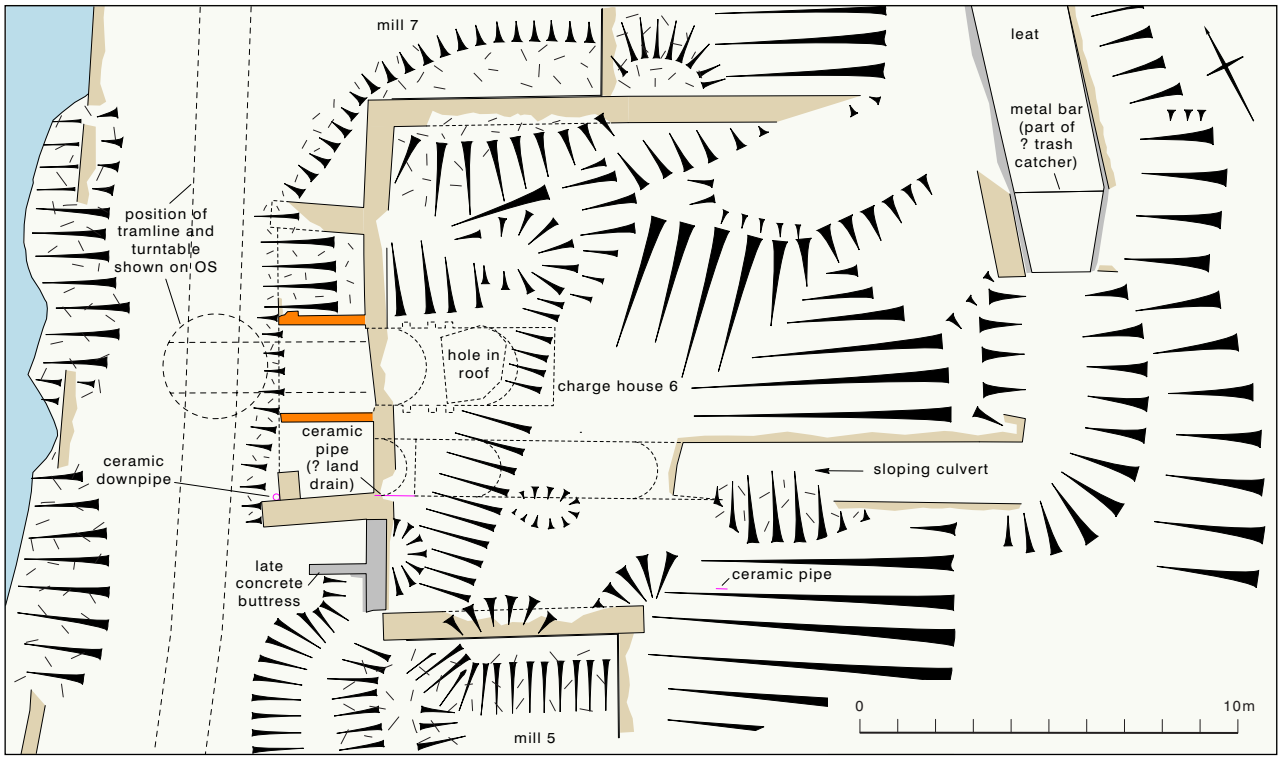

Figure 46: Plan of northern charge house (building 6)
(Drawn by Tony Berry and Philip Sinton. © English Heritage)

Both houses were probably built *circa* 1859-60 (section 4.2 above). Hydraulic power to operate the presses within was generated in separate engine or power houses, but since the engines, turbines and/or motors were housed adjacent to the large and small corning houses, detailed discussion of the various power supply arrangements is reserved for elsewhere (Corning Houses, this section below). The northern press house was rebuilt following an explosion in 1881; the two versions of it will be distinguished here as mark I and mark II. A third press house which existed at the High Works after 1898 is described elsewhere (Oswald *et al* in prep). Before the construction of the southern and northern press houses, pressing was reportedly carried on in the same building as corning and glazing, but since these early 'combined' houses appear to have been converted exclusively to corning *circa* 1860, they, too, are discussed elsewhere (Corning Houses, this section below).

Both dedicated press houses at the Low Works stood on the west bank of the Peasey Beck opposite corning house 12, well removed from all other buildings within the works apart from an expense magazine (building 15) which stood in line approximately mid-way between them. The 1896 OS map (Fig 138) suggests that the magazine lay *circa* 54m north of the southern press house and 35m south of the northern house. The latter distance is less than the legal minima of 50 yards (45.7m) and 40 yards (36.56m) set by the 1772 and 1860 Gunpowder Acts respectively. However, when the northern press houses (no. 16) exploded in 1881, killing the two workers inside and completely flattening the building, Major Ford stated in his report for HM Explosives Inspectorate (Explosives Inspectorate 1881, 1 and 4) that the building had not been proscribed when the 1875 Explosives Act came into force because spacing between buildings generally across the site was considered satisfactory; later in the report he gives the actual distance between buildings 15 and 16 as 'about 45 yards' (that is, in excess of the legal minimum). This suggests an error in the OS map; indeed, the 1911 map (Fig 139) depicts building 15 in a different location equidistant from each press house, but as the scale distance is only *circa* 36m inaccuracies in the mapping seemingly persisted.

'Northern' Press House (building 16)

Major Ford's report on the 1881 explosion in the northern press house (Explosives Inspectorate 1881) states that the destroyed, mark I, building measured some 20 feet by 16 feet (6.1 by 4.9m) internally, and was constructed of stone beneath a slate roof; local newspaper reports (*Westmorland Gazette*, 23 and 30 July 1881) of the accident give the roofing material as iron, but the Explosives Inspectorate report must be considered the more reliable authority. The roof and lower 4 or 5 feet (1.2-1.5m) of the inside of the walls were lined with wood, the rest of the walls with paper, to combat accumulations of powder dust. The building was entered and exited via doorways at either end of the east wall, and lit by a single window between the doorways with a skylight above. It occupied a terrace cut into the western side of the valley, and was further shielded on all sides except the east by mature trees, part of Gatebeck Plantation.

The mark I house contained a single small, hydraulic press capable of handling 540lbs (245kg) of powder at a time. It is unclear where the power for the press was generated: OS maps only name a pressurised-water pipe leading from the large corning house to the southern press house (see below). Whilst it is possible that, at least initially, the

Figure 47: The southern charge house (building 2) from the west ((Photograph: Bob Skingle 2006, DP028064 © English Heritage.NMR)

Figure 48: The northern charge house (building 6) from the west (Photograph: Tony Berry 2006, © English Heritage)

pipe ran on to the northern press house, the 1896 OS map (Fig 138) suggests that the northern press house then received its power from the small corning house (building 17) instead: unnamed line detail connecting the two buildings and crossing the beck by way of a 'F[oot] B[ridge]' is improbable as a fence, raising the probability that what is shown is rather a pressurised-water pipe. According to Major Ford the pressurised-water supply to both press houses was accompanied by a steam pipe to prevent freezing in cold weather.

Very few details survive for the form and design of the replacement, mark II, northern press house, although map evidence (compare Figs 138 and 139) indicates that it originally had a covered awning along the entire length of both its east and north sides, later removed from the northern wall and reduced in scope along the east wall to two small porches at either end of the building. This suggests that, like its predecessor, the mark II house was entered through doorways at either end of the east wall.

According to the MMB, by 1931 hydraulic power for both northern and southern press houses was supplied by pumps which were motor- or turbine-driven depending on the state of the water supply (MMB, 16). This probably reflects improvements made to the power arrangements at both the large and small corning house in the 1920s (see Corning Houses, this section below).

Aerial photographic evidence suggest that the mark II northern press house was set on fire in 1936 when the works closed, as required by Board-of-Trade regulations, for early aerial photographs show it was an unroofed ruin in 1945 (eg NMRC AP library no. 3864). The area now forms part of a waste-recycling depot, and although the site was not investigated by English Heritage observation from across the beck would suggest that no trace survives.

'Southern' Press House (building 14)

Almost no direct information survives for the form of the southern press house, although Major Ford's report into the 1881 explosion of its northern counterpart states that it was very similar to its destroyed neighbour; the report also records that a ridge tile was loosened and a skylight broken (Explosives Inspectorate 1881, 7-8n and 10).

The 1896 and 1911 OS maps (Figs 138 and 139) depict line detail (named as 'Aqueduct' on the latter) running across the valley between the southern press house and engine house 11 attached to the large corning house. This line detail is undoubtedly a pressurised-water pipe transmitting hydraulic power to the press house. Three small stone piers identified by the present survey that stand in line close to the east bank of the beck must represent supports for the pipework, which probably emerged from beneath the tramway in front of the engine house through a wood-lined slot in the revetment wall (Figs 141 and 52-3). The history of, and likely changes to, the supply of hydraulic power to the both press houses is discussed in more detail elsewhere (Corning Houses, this section below).

As with its neighbour, the site of the southern press house falls within the area now occupied by a waste-recycling depot; it was already de-roofed in 1945 (eg NMRC AP Library no. 3864), and it is likely that no trace now survives.

Expense Magazines

As already outlined (Green-Charge House and Charge Houses, this section above), the provision of expense magazines for the temporary storage of powder as it passed between the various stages of manufacture was a requirement of Gunpowder Acts of both 1772 and 1860. Two expense magazines are named on the surviving factory plans of the Low Works (Figs 5 and 140). Of these, one (building 23) given its position relative to other buildings is most likely to have been for the temporary storage of unripe charges only, and is accordingly described elsewhere (Green-Charge House, this section above). The other named expense magazine (building 15) stood on the west bank of the beck in association with the press houses, although there is some uncertainty over its exact position (see Press Houses, this section above). A third expense magazine located at the High Works is beyond the scope of the present report, and is discussed elsewhere (Oswald *et al* in prep).

Expense Magazine (building 15)

Building 15 clearly stood where it did because its principal purpose was to store ripe charges *en route* to the press houses, and press cake (the name given to gunpowder once pressed) prior to removal to the corning houses and elsewhere for subsequent processing. It was in all probability, therefore, erected at the same time as the neighbouring press houses, probably in 1859-60 (certainly none of the buildings on the west side of the beck appears on the 1858 OS map (Fig 137)). However, in the absence of evidence for expense magazines elsewhere on site, building 15 must also have acted as a store for surplus powder in transit between the corning, glazing and stove houses. Legally the building had to be of stone or brick, but there is very little record for its form and method of construction other than the footprint shown by the various maps and plans and the statement contained in the official report of the 1881 press-house explosion that it had a slate roof pierced, perhaps surprisingly, by at least one skylight (Explosives Inspectorate 1881, 10). Map and plan evidence shows that, latterly, it was connected to process buildings on the east bank by a tramline. The 1911 OS map and 1923 factory plan (Figs 139 and 140) also show short tram spurs from the magazine out to each of the adjacent press houses; although the spurs are not depicted on the 1896 map (Fig 138), this must be in error since they existed in 1881 (Explosives Inspectorate 1881, 4).

The site of the expense magazine is now occupied by a waste-recycling depot. This area was not investigated by English Heritage, but the building is not readily apparent on 1945 aerial photographs (eg NMRC AP library no. 3864); it is unlikely that any trace survives.

Corning Houses and associated buildings

After pressing, the next step in the manufacturing process was to 'cut' the press cake up into grains of the required size. This process was referred to as corning or granulating. It resulted in angular grains, which subsequently had to be smoothed and polished at the glazing house.

Before the early 1860s, corning at Gatebeck was carried out in the same buildings - called 'joint' or 'combined' houses - as pressing and glazing (section 4.2 above). There were originally two such buildings at the Low Works, both powered by waterwheels, but by 1865 they had both been given over to corning alone and pressing and glazing had been

transferred elsewhere. The factory plans (Figs 5 and 140) show that one of these newly dedicated corning houses (building 12) stood close to the mill leat towards the middle of the works, while the other (building 17) stood a little further to the north and adjacent to the beck. In an appendix to the official report on the 1881 explosion of the northern press house, the buildings are described as the 'Large Corning House' and the 'Small Corning House' respectively (Explosives Inspectorate 1881, 10) and this terminology will be used as convenient shorthand in this report, although the factory plans and the MMB, which post-date the Explosives Inspectorate report, refer to both simply as 'corning houses'.

By 1898 steam engines had been installed in, or adjacent to, both corning houses, seemingly to run pumps producing hydraulic power for the press houses although they probably also supplied auxiliary power to the corning houses in times of drought or severe frost. Both corning houses were rebuilt between 1923 and 1931 (the large following an explosion, the small presumably because of modernisation) after which both were powered by water (most probably turbines not waterwheels) with electric-motor back-up. The rebuilt corning houses were identical in size and design to each other, and by then the names 'Large Corning House' and 'Small Corning House' were probably no longer in use. Both houses retained their original building numbers, however, and so the successive versions will, in this report, be distinguished as marks I and II. Attendant power houses and stores were also reconstructed at this time, but in some instances were allocated building numbers previously applied elsewhere. For example, prior to 1923, buildings numbered 11 and 13 which flanked the large corning house mark I (and were originally part of the earlier combined house) were in use as an 'Engine House' and as a 'Store House', but the numbers were subsequently applied to a newly erected 'Graphite Store' adjacent to the dedicated glazing house, and to a replacement free-standing 'Power House' to the north of the large corning house mark II. For the purposes of this report, the post-1923 buildings will be numbered 11a and 13a respectively. The engine house attached to the small corning house mark I never had a number of its own. The number of the detached power house which accompanied the small corning house mark II (built after 1923), if it ever had one, is unknown; it will be referred to as building 17a for the purposes of this report.

Press, Corning and Glazing House / 'Large' Corning House and associated buildings (buildings 11, 12, 13 and 13a)

Comparison of map detail shows that the structural elements that comprised the large corning house mark I and its attendant engine house and store house (buildings 12, 11 and 13 respectively) as depicted on the 1896 OS map and 1898 factory plan, already existed in 1858 (compare Figs 138, 5 and 137). This suggests that the large corning house was not newly built when it commenced operations *circa* 1860, but was simply converted out of the earlier combined house. The most likely scenario is that corning was initially carried on in building 12 and continued to be so, whilst buildings 11 and 13 to south and north represent the former press and glazing houses (it is unclear which was which) converted to other uses. It may have been in either of the latter buildings that a labourer was killed shortly afterwards by a falling lintel whilst undertaking work to convert 'a building formerly used as a corning mill' (*Westmorland Gazette*, 13 May 1865). The location of the three parts of the combined house, adjacent to and below the main

mill leat, plus the fact that the narrowing of the leat to half its width behind building 12 shows that a considerable volume of water was taken off at this point, is all evidence that the house, as built, was designed to be powered by water. The implication of the 1851 bill of tender is that the water drove a waterwheel (section 4.2 above), not a water-turbine. The 1858 OS map is difficult to interpret satisfactorily, but line detail running between the rear of building 13 and the mill leat immediately before the latter narrows, is suggestive of a short headrace, indicating that the waterwheel was covered and stood towards the southern end of that building.

Circa 1860 the combined house was converted to corning only, and on the evidence of the 1898 factory plan (Fig 5) the attached disused press and glazing houses converted to an 'Engine House' and 'Store'. The conversion of building 11 into an engine house may date from *circa* 1863, which is when the ICI historian reports the company purchased its first steam engine, nicknamed Garibaldi (section 4.2 above), although that engine could have been located at either the incorporating mills (this section above) or glazing house and small stove complex (this section below) instead. Since the headrace behind building 13 is also depicted on the 1896 OS map (Fig 138), the logical conclusion is that the waterwheel continued in use as the main driver for the corning machinery. Other evidence suggests that the steam engine in building 11 – whatever date it was installed - was primarily intended to operate pumps producing hydraulic power for the two new press houses that had been built on the other side of the beck (see Press Houses, this section above), but it was no doubt also used as a back-up power unit for the large corning house when needed. The engine must have been connected via a flue to a chimney sited some distance away – quite probably the detached chimney (labelled 9a on Figs 131-136) high up on the hillside behind the glazing and stove houses further south, although no connecting flue is indicated on any cartographic source, and field survey detected no evidence for one.

The mark I large corning house (together with the attached buildings 11 and 13) were all destroyed in an explosion on 17 May 1923 that killed the two men working inside. Little is known about the corning house, and nothing about the machinery it contained except that it seems to have been supplied by the Hastie company of Greenock (Tyler 2002, 79). The local newspaper report of the explosion states simply that the house was stone-built and had a wooden floor (*Westmorland Gazette* 19 May, 1923), while the appendix to Major Ford's report listing collateral damage caused by the 1881 press-house explosion, reveals that it had a number of glass windows and that the roof was slated and contained at least one skylight (Explosives Inspectorate 1881, 10). No documentary evidence has been found that casts light on buildings 11 or 13.

According to the 1923 factory plan (Fig 140), the replacement mark II corning house was constructed at right angles across the sites of its predecessor and adjacent engine house, while a new 'power house' (numbered building 13a for the present report) was erected *north* of the destroyed building 13. Again, almost nothing is documented about any of these replacement buildings, although the MMB contains a brief description of the new corning machinery which was of 'Nobel' type, consisted of six pairs of rollers (three with pyramidal teeth and three smooth rolls) and was water-powered with an electric motor on standby in an adjacent building in the event of water shortage (MMB, 19-20). It is almost certain that water power was now supplied by a Vortex turbine that the

company is known to have purchased from Gilkes of Kendal in 1923 (section 4.2 above); the turbine must have been housed in the new building 13a.

Although the mark II corning house was dismantled and/or deliberately burned down in 1936 when the works closed, its concrete floor plus the low brick plinth that supported its timber or metal walls lie buried beneath a shallow layer of humus. The surviving evidence (Fig 141) indicates that the basic plan of the house was very similar to the better-preserved mark IV lower corning house that ICI built at Lowwood a few years later in 1928-9 (Jecock *et al* 2005, 107-12), and comprised two unequal-sized chambers arranged side by side, separated by a blast wall; the larger chamber housed the corning machinery, the smaller, a belt-drive alley where power from the turbine was transferred to line shafts passing through housings in the blast wall and connecting with the motive parts of the corning machine. Although this 'internal' blast wall was demolished in 1936, other free-standing blast walls (labelled BW1-BW4 on Fig 141) erected to shield the mark II house are still extant (Fig 49), together with elements of the rear and end walls of the destroyed mark I house and building 11; parts of building 13 may also survive buried beneath a blast bank (BB1) raised to protect the replacement northern power house (building 13a). Because it was classed as a non-danger building, building 13a was simply abandoned rather than cleansed by fire in 1936, and until recently survived roofed and relatively intact; unfortunately it was flattened by a falling tree shortly before survey (Fig 4). Although all the buildings were aligned roughly north-west to south-east, they will here be described as if they faced due west towards the beck.

The field evidence indicates that in 1851-2 the three buildings or compartments that comprised the initial combined house were constructed on a platform terraced into the base of the hillside, with their rear (east) walls and end walls either built back to earth or positioned just inside a revetting wall that shored up the cut sides of the platform. In 1923, the mark II corning house was constructed to a smaller footprint within the shell of these early buildings, but the north-east corner of the mark I corning house and the rear and end walls of building 11 plus a stretch of revetting wall behind, were kept to retain the platform. At the southern end of the platform, these stone walls are now collapsing and in many places only a thin skin of outer wall face remains *in situ*, the inner face and core having fallen away. However, a metal box that survives in the centre of the southern (end) wall is presumably part of the flue from the steam engine installed in or after 1863. A rectangular concrete base (Fig 50) with a securing bolt at each corner (the south-eastern bolt now obscured by tree roots), that lies on the hillside immediately south of the box may be part of the flue; ditto a short section of ceramic pipe that lies (?loose) on the ground next to the base. A narrow, brick plinth lies immediately west of the base and a second concrete base with two securing bolts lies 2.7m to the east, but both are of unknown purpose. A length of small-bore piping protruding from the eastern retaining wall behind building 11 probably represents the original water supply to the engine; it is in line with a brick-lined inspection or isolating chamber next to the mill leat, now almost completely infilled with earth.

There is no certain surviving evidence for building 13, although a number of metal bearing boxes visible at the base of the south side of an earthen blast bank (BB1- presumably constructed in 1923 to shield the new power house 13a from the mark II corning house, but now much reduced and mutilated), that overlies them may be original fitments from

Figure 49: The southern end of the platform for the large corning house (building 12) shielded by blast walls BW2 and BW3
(Photograph: Bob Skingle 2006, DP028050 © English Heritage.NMR)

Figure 50: Concrete base with securing bolts, possibly part of the mark 1 engine-house flue
(Photograph: Christopher Dunn 2006, © English Heritage)

it, marking the line of drive belts or hydraulic pipes transmitting power between the waterwheel at the southern end of the building and the glazing machinery or press that originally stood further north. Two boxes plus the void for a third are visible, variously 0.5m and 0.7m wide; all are blocked. The existence of a stone-lined box in the wall revetting the pre-gunpowder mill leat (Fig 51) plus a mound close to the river bank suggests that at some time a hydraulic pipe ran between building 13 and the southern press house (building 14) on the west bank; a second mound further north along the river bank raises the possibility that a pipe connected building 13 to the northern press house (building 16), too. If so, building 13 may be where the press was located within the combined house, and after pressing was removed to the two dedicated houses on the west bank, accommodated pumps transmitting power across the river to the new press houses. These early pumps were presumably run off the waterwheel. However, three stone piers on the spit of land between the beck and pre-gunpowder mill leat, opposite the southern end of building 11 (Fig 52) correspond to the site of the 'Aqueduct' shown and named on the 1898 and 1911 OS maps and are undoubtedly supports for pipework (aqueduct should probably be understood as 'pressurised-water pipe'; see Press Houses, this section above). These supports line up with a second, timber-lined, box (Fig 53) in the revetment wall above the pre-gunpowder mill leat, and indicate that after the installation of the steam engine in building 11, the pumps were relocated to the same building. A small outshot which all three editions of OS mapping show attached to the southern side of building 11 is therefore most probably the pump house; what are probably the foundations of this building survive on the hillside.

A stone arch in the wall revetting the side of the pre-gunpowder mill leat (sections 6.1.2 and 6.2.1 above) is the exit portal of the tailrace from the waterwheel-pit of the mark I corning house (Fig 54), culverted under the line of the tramway. The portal is in line with a silted channel on the far side of the pre-gunpowder mill leat, presumably to allow water exiting the culvert to flow straight into the beck and not erode the edge of the leat, although the channel is not shown on any of the three OS map editions; its head was subsequently blocked off with concrete (presumably in 1923 when the tailrace became redundant). A shallow rectangular depression next to the mill leat behind building 12, cut through by the later retaining/blast wall BW4 of the mark II house, corresponds to line detail on the 1858 OS map (Fig 137), but is of unknown function. Whatever its purpose, the feature is not indicated on the 1896 OS map (Fig 138) and would therefore seem to have been disused before the end of the century.

All that remains of the mark II corning house is a rectangular concrete slab, 14.3m long by 5.74m wide - the southern quarter of which stands *circa* 0.6m higher than the rest (Fig 55), seemingly constituting a separate compartment within the building - plus a second, narrower and shorter, slab, immediately west of and parallel to the first, best interpreted as the site of an attendant belt-drive alley; what is now a very low earthwork bank separating the slabs represents the footings of a demolished masonry wall, *c* 1m thick. The wall's thickness and the materials used in its construction indicate that it was more than structural and was intended as blast protection to shield the belt-drive alley from damage in the advent of the corning house blowing up. However, it no doubt also supported pent roofs covering both corning house and belt-drive alley (as in the mark IV lower corning house at Lowwood). It was presumably demolished in 1936 when the house was decommissioned in order to facilitate removal of the corning machinery. A

(Clockwise from top left)
Figure 51: The stone-lined box in the wall revetting the pre-gunpowder mill leat
Figure 52: Stone support for the pressurised-water pipe to the southern press house
Figure 53: The wood-lined box in the wall revetting the pre-gunpowder mill leat
Figure 54: The exit portal of the tailrace from the mark I large corning house
(All Photographs: Christopher Dunn 2006, © English Heritage)

single course of bricks that survives around much of the perimeter of both slabs is a low plinth onto which light-weight timber or metal wall panels - designed to blow out in the event of an explosion - could be attached: a number of iron bolts survive set into the brick and concrete onto which the base plate for the panels would have been secured. Bolts along the northern edge of the southern, raised part of the corning-house slab suggest that there was an internal wall also. For the most part, even where the brick plinth is now missing, brick-impressions are visible in the concrete beneath. However, neither bricks nor impressions are visible close to either end of the belt-drive alley's western wall and along the western edge of the corning-house slab where it extends beyond the belt-drive alley, and these gaps presumably mark the positions of doorways into the different parts of the building.

Short blast walls (BW1 and BW2) that are extant *circa* 8m west of the doorways into the corning chamber seem intended to protect traffic passing along the main tramline in front of the house, from any blast issuing through those doorways; the western face of BW1 shielding the northern doorway is angled at its northern end so as not to intrude on the tramline on that side. A third blast wall (BW3) lies at right angles to BW2, presumably shielding the press-pump house and/or tram traffic to the south. The size

and solidity of a new length of battered retaining wall (Fig 56) constructed immediately behind the corning compartment of the mark II building, connecting earlier masonry, indicates that it was more than simply a retaining wall, and was designed to withstand the blast of the corning house exploding (BW4). All four are essentially intact, although beginning to lose some of their concrete render; where this is the case, it reveals that the walls are constructed in stone and brick beneath at least two coats of render (Fig 49). Together with blast bank BB1 (described above) to the north shielding power house 13a, the mark II house thus had blast protection on all four sides. Blast protection may also have been provided to users of the tramline running out to the expense magazine and press houses on the other side of the beck, for a line of three regularly spaced post-supports along the southern edge of the tram bridge's eastern embankment (Fig 57) indicate that some form of timber screening stood here, too. The supports are built of brick covered in concrete render; they held uprights 0.15m square. (See also Blast Banks and Walls, section 6.2.10 below).

A small, stone platform that abuts the north side of blast wall BW3 is of unknown function or date, but may be connected with the press-pump house. A large piece of concrete that lies on the ground at the southern end of the belt-drive alley, is *ex situ*; although part of the mark II corning house, its original location and purpose is uncertain.

The large corning house mark II was undoubtedly powered by the 12 bhp (8.9kW) Vortex unit (manufacturer's no. 3049) which the company bought from the local Kendal firm of Gilkes in 1923 (section 4.2 above). This was housed in a new brick-built 'Power House' (building 13 on the 1923 factory plan, re-labelled 13a for the purposes of the present report) sited north of the corning house. The building survived relatively intact until recently, as shown by photographs taken by Ted Patterson in 1979 (Figs 58 and 59) and Ian Tyler (2002, 58) *circa* 2000, but unfortunately was almost completely demolished sometime prior to survey in 2006 by a falling tree. The trunk and branches of the tree remained *in situ* across the ruins at the time English Heritage carried out fieldwork and prevented close inspection or recording, particularly of the interior (Fig 4). A concrete header tank (Fig 60) built into the top of the embankment to the mill leat above the power house, and the culverted tailrace (Fig 61) leading from the building, both survive in reasonably good condition, however.

The photographic evidence shows that the power house was gabled east and west beneath a slate roof, and had opposing doorways and windows in its side walls; a thin concrete lintel extending round the south-west corner of the building at eaves height suggests the position of at least one other doorway or window, while a second concrete lintel marks the position of a former opening low in the northern half of the western gable wall. According to the photographs, the latter opening and the side windows were bricked up by 1979: the grey colour of the brickwork matches that used to repair the west gable wall of the mechanics' shop (section 6.2.6 below), suggesting that the blocking dates from the 1960s when the site was leased to Westmorland County Council and used for Civil Defence Training. Some repair work in grey brick is also visible to the gable above the lintel at the south-west corner.

The power house stands on a platform terraced into the hillside beneath the mill leat but slightly above the level of the tramway at the foot of the hillside. A low stone retaining

Figure 55: The raised, southern compartment of the mark II large corning house, looking west (Photograph: Christopher Dunn 2006, © English Heritage)

Figure 56: Blast wall BW4 behind the mark II large corning house, looking north-east (Photograph: Christopher Dunn 2006, © English Heritage)

wall defines the rear of the platform and forms one side of a narrow external walkway round the east end of the building, accessed via a short flight of three concrete steps a few metres to the north. Because of the fallen tree, little internal detail could be seen during survey, but visible impressions on the concrete floor just inside the north-west corner suggests a machine or mounting formerly stood adjacent to the blocked opening in the west gable wall: securing bolts are visible at the two northern corners of a mostly rectangular scar. The opening probably allowed line shafting to pass from the interior of the building, and connect with belt drives oriented at right angles across the front of the building which in turn connected with the belt-drive alley at the corning house. A small concrete base with securing bolts that is visible just beyond the south-west angle of the

Figure 57: Post-supports for blast screen along tram embankment (Photograph: Christopher Dunn 2006, © English Heritage)

building presumably supported some kind of drive mechanism, but seems to lie off the line of the conjectured belt-drives and is much smaller than the corresponding bases which survive at the small corning house (this section, below). It is uncertain whether a single post-support visible outside the west gable wall is *in situ*, but it raises the possibility that the external belt drives were shielded from the weather beneath some kind of canopy. According to the MMB, there was also an electric motor on stand-by to power the corning machinery should there be insufficient water to operate the turbine. This was most probably housed in building 13a also, but no evidence has been found as to where it was located or how it was connected to the line-shafting.

(Clockwise from top left)
Figure 58: Power house building 13a from the south-east in 1978/9
Figure 59 The west gable end of building 13a in 1978/9
Figure 60: Turbine header tank above building 13a, from the east
Figure 61: The exit portal of the tailrace from building 13a
(Photographs: Figs 58-9, Patterson Collection OP04682 and 04668, © English Heritage.NMR; Figs 60-1, Christopher Dunn 2006, © English Heritage)

A concrete header tank survives in the side of the mill leat above the power house (Fig 60). Damage to the front wall suggests that the feedpipe which originally led from it down to the turbine lay on the surface and was salvaged with the turbine when the factory closed. Access to the header tank from building 13a to open and close the feedpipe, and so start and stop the turbine, was via a set of concrete steps, arranged in three flights, north of the power house. Waste water from the turbine must have been directed into a culvert beneath the building which passed under the tramway to discharge into the pre-gunpowder mill leat, for the stone wall retaining that leat in front of the power house is pierced by a concrete-lined, flat-topped portal (Fig 61).

Press, Glazing and Corning House / 'Small' Corning House and associated buildings (buildings 17 and 17a)

Prior to *circa* 1860, what little evidence there is suggests that the small corning house was - like the large corning house previously described - a combined house, where pressing, corning and glazing were carried out in different compartments of the same building (section 4.2 above). According to the 1858 OS map (Fig 137), this combined house was T-shaped in plan, and comprised a main east-west block (shown subdivided into a longer western, and shorter eastern, compartment) with a small northern outshot. There

is no evidence for where different activities took place within the building. Although the 1858 OS map does not show leats leading to or from the building, the 1851 bill of tender implies that the house was water-powered (section 4.2 above), and it has been suggested previously (section 6.2.1 above) that the most likely scenario is that waste water was culverted underground from the preparing house and/or early sawmill to turn an undershot waterwheel. Nothing is known about the design and construction materials of the combined house apart from the short statement in the appendix to the official report listing collateral damage caused by the explosion in the northern press house in 1881, that windows and one skylight were broken and slates loosened at what had by then become the small corning house (Explosives Inspectorate 1881, 10); neither is there is any record of the design of corning, or other, machinery within.

By 1896, map evidence (Fig 138) shows that the small corning house had been extended: the northern outshot had been increased to the same length as the main block and two conjoined buildings erected against the centre of the south side of the block. One of the latter was no doubt an engine house, for the key to the 1898 factory plan specifically describes the small corning house as '… with Engine House added by A[mending] L[icence]'. Since amending licences were only introduced by the 1875 Explosives Act, the engine house must post-date the enforcement date of the act which was 1 January 1876. It is not clear what the engine drove. Its primary purpose was most probably to produce hydraulic power for the northern press house (possible map evidence for the course of a pressurised water pipe between the two buildings has already been reviewed in the discussion of Press Houses, this section above), but undoubtedly the engine also provided reserve power to the corning machine should water levels be too low to operate the waterwheel. At this date, the phrase engine house should be synonymous with steam power, but, if so, there is no map evidence for a flue or chimney at, or anywhere near, the small corning house. The 1896 and 1911 OS maps and both factory plans (Figs 138-140 and 5) do all show a leat or tail race running away south and connecting into the pre-gunpowder leat system (sections 6.1.2 and 6.2.1 above), however, confirming that the house was water-powered; they also show a spur from the main tramline ending at the east end of the main east-west range, suggesting that this was where the actual corning machine was located.

By 1931, the small corning house had been modernised for the MMB states that machines of the newer, 'Nobel', type (apparently of identical design) existed at both corning houses within the Low Works. This new machine was still water-powered (whether by waterwheel or water-turbine is not stated), but now had electric motor back-up; the motor was located in an adjacent building, 'so that in the event of a shortage of water, a switch over to the electric power can easily be made' (MMB, 19-20).

Field evidence (Fig 62) indicates that the small corning house was completely rebuilt sometime between 1923 and 1931 to accommodate the Nobel machine, for practically the only extant feature that can be related to the suite of buildings and features shown on pre-1923 cartography, is the eastern, stone abutment to the 'F[oot]B[ridge] named on the 1896 OS map (Fig 138). Instead, the field evidence shows that the mark I small corning house was superseded by a new, mark II, version, identical in size and plan in practically every respect to the mark II large corning house. It consisted of two chambers separated by a blast wall: the larger (western) chamber housed the corning machinery,

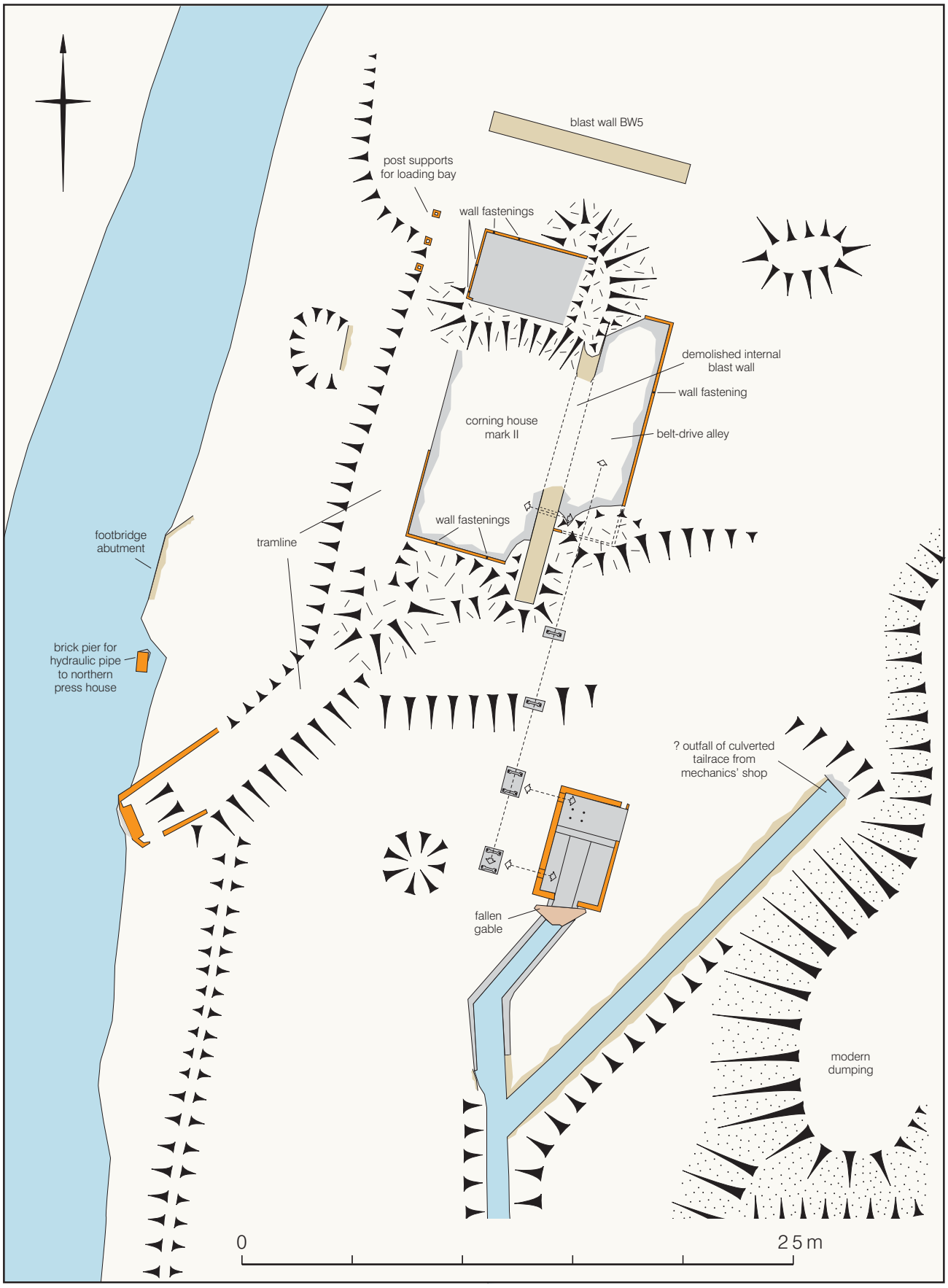

Figure 62: Plan of the small corning house (building 17)
(Drawn by Philip Sinton, © English Heritage)

the smaller (eastern) chamber, a belt-drive alley that transferred power generated in a newly built detached power house (building 17a) situated *circa* 9m to the south, into the corning chamber through housings in the blast wall.

The concrete floor slabs of both chambers survive, as do the ends of the intervening, stone, blast wall up to a height of *circa* 1m, all much obscured by demolition debris and a build-up of leaf mould and earth. A second, free-standing blast wall (BW5) still stands to its full height of over 3m immediately north of the corning house (Fig 63). As at the large corning house, a separate, raised compartment exists at one end of the corning chamber. Also like the large corning house, a brick plinth (with occasional upstanding metal bolts which would have secured the base plates of lightweight timber or metal wall panels to the plinth) runs around much of the perimeter of both chambers, although in this case the positions of doorways in to the chambers are masked by the amount of overlying rubble and humus. An incomplete opening, *circa* 0.24m square, low down in the surviving southern end of the blast wall marks the position of one of the housings through which the line shafts powering the corning machine would have passed. The actual housing has been lost, but it was probably similar if not identical to those that survive at the mark IV lower corning house at Lowwood (Jecock *et al* 2005, 110-12). No doubt the Lowwood corning house also provides the pattern for the position of other housings in the demolished blast wall at Gatebeck.

The bed of a tramline runs along the western side of the corning house next to the beck and terminates outside the raised, northern, compartment of the corning chamber where a line of three concrete post-supports suggests there was formerly a small covered loading bay. The probability is that this marks the position of a doorway through which corned powder was taken out of the building; a similar loading bay probably protected a second doorway at the southern end of the corning chamber through which pressed powder was brought in to the building, but if so the post-supports either do not survive or are buried. At the southern end of the building, the tram bed swings away towards the beck and runs up to a bridge abutment built of rendered brick. No abutment is visible on the other side of the beck (it may survive, buried: there are indications that the river bank here has been built up or pushed out by the modern recycling depot), but the implication is that when the mark II corning house was built the tram spur that had serviced the mark I building from the east was lifted, and the spur between the expense magazine and northern press house extended across the beck in its stead.

Power for the corning house was generated in a detached 'power house' (building 17a). The MMB clearly states that the mark II corning house was water-powered, and although there is no visible evidence for how water was brought to the building, the fact that a tailrace runs south away from it is strong evidence that it housed a water-turbine. The brick walls of the power house stand reasonably intact, although the northern (end) and eastern (side) walls have partly collapsed and the southern gable has fallen and now overlies the head of the concrete-lined tailrace (Figs 64 and 65). Inside the building, the concrete floor is at a variety of levels. The floor over approximately the northern third of the interior is at the same level as the ground surface outside, and it was here that the building was entered by a single doorway located at the end of the east wall. Four iron securing bolts that describe a rectangle, *circa* 0.53m east-west by 0.39m, in the western half of the floor, mark the site of a former machine base or drive-shaft mounting. After

(Clockwise from top left)
Figure 63: Blast wall BW5 north of the small corning house, from the south
Figure 64 Power house (building 17a) from the north
Figure 65: Building 17a from the west, showing belt-drive supports in line with openings in wall
Figure 66: The site of compartment 4 in the glazing house (building 9), looking north
(All Photographs: Christopher Dunn 2005/6, © English Heritage)

1.5m, this upper floor level drops by 0.3m onto a narrow ledge *circa* 0.3m wide, which in turn drops a further 0.6m to a lower floor level over the rest of the building. A shallow, silted, flat-bottomed gulley runs down the centre of this lower level, and lines up with a central opening - possibly originally with a window above - in the south gable wall and the tailrace beyond. Small, rectangular openings at low level at either end of the west wall are each in line with near-square brick or concrete bases outside the building (Fig 65), which in turn are in line with two smaller, oblong bases further north. The four bases all lie at regular intervals and are aligned on the belt-drive alley, and must have been to support belt-drives transmitting power from building 17a to the corning house. The larger, southern, examples both have rendered sides, incised to simulate blockwork, while their top surfaces retain the imprints of two line-shaft supports secured at either end by metal bolts; the more northerly bases bear the imprint of a single line-shaft support only.

A small brick pier in the edge of the river between the brick abutment to the tram bridge and the stone abutment to the earlier footbridge, is probably contemporary with the mark II corning house, and supported a pressurised-water pipe taking hydraulic power from the new power house (building 17a) across the beck to the northern press house.

Glazing Houses and associated buildings

Corning broke the press cake down into angular grains. These were subsequently smoothed and polished by a process known as glazing – tumbling the grains in special wooden barrels for several hours, for part of the time with graphite added. Powders requiring an extra polish were also reeled - that is, tumbled in linen barrels - sometimes with more graphite added.

When it opened in 1852, Gatebeck reportedly had two glazing houses, one attached to each of the corning houses (buildings 11-13 and 17); these early, combined, houses have already been discussed elsewhere (Corning Houses, this section above). A dedicated glazing house existed by 1863, however (section 4.2 above), which must be that labelled building 9 on both the 1898 and 1923 factory plans (Figs 5 and 140). This stood on the east bank of the beck, approximately mid-way between the large corning house and the incorporating mills at the southern end of the factory, and immediately opposite the small stove (building 10). The house's proximity to the mill leat which flowed immediately above and behind, suggests that the building was powered, at least initially, by a waterwheel. Since the cartographic sources do not name a boiler house at the small stove, but do show a long flue running up the hillside behind the glazing house to a detached chimney (unnumbered on the factory plans, but for present purposes identified as building 9a) sited at the edge of Gatebeck Plantation, it also seems reasonable to conclude that the boiler for the stove was within, or attached to, the glazing house. This raises the possibility that the boiler, besides heating the stove, also had the capacity to produce steam for a small engine powering the glazing house; if so, it is perhaps most likely that the steam engine was held in reserve for periods of drought or severe frost when the waterwheel could not operate, rather than it being the primary driver. By 1923, the glazing barrels were reportedly powered by turbine with electric motor back-up. The motor seems to have been accommodated in a separate 'Motor House' that stood behind the glazing house (unnumbered on the 1923 factory plan, but numbered building 9b for the purposes of the present report).

A 'Glazing and Reel House' that existed at the High Works after 1898 is described elsewhere (Oswald *et al* in prep). There is no evidence that reeling was ever carried out within the Low Works; presumably if this was required the powder was despatched to the High Works.

Glazing House and associated buildings (buildings 9, 9a and 9b)

Map evidence (Fig 138) shows that by 1896 the post-1860, dedicated, glazing house was a long, narrow building, subdivided into four compartments (for ease of reference here numbered south to north as compartments 1-4). Compartments 1 and 3 were both relatively small and were most likely waterwheel-, engine- or other forms of power house (see below); compartment 2 is the only one depicted with covered loading bays extending out over the tram spur that passed in front of the building, indicating that it was the only one into and out of which powder was taken and that it accommodated the glazing barrels; the function of compartment 4 is less clear, but it may have served as a store. It has been suggested above that because the glazing house stood adjacent to the main mill leat, it was most likely powered by a waterwheel. Although none of the maps

and plans depicts a headrace leading into the building, the 1911 OS map (Fig 139) does name a 'Sluice' in the west side of the leat above compartment 1 (which is the logical location for the wheel, adjacent to the glazing barrels in compartment 2); a wheel here is also supported by field evidence (see below). Compartment 3 is in line with the small stove and the flue up to the detached chimney 9a, and is therefore the best candidate for the boiler supplying hot water or steam to heat the stove and also the postulated steam engine on standby to power to the glazing house should there be insufficient water to operate the wheel. In this scenario, compartment 4 is most likely to have served as a store for graphite for the glazing process and perhaps coal or charcoal for the boiler.

This arrangement of buildings at and around the glazing house is shown little changed on the 1911 OS map. By 1923, however, compartment 4 had been demolished, to be replaced by a much smaller building detached from the rest of the glazing house. The 1923 factory plan (Fig 140) identifies this new building as no. 11, 'Graphite Store' (for the purposes of the present report re-numbered 11a and described under section 6.2.2 above). The same plan also depicts another new building situated immediately behind compartment 3: this should presumably be equated with one element of the 'Power and Motor House' which the accompanying key shows had been added to the description of the glazing house since the 1898 plan (for ease of reference in the present report, this second building will be referred to as building 9b). This interpretation of the cartographic evidence tallies with the statement in the MMB that in 1931 the glazing house was 'water driven, but … also electrically connected so that in short water periods the latter method of driving is resorted to' (MMB, 23). Since the small stove appears to have been disused by 1931 (Stoves, this section below), the conclusion to be drawn must be that electricity superseded steam as the glazing house's auxiliary motive power source sometime between 1911 and 1923. The use of the term 'Power … House' in 1923 suggests that a turbine had replaced the waterwheel by this time.

In 1896 the tram spur in front of the glazing house serviced both the large corning house and the incorporating mills. Since neither the corning nor glazing house received powder direct from the incorporating mills, the track layout suggests that green and ripe charges were travelling past both buildings en route between the green-charge house and the mills, and the mills and the presses or expense magazine. This may have been deemed a dangerous or unnecessary procedure, for the 1911 OS maps shows the spur then terminated at the glazing house, with the incorporating mills serviced by their own spur which only left the main line further to the south.

As a danger building, the glazing house would have been among those cleansed by fire when the works closed in 1936. This is indeed the impression conveyed by the field evidence, for on the ground the only visible trace of the building is a platform terraced into the foot of the hillside, retained by a stone wall, now rapidly collapsing (Figs 66 and 142). This is presumably the rear wall of the building built back to earth. No other structural traces are visible across the floor of the platform in the area which corresponds to compartment 2 on the maps and plans, suggesting that this part of the building was constructed of materials such as timber or metal rather than stone. In the vicinity of building 9b the ends of at least four, stone cross walls can just be made out returning out of the mass of collapsing masonry and earth that is the rear retaining wall, but this may be because they formed part of compartment 3 which, it has been

(Clockwise from top right)
Figure 67: Compartment 1 in the glazing house (building 9) from the north-west
Figure 68: Headrace above compartment 1, looking west
Figure 69: End of headrace above waterwheel/turbine-pit in compartment 1
Figure 70: Detail of possible flywheel-pit in compartment 1, from the west
(All Photographs: Christopher Dunn 2006, © English Heritage)

suggested above, was built to house a boiler and possibly a steam engine, and would therefore have been more robustly constructed because of the fire risk. Otherwise the use of stone is now only attested in compartment 1 at the southern end of the building and in building 9b, which together presumably constitute the 'power and motor house' recorded by the 1923 factory plan.

Compartment 1 at the southern end of the building (Fig 67) is now ruinous, but seems to have been built initially as a waterwheel house later adapted to accommodate a water-turbine. Only the rear (eastern) wall of the compartment stands to anything like its original height, but the surviving angle of the eaves indicates that it had a south-facing single-pitched roof. A short headrace evidently brought water from the main mill leat that flowed at high level behind the glazing house, into the north-east corner of the compartment. The position of the headrace is marked on the ground today by a simple cut channel (Figs 68 and 69); the absence of any kind of visible lining to the channel sides suggests that the headrace itself consisted of a metal or wooden launder and pentrough - either salvaged for scrap when the works closed or since rotted away. Inside the compartment, the waterwheel/turbine-pit occupied the northern half of the

(Clockwise from top left)
Figure 71: Intersection of the culverted leat with the waterwheel/turbine-pit in compartment 1
Figure 72: Electric-motor house (building 9b) behind the glazing house
Figure 73: Electric-motor bed in building 9b
(All Photographs: Christopher Dunn 2006, © English Heritage)

building, but is heavily infilled by fallen masonry and other debris and there are few visible clues to indicate the position of the wheel or turbine within it; the axle mounts of the former may well have been destroyed or removed when the latter was fitted anyway. Nevertheless, it is tempting to suggest that a flue-like recess in the rear (east) wall (Fig 70) is either a flywheel-pit or a late feature built to accommodate a turbine feedpipe, and that two openings in a low internal wall that divides the southern half of the compartment accommodated wall boxes supporting line shafts turned by cog-wheels or belt drives. The western end of the pit is more open, and evidently connected directly into the culverted leat that ran past the building and acted as the tailrace for it, for its northern and southern edges (Fig 71) are pierced by well-formed segmental arches; the pit must originally have been guarded or capped by some form of railing or grille to prevent people falling in.

Motor house 9b at the north end of the glazing house is likewise now ruinous (Fig 72). It is a small, rectangular building built back to earth on a platform terraced into the hillside between the rear wall of the glazing house and the mill leat behind. Its rear (east) wall stands to something approaching full height, but the front and both end walls are reduced almost to their footings. The rear wall is rendered internally up to a height of about 2m, suggesting the building had a flat or perhaps single-pitched, west-facing, roof surmounted by a parapet. It was entered by a doorway at the east end of the north wall, outside which a flight of concrete steps gives access up to the level of the mill leat. Inside the southern half of the building a concrete bed (Fig 73), roughly rectangular in plan, with six securing bolts, two along

the eastern side and four along the west, is most plausibly the bed for the electric motor mentioned by the MMB. Power was presumably transferred via belt drive, down into a new gearing chamber constructed on the site of the former engine house (compartment 3) below, where it connected with a line shaft (fixed to the old engine mountings) that transferred power to the barrels in compartment 2 of the glazing house. A narrow aperture high up in the east wall above the motor bed and connecting with a small, brick-lined vertical vent emerging at ground level immediately outside the building, is of uncertain purpose: although suggestive of a ventilating flue, an electric motor by its very nature needs no exhaust outlet, and cooling, if required, could easily have been provided by louvres and windows in the roof and walls, raising the possibility that the building housed some form of oil engine or generator before the electric motor was installed. A ceramic pipe set into the ground just to the north of the flue is probably part of the building's rainwater goods.

The flue from the glazing house runs up the hillside to a detached chimney situated on the edge of Gatebeck Plantation. The flue is a stone-lined channel *circa* 1.2-1.75m wide by 0.9m deep, originally capped by massive stone flags supported on iron bars, although many of the flags are now missing or broken (Fig 74). It presumably acted as a conduit containing a number of separate metal flue pipes, including one from the large corning house (this section above). Spoil from digging the channel has been thrown to the north, creating an upcast bank and number of linear spoil dumps across the hillside (Fig 143). The chimney, which survives in remarkably good condition, measures 3.04m square externally and is over 11m tall.

Figure 74: The flue from the glazing house and the base of chimney 9a. (Photograph: Simon Taylor 2006, © English Heritage)

Stove Houses and associated boiler houses ('Stoves')

Once glazed, gunpowder had to be dried to remove any residual moisture left over from incorporation and not removed by glazing. This was done at the stove or drying house, where the powder was spread onto trays contained in racks and dried by the circulation of hot air. Although gloom stoves – in which the air temperature within the building was raised by direct radiation from a metal sheet shielding an external open fire - persisted at some gunpowder works until the closing decades of the 19th century (for example, the nearby Elterwater factory employed a gloom stove as late as 1881 (Jecock *et al* 2003, 70)), Gatebeck appears always to have used the safer and more modern technique of heating the building using piped steam or hot air. As such stove complexes consisted of separate stove and boiler houses in close proximity - often with a detached chimney some distance away to lessen the danger of sparks being blown across the works - the terms stove house and boiler house will be reserved for the individual buildings, with 'stove' and 'stoving' used to refer to the overall suite of buildings and to the process.

The earliest evidence we have for the location - and indeed existence - of stoves at Gatebeck is the 1898 factory plan (Fig 5), which identifies two stove houses within the Low Works: a so-called 'Small Stove' (building 10) immediately west of the glazing house on the east bank of the beck and another labelled simply 'Stove' (building 38) situated in the middle of a building range on the opposite side of the beck north of the main works' entrance. Since neither building is depicted on the 1858 OS map (Fig 137), there is no way of knowing for sure where stoving was carried out at this early time, although the best candidate is the isolated building close to the beck (numbered building 107 on Fig 130). For the same reason it is not possible to be certain of the date(s) of construction of the two later, documented, stoves, but it would not be unreasonable to suggest that the small stove was constructed at the same time as the adjacent glazing house *circa* 1860. A third stove appears to have been converted out of a former wagon shed (building 42) adjacent to building 38 sometime in the first quarter of the 20th century since the building is designated as 'Stove Reserve' on the 1923 plan; if so it was disused by 1931. A fourth stove that operated at the High Works after 1898 is described elsewhere (Oswald *et al* in prep).

Small Stove (building 10)

The available cartographic and documentary evidence (Figs 5 and 137-40) suggests that the small stove was a simple, rectangular building which underwent no change between 1896 and 1923; it seems to have been disused by 1931 for the MMB states that only one stove was then operational at the Low Works (MMB, 34), and from the description this is most likely to have been building 38. Maps and plans (especially 20th-century ones) also suggest that the small stove (or rather its associated boiler house) was connected via a flue to a detached chimney sited high up on the valley side behind the glazing house. (Although not labelled in the key to either of the factory plans, the chimney is identified on Figs 131-6 in the present report as building 9a). Neither of the factory plans identifies the boiler house, and it has already been suggested that the latter was integral with the glazing house (Glazing Houses, this section above) and drove a steam engine providing auxiliary power to the latter

building as well as providing steam/hot air to the stove. Heat was probably fed to the stove house via pipes laid beneath or carried over the intervening tramlines. Boiler house and the flue and chimney from it are all considered in more detail elsewhere (Glazing Houses, this section above), but the physical remains of the small stove house are described below.

The small stove house (Fig 142) was stone-built. Only the lowest courses of the walls now survive, although when viewed from outside, the western end of the building appears better preserved as the walls are raised directly on an underlying stone platform constructed in order to level the floor of the building and elevate it above the threat of flooding from the beck (Fig 75). On the ground, the plan of the building is incomplete due to obscuring tumble, but enough survives to show that it originally measured some 10m by 5m overall and must have been entered through a doorway in the, now largely obscured, eastern end wall. Where opposing wall faces can be made out, the walls are 0.6m thick. It is unclear whether a narrow, shallow channel that commences some 13m south of the building and runs for 10m towards what appears to be the start of a stone revetment along the eastern bank of the beck, is connected with the stove in some way; alternatively it may represent the original tailrace from the pre-gunpowder mill (section 6.1.2 above). The purpose and origins of a low bank that runs south from the south-east corner of the stove house are similarly obscure. Both earthwork features are, in any case, now heavily overgrown.

Figure 75: The small stove (building 10), looking south-west
(Photograph: Bob Skingle 2006, DP028054 © English Heritage.NMR)

Stove and Stove Reserve (buildings 37 - 42)

According to the 1898 factory plan (Fig 5), a long, narrow, rectangular building on the west side of the beck north of the main works entrance was subdivided into three compartments internally, numbered 37, 38 and 39 from west to east; in the accompanying key the function of the two end compartments is given as 'Ante Room', that of the central compartment as 'Stove.' A smaller, almost square building depicted adjacent to the east end of the main range and slightly offset from it, identified as building 40, 'Stove Fire Place', is presumably a boiler house; it seems to have been essentially free-standing, although connected to the main range by unnamed line detail - probably pipework. Building 41, labelled 'Chimney for d[itt]o [that is, building 40]', does not appear on the 1896 OS map on which the factory plan is based, and its site has been roughly inked in on the plan a short distance north-east of building 40. This 'Ch[imne]y' is both depicted and labelled on the OS 1911 map (Fig 139); the later map, however, locates the chimney north, not north-east, of the boiler house. One of the draft keys for the 1898 plan (CRO(K) WDB/35/680f) has the additional information that the three compartments comprising the stove were protected by two lightning conductors; it also identifies the buildings as nos. 36-38, but this must reflect an earlier factory numbering system (section 4.2 above).

The 1923 factory plan (Fig 140) bears the same building depictions, numbers and descriptions as the 1898 plan, but in addition building 42 situated a little south-east of, and on the opposite side of the tramline running past, the stove, is now identified as 'Stove Reserve'; in 1898 this building had been 'Wagon Shed'. The precise implications of this change of use are unclear, but it is most likely that sometime after 1898 the wagon shed had been converted into an additional stove house which could be brought on line alongside, or in place of, building 38, as and when production levels of blackpowder required or the main stove house needed maintenance. Although the plan shows no line detail interpretable as pipework connecting building 42 to the boiler house (building 40), the latter was no doubt capable of supplying hot air to both adjacent stove houses. Indeed, a pipe connecting the two buildings is visible, suspended above the intervening tramway, just right of centre frame in an historic photograph from the Mike Davies-Shiel collection, reproduced by Tyler (2002, 63 bottom). The photograph is wrongly identified by Tyler: although captioned 'Gatebeck Tramway near *store*s and changing room circa 1920', comparison of the layout of tramlines with historic map detail strongly suggests that the buildings visible in the background are not those claimed (buildings 25-27), but rather the *stove* and boiler house (buildings 37-39 and 40); building 42 would be visible at right of frame were it not obscured by trees. Additional detail visible on the photograph includes the position of doors and the existence of a number of skylights in buildings 37-9 and 40, while a line of wooden rails attached to posts at right of frame presumably carried cabling transmitting electric light and power around the factory: a similar system of cabling supported on rails and poles existed at Lowwood in the late 1920s during ICI's ownership of that factory (eg Jecock *et al* 2005, 93 and 150).

By 1931, ante room 39 appears to have housed a 'Davidson Tubular Steam Heater' - essentially a heat exchanger which used steam piped from the boiler to heat air which was then blown by fan into a single outlet duct that ran the length of stove house 38; smaller pipes led off this duct and carried the hot air directly over the topmost drying

racks. Ventilators were arranged along the base of the side walls to encourage the air within the building to circulate. There were two lines of racks within the stove house at this time, one either side of a central walkway; no doubt the racks had always been arranged this way. Both loose powder and cartridge pellets were dried, but not fuse or fireworks powders. In theory, powder and pellets were dried for 12-15 hours, but in practice the racks were filled one day and emptied the next (MMB, 34-6). A similar method of heating the stove house using piped air is recorded at Lowwood (Jecock *et al* 2005, 135-6). There, the conversion of the stove formed part of a programme of modernisation instituted by ICI *circa* 1929, suggesting that the Gatebeck heater may have been a similar recent ICI improvement; it presumably replaced a system of heating the stove house using piped steam. The lack of mention of the stove reserve suggests that it was disused by this time.

The land on which the stove stood now forms part of the Gatebeck Caravan Park, which was not investigated by English Heritage. The buildings were already unroofed and ruinous on 1945 aerial photographs (eg NMRC AP library no. 3864), but it is not known whether any traces now survive. In contrast building 42 appears to be still roofed on the photographs. This suggests that it had ceased to be classed as a danger building prior to the works closing in 1936 and was therefore not set alight at that time, although it is doubtful whether anything now survives.

Dusting, Sizing and Packing Houses and associated buildings

After stoving, loose powder was sent to the dust and/or sizing house where the powder was passed through a series of sieves of different mesh size to check the grains were of the correct grade and to remove under- and over-sized particles, before being sent on to the packing or heading-up house to be weighed into barrels and crates ready for despatch (heading-up refers to the closing of the barrels, and a heading-up house is therefore simply another name for a place where loose powder was packed). Before the 1875 Explosives Act, powder loose-packed into barrels was really the only form in which gunpowder was sold, although later it was also occasionally packaged in cases. After the Act, powder was also marketed pre-formed into solid blasting cartridges; these were sold, wrapped, by the box. Cartridge packing, however, was a totally different process to loose packing and was normally carried out in a separate building (section 6.2.4 below). At many gunpowder works dusting/sizing and packing were performed in separate buildings, but the evidence suggests that at Gatebeck both operations were carried out beneath the same roof. The location of the Low Works packing house (building 43) is known after 1898, but since building 43 did not exist in 1858 it must have replaced an earlier packing house sited elsewhere. The identity of that 'early' packing house is unknown, but a likely candidate is building 106 (section 6.2.7 below and Fig 130). If correct in this identification, the implication is that building 43 existed by 1864, for building 106 had been demolished by that time to make way for the new saltpetre refinery.

Packing House and Packing-House Cooperage (buildings 43 and 44)

The only direct evidence for the existence of dust houses at Gatebeck is contained in the MMB, which states that *circa* 1931 there were two at the factory, one at the Low Works and one at the High Works. Unfortunately, neither factory plan of the Low Works records the location of such a building. Since the corresponding plans of the High

Works, however, name the dust house there as 'Dusting and Packing House' (Oswald *et al* in prep), it is highly likely that the Low Works' example was similarly combined with the packing house. The Low Works 'Packing House' is identified on both factory plans as building 43 located on the west bank of the beck, 90m north-east of the stove 38. It was integral with an adjoining building identified on those plans as building 44, 'Cooperage for d[itt]o [that is, building 43] and Cask Store'. The combined building is T-shaped in plan, with the dusting/packing house seemingly occupying the stem of the T and probably the western portion of the head, and the cooperage/cask store the remainder. It is most improbable that barrels or boxes were actually made here; more likely, lids were put on.

The dusting machinery at the Low Works was a simple device, described in 1931 as a large wooden hopper divided into two sections, with a chute connected to the top of each section. Powder poured into the chute was delivered onto a horizontal sieve which was agitated by hand. A second sieve lay below this, arranged at a slight angle. The description is somewhat vague as to how it all worked, but it appears that the top sieve trapped oversized grains (called 'chubbins') and the second sieve grains of the desired size, while undersized grains ('dust') passed through both into a box on the floor (MMB, 37-8).

The MMB also details the packing process as organised in 1931. Powder was weighed on a set of suspended scales, before being emptied into a barrel lined with a calico bag. The bag was then closed and tied, and the barrel 'headed up' and stencilled. If the powder was to be despatched in boxes instead, the powder was put into the bag before the latter was placed in the box. Powder for cartridges was poured straight into barrels without any calico liner, and stored in the magazine until required (MMB, 40).

The dusting machinery no doubt occupied the southern (front) portion of the building, with packing carried on in the rear. This is suggested by the arrangement of tramlines around the building (Figs 5 and 138-40): the main line passing in front of the building would have enabled powder to be brought directly from the stove, whilst a short spur leading from the rear of the building and joining the main line a little north of building 43/44 would have enabled filled barrels and crates to be sent directly to the magazine.

The site of building 43/44 lies within what is now Gatebeck Caravan Park, which was not investigated by English Heritage. Immediate post-World War II aerial photographs (eg NMRC AP library no. 8) show the buildings as already severely ruinous, however. It is not known whether any trace of the structures survives.

Magazines and associated buildings

Under the Gunpowder Act 1772, gunpowder, once manufactured, had to be removed as quickly as possible to a magazine located in a remote place, whose site had been approved by local Justices of the Peace. The Act also stipulated that such 'powder' magazines had to be constructed in brick or stone (Cocroft 2000, 28). The legislation was tightened by subsequent Acts of 1860 and 1875: the first laid down that what were termed 'store magazines' for the keeping of finished powder, had to be at least 140 yards (128m) distant from any other building where gunpowder was manufactured or stored, and also had to be fitted with a lightning conductor (Public Statutes General 1860, 616-17); the second set up a completely new licensing régime for what were now designated 'factory'

magazines, which required all such sites to be approved by the Secretary of State at the Home Office, advised by the newly created HM Explosives Inspectorate (Public Statutes General 1875, 146-53).

Both the 1898 and 1923 factory plans (Figs 5 and 140) identify building 45 as the Low Works magazine. This building did not exist in 1858 (Fig 137), and was probably only erected *circa* 1860 as a result of the legislation enacted that year. There is no firm evidence to indicate the site of the earlier magazine, but it was almost certainly building 31. In order to help make the distinction between the two magazines, building 31 will be described in this report as the 'early' magazine, building 45 as the 'store' magazine. The store magazine had its own dedicated cooperage (building 47, designated 'Magazine Cooperage') housed in a building opposite, although what tasks were performed here is unclear.

'Early' Magazine (building 31)

Building 31 is the best candidate for the original Low Works magazine since it is one of the more isolated buildings shown on the 1858 OS map (Fig 137), and is described in the key to the 1898 factory plan (Fig 5) as 'Magazine now used as Cartridge House and Changing Room'. It may represent an oversight on the part of the Kendal Justices of the Peace who granted John Wakefield III permission to erect the works in 1851, that the site of this magazine was not specified more closely in the licence they issued (as for example was that of the Lowwood Gunpowder Works magazine in the licence that Lancaster magistrates issued in 1798 (Jecock *et al* 2005, 14)). This early magazine was presumably proscribed under the 1860 Gunpowder Act. A discussion of the building's plan and later history drawn largely from map evidence may be found under the description of the Cartridge-Packing House into which it was converted in 1880 (section 6.2.4 below).

'Store' Magazine and Magazine Cooperage (buildings 45 and 47)

Both factory plans (Figs 5 and 140) depict the store magazine (called simply 'Magazine') as an isolated building on the west bank of the beck at the northern end of the factory, a little way south of Gatebeck Bridge. Like the packing house (this section above), it had its own dedicated cooperage (building 47, labelled 'Magazine Cooperage'); this stood on the opposite side of the main tramline connecting the Low and High Works which ran past the south-east (end) wall of the magazine. It is most unlikely that barrels or boxes were actually made at the cooperage; instead, tasks performed here may have included 'heading-up' (that is, putting lids on) boxes received from the cartridge-packing house (barrels of powder were presumably headed-up at the packing-house cooperage). The southern end of the magazine cooperage was in separate use as a 'Covered Wagon Shed'; the function of this latter building (building 46) is discussed elsewhere (section 6.2.9 below).

Measurements written on a draft of the 1898 factory plan (CRO(K) WDB/35/680c) record that the store magazine stood 159 yards (145m) north-east of the packing house and its associated cooperage - the nearest building(s) which handled powder; the 1896 and 1911 OS maps (Figs 138 and 139), in contrast, suggest the distance was much closer to the legal minimum set in 1860. It is unclear whether it is the plan or the maps which are in error. One of the draft keys for the 1898 plan (CRO(K) WDB/35/680f) labels the building as 'Magazine with lightning conductor', confirming that it met another of the

1860 legal requirements. The draft key also records the building as no. 44, not 45, but this probably reflects an earlier factory numbering system (section 4.2 above).

The sites of the store magazine and its cooperage form part of Gatebeck Caravan Park which was not investigated by English Heritage, but aerial photographic evidence indicates that the buildings were – predictably - amongst those burned down when the works closed in 1936, for most upstanding remains seem to have disappeared already by 1945 (eg NMRC AP library no. 8). It is not known whether any surface trace now survives.

6.2.4 The Manufacture of Blasting Cartridges

The Explosives Act 1875 made the filling of blasting cartridges illegal except on licensed premises. Before the Act, cartridge preparation had been very much a home industry, often carried out by miners working by candlelight (Marshall and Davies-Shiel 1969, 84). After the Act, most blackpowder manufacturers obtained amending licences authorising new or converted buildings for the production of compressed cartridges (also known as 'pellets'). Gatebeck obtained its licence in 1880 (section 4.2 above).

Cartridge-Pressing and Cartridge-Packing Houses

If the factory plans (Figs 5 and 140) are read at face value, the works possessed two cartridge-pressing houses and one cartridge-packing house after 1880 (buildings 49, 50 and 31), although it is not known if both pressing houses were built at once. The pressing houses stood on the narrow spit of land between the main mill leat and the east bank of the river, roughly opposite the dusting, sizing and (loose) packing house (building 43) on the west bank; the packing house was converted out of what had been the 'Early Magazine' located further south along the leat (section 6.2.3 above). However, the MMB refers to three cartridge-pressing ('pellet-pressing') houses at the Low Works in 1931, although of the three presses one was condemned as unsafe and the building housing it not operational (MMB, 28). Comparison of the 1923 factory plan with the 1911 OS map (Figs 140 and 139) suggests that the condemned house may, in fact, have been building 50, for the later plan depicts that building as divided into three 'compartments' labelled 'A', 'B' and 'C': compartments 'A' and 'B' relate to building 50 as shown on earlier maps and plans, compartment 'C' to a new building that had been erected since 1911 immediately north of the old. Since on safety grounds it is extremely improbable that the Explosives Inspectorate would have authorised a new building so close to a functioning press house, it suggests that building 50c was in fact a replacement for building 50a-b.

It was normal practice at this time for gunpowder works to employ women to wrap cartridges and pack them into boxes. As with all gunpowder workers, the women had to change into special protective clothing without pockets before starting work, and the cartridge-packing house reportedly doubled as the women's dressing room (see also Buildings associated with safety precautions, section 6.2.6 below).

Cartridge-Pressing Houses (buildings 49, 50a-b and 50c)

The factory plans and the two later OS maps (Figs 5 and 138-40) portray all three cartridge-pressing houses (buildings 49, 50a-b and 50c) as essentially T-shaped buildings served by a tramline that ran in front of their north-west walls immediately above the

beck. South of the southernmost house (building 49), the tramline is shown forking with one branch leading to the cartridge–packing house and the other crossing the beck to run past stove 38; north of the other two pressing-houses the tramline again crossed the beck to end at the factory magazine. Evidently, therefore, all three cartridge-pressing houses were able to receive dried loose powder from either the stove or magazine as appropriate, and send compressed pellets directly to the packing house and then on to the magazine. The maps and plans show projections interrupting the course of the tramline in front of all three buildings, suggesting loose powder arrived at, and the finished cartridges were taken out of, each through a single doorway protected by a covered loading bay in the north-west wall. It is possible that building 49 may have had a second doorway, since the 1898 OS map depicts a short spur terminating at what appears to be a covered loading bay outside the south-western end wall; the 1911 OS map and 1923 factory plan, however, agree in portraying the spur as terminating a few metres short of the building, and it may be that this second, putative, doorway was by then disused.

The presses that existed within buildings 49 and 50c in 1931 are described by the MMB. They were presumably then relatively new. Each consisted of a stationary cast-iron head and movable table connected by four mild-steel, brass-sheathed columns of 5-inch (127mm) diameter. A cast-iron pin plate was placed on the table, and a mild-steel mould block laid on top and fastened to the columns; the former had either 116 or 171 tapered pins projecting from it, the latter 116 or 171 holes bored in it - each containing a 'melloid' mould to hold the powder. The block with 171 holes produced pellets of $1^{3}/_{16}$ or 1¼-inch (30.16-31.75mm) diameter, the larger size pellet with a central hole, the smaller without; the block with 116 holes made two weights of pellet $1^{7}/_{16}$ inches (36.51mm) in diameter, both with a central hole. Attached to the press head was another cast-iron block containing plungers made of 'Bull's Metal'; the plungers were arranged directly in line with the holes in the mould block and were of a diameter to fit the moulds exactly. When pressure was applied, the bottom ram moved up, raising the pin plate and mould block towards the plungers which entered the moulds and compressed the powder. When pressure was released, the pin block sank with the ram but the mould block remained stationary supported by cataract suspension gear. A wooden box was then pushed onto the pin plate and pressure re-applied, causing the mould block to rise once more against the plungers which pushed out the cartridges into the wooden box below. The whole operation was then repeated. Pressure was applied hydraulically (MMB, 28-33). Although there is no discussion in the MMB of where or how that pressure was supplied, it most likely came from the company's supply of pressurised water from the Fall Beck reservoir (section 4.2 above). The blueprint of one of the presses plus the pin plate and mould block for the smaller diameter pellets survives in the Patterson Collection at the NMRC.

Nothing structural is now visible of any of the buildings, although their sites are identifiable on the ground as rubble-strewn, overgrown, walled platforms cut into the side of the embankment retaining the main mill leat. No measured survey was undertaken, but a concrete block of cruciform plan measuring 1.05m square and with a central perforation of 0.57m diameter lies on the platform of building 49 (Fig 76); it is of unknown origin or purpose. A number of post-supports also survive set into the ground behind and above both platforms – one above building 49, and four in line *circa* 2.9m apart above building 50 (Fig 77). As with others that survive along the tram spur

Figure 76 (above left): Concrete block at site of cartridge-pressing house 49
Figure 77 (above right): Concretre post-support behind cartridge-pressing house 50
(Photographs: Christopher Dunn 2006, © English Heritage)

out to expense magazine 15 (Large Corning House, section 6.2.3 above), the supports are probably the bases for timber uprights supporting some form of blast screen – presumably in this case to shield Gatebeck Farm and/or workers using a footpath that formerly ran along the side of the mill leat (Figs 137-8) to reach the sluicegate at the leat head (see also Blast Banks and Walls, section 6.2.10 below).

Cartridge-Packing House (building 31)

The factory plans and later OS mapping (Figs 5 and 138-40) all show the cartridge-packing house as a T-shaped building aligned south-west/north-east alongside the main mill leat; the head of the T is depicted subdivided into three compartments, the tail into two. Comparison with the 1858 OS map indicates that the southernmost compartment of the head and northernmost compartment of the tail did not then exist, and must represent additions to the structure, most likely made when the building was converted from a magazine into the cartridge-pressing house *circa* 1880; one of the additions may have acted as the women's changing-room. The northernmost compartment of the head may have been no more than a covered loading bay, for the 1896 OS map and 1898 factory plan both show the tram line from the cartridge-pressing houses ending against its north-east wall plus another spur running parallel to it outside the building to the north-west; only the latter spur is shown on the later map and plan.

The building no longer exists, presumably burned down when the works closed in 1936 and the ruins subsequently levelled. However, its site (not surveyed) is covered by static caravans, and it is possible that evidence for it is currently obscured.

6.2.5 Testing the Powder

In the 19th century the Government required gunpowder supplied to it for military use by civil contractors to be tested or proved before it was accepted into government magazines. Two tests were used: one involved firing a special steel musket-ball through fifteen wooden boards, ½-inch (12.7mm) thick and placed ¾-inch (19mm) apart; the other firing a 64lb (29kg) cannon ball from a mortar angled at 45° using a 2oz (0.06kg) charge of powder, with the expectation that the ball be

propelled at least 247 feet (75.29m) (Cocroft 2000, 46-8; Tyler 2002, 117). Although proofing ranges to satisfy the latter test are evidenced in Cumbria at the Lowwood and New Sedgwick factories (Jecock *et al* 2005, 153-4; Dunn *et al* 2003, 90-2) - the former a short-lived affair for testing military-grade powder, the latter probably for testing sporting powders – there is no evidence that Gatebeck was engaged in the production of propellant powders or that it ever had its own proofing range. Indeed it was more normal for blasting powder (the mainstay of Gatebeck's ouput) to be tested by 'flashing' on hot copper sheets, and later by chemical analysis in the laboratory. Although a laboratory existed at Gatebeck between at least 1881 and *circa* 1898 (section 6.2.6 below), this need not have been a proofing laboratory: it could, for example, have been for checking the quality of saltpetre or even have been a research laboratory, for in the final years of the 19th century the Wakefield company is known to have employed two experimental scientists to develop a new range of safety powders for use in coal mines where there was a risk of firedamp (Vickers 2003, 209; section 4.2 above).

6.2.6 Ancillary Buildings

Buildings associated with safety precautions

It was standard gunpowder-industry practice for the keepers of the incorporating mills (those whose jobs it was to load green charges and unload ripe charges) to supervise the incorporation process – which could take anything from one to several hours - from the safety of a watch house. This was in order to minimise the risk of death and injury if a mill exploded, as frequently happened (see Appendix 1 below).

As a further safety precaution, many gunpowder factories also searched their entire workforce for contraband - that is, items such as pipes and matches and anything metallic which presented a risk of striking a spark and therefore might cause explosions - when they reported for shift. People employed to work in danger buildings were also required to put on special clothes and shoes. The clothing (made from inflammable materials) was designed to provide a degree of protection against burns, but also lacked pockets as an added safeguard against the secretion of contraband about the person; the shoes were either entirely of leather or only contained non-ferrous nails so as to reduce the risk of striking sparks. Searching and the donning of such apparel were made statutory requirements under the Explosives Act 1875, but seems to have been normal practice at most works by this date anyway (Public Statutes General 1875, 151; Cocroft 2000, 60 and 99): Lowwood, for example, introduced leather clothing for its workers in 1805, and the Wakefield company at had been so doing for workers at its Old Sedgwick factory for some time prior to that (Palmer 1998, 48). After *circa* 1880 many gunpowder works, including Gatebeck, employed women to wrap and pack cartridges, and therefore had to supply segregated changing facilities, too.

Gunpowder works obviously also required fire engines on hand all the time to fight fires. After the 1875 Explosives Act, such engines were also needed to hose down the interior of process buildings and wash away, or at least dampen down, powder residues prior to maintenance work.

Watch House and associated chimney (buildings 4 and 4a)

Both factory plans (Figs 5 and 140) identify the 'Watch House' as building 4, sited between incorporating mill pairs 3 and 5. According to Tyler (2002, 45), 'Moss Cottage', located at the junction of the access road into the factory with Gatebeck Road (Figs 138-9), also acted as a watch house when the works opened, but this is inherently unlikely given, first, that there were no incorporating mills on site in the early years (section 4.2 above), and secondly, the building's distance from the mills that were later constructed; perhaps watch house is in error for rest room. The first mills at the works (buildings 5 and 7) were built *circa* 1859 (section 4.2 above), and watch house 4 must therefore date from this time as well.

The building was a squat L-shape in plan (Fig 78), was built of stone rubble and was terraced into the hillside, the rear wall being back to earth. Since its abandonment, it has become substantially ruinous and its walls reduced to stubs (Fig 79), but it clearly consisted of two rooms: a main room, entered via a central west-facing doorway, with a fireplace at the rear; and a smaller room to the left of the main room with a connecting doorway but no external entrance. The smaller room retains traces of internal rendering, but there is no evidence of rendering in the main room. A number of iron pins in the rear wall of the main room are of unknown purpose (Fig 80). The fireplace must have accommodated a stove rather than an open fire, for it was vented by a pipe that rose through a recess in the wall to a shallow channel in the hillside terminating at a remote detached chimney; the pipe is now missing, presumably salvaged for scrap along with the stove, but the iron cover to a soot box or inspection chamber survives *in situ* at the transition between wall flue and channel

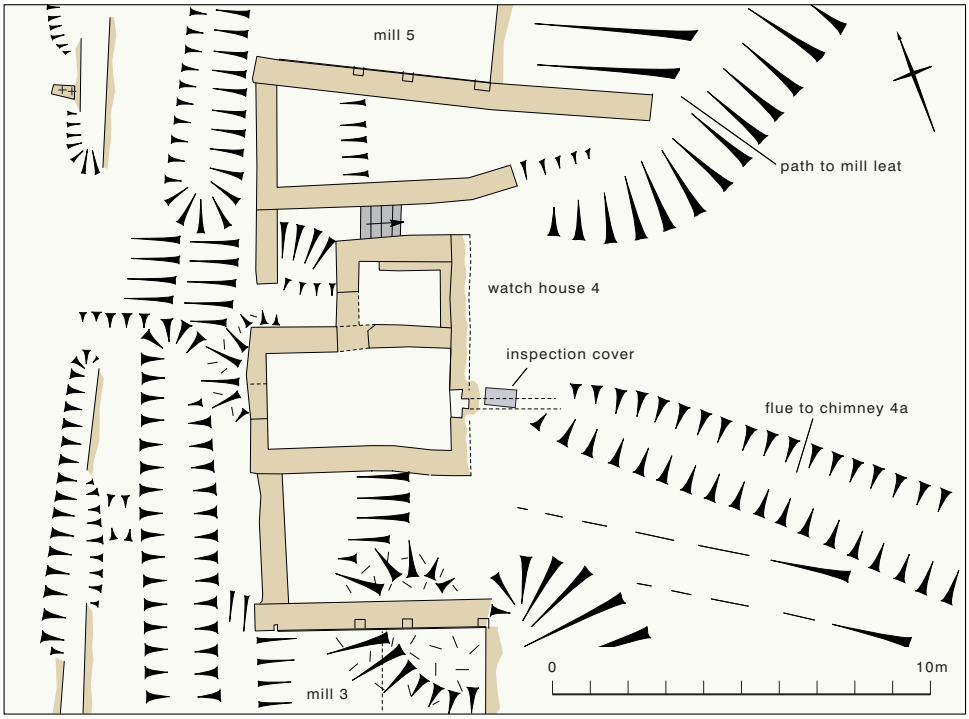

Figure 78: Plan of watch house (building 4)
(Drawn by Tony Berry and Philip Sinton. © English Heritage)

Figure 79: The watch house from the west, showing wall flue and steps to leat (Photograph: Christopher Dunn 2006, © English Heritage)

(Fig 81). A flight of stone steps rises to the immediate left of the watchman's house and provided access to the main mill leat behind the adjacent incorporating mills, presumably for inspection and maintenance purposes and/or control of the flow of water into the culverted leat below the mills. The detached chimney (unlabelled on the factory plans, but for the purpose of the present report numbered building 4a) is also now ruinous, and survives to a height of no more than 1m; it is rubble-built with ashlar quoins (Fig 82).

Figure 80 (above left): Iron pins in the rear wall of the watch house
Figure 81: (above middle): inspection cover at top of wall flue
Figure 82 (above right): The watch-house chimney (building 4a)
(All photographs: Christopher Dunn 2006, © English Heritage)

Men's Changing-Room (building 27)

The earliest record of the existence or location of a dressing-room for the male workforce to change in and out of the protective clothing that they were required to wear during their shifts, is the 1898 factory plan (Fig 5). This plan labels building 27 (the northernmost of three compartments in a building range numbered 25-27, orientated approximately north-south and situated towards the centre of the works) as 'Changing Room'. A range of very similar footprint to building 25-27 existed by 1858 (Fig 137), and the presumption must be that the entire range was erected as part of the first phase of development of the site in 1851-2, and that its northern end was specifically designed to be a changing-room: even though the wearing of protective clothing did not become a legal requirement until 1875, the Wakefield company issued special leather clothing to its Old Sedgwick workforce as early as 1805 (Palmer 1998, 48), and there is no reason to doubt that it continued to do so after the transfer of premises to Gatebeck. Building 27 retained the same function until at least 1923 - and probably right through to the works' closure in 1936 - for the later factory plan (Fig 140) describes it as 'Changing Room and Mess Room'. In the absence of a specified search house, it is likely that the men were searched for contraband whilst changing.

English Heritage located no structural trace of building 27 during investigation.

Women's Changing-Room (building 31)

The earliest record of the location of the female dressing-room is likewise the 1898 factory plan (Fig 5), which labels building 31 as 'Magazine, now used as Cartridge House and Changing-Room'. Because cartridge-packing was chiefly carried out by women, this must be a reference to a female dressing-room. The building can only have been in use as such since 1880, however - the year that Gatebeck commenced production of compressed cartridges; it had originally been built, as the factory plan description makes clear, as a magazine. The building still served as the 'Cartridge Packing House and Changing Room' in 1923 (Fig 140), and probably continued to do so until the works closed in 1936. In the absence of a specified search house, it is likely that the women were searched for contraband in the changing-room.

Building 31 is no longer extant and no trace was found during survey (see Cartridge-Packing House, section 6.2.4 above).

Tailor's Shop (building 35, now 'Millbrook House')

The evidence suggests that in the 19th century the special protective clothes that the workforce were required to wear to carry out their duties were made on-site, for a 'Laboratory and Tailors' Shop' existed in 1881 (Explosives Inspectorate 1881, 10). The building then had the factory number, 34; its location is not given, but is undoubtedly the same as what the 1898 factory plan describes as building 35, 'Store and Tailor's Shop' (see Laboratory, this section below), located close to the works' entrance. The fact that no tailor's shop is named on the 1923 factory plan suggests that protective clothing was later bought in from external suppliers.

Building 35 is now converted to domestic accommodation and called Millbrook House; its architectural form is described under Laboratory (this section below).

Shoemaker's Shop (building 19)

Powder workers were also required to wear special shoes to guard against the ingress of grit into danger buildings which might cause sparks and therefore explosions. The earliest evidence for the existence and location of a specialist on-site cobbler is the appendix listing collateral damage arising from the 1881 press-house explosion, which describes building 19 as a 'Shoemakers' Shop' (Explosives Inspectorate 1881, 10). According to the later factory plans (Figs 5 and 140), building 19 still had this function in 1898 and 1923 (although with the position of the possessive apostrophe moved to suggest only a single shoemaker worked inside). This fact, together with the observation that building 19 existed from at least 1858 (Fig 137), suggests that in contrast to other work attire, special shoes were always made on site.

Cartographic evidence shows that the shoemaker's shop was a very small affair only a few metres square, which stood at the foot of the hillside between the large corning house and mechanics shop, immediately north of the pattern store (building 18). The only description of the building states that it had two windows and a skylight (Explosives Inspectorate 1881, 10). English Heritage found no trace of it during investigation.

Fire-Engine House (building 27a)

The only evidence for the existence of a 'Fire Engine House' at the Low Works is the 1923 factory plan (Fig 140) which identifies building 27a as performing that function. It stood towards the centre of the works at the northern end of the building range numbered 25-27. The fact that the building does not figure on the 1898 factory plan suggests that it was only put up sometime in the first two decades of the 20th century. The identity of its predecessor is unknown, although there would almost certainly have been a fire engine stationed at the works in the 19th century if only because the 1875 Explosives Act made it a legal requirement that danger buildings were hosed down before maintenance and repair. The most likely scenario is that prior to the construction of building 27a, the engine was accommodated in one of the store buildings on site, perhaps even the nearby building 26.

No trace of building 27a was found during survey.

Buildings associated with carpentry, coopering and maintenance

Gunpowder works consumed large quantities of timber. After constructing, fitting out and then maintaining the many buildings, the most obvious need was for planks and staves to make the barrels (and later cartridge boxes) in which powder was transported and sold. Much of the infrastructure and machinery (for example, waterwheels, axles, pit-wheels, bevel and pinion wheels, cog teeth, drive shafts, sieve frames and such like), as well as the wagons, dreys and bogies, was also constructed in timber and needed specialist on-site repair and maintenance. Facilities were also needed for metalworking and blacksmithing. At a basic level, therefore, a gunpowder factory could be expected to contain a sawmill, one or more cooperages and carpenter's shops, and perhaps a smithy; many, including Gatebeck, also possessed other, more specialised, facilities. The location of the Gatebeck cooperage prior to 1880 is unknown; barrels may have been purchased externally in the early years rather than made at the works. After 1880, however, a specialist Cooperage was established on a new site adjacent to the gunpowder works; although not part of the Low Works proper, a brief discussion of the complex (identified as buildings 53 to 75 on the 1923 factory plan) is included below.

Sawmill/Mechanics' Shop (building 20)

Building 20 in the central part of the site is included on the 1858 Ordnance Survey map (Fig 137), and is therefore likely to date from the first phase of development of the Low Works in 1851-2. The 1898 and 1923 factory plans (Figs 5 and 140) both describe it as 'Mechanics Shop', which for ease of description will be the shorthand used for it throughout the present report. It is probable, however, that the building started life as the sawmill referred to in the 1851 bill of tender, only losing that function *circa* 1880 when the company opened its new Cooperage on the site of the former Waithman's bleachery in Gatebeck hamlet (section 4.2 above; this section below); it had certainly ceased being the sawmill by 1881 for it is referred to as 'Millwrights Shop' in that year (Explosives Inspectorate 1881, 10) – a label consistent with its subsequent description as mechanics' shop. The building faces roughly north-west, but is discussed here as though it faced due north.

The 1858 map depicts the building as of masonry construction with two attached ancillary structures: one extending along most of the rear wall, the other a small projection at the western end of the north front. Both ancillary structures are distinguished on the map by a shading convention indicative of construction predominantly of timber or iron. Two buildings to the immediate west and north-west (numbered 100 and 101 for the purposes of the present report, see Figs 130-1 and section 6.2.7 below) are likewise depicted as of timber or iron, and were probably associated timber stores. All these non-masonry additions and structures had disappeared by the time of the 1896 map (Fig 138), by which time a small building had been constructed against the east gable wall of the mechanics shop, infilling the space between it and the stables (building 21) to the east. The roof of this infill building prevented access to the original first-floor taking-in doorway of the mechanics' shop and a window on the north front of the latter was adapted to serve in its place (see below). It is likely that all these structural alterations occurred at the same time as, or shortly after, building 20 ceased to be used as a sawmill *circa* 1880.

The ground floor was probably always given over to machine processes; the first floor is likely to have been used primarily for storage, the roof-space wholly so. The narrow space between the rear of the building and the nearby mill leat was formerly a roofed 'shaft alley' containing a line-shaft powered by ring gearing from a waterwheel external to the west gable wall. It is possible that the waterwheel was superseded by some form of engine against the east gable wall. The building was originally four bays long, but the westernmost bay was almost entirely removed in 1965 owing to structural instability and the present grey brick west gable wall constructed, although all three roof trusses were retained. At the time of survey observation was limited internally by storage and access to the upper floors was restricted.

The mechanics' shop (Fig 83) is a gabled building of two storeys – the upper floor noticeably taller than the ground floor – in a severely cut-down Italianate style (Fig 84). It is built of uncoursed limestone rubble with roughly dressed limestone quoins, lintels and sills. The masonry is partially covered by the remains of an ochre-coloured render. The roof is of slate with plain ceramic ridge tiles. To the north and west the building fronts level ground (where the 1896 OS map shows a tramway passing close alongside); to the rear the ground rises but a level gap of *circa* 1.4m, formerly roofed as a lean-to, separates the building from the revetment wall retaining the mill leat (Figs 85 and 105). Water from the leat supplied a short headrace and pentrough turning a wheel housed externally on the former west gable wall. The building originally consisted of four structural bays with

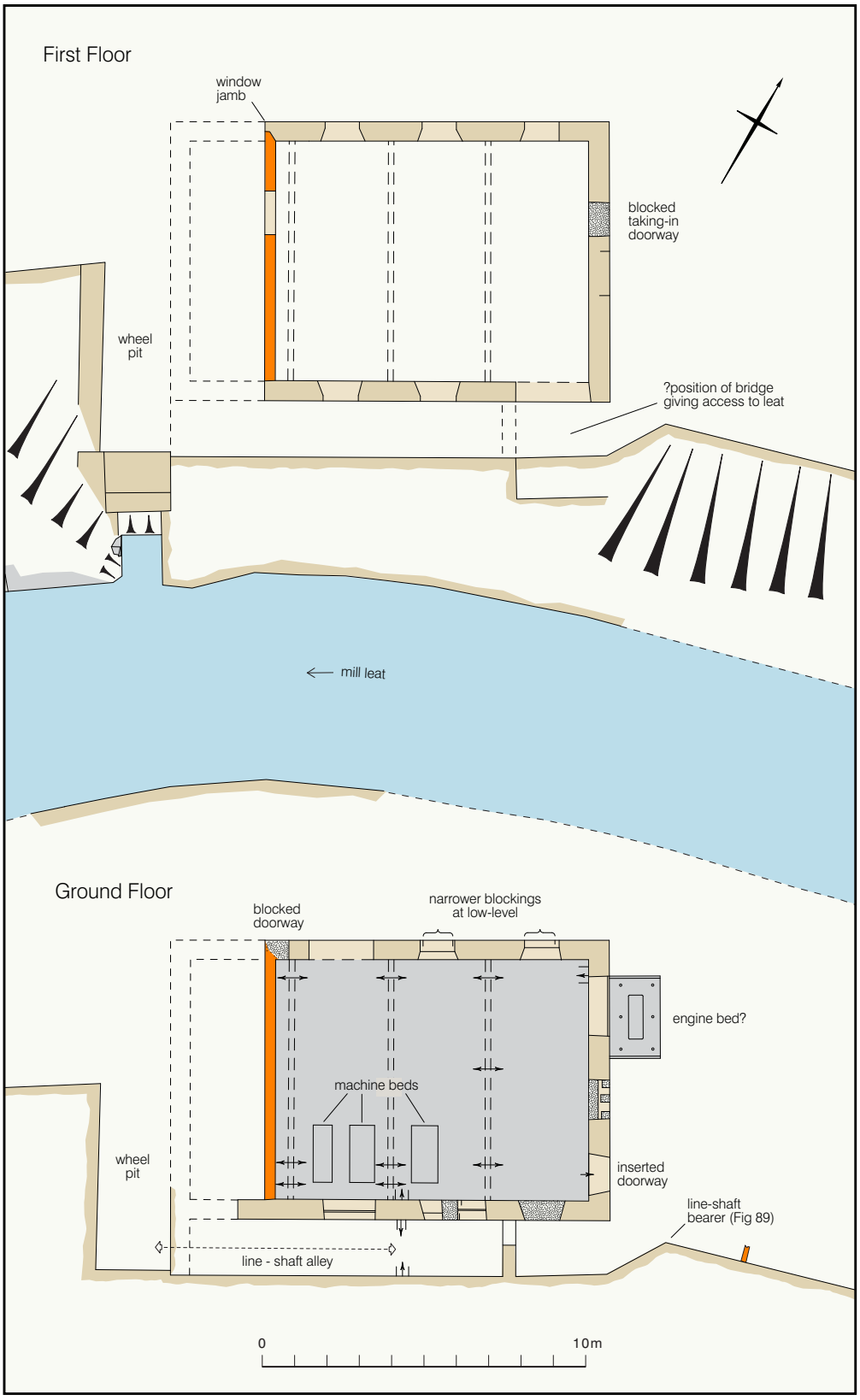

Figure 83: Plan of the sawmill/mechanics' shop (building 20)
(Drawn by Naomi Archer and Philip Sinton. © English Heritage)

Figure 84: The sawmill/mechanics' shop from the west
(Photograph: Christopher Dunn 2005, © English Heritage)

lengths of 3.02m, 2.83m, 2.89m and 3.02m, but has been truncated by nearly a whole bay at its western end and now stops 2.9m short of its original length, leaving a stub of the rear wall projecting beyond the present grey brick west wall. On the front wall the quoined eastern jambs of two openings, one on each floor, confirm that this wall, too, originally extended further west.

On the front elevation a large arched entrance in the third bay from the east opened onto the ground floor; it has a projecting keystone and imposts, and rock-faced voussoirs, all with marginal tooling. Another, narrower, doorway with a lintel opened into the lost westernmost bay, but only the east jamb remains. It is likely that this provided the normal pedestrian access. The fact that it is not aligned beneath the former first-floor window in this bay, but instead is offset to the eastern end of the bay, suggests that it respected a feature against the west gable wall – perhaps a staircase or ladder to the first floor – but subsequent rebuilding has eradicated further evidence for this arrangement. The other two ground-floor bays each contained a window, and there were four first-floor windows (only the eastern jamb of the westernmost remaining). The window openings, of which only two first-floor examples remain unaltered, have timber internal lintels and are appreciably taller on the first floor than on the ground floor.

In the east gable wall there are two blocked doorways, a wide one at ground-floor level close to the north wall and a taking-in doorway, offset slightly less towards the north, at first-floor level. Both have dressed limestone quoins in keeping with other original openings but the ground-floor doorway has a timber lintel outside as well as

Figure 85: Roofed lean-to behind sawmill/mechanics' shop, used as a line-shaft alley (Photograph: Simon Taylor 2006, © English Heritage)

inside (all the other original openings have a stone exterior lintel). It appears to be an original opening that has had its lintel replaced, perhaps because it was widened (possibly to bring a branch of the tramway inside the building prior to the erection of the infill building before 1896, although there is no cartographic evidence to support this theory). It is now a window. The first-floor taking-in doorway has a large timber block above the centre of its roughly dressed limestone lintel indicating the position of a former hoist.

The fenestration of the south elevation, which is partially overshadowed by the revetment retaining the mill leat, has been much altered. On the ground floor, opposite the arched entrance, there was a doorway opening into the rear lean-to, and there were two windows further to the east. The first-floor window openings in the second and third bays from the east retain their original form, but others have been enlarged or lost (Fig 86). The likely exception to the pattern of one window per floor per bay is in the easternmost bay at first-floor level. Here the present large opening looks like a modification of an original taking-in doorway which must have been served (as later) by a bridge giving access to the side of the mill leat. The opening, like the wide ground-floor doorway in the east gable wall, is more strongly quoined than the windows, but this may be a practical expedient to minimise abrasion. The position of this doorway suggests that some materials and items - perhaps for repairs to sluice gates along the mill leat, for example - may have been transported by water either to their final place of use or alternatively between the mechanics' shop and the joiners' shop and smithy (buildings 29 and 30) also sited adjacent to the leat.

Figure 86: The rear (south) elevation of the sawmill/mechanics' shop (Photograph: Christopher Dunn 2006, © English Heritage)

The form of the original west gable wall can only be conjectured. It may have incorporated one or more openings (the inclusion of a double-height window in the rebuilt brick wall suggests a need for light from this quarter), but on the ground floor the presence of the waterwheel and associated tailrace probably precluded openings. The waterwheel-pit is now largely infilled, while the tailrace must have been culverted underground, probably emerging close to the small corning house (Fig 62).

The interior (Fig 87) seems to have consisted of a single undivided space on each of the full storeys with the possible exception of the lost westernmost bay, where evidence is now missing.

All the floor and roof timbers are of softwood. The original transverse first-floor beams survive but closely spaced redundant seatings on their upper surface indicate that the present joists laid across them are replacements. Evidence for an attic floor (partly within the roof-space) consists of a single beam just above the first-floor window heads and directly beneath the second truss from the east. This has more widely spaced joist seatings distributed on each side of two notches close to the centre of its western face. The spacing of the joists suggests lighter floor loadings than on the first floor; the notches (one still occupied by a remnant of upright timber) perhaps indicate the position of a stair.

The roof is supported by three king-post trusses of which one is now close to the rebuilt west gable. Each king-post has an expanded head and a pair of raked struts rising from off-sets at its foot. The king-posts are through-bolted at the base and the feet of the principal rafters are bolted to the tie-beams. There are two sets of trenched purlins. The common rafters give no indication of the damaged skylights referred to (but not located) in Major Ford's report on the 1881 press house explosion (Explosives Inspectorate 1881, 10), and it

Figure 87: Interior view of the rear wall of the sawmill/mechanics' shop, with bearing box shown in detail at inset (Photograph: Simon Taylor 2006, © English Heritage)

is possible that they date from a subsequent re-roofing (the ceramic ridge tiles, which are not original, confirm that some repairs have been carried out, though not necessarily as a result of the explosion). However the form of the roof, with its oversailing rafter feet, is consistent with the date and style of the original building, as are the roof trusses, though they could not be examined at close quarters (one area of the roof is obscured internally by a storage level resting on the central portions of the central and western tie-beams).

Little survives to indicate the arrangement of the waterwheel powering the mechanics' shop, but it is clear that water was taken from the mill leat immediately west of the original west gable wall. Power was transmitted from the wheel via ring gearing that drove a line-shaft (now lost) passing at a little above head height through the formerly roofed-in space between the mechanics' shop and the mill leat. Bevel gears allowed power to be brought into the ground floor of the building immediately east of the central ceiling beam: the cast-iron bearing box remains *in situ* (Fig 87) as does another in the revetment wall opposite. (The bearing boxes are set into openings, the jambs of which incorporate some brick, but this is not unusual in otherwise stone-built buildings of the period). Inside the building the evidence for overhead line-shafting is fragmentary, and mostly confined to bolt-holes for lost iron bearers mounted on the ceiling beams. There was a shaft along the north wall (there is a corresponding small bearing box in the east gable), one down the centre of the building and one along the south wall

(where there is evidence for two – presumably successive – line-shaft positions). From the overhead shafts power would have been transmitted to individual saws, lathes, etc, by belts (a number of machine bases survive). Power does not appear to have been carried up to the first floor. On the front wall in the second bay from the east there is a blocked opening at ground level, bridged by a heavy limestone lintel. Its purpose is unclear, but one possibility is that it allowed power to be brought outside at ground level, for example to power a grindstone for sharpening edge-tools. There is also a blocking beneath the easternmost ground-floor window, but here there is no lintel and the opening appears to be a later alteration.

The remains of some insubstantial roof timbers and a line of mortar flashing can be seen on the exterior of the south wall, indicating that the shaft alley was formerly covered with a lean-to roof. This roof cut across the first-floor windows, suggesting that it was not part of the original design of the sawmill, though skylights may have helped to maintain light levels within the main building as well as illuminating the otherwise poorly lit lean-to. But the evidence of the 1858 map, coming so soon after the building was constructed, suggests that the transmission system, and a structure to house it, were original features of the building. In this connection the Ordnance Survey map convention indicating a timber or iron structure may be significant. In its present ruinous form the lean-to structure extends 10.68m east of the former west gable, amounting to slightly more than three-quarters of the original length of the mechanics' shop (13.6m). These dimensions correspond with the depiction on the 1858 map. But the existing structure is not predominantly of timber or iron, as suggested by the map, since both the revetment forming the south wall, and the short east wall, are of stone. Whilst it is possible that the short west wall was constructed differently, and that this alone accounts for the mapping convention, it is also possible that there was at first a more lightly built, and possibly lower, structure, which was later replaced wholly or largely in stone.

The building has been altered considerably since it was first built, and not all the alterations are fully intelligible. Probably the most significant alterations occurred around 1880 when the original sawmill was adapted to serve as the millwrights'/mechanics' shop and when (probably at the same time) the space between the mechanics' shop and the former stables to the east was infilled. This infill building has since been demolished but the scar of the roof is clearly visible on the east gable wall of the mechanics' shop (Fig 105), with purlin sockets and the remnant of a mortar flashing dividing patches of yellow ochre external render and white interior limewash. The purlin sockets are blocked with grey brick similar to that used in the rebuilt west wall, suggesting that the infill building was removed during the period of Civil Defence use of the site between 1956 and 1968. This roof rendered unusable the original taking-in doorway in the east gable wall, and another was created by lowering the easternmost first-floor window to floor level and inserting a hoist beam above the lintel. The rear taking-in doorway remained in use and was provided with a roofed projection - perhaps at the same time, but certainly by 1896 (Fig 138).

No information has emerged on the function of the infill building, but the insertion of a new doorway linking it with the mechanics' shop suggests that the uses of the two buildings were related. One possible use of the infill building is as a smithy making bespoke castings and forgings required by the mechanics' shop, but against this is the fact that a 'Smithy' (building 30) is named on both the 1898 and 1923 factory plans further


Figure 88 (above left): The engine-bed outside the east gable wall (Photograph: Simon Taylor 2006, © English Heritage)
Figure 89 (above right): Detail of the line-shaft bearer east of the mechanics' shop (Photograph: Christopher Dunn 2008, © English Heritage)

north adjacent to the saltpetre refinery and store. Three surviving features relate to the infill building. To the north it was either open-fronted or incorporated a wide entrance, since the end of a timber lintel remains embedded in the gable wall. Against the gable wall there is a large bed for an engine (Fig 88) or other fixture blocking the earlier wide doorway linking the two buildings. This raises the possibility that latterly the mechanics' shop was powered by an external engine rather than by water, but if so the existing power transmission system seems to have been retained. The same wall also contains a large area of 20th-century brick patching, partly obscuring the first-floor taking-in doorway, and incorporating ventilation slots on the ground floor. The vertical extent of the patching suggests making good after the removal of a flue, but the outline is irregular and there is no sign of an associated chimney. If the waterwheel was retained, power may have been carried beyond the original shaft alley into the rear of the infill building: there is what appears to be a line-shaft bearer (Fig 89) attached to the revetment immediately east of the mechanics' shop, and in line with an opening in the original east wall of the lean-to (Fig 85).

In 1965, towards the end of the period during which the mechanics' shop was being used for Civil Defence purposes, the original west gable wall was found to be unstable and was taken down and replaced by the present brick wall further east (section 4.2 above). Mechanical power supply is likely to have ceased in or by 1936, long before the building was truncated, and there are no bearing boxes in the present west wall. The rebuilding of the gable wall may have been accompanied by the replacement of the upper floor. Between the first and second trusses from the east (in what is now the central bay) two storage levels have been created on the north side of the bay by bolting upright timbers to the tie-beams and ground-floor ceiling beams, creating braced open-work partitions between the uprights and the north wall, and laying new joists and boards across the ceiling beams and at a higher level supported by the partition. The storage area was open-fronted to the south.

Saw Pit or Engineering Store (building 24)

The 1898 factory plan (Fig 5) identifies building 24, standing directly opposite the sawmill/mechanics shop as 'Saw Pit'; it also shows it as comprised of a main, rectangular, block and a much smaller, free-standing, building situated only a metre or so to the south-west. The main block appears to have existed by 1858 (Fig 137), but the free-standing building was probably only added after *circa* 1880 for in 1858 its site was occupied by building 101 (Fig 130). Nothing more is known about the saw pit. By 1923, both parts of the building were reportedly in use as an 'Engineering Store' (Fig 140).

Photographs taken by Ted Patterson in 1979 (one reproduced here as Fig 90) reveal that the main block consisted of stone end walls beneath a slate roof, with the south-east side wall composed of vertical timber panels (some possibly opening as doors) with a series of six-light small-pane windows above; the form of the opposing wall is unknown.

Figure 90: Engineering store (building 24) from the south in 1978/9 (Photograph: Patterson Collection OP04684, © English Heritage.NMR)

Circa 1975, planning permission was granted to convert the building into a wash house and toilet block for the new caravan park (Millbrook Caravan Park 1975, 6), but since the latter is rendered externally and was not inspected internally by English Heritage, it is not known how much, if any, original structure is preserved.

Joiners' Shop (building 29)

Both the 1898 and 1923 factory plans (Figs 5 and 140) describe building 29 as 'Saltpetre Store and Joiners Shop', and show it as a large, almost square building oriented south-west to north-east in line with the mill leat which flowed just inside its south-east wall. The construction date of the building is probably broadly contemporary with the redevelopment of this part of the works around 1864 when the new saltpetre refinery was put up (section 6.2.2 above), for the 1858 OS map (Fig 137) shows that a building of substantially different plan then occupied the site. It has previously been suggested (Saltpetre Stores, section 6.2.2 above) that, functionally, the building was divided along a line passing north-west to south-east through it (although the exact position of that line is unknown), with saltpetre stored south of the line and the joiners' shop occupying areas further north. The fact that the building extended

over the mill leat suggests that the latter may have been used to transport materials and fittings between those elements of it that served as the joiners' shop and other maintenance buildings within the factory (see Mechanics' Shop, this section above, and Water Transport, section 6.2.9 below). In all likelihood, a rectangular block that abutted the south-east wall and connected building 29 to the smithy (building 30, this section below) beyond, was part of the same building, but if so it was a later addition (although one that existed by 1896, see Fig 138) for it is omitted from the draft of the 1898 factory plan (CRO(K) WDB/35/680c) which shows buildings 29 and 30 as separate from each other. For the purposes of this report, this late connecting block will be called the infill building; its relationship to both leat and smithy suggests that it more likely went with the joiners' shop than saltpetre store.

Aerial photographic evidence shows that building 29 was demolished between 1950 and 1970 (NMRC AP library nos. 1073 and 10051), and much of the area is now obscured by static caravans. However, the more easterly parts of the building survive (Fig 91) - principally traces of stone and

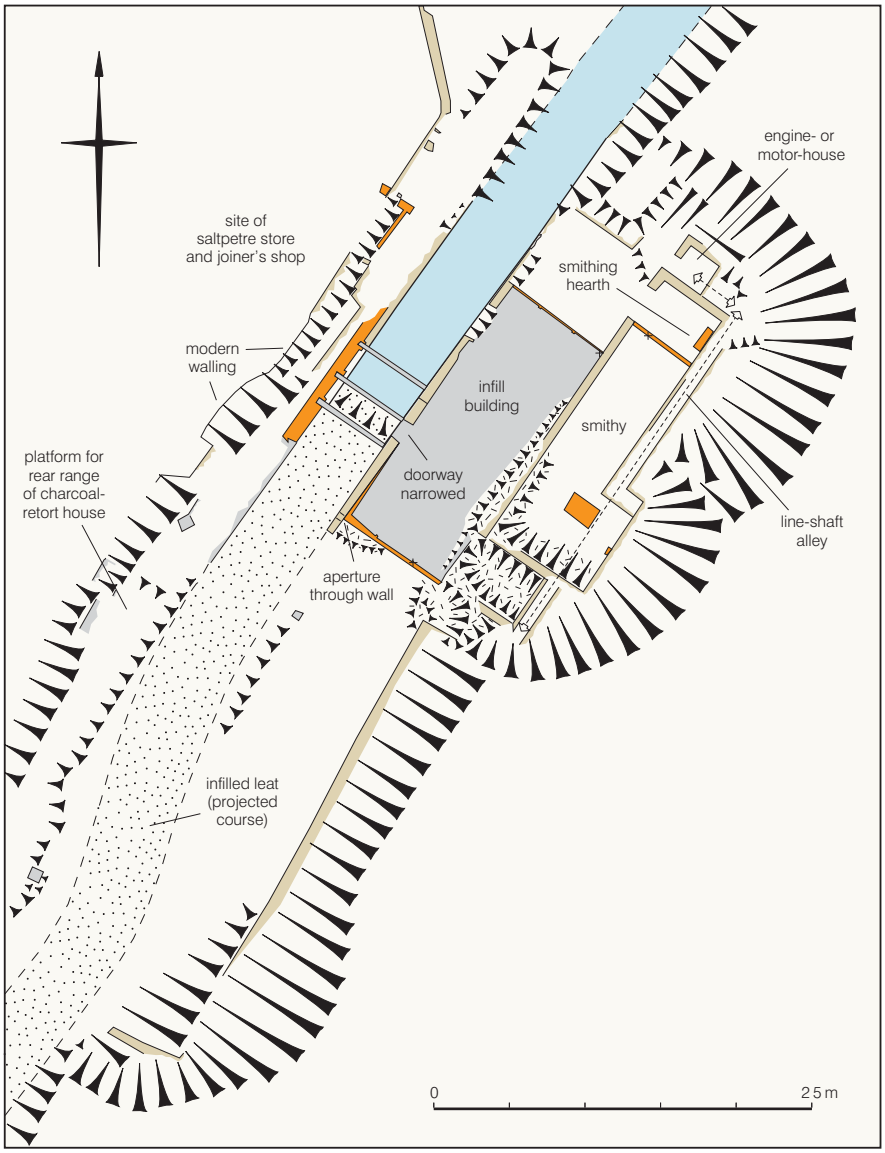

Figure 91: Plan of the joiners' shop, infill building and smithy (buildings 29 and 30) (Drawn by Philip Sinton, © English Heritage)

Figure 92: Joists spanning the mill leat at the joiners' shop
(Photograph: Bob Skingle 2006, DP028090 © English Heritage.NMR)

brick walls at the foot of the leat embankment and adjacent to the leat itself, three large iron joists encased in concrete laid across the leat (Fig 92) and the floor slab of the infill building (Fig 93). Of

Fig 93: The infill building between the joiners' shop and smithy, from the south-west
(Photograph: Christopher Dunn 2006, © English Heritage)

these, only the last is described further. The floor slab consists of a brick plinth *circa* 0.6m high on top of which is 0.3m of concrete, laid in three spits (presumably due to the thickness of flooring required, but all representing a single constructional episode) (Fig 94). The side walls of the building were provided by the existing structures to east and west (buildings 29 and 30), but the two end walls appear to have been formed by metal panels (the edge of the concrete is corrugated) bolted to metal bars set into recesses in the concrete floor (Fig 95). The lack of evidence for external steps against either end wall suggests that the building was only accessible from the smithy and adjacent parts of the joiners' shop. Due to the layer of humus and wall tumble that now obscures the floor and weed trees rooting on and around the walls, it was not possible to identify machine bases or other evidence of internal fittings that might shed light on the nature of the tasks carried on inside the building.

Fig 94 (above left): Detail of the north-east end of the floor slab of the infill building
Fig 95 (above right): Detail of wall fastening in floor slab of infill building
(Photographs: Christopher Dunn 2006, © English Heritage)

Smithy (building 30)

Both factory plans (Figs 5 and 140) name building 30, situated on the eastern periphery of the cluster of buildings at the centre of the works, as 'Smithy'. It was constructed sometime between 1858 and 1896 on a platform terraced into the hillside east of the main mill leat (compare Figs 137 and 138). By 1896 it adjoined building 29 to the west, but other map evidence suggests that it was originally free-standing (see Joiners' Shop, this section above). The 1896 map shows it as a rectangular range subdivided into three blocks, of which the central block is the largest. The 1911 map (Fig 139) differs in showing the central block as wider towards the south and the northern block as only extending half the width of the building, but this could represent the correction of errors in the earlier survey rather than alterations to the building's plan.

Much of the smithy is now ruinous with the interior overgrown by weed trees and obscured by collapsed masonry (Fig 96); only the south-eastern (rear) and north-western (end) wall of the central and south blocks, the former built back to earth, survive to anything approaching their original height. The central block evidently comprised two compartments (Fig 91), both most likely entered by doorways facing the leat. Each compartment appears to have been independent of its neighbour, however, for there is no evidence of access between them; nor is there evidence of access between the central block and that to the south which must also have been entered from the east. A brick smithing hearth with stone lintel and small brick flue stands against the rear wall of the northern compartment (Fig 97), opposite the doorway. Much of the floor of

Figure 96: The smithy, looking north-east
(Photograph: Christopher Dunn 2006, © English Heritage)

Figure 97: Smithing hearth within building 30
(Photograph: Bob Skingle 2006, DP028089 © English Heritage.NMR)

the building is masked by humus and tumble, but a brick base is visible lying slightly off-centre in the wider, south end of the southern compartment. A ledge, *circa* 0.82-0.87m wide that runs along the hillside above and behind the rear wall of both the central and southern blocks would appear to be a line-shaft alley distributing power within the building. Motive power probably came from an engine or motor housed in the small northern block, but a fallen tree prevented close inspection of the interior during survey and no evidence was found to suggest what form of power unit was sited here. A series of metal rings in the rear wall of the southern block suggests that it may at one time have been used as a stable.

Pattern Store (building 18)

The two factory plans (Figs 5 and 140) agree in identifying building 18, immediately adjacent to the mill leat embankment between the mechanics' shop and large corning house, as 'Pattern Store'. The name suggests that the building acted as the store for the templates ('patterns') for the multitude of wooden and metal items used at the works, such as wagon wheels, waterwheels, etc, which would have needed replacement and repair on a regular basis. The building is depicted on the 1858 OS map (Fig 137) and was undoubtedly built, therefore, in 1851-2 during the first phase of development of the factory; in addition, it seems to have served the same function throughout the lifetime of the works, for it is referred to as the 'Pattern Shop' as early as 1881 (Explosives Inspectorate 1881, 10) when it is recorded that it sustained damage to its slated roof, to a window in its end wall and to a skylight.

Cartographic evidence shows that the building comprised a main, rectangular block plus a smaller southern outshot. All that is now visible of the main block is the substantial rear, stone wall (Fig 98), built back to earth at the foot of the embankment, plus the low stub of a single-skin brick-built wall returning at right angles from it and defining the building's southern end. The rear wall is a substantial structure, up to *circa* 2.2m high and 0.9m thick at the base but narrowing down to half that towards the top which extends slightly above the embankment behind; the low parapet so formed is pierced by three square sockets, and has indications of additional, open-sided sockets at either end, each set *circa* 2.8m apart, suggesting that three, near regularly spaced, roof joists divided the building up into four bays internally. The area in front of the wall is now obscured by soil build-up, but probing through the soil suggested *in-situ* hard flooring only a short distance below the modern ground surface. A length of much lower, stone walling, now partly obscured or collapsed, that extends the rear wall of the main block southwards would seem to be the rear wall of the outshot; the wall returns westwards after 8.9m as a low stub terminating against the eastern reveal of a window.

Cooperage (buildings 53-75 on the 1923 factory plan)

Wakefield's Cooperage was built in 1880 on the site of the disused Waithman's bleachery, but closed alongside the gunpowder works following the cessation of blackpowder production in 1936. The site was subsequently sold off and redeveloped as an industrial estate (section 4.2 above). Little is known about the development of the Cooperage during the 50 or so years it existed, or the form and function of individual buildings, and the following account is no more than a very brief overview distilled in the main from historic maps and a few surviving photographs.

Figure 98: Rear wall of pattern store (building 18), from the north (Photograph: Christopher Dunn 2005, © English Heritage)

The earliest map depiction of the complex is the draft 1898 factory plan (CRO(K) WDB/35/680c). That plan cannot be dated more closely than 1880-96, but, with the notable exception of two long, narrow buildings at the northern end of the complex (probably timber sheds), it shows a building layout that differs little from the portrayal of Waithman's bleachery on the OS 1858 map (Fig 137). (The draft factory plan depiction is replicated on Fig 132 in the present report). The eastern shed had been demolished by 1896, however, when the OS map was revised (Fig 138), and replaced by another building identical in size and much closer to, and parallel with, the western shed; in addition, a number of new buildings had been added to the former bleachery, and two new open-sided structures erected to the north-east, again almost certainly timber or storage sheds of some kind.

The cartographic evidence also demonstrates that Wakefield's made early improvements to the system of waterwheels and/or turbines powering the complex, for already by the time of the draft factory plan a new weir had been constructed south of that which supplied the original millpond, and a leat dug from it leading directly to the site of the old wheel which must have stood at the southern end of the millpond. The old weir and millpond are still depicted - and were probably still in use, for the short headrace at the southern end of the millpond is shown redirected slightly to the east suggesting it fed a second waterwheel or turbine east of the old - but by 1911 (Fig 139) at least the second wheel was evidently disused for the millpond and much of the channel to it from the topmost weir appears to have been infilled. The 1923 factory plan (Fig 140) names the buildings in the general vicinity of these waterwheels as 'Saw Mill', but unfortunately contains no key giving the functions of the 23 individual buildings making

up the Cooperage complex, even though these are numbered on the body of the plan as buildings 53-75; building 54, however, at the end of the head race at least latterly was in use as a 'Turbine Shed' (Millbrook Caravan Park Company Collection, item 7). Something of the appearance of the complex can be gauged from a photograph in the possession of Brian Gregg (a copy of which exists in the NMR as AA035261), partly reproduced by Tyler (2002, 87 top) who suggests it dates to *circa* 1920. The tall chimney in the photograph existed by 1911 (Fig 139), and suggests that the sawmill may have been powered by steam as well as water.

Other Ancillary Buildings

Foreman's House (building 34, now 'Brook House')

The 1898 factory plan (Fig 5) identifies building 34, located on the north-east side of the entrance road into the works, adjacent to the beck, as 'Foreman's House'. The building had evidently served this function since at least 1881, for the annex to Major Ford's report on the explosion of the 'northern' press house (Explosives Inspectorate 1881, 10) itemises damage sustained by a 'Foreman's House' as 'One pane of glass in each of two windows broken'. Although the building is identified in that report as no.33, the factory numbering system in the 1880s appears to have been slightly different to that in use in 1898 (section 4.2 above), and what was building 33 in 1881 is without doubt the same as that known as building 34 after 1898. There are no earlier documentary references to the function of the building, but its proximity to the entrance with a commanding view of the passage of traffic in and out of the works strongly suggests that it was built specifically as a foreman's house. A datestone that survives in the south-west façade (see below) shows that it was erected as part of the first phase of development of the site in 1851-2. However, by 1923 (Fig 140) the building had become an 'Office', and the foreman apparently now only had an office (building 25, described as unused in 1898), not a house, on site. Building 34 (which is still extant) is a two-storeyed, double-fronted building, but building 25 (which has been demolished) appears to have been but one compartment in a long, single-storey range. Taken together, the evidence suggests that before 1898 the foreman (and his family) lived on site, but had ceased to do so by 1923. An architectural description of building 34 follows below; building 25 is discussed further under offices (this section, below). At the time of survey, building 34 was once again in use as domestic accommodation, now known as Brook House. The following description refers to the building as it was at the time of survey, before modernisation during 2006-8.

Brook House is T-shaped in plan, two storeys high and built of thinly-rendered stone rubble with limestone quoins, lintels and window sills (Fig 99). The gabled roof is slated and has plain grey ridge tiles. The house is double fronted with a three-bay front elevation with a central entrance which has a small open-sided timber porch with king-post gable. The bay above is blind but is occupied by a tablet, which bears the inscription 'IW. 1852', positioned close to the eaves; the two initials must refer to either John Wakefield III (the I denoting a J) or Isaac Wakefield, his uncle. At ground- and first-floor levels the entrance and tablet respectively are flanked by window openings containing sash boxes and hornless, vertically sliding, three-paned sashes. Two-flued chimney stacks rise above each gable end indicating four heated rooms in the body of the house.

Figure 99: The south-west elevation of Brook House (formerly building 34: foreman's house and office) (Photograph: Simon Taylor 2006, © English Heritage)

The north-west elevation of the body of the house is blind except for a right-side, ground-floor window opening with limestone lintel and sill, and sash box with two-pane, vertically sliding, hornless sashes. This window faces directly towards the entrance to the works and the bridge over Peasey Beck and would have enabled the foreman to monitor access to the site from within the house. (Buildings known or believed to have been the manager's or foreman's house at both the Blackbeck and Lowwood factories occupied a similarly commanding position viz à viz those works (Dunn *et al* 2004, 127; Jecock *et al* 2005, 194, 212)). The rear wing has, on this side, a single visible window opening at first-floor level, with three-light sliding sashes like those to the front. The ground floor is obscured by a stone-rubble walled shed with a pitched, slate-covered roof. The south-east elevation of the body of the house is blind but there are single ground- and first-floor window openings, with secondary window frames, in this side of the rear wing.

The main entrance opens onto a small stair hall with doorways containing six-panel doors to the immediate left and right, which lead directly into the two main ground-floor rooms, each of which have walk-in front windows and central fireplaces, with secondary chimney pieces, in the side walls. Much of the joinery in these rooms dates from the 1950s but a recessed dresser in the north-east wall of the south-east room is probably original 1850s' work. The rear wing now contains a modern bathroom and kitchen on the ground floor and there are three bedrooms overall on the first floor, the two front ones retaining original six-panel doors to the stair top.

The modernisation of Brook House during 2006-8 involved the replacement of all the windows, the application of a new layer of thick smooth render which has obscured the formerly visible stone fabric of the house and the refitting of the interior.

Mess Room (buildings ?48 and 27)

According to Tyler (2002, 45), Moss Cottage on the west side of Gatebeck Road opposite the works entrance (Figs 138-9) functioned as the factory's first mess room. It is not at all clear that Wakefield's owned Moss Cottage, however, and it is possible that Tyler has confused it with the unnamed cottage almost directly opposite that did stand within the licensed area (no. 48 on the two factory plans (Figs 5 and 140); see also section 6.2.7 below). The location of the factory's early mess facilities is therefore uncertain, but by 1923 (Fig 140), building 27, the Changing-Room, doubled up as the 'Mess Room'.

Laboratory (building 35, now 'Millbrook House')

In the annex to Major Ford's report on the explosion of the 'northern' press house in 1881 itemising damage sustained by other buildings, building 34 is described as 'Laboratory and Tailors' Shop' (Explosives Inspectorate 1881, 10). On a rough copy of the key for the 1898 factory plan, building 34 is similarly identified as 'Laboratory & Reading Room' (CRO(K) WDB/35/680f). This version of the key is simply entitled 'Reference', but has the added rider '… for figures in black, new References in Green', showing that it should be read in conjunction with a particular, draft copy of the factory plan (CRO(K) WDB/35/680c) on which certain building numbers in black ink have been crossed through and corrections appended in green. From this it is apparent that the building referred to is not that which appears as no. 34 on both the final version of the 1898 and the 1923 factory plans, but rather that numbered 35 on those plans.

Cartographic evidence indicates that building 35 probably belongs to the first phase of development of the factory in 1851-2, for it existed by 1858 (Fig 137). There is no evidence for its function at this early time, but references to it as 'Laboratory' in 1881 and as 'Laboratory and Reading Room' on the draft 1898 factory plan probably indicates its principal use during much of the second half of the 19th century. The evidence is less clear as to what actually went on in that laboratory. Laboratories fulfilled a variety of functions at gunpowder works, including testing the quality of saltpetre and proving the quality of powders produced; it is known that around the end of the 19th century Wakefield's also employed two research scientists to develop a range of safety powders (section 4.2 above), and it is possible, although perhaps unlikely given the proximity of the laboratory to other structures, that that development work was being undertaken in this building. There is no record of a laboratory at Gatebeck after 1898, and building 35 had a varied subsequent documented history as 'Store and Tailor's Shop' in 1898 and as an office in 1923. In the 1970s the building was extended to the south-west and converted into domestic accommodation for the owners of Millbrook Caravan Park, and is now known as Millbrook House.

Although the building (Fig 100) has been extensively remodelled and extended, its appearance prior to conversion is known from photographs (belonging to the residents at the time of survey) taken during the early stages of the work. It was two-storeys

Figure 100: Millbrook House (formerly building 35: laboratory, store and tailor's shop or office), from the north-east
(Photograph: Christopher Dunn 2005, © English Heritage)

high and of roughly coursed stone rubble with a simple gabled roof of king-post roof construction, with iron-strapped collar beams rather than tie beams, covered with slates with a single stone-built two-flued ridge stack at the south-west end. It was three bays long and the south-east elevation had a doorway, with a timber surround and hood on shaped brackets and a four-panelled door with low overlight, on the right side. There were paired ground- and first-floor window openings, with wooden sills containing three-pane, vertically sliding sashes at ground-floor level, and six-pane casements with single, central, upper-hinged sashes at first-floor level. The south-west elevation (now obscured by the modern extension) had narrow rectangular window openings on the right-hand side at ground- and first-floor level with wooden sills and frames with two-pane vertically sliding sashes. The north-east elevation was the same as the south-west elevation with window openings on the left-hand side and an additional rectangular aperture with a wooden sill high in the gable containing a recessed panel perforated with a central diamond opening and four circular openings, bearing traces of plaster. The purpose of this panel is unclear but it might have been a ventilator - perhaps related to the building's early use as a laboratory - or formerly borne a sign board. A small wooden lean-to (since demolished) with a south-east-facing door stood at ground level against the right-hand side of the gable wall, but the date of this structure is unknown. The appearance of the north-west elevation prior to conversion is also unknown.

The remodelling and extension work involved the blocking of the doorway in the south-east elevation and the first-floor window in the north-east elevation, and the replacement of all surviving windows. It is also likely that the fenestration of the north-

west elevation was altered and that the present entrance there was inserted at this time. The building was additionally extended in concrete block to the south-west by two bays with a further new entrance, in the north-east side of a projecting outshot with a catslide roof, on the south-east side of the extension.

Offices (buildings 25, 34, 35 and 36, 'Millbrook Cottage')

The quantity and location of office accommodation at Gatebeck changed with time. The 1898 factory plan (Fig 5) records only a single 'Office', namely building 36, one of the small cluster of buildings at the entrance to the works. As the 1858 OS map (Fig 137) shows a shorter building occupying very much the same site, it is perhaps most likely that this is building 36 which had been extended to the north-east by 1896 (Fig 138). The 1923 factory plan (Fig 140) records building 36 as still in use as an office, but in addition the nearby former foreman's house (building 34) and laboratory/tailor's shop (building 35) were also now serving as office accommodation, with building 25 converted into a separate, on-site 'Foreman's Office'. Only the original office, building 36, is described further below: building 25 has already been discussed in conjunction with the conjoining Men's Changing-Room and buildings 34 and 35 in connection with their earliest recorded function (all this section above).

Building 36 was converted into domestic accommodation during the late 20th century, and is now known as Millbrook Cottage (Fig 101). Heavy render obscures much of the evidence for the earlier pattern of doors and windows, but the building's appearance prior to conversion is partly known from photographs taken during the course of the conversion work.

The present structure is long, single-storeyed and one room deep, is built of stone rubble and has a pitched slate roof. The south-east elevation is six bays long with a gabled entrance in the third bay from the left. Local residents report that this was formerly a garage entrance, inserted in 1966, but since reduced in size, with brick infill, for pedestrian use. The window opening in the sixth bay from the left is smaller than the rest and has quoined jambs, now almost completely concealed beneath render. The rest of the window openings in this elevation are either replacements or insertions and have slate sills. The window in the fifth bay from the left has a blocking beneath it suggesting conversion from a door. The north-east end elevation has a single window, with quoined jambs, on the left side. It has been partially blocked and a smaller light inserted. There is a further blocking on the right side, possibly a former door, and between the two blockings is a round-arched niche with a hinged, iron cover-plate, perhaps a soot box for the single-flued ridge chimney which rises through the roof at this end of the building. The north-west elevation is six bays long with a doorway in the third bay from the left and window openings with slate sills in the others. The fifth bay from the left contains a smaller window which might have been reduced in size or even be a conversion from a door. A single-flued square stone stack rises through the pitch of the roof behind it. There is a soot box in the wall between the first and second bays from the left and although there is no chimney in this position now, it is close to a rise in the ridge line of the roof which indicates the presence of a substantial internal wall which might be the original end wall of the building. Any chimney formerly in this position might have been removed when the building was extended. There is another niche, with an iron-framed entrance, lacking its cover, between the third and fourth bays from the left. It is round-backed, brick-lined and has

Figure 101: Millbrook Cottage (formerly building 36: office) from the north-east (Photograph: Simon Taylor 2006, © English Heritage)

a ceramic pipe rising through the wall from its top. The purpose of this niche is unclear. The south-west elevation has a tall central blocking beneath a lintel, presumably a former window, which was dropped before blocking, with a doorway to its left.

Cycle Shed (building 55)

The 1923 factory plan (Fig 140) depicts a cycle shed (building 55) standing on the west bank of the beck immediately north of the access road to the Low Works. The fact that the number allocated to the shed duplicates that previously allocated to one of the Cooperage buildings (the factory plan is seemingly based on an earlier document that identified all buildings at the Low Works and Cooperage in a single sequence of numbers from 1 to 75, with 1-52 covering the Low Works and 53 to 75 the Cooperage), suggests that the shed had only recently been put up; certainly it post-dates 1911 (Fig 139).

No trace of the shed was located during field investigation.

Stores (buildings 13, 26 and 54)

Between them, the two factory plans (Figs 5 and 140) identify three buildings at the factory which were in use as 'Store[s]' at various dates, namely buildings 13, 26 and 54. Of these, building 13 and 26 have already been reviewed in conjunction with the early combined Press, Corning and Glazing House / Large Corning House (section 6.2.3 above) and Men's Changing Room (this section above), and it is only building 54, described as 'General Store' on the 1923 factory plan, that needs further discussion here.

Building 54 was a late addition to the stock of buildings at the Low Works, for map evidence demonstrates that it was not built until sometime between 1911 and 1923 (compare Figs 139 and 140). It stood on the north side of the entrance road to the factory, between the beck and Brook House. It was demolished some years ago, and replaced by the present 'Millbrook Lodge' which has not been investigated by English Heritage. Nothing is known about the store's form or appearance.

6.2.7 Unidentified Gunpowder Buildings

Unidentified buildings (buildings 100-107)

The 1858 OS map depicts several buildings that had been demolished by 1896 (compare Figs 137 and 138), and whose function strictly speaking is therefore unknown. These are identified on Fig 130 in chapter 7 of this report as buildings 100-107. Nothing is known about their appearance, but suggestions have already been made as to the likely function of most, namely: buildings 100, 101 and 104, probably wood, charcoal or sulphur stores (section 6.2.2 above); building 102, possibly stables (section 6.2.9 below); building 105, probably the early saltpetre/sulphur store and/or refinery (section 6.2.2 above); building 106, possibly the early packing house (Dusting, Sizing and Packing Houses and associated buildings, section 6.2.3 above); and building 107, possibly the early stove house (Stove Houses and associated boiler houses, section 6.2.3 above).

Cottage (building 48, now 'Holmleigh')

The two factory plans (Figs 5 and 140) both identify a building on the eastern side of the junction of Gatebeck Road and the access road to the works, as building 48, 'Cottage'. That this cottage definitely lay within the curtilage of the factory and belonged to it, is proven by the thick line labelled 'a' on the 1923 plan denoting the limit of the licensed area. Map evidence shows that the Wakefield company must have erected the cottage sometime between 1858 and 1896 (compare Figs 137 and 138), but when precisely and who lived there is not known. Tyler (2002, 45) states that Moss Cottage, on the opposite side of the road and apparently outside the curtilage of the works, was owned by the company and was in use as a watch house and canteen and rest room; perhaps building 48 is meant instead.

The cottage (Fig 102), now called 'Holmleigh', still exists, but has not been investigated architecturally by English Heritage.

6.2.8 Transport to and from the Works

The Gatebeck factory was well placed for maritime and overland transport links to other parts of the country (Fig 2): it lay only *circa* 6km from the port of Milnthorpe on the Kent estuary, 5km from Milnthorpe station on the Lancaster & Carlisle Railway (part of the newly opened west coast main line between London and Glasgow) and 2km from the Kendal extension of the Lancaster Canal (on which the Wakefield company built a wharf at Crooklands, although the date the Crooklands wharf was constructed is unclear and until it was ready it is likely the company continued to use their existing wharf 3.5km away on the outskirts of Sedgwick village (Jecock and Dunn 2002, 15-16 Fig 5)). Initially,

Figure 102: Holmleigh (formerly building 48: cottage), from the north-west (Photograph: Bob Skingle 2006, DP028092 © English Heritage.NMR)

raw materials and finished gunpowder travelled between the factory and port, station or wharf by horse and cart along the country roads, but from 1876 the factory had a dedicated tram link (the 'Gatebeck Tramway') running to the Crooklands wharf and to Milnthorpe station; this was horse-drawn. The import and export of goods through the port of Milnthorpe largely ceased *circa* 1861 due to the construction (completed 1857) of a railway viaduct across the Kent estuary, which presented both a physical barrier to shipping and caused the navigable channels upstream of the viaduct to silt and change course. According to Tyler (2002, 46), the ports of Arnside and Blackstone Point further down the estuary to some extent replaced Milnthorpe (Fig 2), but it is not clear how much use the Wakefield company made of them; instead, it seems that after the demise of Milnthorpe, supplies of chemicals bound for Gatebeck were regularly offloaded at Glasson Dock instead (Hadfield and Biddle 1970, 425), where a branch of the Lancaster Canal connected with the Lune estuary just south of Lancaster (Fig 1), for onward shipment by canal to Crooklands, and horse and cart or tram bogie thereafter.

Although Gatebeck's sourcing of raw materials has not been researched in detail for the present report, it is likely that between 1852 and 1864 the company procured most of its supplies of potassium nitrate saltpetre at the regular London auctions held by the East India Company. After that date, South American saltpetre may have been purchased instead or as well as the Indian (Bengal) variety due to the introduction of the 'Wakefield process' by which inferior sodium nitrate (N/S) saltpetre was transformed into the superior potassium nitrate (N/P) form (section 4.2 above). Other Cumbrian

gunpowder manufacturers, such as the Lowwood company, imported sulphur from Italy, and it is probable that Wakefield's would have done so, too. Bengal saltpetre may have been transported from London north to Gatebeck by cart or canal, or by ship to Liverpool where it was offloaded onto smaller coastal-trading vessels for onward carriage to Milnthorpe or Glasson Dock; sulphur seems to have been imported through Liverpool and shipped north in similar fashion (Palmer 1998, 15-18; Bingham 1987, 54-5). Until the mid-1860s, Wakefield's manufactured their own charcoal within the factory (section 4.2 above); after that date, charcoal was purchased from local suppliers including, reportedly, Chadwick's Bobbin Mill at Staveley (Tyler 2002, 50). Coppice wood and, later, charcoal were no doubt carted to Gatebeck, although the construction of a new charcoal store (building 55, section 6.2.2 above) at the southern end of the works adjacent to the Gatebeck Tramway between 1911 and 1923, strongly suggests that in the 20th century it was arriving by rail or canal from farther afield. Apart from local orders (termed 'the country trade'), most gunpowder was sold through agents in Liverpool and elsewhere, and therefore travelled similar routes but in reverse.

There were no incorporating mills actually at Gatebeck before 1858-9 (section 4.2 above), and green charges manufactured at the works were transported to, and the ripe charges brought back from, the existing mills at the company's Basingill outstation. Even after 1859, charges still travelled to and fro between Gatebeck and Basingill on a daily basis, for the water power and incorporating capacity available at the latter site was too valuable not to use and the Basingill mills remained open until 1929 (Hunt and Goodall 2002, 12). Transport was again by horse and cart along public roads, probably in covered wagons such as that shown in an early 20th-century photograph reproduced by Tyler (2002, 89 top; a copy also exists in the NMR as AA035262).

Stables existed within the works, where no doubt the horses were kept that worked the Tramway and drew the carts to Basingill and elsewhere. But since horses also propelled tram bogies within the factory, these buildings are described in section 6.2.9 below. No investigation of the course of the Gatebeck Tramway has been made for the present report.

6.2.9 Transport around the Works

The limited evidence for how powder was transported around the factory in the course of manufacture suggests that it was initially moved by road. Around 1875, and certainly by 1881, however, most transport seems to have been undertaken in man- and horse-drawn wagons (frequently called bogies) running on a system of narrow-gauge tram lines. There is circumstantial evidence that limited use of water transport was also made to move items of equipment between construction and repair facilities adjacent to the mill leat.

A number of transport-related buildings - stables and wagon sheds – are described briefly below in conjunction with the internal tramway system.

Road system

By at the latest 1881, Gatebeck had a system of internal tram lines connecting its widely spaced process buildings (this section below), and it is likely that materials and powder were mostly moved around the works in horse-drawn tram bogies. However, for the

first 20-25 years of the factory's life before the network of tram lines had been built, powder under production would have been transported along roads and tracks (as depicted, for example, on the 1858 OS map (Fig 137)), most probably in canvas-covered tubs mounted on hand-pulled wheelbarrows, as recorded at Lowwood (Jecock *et al* 2005, 180) and Elterwater (Tyler 2002, 172 top). Horse-drawn carts may have been employed for the longer journeys, but if so, the horses would have been soft-shod in brass or copper shoes to avoid the risk of striking sparks on the road surface.

The road network must obviously have changed and developed over time as buildings were moved and new ones added. However, there is no indication that the roads were ever surfaced or maintained in any special way to prevent the ingress of dirt or grit into danger buildings – a potential source of sparks and therefore explosions – as is documented for example at Elterwater (Tyler 2002, 176). Wheelbarrows are recorded as still in use at Gatebeck in the 1930s to transfer charges between mixing house and green-charge house (section 6.2.3 above), but it is likely that this was very much the exception by this time.

Water transport

There is slight evidence that the mill leat at Gatebeck may occasionally have been used to transport materials and equipment between buildings. However, unlike at Lowwood, where there is documentary evidence that the main leat was used to move powder between certain process buildings (Jecock *et al* 2005, 181), at Gatebeck the evidence, which is entirely circumstantial, suggests that use of the leat was limited to transferring heavy or bulky pieces of equipment under construction or repair between the sawmill/mechanics' shop and joiners' shop. The evidence consists of a taking-in door at the sawmill/mechanics' shop at first-floor level facing the leat, and the observation that the joiners' shop straddled the leat which would, in theory, have enabled equipment to be loaded or offloaded inside the building (section 6.2.6 above). Given the leat's restricted width and depth, any boat operating on it must have been akin to the flat-bottomed punts in use at the Marsh Works, Faversham (Kent), in the 1930s (www.faversham.org/photogallery.gunpowder.asp).

Tramway system

A network of tramlines existed within the works by 1881, for a tramline is mentioned in the official report into the explosion of the northern press house in that year (Expense Magazine, section 6.2.3 above). However, the date that tracks were first laid is unclear. The Gatebeck Tramway connecting the factory to Crooklands Wharf and Milnthorpe Station was built in 1875 to a gauge of 3 feet 6 inches (1.07m), opening in January 1876 (section 6.2.8 above). According to Tyler, the internal tram network was built to a narrower gauge. If correct, this suggests that the two parts of the system were laid at different times, with the internal lines probably the earlier. Tyler's evidence for different gauges is unconvincing, particularly because there is no evidence on any of the maps for transfer sidings (section 4.2 above), but it is nevertheless still feasible that Gatebeck had an internal tram system by the late 1860s or early 1870s since Wakefield's local competitors were all constructing tram networks around this time. Part of a probable wooden sleeper, apparently *in situ*, was observed during survey *circa* 14.5m south of the glazing house. Its dimensions are *circa* 0.14m wide by at least 1.39m long; such a length would be consistent with a track gauge of 1.07m.

The earliest surviving record of the track plan is the 1896 OS map (Fig 138), which depicts a complex network of lines around the works. However, the present report has found evidence that the map omits parts of the network, namely short spurs out from the expense magazine to the two press houses and possibly another in the vicinity of the mixing house (section 6.2.3 above). Comparison with the 1911 OS map (Fig 139) suggests minor additions and changes were made to the network over the next 15 years, most no doubt intended simply to ease the transfer of materials between buildings, but at least one – the creation of a dedicated spur to the incorporating mills and the shortening of the previous route past the large corning house and glazing house to end at the latter building – was presumably undertaken because of safety considerations (Glazing House, section 6.2.3 above). Although not recorded cartographically, the present investigation has produced evidence that when the small corning house was reconstructed between 1923 and 1931, the spur to the northern press house was extended across the river to replace the existing spur that approached the building from the east (Small Corning House, section 6.2.3 above).

The track was lifted when the works closed, and although a number of rails lie scattered about the works (some upended and stuck into the ground north of boiler house 8 for example, presumably as fence posts) there is little evidence of the permanent way apart from bridge abutments where the lines intersected watercourses. The most impressive of these abutments lie on the spur out to the expense magazine and press houses where it crosses the pre-gunpowder mill leat (Fig 103) and beck, but a number of smaller abutments survive along the banks of the beck within both Millbrook and Gatebeck Caravan Parks.

Figure 103: Bridge abutments on the tram spur to the press houses (Photograph: Christopher Dunn 2006, © English Heritage)

Wagon Sheds (buildings 42 and 46)

The 1898 factory plan (Fig 5) identifies two wagon sheds at Gatebeck: buildings 42 and 46. Building 42 is simply described as 'Wagon Shed', building 46 as 'Covered Wagon Shed'; the reason for the difference in nomenclature is unknown. The descriptions might be interpreted as referring to road carts, but a more likely reading is that both buildings were sheds for tram bogies: certainly the plan shows a tram spur running right up to the southern end wall of building 46 (and presumably continuing inside) while a tramline passes directly in front of building 42. The absence of any indication of a spur from the tramline into the latter building might simply be down to the limitations of the scale of the mapping; alternatively it might suggest that bogies were taken in and out of that building manually. Both buildings were located on the west bank of the beck in a part of the factory that does not seem to have been developed before 1860; building 42 stood opposite the Stove (buildings 37-39), and building 46 opposite the Store Magazine (building 45). If they were erected specifically as sheds for bogies, however, they are unlikely to have been constructed much before 1875 (this section, above). By 1923 (Fig 140), building 42 had been converted into an auxiliary stove house (Stove Reserve, section 6.2.3 above).

The buildings lie within the area now occupied by Gatebeck Caravan Park which was not investigated by English Heritage, and it is not known if any trace survives.

Stables (building 33, now 'September Cottage', and building 21)

The factory plans (Figs 5 and 140) record two 'Stables' at the works: one (building 33) behind what was originally the Foreman's House close to the entrance to the factory, the other (building 21) sited against the revetment wall retaining the main mill leat on the east side of the valley floor. The former no doubt dates from the first phase of development of the works since the building is depicted on the 1858 OS map (Fig 137); the latter is not recorded cartographically until 1896 (Fig 138), and replaced buildings (nos. 102 and 103) of unknown function, one of which may have been a smaller stables.

The rear wing of the Foreman's House (now Brook House, section 6.2.6 above) continues as an L-shaped former stable block (building 33). The stables were apparently still in use in 1898 but are reported as disused by 1923 (Figs 5 and 140). They were converted to domestic use in the second half of the 20th century, and the building (Fig 104), now known as September Cottage, has been heavily altered. Like Brook House, it is two storeys high and built of stone rubble with a gabled, slate-covered roof. Little evidence of the building's original use as stables remains but there is a row of ventilation slits at first-floor level in the north-east elevation, indicating former use for hay storage above, and circular ventilation holes at the tops of the side gables. All that now survives of the other stables (building 21) is the rear (stone) wall built back to earth (Fig 105) and slight traces of the returns of three walls coming off it, presumably the stables' two end walls plus one internal subdivision: of these, the west end wall is built in brick and may be a late rebuild.

Figure 104: September Cottage (formerly building 33: stables), from the north (Photograph: Bob Skingle 2006, DP028045 © English Heritage.NMR)

Figure 105: Rear wall of stables (building 22) and north gable of mechanics' shop showing the scar of the infill building (Photograph: Christopher Dunn 2005, © English Heritage)

6.2.10 Other Features within the Works

Blast Banks and Walls

The incorporating mills and, much later, both mark II corning houses, were all constructed with blast walls as an integral part of their structure (Incorporating Mills and Corning Houses, section 6.2.3 above), but in comparison with other Cumbrian gunpowder factories, the Low Works appears to have had very few free-standing blast walls and banks. The reason(s) for this are not immediately apparent. In part it might be an accident of survival: large swathes of the factory have been redeveloped since the works closed, making it impossible now to know for certain what has been lost without record. But against this, none of the three editions of historic OS mapping (Figs 137-9) depicts banks or short lengths of walling indicative of blast protection in the redeveloped areas. A more likely explanation, therefore, is that danger buildings were generally considered far enough apart and sufficiently shielded by mature trees (it was a recognised fact that tree canopies helped to limit the extent of fall-out of debris, and therefore the risk of explosions communicating to adjacent structures, when process buildings blew up) that additional blast protection was deemed unnecessary, even by the Explosives Inspectorate who after 1875 demanded a considerable increase in the number of walls and banks at other Cumbrian blackpowder factories (for example, Lowwood (Jecock *et al* 2005, 185 and 221)). Gatebeck's good safety record probably had some part to play as well: excluding 'blows' in incorporating mills, the factory experienced only two major explosions - first, in the northern press house in 1881 and second, in the large corning house in 1923 (Appendix I) – which may have led the Explosives Inspectorate to look favourably upon it. However when the large corning house mark I (which was relatively unshielded) did blow up in 1923, the replacement mark II house was completely surrounded by a combination of walls and banks (BW1-4 and BB1). It is probably because of this precedent that when the small corning house was modernised a few years later, it, too, was provided with a free-standing blast wall (BW5) shielding buildings to the north (the internal blast wall was probably deemed sufficient to shield buildings lying to the east, particularly buildings 24 and 25-7, as well as more immediately the adjacent belt-drive alley). There is evidence that by the 1920s and 1930s Gatebeck also had a number of lesser, timber, blast screens, as evidenced by surviving lines of post-supports close to the large corning house mark II (Figs 57 and 141) and cartridge-pressing house 50. All free-standing blast structures are described in conjunction with the buildings they protected (sections 6.2.3 and 6.2.4 above).

Unidentified features

An irregular platform, the floor of which is a maximum of *circa* 14.3m long by 2m wide, has been terraced into the hillside immediately north of the incorporating mills and east of the mill leat (Fig 143). Its function and date are unknown: no trace of wall lines or other structural detail was observed during survey, and the feature is not shown on any historic map or plan. The position adjacent to the leat and close to the mills is suggestive, however, of the site of a steam-boiler house. If so, there would presumably have been some kind of flue-pipe running from it connecting in to the stone-lined flue leading to the detached chimney (building 9a) behind the glazing house. Although no definite trace of such a structure was found, two small delves in the hillside above the glazing house (Fig 142) may mark the positions of supports for it.

6.2.11 Workers' settlements and industrial housing

Endmoor village

Endmoor is situated on the main Kendal to Lancaster road, now part of the modern A65, approximately 10km south of Kendal within the former township and modern civil parish of Preston Richard and the ecclesiastical parish of Heversham. It was an established agricultural settlement well before the development of the Gatebeck Low Gunpowder Works: the place name is recorded as early as 1586 (Smith (ed) 1967, 96). Until the late 19th century its nucleus was a scattered linear settlement of around a dozen houses, including a possible row of farm workers' cottages, an inn and probably a smithy, extending northwards from Endmoor Farm. Its parishioners attended St Patrick's Church which lies a little over 1km to the south of Endmoor Farm on St Gregory's Hill, close to Crooklands and the crossing point of Peasey Beck; the present church was built in 1852, to designs by Sharpe and Paley, replacing an earlier church on the same site dedicated to St Gregory.

Endmoor grew relatively rapidly after 1852 and the establishment of the Gatebeck Gunpowder Works, with parts of three terraces of workers' housing built in the following decade followed by another two by the 1890s and a sixth sometime afterwards. In addition, Enyeat House - since demolished but shown in early photographs to have been a linear-plan house of two storeys plus attics, echoing earlier three-cell hearth passage forms (Sturt *et al* 1990, 16) - was built for Colonel John Weston in 1873 who had come to Endmoor the previous year and was later manager of the gunpowder works (section 4.2 above). As the population of the village increased, so did the provision of services: a school was built in 1862, and a Workmen's Institute, with meeting rooms and library services, was established later in the century replacing a public house at the junction of Dove Nest Lane and the main road (Sturt *et al* 1990, 19). By 1902 the settlement was also large enough to support a sizeable purpose-built branch of the Kendal Co-operative Society, a store selling both agricultural feeds and groceries.

The 1858 OS map (Fig 137) shows Endmoor much as it was before the coming of the gunpowder works. Endmoor Farm (Fig 106), now a cattle farm, was probably built during the late 18th or early 19th century. It consists of a two-storeyed, three-cell linear-plan farmhouse, built of random stone rubble, with rough-dressed stone quoins to the corners and to the three chimney stacks, each of which contains two flues, with a slated gabled roof. It stands hard up against the main road, aligned north-east to south-west, and has an entrance in its north-west side with a small gabled porch. Adjoining the farmhouse on its north-east side is a two-storeyed mixed agricultural range, a form of 'bank barn', also built of random stone rubble with heavy stone quoins to the corners and with a gabled and slated roof. Accommodation for cattle, and possibly stabling, was provided on the ground floor with hay and probably grain storage above. This block is set at right angles to the main road, and its north-west end which projects slightly forward of the farmhouse, has a central ground-floor entrance flanked by windows, which probably provides access to a central feeding and manure passage. There are slit vents in the wall at first-floor level and two porch-like lean-to shelters on the north-east side which also has a further ground-floor doorway at the north-west end and a first-floor taking-in door. The farm was substantially enlarged during the 20th century with the addition of extensive new cattle accommodation on the south-east side of the farmyard.

Figure 106: Endmoor Farm
(Photograph: Simon Taylor 2006, © English Heritage)

Figure 107: Front elevations of Bela View and Nos. 21-25 Low Cottages, Endmoor
(Photograph: Simon Taylor 2006, © English Heritage)

Slightly less than 0.5km to the east of Endmoor Farm lies Challon Hall, a six-bay gabled farmhouse, rebuilt in 1760 by Robert Dickinson and subsequently owned by the Wakefield family until 1954 (Sturt *et al* 1990, 15). Opposite Endmoor Farm, on the north-west side of the main road, stood the 'Stag's Head Inn', shown as a rectangular block and labelled on the 1858 OS and shown, but not labelled, on the 1896 OS map (Figs 137 and 138); it has since been demolished. One terrace of two-storeyed, single-fronted houses and a small number of detached, double-fronted, central-entry, rubble-built houses otherwise line the main road to the north-east. At the junction of the main road and Dove Nest Lane stands a low, long, single-storeyed building of random rubble with a single stack at its north-east end. This building is shown on the 1858 OS map and is labelled as 'Smithy' on the 1896 OS map. It has been altered and extended but its early form is consistent with original use as a smithy.

Construction of gunpowder workers' housing in Endmoor began within six years of the opening of the Low Works. The first houses, three terraces (originally called Dove Nest Cottages but later known as Low Cottages) beside Dove Nest Lane were begun between 1852 and 1858 and, although built in phases, were probably completed shortly afterwards. By 1896 two further terraces known as Woodside Terrace and Woodside had been built to the north-west of Low Cottages, on the north-west side of Woodside Road. Another, also called Woodside, was added sometime later.

Dove Nest or Low Cottages

Low Cottages, originally known as Dove Nest Cottages, consist of three terraces on the east side of Dove Nest Lane, aligned roughly parallel with Peasey Beck, and next to a slightly larger and possibly pre-existing house, or perhaps public house (Sturt *et al* 1990, 19), now known as Bela View. There are two southern terraces which stand parallel to each other and a further terrace, slightly offset from them, to the north. Between them is a range of peat houses with a central communal washhouse. The OS map of 1896 (Fig 138) shows an old quarry directly opposite Nos. 1-12 Low Cottages, the last of the three terraces to be built, and it is possible that this was the source of building stone for those houses (the quarry is not shown on the OS map of 1858 (Fig 137)). Dove Nest Lane branches from the main road opposite the former Workmen's Institute (previously the site of a smaller public house) and no doubt originally led south to Challonhall Bridge, but by 1858 a northern branch that perhaps originally was a dead end giving access to Bela View only, had been extended past the cottages as a track or footpath to enter the Gunpowder Works from the south. This arrangement meant that when the houses were completed the inhabitants lived roughly equidistant from the entrance to their place of work and from the village and pub (later replaced by the Workmen's Institute) on the main road. The western end of Dove Nest Lane is now blocked to traffic and a new road, Enyeat Road, built across the former grounds of Enyeat House and lined with late 20th-century houses, connects Dove Nest Lane with the main road.

Bela View

Bela View (Fig 107), named after the River Bela (also called Peasey Beck), is a two-storeyed, double-fronted, central-entry house facing south-west and along the river valley. It is built of random stone rubble and has roughly dressed stone quoins to the

corners. The gabled roof is slated and there are two gable-end ridge stacks each with three flues in line. There is a small gabled porch to the front entrance and the rear elevation, which now overlooks the court between Nos. 21-25 and Nos. 13-20 Low Cottages, has a rear entrance, offset to the left, and has been irregularly re-fenestrated. Bela View is now linked to Nos. 21-25 Low Cottages by a wing at the rear of No. 25 but this clearly butts against the quoined corners at the west end of Bela View, indicating that Bela View is earlier than the terrace with which it now forms an L-shaped range. Ian Tyler (2002, 67) states that the 'end house' of the terraces (Woodbank, Woodside and Low Cottages) at Endmoor was a 'toffee house' and that beneath it and down some steps was a 'pot house' called the 'Rampant Cat'; the toffee house may have been No. 25 Low Cottages, the pot house Bela View.

Nos. 21 – 25 Low Cottages

Nos. 21-25 Low Cottages (Fig 107) is a row of five, two-storeyed, double-fronted houses, one-room deep with central entrances and staircases, built of rendered stone with slated, pitched roofs. Each house has a small front garden, originally separated from the road by a low wall of massive stones, most of which have been lost. No. 25 retains its original 16-pane, hornless hung sash windows and a Gothic-style front door set in a beaded frame with three-light rectangular overlight. Window sills are deep, with a tooled margin and a groove beneath the tooling, although the sills of Nos. 24 and 25 differ slightly from those of Nos. 21-23. A projecting inclined slate band on shaped stone brackets runs along the front and around the south gable of the terrace at first-floor level, with a break between No. 23 and No. 24. No. 25 has south-facing, centrally-positioned windows with bracketed hoods in its gable end at ground and first-floor levels; these are lacking in the opposing gable end of No. 21. Originally, the houses appear to have been blind-backed and lacked back doors and, apart from No. 25, rear wings, but later doors and windows have been inserted into the rear elevations, opening on to a rear courtyard. Cartographic evidence and the discontinuities between Nos. 21-23 and 24-25 indicate that, although built to a single design, this terrace was built in at least two phases with Nos. 24-25, at the south end of the terrace, being the earliest. These two, along with Bela View and a block linking it with No. 25 are shown on the 1858 OS map (Fig 137); the remainder of the terrace appears complete on the 1896 OS map (Fig 138).

Nos. 13 – 20 Low Cottages

Nos. 13-20 Low Cottages is a terrace of eight, single-fronted houses built of random stone rubble, unrendered, with large, roughly shaped stone lintels and sills to windows and doors and slated, pitched roofs. Each house is two rooms deep and has four heated rooms in total, the four flues being contained in a single ridge stack, one per house. The terrace lies to the south and east of Nos. 1-12 and parallel to Nos. 21-25, and faces south-east at the top of a slope overlooking Peasey Beck and the incorporating mills of the Low Works. Each house has a small front garden running down the slope to the east, with stone steps leading up to the front door. The rear elevation of the terrace indicates a difference in plan form between Nos. 13-16 and Nos. 17-20: the former have a symmetrical one-up-one-down window pattern and no back door, while the latter (Fig 108) have an original back door with two full-size and one small window opening on to the rear courtyard. Cartographic evidence, supported by the differences in the rear

elevations, indicates that this terrace was built in at least two phases, as Nos. 17-20, at the south end of the terrace, are first shown on the 1858 OS map (Fig 137) but Nos. 13-16 not depicted until the 1896 OS map (Fig 138).

Nos. 1-12 Low Cottages

Nos. 1-12 Low Cottages (Fig 109) is a terrace of originally ten, two-storeyed, single-fronted houses without rear wings, built of roughly-coursed stone rubble with slated, pitched roofs. There are rock-faced lintels with marginal dressing to the windows and the two end houses each project forward of the rest of the terrace as gable-fronted pavilions with rock-faced, marginally dressed limestone quoins and attic windows in their gable ends. A projecting stone band runs along the front and sides of the front of the terrace at first-floor level, supported on shaped stone brackets positioned either side of each front door where the band projects forward as a hood. The end houses are larger than the mid-terrace houses (which are two rooms deep and each have four heated rooms in total, the four flues being contained in single ridge stacks, one per house) and might have been built for workers holding more senior positions at the Low Works. The roof line and eaves step down between Nos. 6 and 7 and the arrangement of front doors and chimney stacks is reversed in the southern half of the terrace, but there is no evidence to suggest phased construction. The rear elevations mirror the frontages with back doors opposing the front doors. The houses were separated from the lane by front gardens, originally with walls of large limestone blocks, most of which have been removed. The walls are, however, shown in an early 20th-century photograph (Sturt *et al* 1990, 31) which also shows the original hornless, 16-pane hung sash windows now only retained at No. 9.

The terrace is not depicted on the OS map of 1858 but is shown complete on the OS map of 1896 (compare Figs 137 and 138). The projecting pavilions, originally single dwellings, had been subdivided to form two smaller dwellings by 1911 (Fig 139), and both have subsequently been enlarged by the addition of lean-to extensions built onto their ends. Nos. 3-6 also had small gabled porches added to the front doors and some have had small lean-to extensions built onto the rear.

Peat houses and washhouse

A continuous, single-storeyed, south-facing linear block containing what are probably fourteen peat or coal houses, four further units in two rear wings and a central, communal washhouse (for domestic laundry) stands between Nos. 1-12 Low Cottages to the north and Nos. 13-20 and 21-25 Low Cottages to the south (Fig 110). The block is built of random stone rubble, with roughly dressed sandstone quoins to the corners and large irregular stone lintels to the doors. The roof is single-pitched, except over the wings and wash house, and is hidden behind cheek walls which rise as flat-topped parapets at either end. The peat or coal houses are small and rectangular with simple plank doors and no windows (Fig 111). The washhouse is gabled to the rear and extends northwards from the rear of the main block, but is entered from the south. Its doorway, the eighth from the left, is wider than those of the peat or coal houses and has a louvred vent above it: the rear elevation of the washhouse also has a blocked aperture in the gable, which probably once contained a similar louvred vent. It is lit by windows in each side of the projecting section. There is a single ridge chimney towards the rear of the building,

Figure 108: Rear elevations of Nos. 17-20 Low Cottages, Endmoor (Photograph: Simon Taylor 2006, © English Heritage)

Figure 109: Front elevations of Nos. 1-12 Low Cottages, Endmoor (Photograph: Simon Taylor 2006, © English Heritage)

presumably for a copper, and at the time of survey a local resident remembered a boiler and sinks formerly surviving in the washhouse. The washhouse is flanked by two similar but smaller gabled wings, each containing two further peat houses, or possibly privies serving 1-12 Low Cottages with, originally, doors in pairs facing east and west in each wing respectively.

Privies

It is unclear what provision for sanitation originally existed at Low Cottages. It is unlikely that the workers' houses were originally equipped with internal water closets but there were apparently no privies, only the fuel stores and washhouse described above, provided by the builders. Chamber pots and proximity to Peasey Beck might have been initially considered sufficient. However, sometime after 1911 two roughly square privy blocks were built in the yard between Nos. 13-20 and Nos. 21-25, one at either end. The one at the north-east end of the yard contains eight privies in back-to-back fours (Fig 112), and the one at the south-west end of the yard contains six privies in back-to-back threes. Both blocks are built of concrete brick and have pitched slate roofs. They were probably erected in the 1920s or 30s, when concrete brick was often used for cheap industrial and utilitarian buildings, perhaps by ICI following its takeover of the gunpowder works as part of improvements to the workers' welfare facilities mirroring improvements the company was making at Lowwood Gunpowder Works during 1928-9 (Jecock *et al* 2005, 38-9 and 234).

Woodside Road terraces

At least two terraces of gunpowder workers' houses were built on the west side of Woodside Road between 1858 and 1896 (compare Figs 137 and 138). A third terrace was also built but it is unclear when it was completed because, although it is almost identical to the others, it is not shown on either the 1896 or 1911 OS maps or on the 1923 factory plan (Figs 138-40). Since it is unlikely that such a traditional terrace of simple houses would have been built after the First World War it is possible that they were completed before 1911 but omitted from the OS map in error, were built between 1911 and 1914 or, less likely, during the First World War.

Woodside Terrace

Woodside Terrace (Fig 113) is so named on the 1911 OS map (Fig 139) and is a terrace of twelve, single-fronted houses without rear wings, numbered from south to north. It is built of random stone rubble with marginally dressed, rock-faced limestone quoins to the corners and lintels to the doors and windows. The pitched roof is slated and has ceramic roof tiles and gable finials, and the ridge and eaves step down between Nos. 4 and 5 and again between Nos. 8 and 9 as the land falls to the north. Each house is two rooms deep and its plan form is a mirror of its immediate neighbour. With the exceptions of Nos. 1 and 12, which have isolated front doors in their left- and right-most bays respectively, front doors are situated beside each other in pairs. The rear elevations each have a roughly central back door flanked at ground-floor level by a rear kitchen window on one side and by a smaller window, possibly for a water closet or pantry under the stairs, on the other, in alternating sequence between houses. Each house had four heated rooms, two up and two down; single ridge chimney stacks, containing eight flues in line, are shared by each pair of houses.

Figure 110: Rear elevations of peat houses and washhouse at Low Cottages, Endmoor (Photograph: Simon Taylor 2006, © English Heritage)

Figure 111: Front elevations of peat houses and washhouse at Low Cottages, Endmoor (Photograph: Bob Skingle 2006, DP028030 © English Heritage.NMR)

Figure 112: Privies at Low Cottages, Endmoor
(Photograph: Simon Taylor 2006, © English Heritage)

A back lane separates the terrace from three intermediately spaced, east-facing linear blocks, with single-pitched slate roofs, containing what were probably peat or coal houses, possibly interspersed with privies. The south block now contains five units, the middle block seven and the partially demolished north block four. Some of the units have higher roofs, possibly indicating a different original use from their neighbours or that they have been extended upwards at some point. There is also a single, low, stone shed, much broader than the others blocks and lit or ventilated by slit windows at the rear suggesting animal housing as an original use.

Nos. 1-6 Woodside

Nos. 1-6 Woodside (Fig 114) is a terrace of six houses built of random rubble with rock-faced limestone dressings similar to those at Woodside Terrace which it resembles in most other respects. It is, however, set further back from Woodside Road and the houses have long front gardens, front doors originally being reached by a communal footpath immediately in front of the terrace. Decorative bands of limestone are built into the rubble stone of the northern three houses and it is possible that this reflects different phases of building. A back lane separates the terrace from a single, centrally-placed, east-facing block of three former peat or coal houses or possibly privies, with a single-pitched roof and rendered walls (Fig 115).

Nos. 7-12 Woodside

Nos. 7-12 Woodside (Fig 116) does not appear on the 1896 and 1911 OS maps or the 1923 factory plan, but whilst erroneous omission is unlikely, at least by the Ordnance

Figure 113: Front elevations of Woodside Terrace, Endmoor
(Photograph: Bob Skingle 2006, DP028033 © English Heritage.NMR)

Figure 114: Front elevations of Nos. 1-6 Woodside, Endmoor
(Photograph: Bob Skingle 2006, DP028034 © English Heritage.NMR)

Figure 115: Peat houses or privies at Nos. 1-6 Woodside, Endmoor (Photograph: Simon Taylor 2006, © English Heritage)

Figure 116: Front elevations of Nos. 7-12 Woodside, Endmoor (Photograph: Simon Taylor 2006, © English Heritage)

Figure 117: Peat and washhouses behind Nos. 7-12 Woodside, Endmoor (Photograph: Simon Taylor 2006, © English Heritage)

Survey, the nature of the building and the accommodation provided - both of which are largely identical to those at Woodside Terrace and Nos. 1-6 Woodside - would suggest a pre-First World War building date. It is a terrace of six houses and stands a little to the north of Nos. 1-6 Woodside although it has a slightly different orientation and has smooth sandstone rather than rock-faced limestone dressings. The pitched roof is of slate and has plain grey ridge tiles but no gable finials. A back lane separates the terrace from a large, long, single-storeyed, rectangular gabled block containing a washhouse at ether end and fourteen former peat or coal houses arranged in two back-to-back rows of seven (Fig 117). The roof of the block is slated and the outer walls are of random stone rubble, with large but smooth sandstone quoins at the corners. The internal partitions are of red brick. Each peat or coal house has only a simple plank door while each washhouse has an entrance on its south-east side and a window in it north-west wall. The washhouse at the north-east end retains a circular copper, with a wooden lid, over a firebox within a square, red-brick housing set in the north-west corner (Fig 118). Given its size, it is likely that the facilities in this block were originally also used by the residents of Nos. 1-6 Woodside, suggesting that it is also close to it in date.

Other buildings in Endmoor

Workmen's Institute

The former Workmen's Institute (Fig 119) had been established by 1896 (Fig 138) and is situated on the main road through Endmoor, opposite its junction with Dove

Nest Lane. It occupies the site of a public house shown on the 1858 OS map (Fig 137) and, as there was already an inn at Endmoor (The Stag's Head to the south-west) it is possible that the public house was opened to serve the newly arriving gunpowder workers being, as it is, at the end of the workers' route from the factory to the village, as described above. The Workmen's Institute was established sometime between 1873 and 1896 by Colonel John Weston of Enyeat House, supposedly to curb the drinking habits of his workers and improve their education and health (Sturt *et al* 1990, 19). It probably incorporated the fabric of the former public house which was extended by four bays to connect it with an L-shaped range, also shown on the 1858 OS map, a little to the north-east, although this is difficult to verify because the building is covered with thick, smooth render which hides any clear evidence of phasing. The present complete range is two storeys high and eleven bays long overall, with a slated, pitched roof. There is a small, single-storeyed, gabled cottage attached to the south-west end which, when built, probably infilled the gap between the former public house and a smaller detached and forward-set building shown on the 1858 OS map but since demolished, although part of its end wall survives beside the end wall of the cottage which is built up against it and projects forward of its front. The former public house probably survives as the south end of the main range and is three bays long with a main entrance which has an open gabled porch with bench seating on each side, occupying the second bay from the left. The windows are wider than those of the linking block which is three window-bays long and has a further entrance bay at its north-east end. The north-east end of the range is comprised of the earlier L-shaped building which is four bays long, its first two bays beneath the gabled end of a block which extends backwards to form what is now a rear wing. The third bay from the left contains another entrance.

At its height the Workmen's Institute offered a medical fund and a lending library as well as recreational facilities which included a billiard room (*ibid*, 19). The northern part of the range also formerly housed the village post office. The Institute is now, once more, evidently run as a public house and is known as The Club Inn.

Endmoor School

The school at Endmoor (Fig 120) was built in 1862: the date appears in a panel in the gable over the hall block. The building is one and two storeys high and is of random stone rubble, with dressed stone quoins to the corners, in a rough Tudor style. It is an irregular L-shape in plan and has a gabled hall aligned south-east to north-west, with a six-light mullion and transom window, above which is the datestone, at the street end. Two-storeyed, gabled and hipped former classroom wings are attached to the north-east side and there were formerly single-storeyed hipped and gabled classroom wings attached to the south-west side. The school was enlarged in 1970 by the addition of a single-storeyed system-built wing (*ibid*, 26), since demolished, and it finally closed in 1990. Endmoor School has since been converted into two separate dwellings, a process which evidently involved the removal of the original south-west classroom wings from the former hall; it is now known as School House.

Figure 118: Copper in washhouse at Nos. 7-12 Woodside, Endmoor (Photograph: Simon Taylor 2006, © English Heritage)

Figure 119: Workmen's Institute, Endmoor (Photograph: Simon Taylor 2006, © English Heritage)

The Co-operative store

The Co-operative store (Fig 121), a branch of the Kendal Co-operative Society Limited, was built in 1902 in the angle formed by the fork of the main Kendal to Lancaster road and Woodside Road. It is a two-storeyed building of random stone rubble with roughly dressed stone quoins to the corners. The main block has a hipped, slate roof and faces south. The ground floor was formerly occupied by a large shop front, originally with large shop windows flanking a central entrance with a classical entablature - lacking an architrave but with a double-ovolo moulded cornice above a frieze – over all. The first floor was probably used for warehousing and the central bay terminated vertically with a faux timber-framed gablet, now rendered. To the rear is a gabled cross wing with a ground-floor taking-in door in the west end, below another faux timber-framed gable, and living accommodation, also provided in attached and gabled rear and side wings, in the east end. The stores closed in the late 1970s and the building is now used only as domestic accommodation.

Gatebeck hamlet

Gatebeck is a small hamlet lying to the east of the Gatebeck High Works and approximately 1.5 km to the north east of Endmoor. It is a small linear settlement aligned north-south along the contour of the river valley, following the course of a rural lane between Endmoor and Old Hutton on the east side of Peasey Beck, within the civil parish of Preston Patrick. Although the place name contains Scandinavian elements, the settlement is not recorded prior to 1685 (Smith (ed) 1967, 63). To the east the land rises fairly steeply and to the west drops gently down to the Beck.

Nearly all the surviving historic domestic building stock in the hamlet pre-dates the advent of the nearby gunpowder works. Most probably originated as accommodation for foundry workers, linen workers or bleachers: the Waithman family opened a bleachery at Gatebeck sometime between 1826 and 1841 on the site of an earlier foundry operated by Messrs Winder (section 4.2 above), and linen manufacture was a significant industry in the wider area during the first half of the 19th century. Almost the entire population of Gatebeck appears to have been involved in the linen trade by the middle of the 19th century as spinners, reelers or bleachers, many of them Irish immigrants. The 1851 Census shows that six of the then thirteen households in Gatebeck consisted solely of Irish immigrants, mainly spinners; four of the remaining households were made up of various members of the Taylor family, one of whom was described as 'Manufacturer' and others as 'Managing Bleacher', 'bleacher[s]', 'scholar[s]' and 'Schoolmistress' (Cumbria Family History Society 1992, 79-80). The nearby Lancaster Canal provided a direct link to a flax mill on the outskirts of Burton-in-Kendal and to linen weavers in Holme, and it is probable that boat-loads of raw flax and unbleached linen cloth were regularly exchanged for reels of linen yarn and bleached and finished cloth. The production of turned wooden bobbins was also a significant industry in Crooklands and Park End, and the bobbin mills there presumably supplied, among others, the spinners at Gatebeck.

Map evidence shows that three ranges of workers' housing existed at Gatebeck by 1858: one at the south end of the hamlet on the east side of the road (now numbered 1 - 4a Gatebeck), and two more a little to the north on the west side of the road (Nos. 5 - 8 and 9 - 16 Gatebeck respectively); part of Nos. 5 – 8 Gatebeck is labelled as 'School'

Figure 120: Endmoor School
(Photograph: Simon Taylor 2006, © English Heritage)

Figure 121: Co-operative store, Endmoor
(Photograph: Simon Taylor 2006, © English Heritage)

although it had evidently ceased to function as such by 1896 (compare Figs 137 and 138). It is not clear who built this housing or when, and whether it was intended for foundry workers or textile workers (including bleachers), or both; by 1851, however, most of the inhabitants relied on the textile trades for their livelihoods. Many of the houses were occupied at this time by a family and a large number of lodgers: the 1851 Census records that one household then comprised eleven people of whom six were lodgers, all spinners. The expansion of the Gatebeck gunpowder works to the vicinity of Gatebeck village with the leasing of the bleachery site and its conversion into a saw mill and Cooperage in 1880 and the subsequent construction of the High Works in the mid-1890s, evidently meant that housing need in the hamlet increased. Unlike in Endmoor, where gunpowder workers' housing was provided for in the form of purpose-built terraces, accommodation in Gatebeck seems largely to have been provided from the existing building stock. Between 1858 and 1896, however, a terrace of six to eight houses was added at the north end of the hamlet, on the west side of the road, close to the point at which the road forks to Holmescales and Crosslands Farm. This terrace is shown on the 1896 and 1911 OS maps (Figs 138-9) as a row of four houses flanked by end houses, both of which project forward and backwards as pavilions. These end houses are shown subdivided into two dwellings on the maps but this might have been a later alteration to the original plan forms. That the terrace was added to the hamlet's housing stock after 1858 but before 1896 suggests that it was built *circa* 1880 to help meet the housing need of workers at Wakefield's Cooperage, but there is the possibility that it was not built until a decade or so later for workers employed at the High Works, the buildings of which appear on the 1896 OS map although the factory itself did not commence operations until 1898 (section 4.2 above). Comparison with workers' housing in Endmoor erected by Wakefield's might have shown that they were indeed built by the same company, but the Gatebeck terrace was demolished in the second half of the 20th century and another house, No. 7 of Nos. 1 – 7 Fall Beck Cottages, subsequently built on part of the site (Sturt *et al* 1990, 35). However, OS maps do demonstrate that the Gatebeck terrace had a similar footprint to Nos. 1-12 Low Cottages in nearby Endmoor (a terrace built at about the same time for gunpowder workers at the Low Works). No other housing appears to have been built in Gatebeck during the operative life of either the Cooperage or the High Works.

Nos. 1 – 4a Gatebeck

Nos. 1 – 4a Gatebeck (Fig 122) is now a range of five dwellings of two and three storeys built of random stone rubble with pitched slate roofs. At the core of the range is a block of what are now three, three-storeyed dwellings and one, two-storeyed dwelling (Nos. 2 – 4 Gatebeck and No. 4a Gatebeck respectively), apparently one room deep and, in the case of Nos. 2 – 4, originally blind to the front at second-floor level. Nos. 3 and 4 are single fronted and originally had large, roughly dressed stone lintels to single ground- and first-floor windows. The lintels remain *in situ* but both houses have been re-fenestrated. No. 2 is now a double-fronted, central-entry house and has cambered arches with roughly dressed stone voussoirs rather than stone lintels to the first-floor window openings, but might originally have been two, single-fronted houses (like Nos. 3 and 4). The ground-floor windows also have stone voussoirs but have been widened. Nos. 3 and 4 have small gabled stone porches and there is a later timber porch to the front door of No. 2. There is no clear joint between Nos. 3 – 4 Gatebeck and No. 4a which is built of

Figure 122: Front elevations of Nos. 1-4a Gatebeck
(Photograph: Simon Taylor 2006, © English Heritage)

the same type of random stone rubble as Nos. 2 – 4 and has a similar stone lintel to its ground-floor window as Nos. 3 - 4. It has good quoins to its north-west corner, similar to those at the south-west corner of No. 2, and it is likely that it is part of the same build unit as Nos. 2 – 4, which might therefore have originally comprised a terrace of four or five three-storeyed houses. No. 4a is now only two storeys high but the projecting gable end of No. 4 is uneven and rendered, suggesting a patch which might indicate that No. 4a has lost a storey and that the houses originally had a shared loft or garret. A later, lower, two-storeyed, single-bay gabled block butts against the north end of No. 4a. It has good quoins to its north-west corner but they are lacking from the south-west corner; the windows in the front elevation are insertions and entry is via the north end. It now forms one dwelling with No. 4a. At the south end of the range is a further addition, No. 1 Gatebeck, which butts against No. 2. It is a two-storeyed, single-fronted house with large, roughly dressed stone lintels to the windows and door which is on the left side of the frontage, its left jamb formed by the former side of No. 2 where quoins have been removed. The lintel above is also set partly within the wall of No. 2 and above it the corner of No. 2 is quoined. There is a single, two-flued ridge stack at the south end.

The existence of three-storeyed buildings in Gatebeck is unusual. No similar buildings appear in Endmoor and it is likely that they originated in connection with the former bleachery which would suggest a building date in the second quarter of the 19th century. There are no original second-floor windows - either of long workshop or domestic type - in the front elevations of Nos. 2 – 4 Gatebeck so these upper floors might have provided space for the storage of reels of linen thread or for bales of cloth before or after the bleaching process. Alternatively, given the lack of evidence of lifting tackle or taking-in doors, these three-storey buildings might have provided tenement accommodation for workers at the bleachery (or even the earlier foundry), although second-floor windows might be expected if this was the case.

Nos. 5 – 8 Gatebeck

The buildings which now comprise Nos. 5 – 8 Gatebeck are shown on the 1858 OS map (Fig 137) as a linear range of three buildings (the northernmost labelled as 'School') on the west side of the road. The 1896 OS map (Fig 138) shows five units which are roughly analogous with the range that exists today, although there has been some demolition and rebuilding; different divisions are shown on the 1911 OS map (Fig 139), probably reflecting changed patterns of occupation since reversed.

Nos. 5 – 6 Gatebeck

At the south end of the range is a three-bay, two-storeyed house with a central entrance with a small gabled porch (Fig 123). It has a slated, pitched roof with two-flued ridge stacks at each end. It is now thickly covered with even render and the front windows have replacement cement sills. There is a single ground-floor window on the left side of the south gable and a simple lean-to

Figure 123: Front elevations of Nos. 5-6 Gatebeck
(Photograph: Simon Taylor 2006, © English Heritage)

extension with a corrugated iron roof against the north gable. It is now numbered 5 – 6 but No. 6 was probably originally the number of a house which formerly butted to the immediate north but which has been demolished leaving a gap between the present Nos. 5 – 6 and 7 – 8 Gatebeck. The lean-to extension on the north side of Nos. 5 – 6 now partly occupies this gap.

Nos. 7 – 8 Gatebeck

Nos. 7 – 8 Gatebeck (Fig 124) are now a pair of two-storeyed, single-fronted houses with a pitched slate roof with paired front doors, now with a single, gabled, stone porch. There are paired, single-storeyed, rear wings, that of No. 8 extended to full width. The

Figure 124: Front elevations of Nos. 7-8 Gatebeck
(Photograph: Simon Taylor 2006, © English Heritage)

OS map of 1858 (Fig 137) shows these as a single building labelled as 'School' and it is possible that the two cottages were originally a single three-bay house. They had, however, been subdivided by 1896 (Fig 138).

Ancillary building opposite Nos. 5 – 8 Gatebeck

On the opposite side of the road from Nos. 5-8 Gatebeck stands a rectangular, single-storeyed building (Fig 125) of roughly-coursed stone rubble, lacking quoins to the corners but with a pitched slate roof of diminishing courses, and also in existence by 1858 (Fig 137). Its west front has three regularly spaced, full-height openings, the outer two with simple plank doors, the central one part blocked to convert it into a window. The original function of the structure is unclear but it might have been built as a peat house or animal shelter. A large vehicle entrance has subsequently been inserted into its south end and so its last use was probably as a vehicle house, any internal partitioning having been removed to facilitate this.

Nos. 9 – 16 Gatebeck

Nos. 9 – 16 Gatebeck now form a continuous T-shaped range with a large yard in the south-west angle, most of which was in existence in 1858 (Fig 137). The cross of the T (formed by Nos. 9 – 11 and 15 – 16) fronts the road while the stem (formed by the rear wing of No. 15 and by Nos. 12 – 14) extends westwards behind No. 15. Local residents report that the range originated as agricultural buildings although there is no clear evidence for this other than that the houses primarily front the rear yard rather than the road as one would expect.

Figure 125: Ancillary building opposite Nos. 5-8 Gatebeck
(Photograph: Simon Taylor 2006, © English Heritage)

Nos. 9 – 16 Gatebeck

Nos. 9 – 11 are now three, three-storeyed houses (Fig 126) and are shown as three units on the OS map of 1858 (Fig 137). Although heavily rendered they are almost certainly built of stone rubble and have pitched slate roofs. The east elevations each have a single tier of rectangular windows on all floors with stone sills; Nos. 9 and 11 have an additional ground-floor window to the left of each tier. The west elevations (Fig 127) also have single full-height window tiers to each house and ground-floor entrances, now behind secondary porches with single-pitched roofs. Nos. 10 – 11 have latterly been converted into a single dwelling.

No. 15 is a low, two-storeyed house with a three-bay façade to the road (Fig 126): the left-most bay is occupied by an inserted doorway and the next two bays by ground- and first-floor windows. The ground-floor window in the right-most bay is wider than the others and might be a conversion from an earlier doorway as there is what might be a former stone threshold beneath it and the OS map of 1896 (Fig 138) appears to show a porch in this position. Thick render, however, obscures any conclusive evidence. The rear of No. 15 extends westwards as a short wing (Fig 127) and the range continues as Nos. 13 and 12, all now simple, single-fronted, two-storeyed houses with continuous eaves. Nos. 12 and 14, which are contiguous at the west end of the range in spite of non-consecutive numbering, were probably built as a pair at the end of the rear wing of No. 15 and have a slightly higher ridge line and a single central ridge stack. That said, the non-consecutive numbering might indicate that No. 14 was originally part of a larger No. 12 and was renumbered when it was partitioned into a separate dwelling. No. 13 appears originally to have been part of the rear wing of No. 15 or an extension of it, but is now combined with No. 12 to form a single dwelling. Local residents report that Nos. 13 – 14 were formerly in use as a public house.

No. 16 Gatebeck butts against the north end of No. 15 Gatebeck and, unlike the other dwellings in the range, faces eastwards, fronting the road. It appears to have been two dwellings - a two- and a one-bay house - at some point in the past: it is shown as two on both the 1896 and 1911 OS maps (Figs 138-9) but as only one on the 1858 OS map

Figure 126: Front elevations of Nos. 9-11 Gatebeck
(Photograph: Simon Taylor 2006, © English Heritage)

Figure 127: Rear elevations of Nos. 9-11 Gatebeck and south elevations of Nos. 12-14
(Photograph: Simon Taylor 2006, © English Heritage)

(Fig 137). The two-bay house, at the south end, originally had a doorway in the second bay from the left but this has been converted into a window by the insertion of a broad sill and infilling below. Joints, however, are visible on either side of the window, and that to the right is full height. The single-bay house originally faced north and had an entrance at its right-hand end which possible survives as a connecting doorway between the original house and a two-bay extension, with a new front door facing the street at its left end, built onto the north end in the late 20th or early 21st century.

Ancillary block in the yard

The yard into which all the houses, except No. 16, face has a linear rendered block of six peat houses or privies built between 1858 and 1896 (compare Figs 137 and 138) along its western side. The block (Fig 128) is single-storeyed and has a single-pitched roof now covered with corrugated iron. Six doorways with simple plank doors arranged in pairs face eastwards onto the yard. A further ancillary building, shown on both the 1896 and 1911 OS maps (Figs 138-9), formerly butted against the south end of the block but has been demolished leaving the scar of its roof line in the south end wall.

Figure 128: Ancillary block at Nos. 9-16 Gatebeck
(Photograph: Simon Taylor 2006, © English Heritage)

6.3 Phase 3. Features Post-dating the Gunpowder Works

6.3.1 World War II

Fox holes and mortar positions

The survey has identified a considerable number of earthwork features (perhaps as many as 30 in total) that seem best interpreted as fox holes and/or mortar positions, dating to World War II when it is known that the site was requisitioned by the army for military training (section 4.2 above). Most of these features lie on the steep hillside overlooking the eastern side of the factory (Fig 143); a single, more substantial, example has been dug into the top of the mill leat embankment north of the large corning house. They characteristically comprise a shallow, often sub-rectangular, hole with vertical edges, frequently with the spoil thrown out to form a low mound or platform on the downhill side.

1945 aerial photography (eg NMRC AP library no. 3864) suggests military features – foxholes and slit trenches - were also dug on the west bank of the beck within the area now occupied by Gatebeck Caravan Park, but this area was not investigated by English Heritage and it is not known if any survive.

6.3.2 Structures of the 1950s and later

Nissen Hut and toilet blocks

In 1958, Westmorland County Council erected two toilet blocks at the Low Works as part of their use of the site for Civil Defence training exercises (Millbrook Caravan Park 1975, 6): these have been modernised and remain in use today as part of the caravan park's facilities.

A six-bay, 16-foot span Nissen hut with original dormer window (Fig 129) stands between the toilet blocks. Although most likely erected by the County Council at the same time as the toilet facilities, it is possible that it dates instead from the military use of the site in World War II. The building now serves as the caravan park shop.

Figure 129: Nissen hut from the west
(Photograph: Bob Skingle 2006, DP028047 © English Heritage.NMR)

Another wash and toilet block was erected by the caravan park owners in the mid-1970s on the site of gunpowder works' building 24 (Saw Pit and Engineering Store, section 6.2.6 above) at the southern end of the factory.

None of these buildings has been investigated or recorded in detail by English Heritage.

7. DISCUSSION AND CONCLUSIONS

Chapter 4 of this report reviewed the documentary evidence for the industrial development of Gatebeck Low Works, while chapter 6 presented a detailed account of individual buildings and features based on the historical sources and investigative field survey of the visible archaeological and architectural evidence. The present chapter is intended as a commentary on all this evidence, highlighting uncertainties in the data, contradictions between datasets and problem areas requiring further research; it is also a first attempt to set that information into its wider local and national historical context.

7.1 The Pre-Gunpowder Landscape

With the exception of a few lynchets and small structures of uncertain age or function, the only features identified by the present investigation demonstrably earlier than the gunpowder works are a weir and associated leat system at the south-western edge of the survey area (section 4.2 above). The presence of a weir and small millpond here is strong evidence for some form of industrial activity on the Challon Hall estate prior to the advent of gunpowder manufacture, but the site of the mill probably lies beneath the later small stove house, while the original form of much of the leat system has been obscured by its later re-use as the gunpowder works tailrace. English Heritage has traced no historical reference for when the putative early mill operated or what it processed, but Mike Davies-Shiel's claim (personal communication) to have observed bloom slag in the banks of the beck suggests it was a bloomery forge. The mill/bloomery forge was undoubtedly long since redundant, even demolished, when construction work started on the gunpowder works in 1851-2. Access to it seems to have been from the north via a track running south from Gatebeck Farm.

7.2 The Gunpowder Works

7.2.1 The Early Years of the Low Works, *circa* 1851-8 (Fig 130)

It is unclear what John Wakefield III's precise motives were in applying for a licence to manufacture gunpowder at Gatebeck. The lease on the company's existing Larkrigg Mill factory (now often called Old Sedgwick), which the original five partners in the firm that became Wakefield's had taken out in 1768, ran for a maximum of four 21-year terms (section 4.1 above). It was thus due to expire in 1852, and John Wakefield's application to Justices of the Peace in October 1850 to erect new premises 4km away at Gatebeck could be viewed in two ways: to strengthen his hand in his negotiations over a new lease, or to prepare a fall-back position should those negotiations fail. But the Old Sedgwick factory was small and cramped; it also lay on a river (the Kent) whose waters were relatively uncontrolled - there had been problems periodically during the lease with both drought and flood, meaning that at times gunpowder production was halted because of insufficient water in the river or damage to the weir (Jecock and Dunn 2002, 14). In contrast, the proposed Challon Hall/Gatebeck site lay adjacent to the Peasey Beck whose waters were far more effectively regulated by the Killington reservoir, constructed in 1819 to supply water to the Kendal extension of the Lancaster Canal. Furthermore the estate was owned by Wakefield's uncle, Jacob, thus ensuring a landlord likely to be far friendlier and accommodating to the enterprise as a whole. On balance, therefore, it may well be that in 1850 Wakefield had already decided in his own

mind that he was going to transfer operations to Gatebeck, and his negotiation with the Sizergh estate to renew the Old Sedgwick lease was merely a tactic to ensure continuity of production before the new premises could be got ready.

The tender to build the Gatebeck factory was advertised by Wakefield and his then business partner, William Bainbridge, in November 1851, and construction had proceeded far enough for limited production of blackpowder to commence in 1852 (section 4.1 above). The architectural designs were drawn up by Miles Thompson (1808-68), who from about 1825 assisted in the Kendal practice of Francis Webster (1767-1827) and his son, George (1797-1864); Thompson became George Webster's partner in 1845, and within a year or two was in effective sole charge following the latter's retirement (Taylor 2004, 39-41). It is likely that Francis Webster had already acted for the first John Wakefield (John Wakefield III's grandfather) in designing the Old Sedgwick factory's extra incorporating capacity at Basingill in 1790, and may also have been the architect employed to build the rival Lowwood and Elterwater gunpowder works in 1798-9 and 1824 (Taylor 2004, 160-1). Thompson's drawings for Gatebeck do not survive, but the 1858 OS map (on which Fig 130 is based) undoubtedly preserves a plan record of his scheme. Many of the buildings he was responsible for were demolished before 1900 without photographic or other record, but if the few that survive today are at all representative, he worked mostly in the local vernacular tradition (the present Brook House, Millbrook House, Millbrook Cottage and September Cottage situated at the factory entrance are extant examples; sections 6.2.6 and 6.2.9 above), but deployed occasional, fashionable, Italianate, influences (for which the Webster practice is particularly noted) as at the early sawmill (Sawmill/Mechanics' Shop, section 6.2.6 above). It is possible, although unlikely, that Thompson was also involved in the design of the small number of workers' houses that the company had erected in nearby Endmoor village by 1858 (section 6.2.11 above).

The factory was powered by a mill leat that left the river above Gatebeck Farm and followed the contours of the east side of the valley for *circa* 700m before turning a sharp right angle and running downhill to discharge into the tailrace from the pre-gunpowder mill (section 6.2.1 above). As first built this leat powered only four waterwheels, which the present report has suggested were situated at the sawmill, mixing house and two combined houses mentioned in the bill of tender (section 4.2 above). However, the fact that already by 1858 the leat continued for almost 100m beyond the last of these buildings (the more southerly of the combined houses, subsequently the large corning house), suggests that it was constructed with a view to additional buildings requiring power being sited along it at a later date. It is quite possible that the original intention was merely to erect one or more incorporating mills, for the early factory lacked its own incorporating facilities, relying instead on the company's existing stock of incorporating mills at the Basingill outstation which continued in use after Old Sedgwick closed (sections 4.2 and 6.2.8 above). However, if this was the case, those plans seem to have been revised in the foreknowledge of impending legislative change enacted in 1860 (section 7.2.2 below).

The evidence of the 1851 bill of tender and the ICI historian shows conclusively that initially the factory possessed two combined houses: buildings in which two or more stages in the manufacturing process were carried out alongside each other, albeit perhaps in separate compartments. In Gatebeck's case, the combined houses accommodated three processes:

pressing, corning and glazing (section 4.2 above). English Heritage has previously queried (Jecock and Dunn 2002, 24; Jecock *et al* 2005, 100-1 and 207-8) whether blasting powder produced in Cumbria was pressed as a matter of course before the mid-19th century, largely because there is no specific mention of press houses at either Old Sedgwick or, before *circa* 1860, at Lowwood, and it is recorded that Elterwater definitely operated without a press prior to 1829 (Jecock *et al* 2003, 64-5). However, the evidence for combined houses at Gatebeck suggests it is more likely that the so-called corning houses at Old Sedgwick and Lowwood were actually combined houses accommodating presses and probably glazing barrels as well. Such a suggestion certainly helps to make sense of the (previously unexplained) presence of a 'pump trough' at the higher corning house mark II at Lowwood in 1863 (Jecock *et al* 2005, 105-7), for example.

Unanswered questions relating to Gatebeck's layout at this time include the location of the first stove and dusting/packing house: the buildings performing those functions in 1898 did not exist in 1858. Since both were danger buildings, however, and therefore would have been sited well away from other structures, the present report has been able to suggest possible candidates in each case (section 6.2.3 above).

7.2.2 Expansion and compliance with the 1860 Gunpowder Act, 1859-74 (Fig 131)

Old Sedgwick closed and Gatebeck came into full production in 1854 (section 4.1 above), suggesting that work on the factory's initial complement of buildings was largely complete by that date. However, a new burst of building activity that commenced *circa* 1859 saw the expansion of the factory onto the west bank of the Peasey Beck, the erection of the first of an eventual total of eight incorporating mills, the separation of the two combined houses into dedicated press, glazing and corning facilities, and the construction of a new saltpetre refinery, stove, packing house, expense magazine, store magazine and other buildings. Much, if not all, the expansion seems to have been complete by 1864, but for present purposes the phase has been taken as ending in 1874 immediately prior to the next period of major investment (section 7.2.3 below). Because there is no direct cartographic evidence for the layout of the factory in this period, the diagram produced to illustrate developments (Fig 131) is an amalgam based on the known or inferred construction and demolition dates of buildings depicted on the 1858 and 1896 OS maps. Also, because it is uncertain when tramlines were first laid within the works, it has been assumed for phasing purposes that it was not until 1875, coincident with the laying of the Gatebeck Tramway between the factory and Milnthorpe railway station (section 7.2.3 below); the internal tram network is accordingly omitted from Fig 131.

The quantity of powder a factory could produce was largely determined by the number of incorporating mills it possessed, and some of the developments in this phase (such as the construction of extra incorporating capacity) were, as stated by the ICI historian (Imperial Chemical Industries 1929, 338), almost certainly due to an increase in demand for blackpowder; indeed, anecdotally it is reported that the supply of blackpowder in Britain more than doubled during the three years of the Crimean War (1854-6) alone (Jecock *et al* 2005, 214). However, developments were probably also influenced by other factors: improvements in technology (saltpetre refinery); changes in legislation (press houses, glazing house, magazines); or because making these improvements simply had knock-on consequences elsewhere (existing buildings now too close to, or in the way of, new ones, for example).

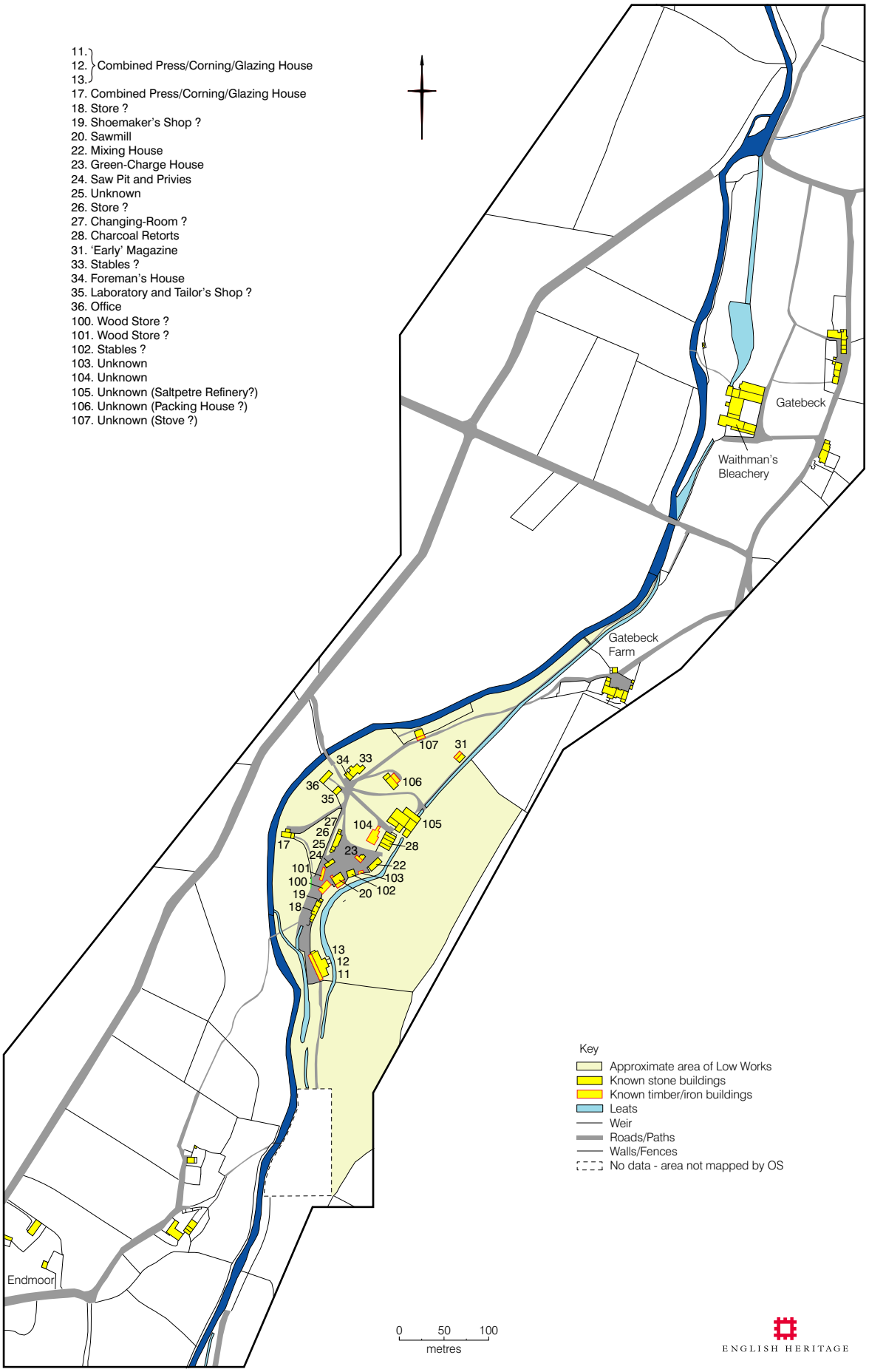

Figure 130: Phase diagram of Gatebeck Gunpowder Works, circa 1851-8 (Drawn by Philip Sinton, © English Heritage)

The period under review opens with the creation of (probably two pairs of) incorporating mills at the southern end of the factory (section 4.2 above). The exact date of these mills is uncertain, but must be either 1858 or 1859: the death of a 'mill-keeper' at Gatebeck is strong evidence that they were operational by early 1859, while the fact that the 1858 OS map clearly shows the main mill leat terminating over 100m north of where the mills were to stand indicates that building work, if it had started, was not yet complete. (Conversely, the mills' omission from the map cannot be taken as evidence that construction was not already underway because the relevant part of the map was never surveyed). Before the building of the Gatebeck mills, green charges were taken by horse and cart to the company's Basingill outstation for incorporation. Even after 1859, charges still travelled to and fro between Gatebeck and Basingill on a daily basis, for the water power and incorporating capacity available at the latter site was too valuable not to use (section 6.2.8 above).

The design of the Low Gatebeck mills was very different to that of the Basingill contingent. The latter were all under-driven, two-storey affairs, with the drive and gearing mechanisms accommodated in stone-built chambers either side of a central waterwheel house, and power transmitted up through the floor of each chamber directly to the central spindle of the edge-runner mills housed in wooden superstructures at first-floor level (Hunt and Goodall 2002, 21-30). In contrast, the Low Gatebeck examples were over-driven, single-storey stone chambers, with power seemingly brought into the chambers laterally and at high level and transferred down to the edge-runner mill spindles (section 6.2.3 above) – a design more reminiscent of the mills used by Wakefield's competitors at Elterwater and Lowwood (Jecock *et al* 2003, 48-64; 2005, 82-98). Under-drive seems to have been the company's preferred design option wherever possible, for when new mills were constructed at Gatebeck High Works in the 1890s, at least four of the eight mills replicated the Basingill blueprint (the design of the other four mills is not known since they were disused by 1923 and demolished without proper record sometime thereafter (Oswald *et al*, in prep)). The reasons why the Basingill design was not replicated at the Low Works is almost certainly due to topographical constraints: whereas the Basingill mills could be readily accessed at both ground- and first-floor level, thus making for ease of delivery of charges to, and removal from, the edge runners, the position of the Low Gatebeck mills relative to other parts of the factory made it impracticable to take charges in and out at anything other than ground level; furthermore, the level of the adjacent Peasey Beck presumably ruled out housing the drive and gearing mechanism in basements beneath the incorporating chambers and thereby the option of under-drive. The Basingill mills were all clearly powered by waterwheels situated in central waterwheel houses. Although the plan of the Gatebeck mills is ostensibly similar, comprising mill chambers either side of what appears to be waterwheel houses, there is no convincing evidence that the houses ever accommodated waterwheels and they seem more likely to have accommodated water-turbines. Even so, the way in which the turbines were supplied with water is not at all clear, and the details of the power-supply arrangements to the incorporating mills remains an area for further research.

There is uncertainty, too, over the exact construction dates of the dedicated press and glazing houses (buildings 14, 16 and 9), although all were erected between 1859 and 1863 (section 4.2 above) and thus date to around the time of the 1860 Gunpowder Act. The ICI historian attributes the separation of the old combined houses to economic factors: namely the growth in demand for blackpowder necessitating larger, improved facilities. But it may be

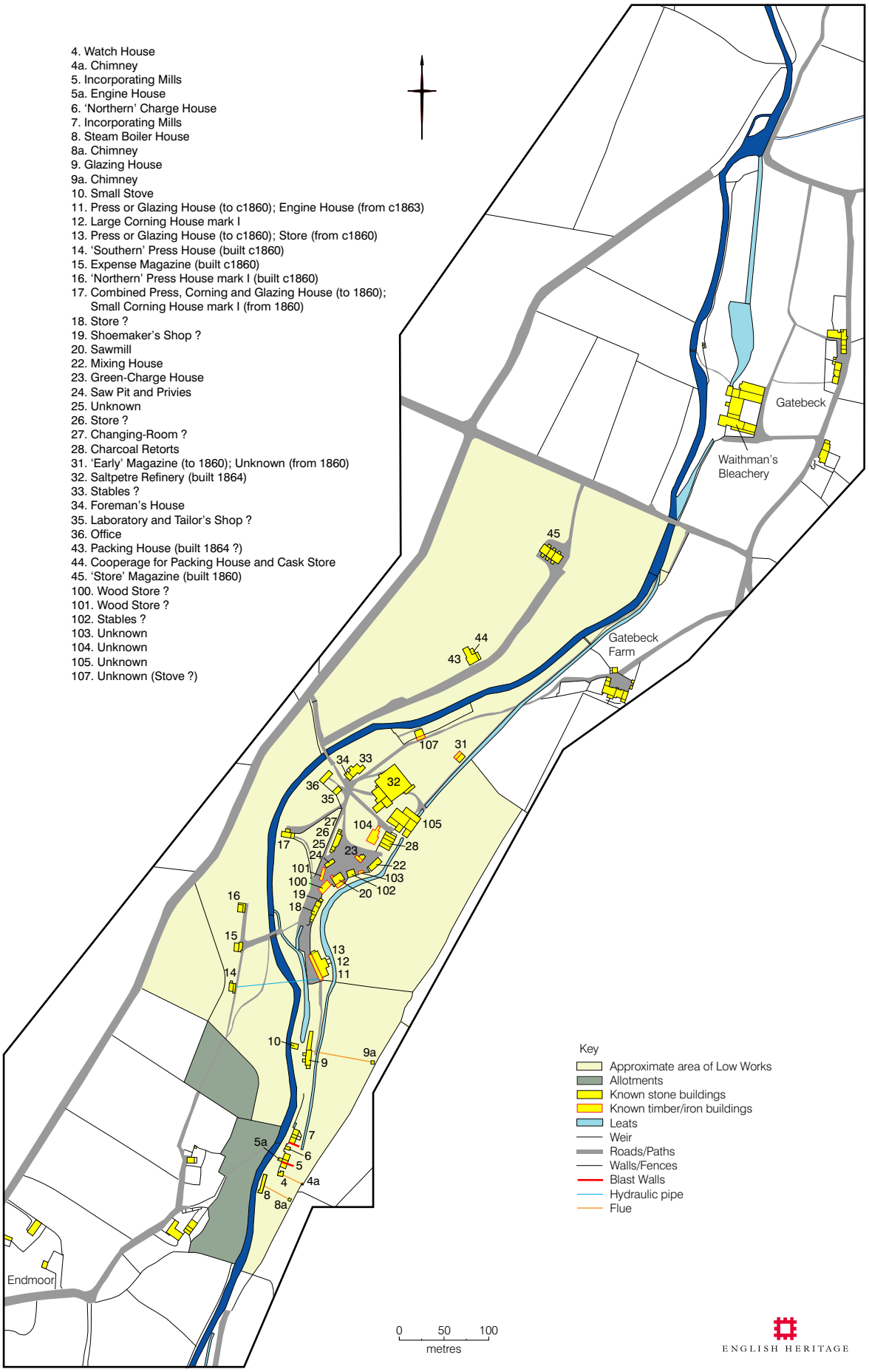

Figure 131: Phase diagram of Gatebeck Gunpowder Works, circa 1859-74 (Drawn by Philip Sinton, © English Heritage)

that the passage of the Act was a contributory factor, since its main provision - restricting the quantity of powder that could be present inside individual process buildings at any one time (Public Statutes General 1860, 616) - probably rendered combined houses uneconomic if not actually illegal. It is unclear how soon the intentions and draft provisions of the Act were known to gunpowder manufacturers, but if flagged some time in advance, factory owners would have had considerable warning of the impending requirement to separate their press, corning and glazing facilities. At Gatebeck, this may explain the apparent construction as early as 1859 of new press houses plus the expense magazine required by the Act, all spaced slightly further apart than the new soon-to-be legal minimum distance (section 6.2.3 above). It may also explain why the mill leat had been extended southwards already by 1858-9 and the incorporating mills erected at the new terminus - to make room at the old terminus for the construction of the dedicated glazing house required by the act.

According to the ICI historian, the company acquired a series of steam engines to generate auxiliary power for process buildings in case their primary motive power source –waterwheels - could not operate; the first such engine, nicknamed 'Garibaldi', was purchased in 1863 (section 4.2 above). Tyler states that this was installed at the engine house (building 11) that one of the disused chambers in the southern combined house had been converted into by 1898, where it drove the pumps for the new press houses. While he may be right, in the absence of the detailed evidence on which the claim is based, the present report has suggested that 'Garibaldi' may have been destined instead either for engine house 5a at the incorporating mills, or, perhaps more likely, the glazing house (section 6.2.3 above), both of which processes are later recorded as also having steam back-up. The lack of any named boiler house associated with the small stove, plus the stove's proximity to the glazing house, strongly suggests that the boiler house for the former was integral with the latter. The implications of this are that small stove and glazing house were designed and built as a single operation in 1863, and that as well as producing steam to heat the stove, the boiler house was intended right from the start to power a small engine to keep the glazing barrels turning in times of drought.

The final major building development of this period was the construction of a replacement saltpetre refinery, opened in 1864, to carry out a novel process (known in time as the Wakefield Process) to manufacture potassium nitrate (N/P) saltpetre from the inferior sodium nitrate (N/S) form, rather than having to refine it from impure N/P saltpetre imported from Bengal (section 4.2 above). The origins of the process have not been traced, but the ICI historian (Imperial Chemical Industries 1929, 338) implies that Wakefield's were the first to introduce it to this country from abroad rather than its inventors. The construction of the new refinery may have necessitated the re-siting of the then packing house (section 6.2.3 above). At very much the same time, the company stopped producing charcoal in-house and started buying in supplies instead (section 4.2 above). Although Gatebeck was one of, if not *the*, first Cumbrian gunpowder manufacturer to move from self-reliance in charcoal manufacture to purchasing supplies on the open market, the switch was followed by all its competitors: Elterwater reportedly ceased charcoal production in 1866 (Marshall and Davies-Shiel 1969, 77), and Lowwood, New Sedgwick and Blackbeck had all followed suit by the early 20th century (Jecock et al 2005, 63-4; Dunn *et al* 2003, 38; 2005, 44). The reason was presumably one of cost.

From the middle of the period under review, there were changes to the management team running the company, with the transfer of effective control of the business to John Wakefield III's son, William Henry, and other family members in the 1860s, the death of

John III in 1866, and the bringing in of John Weston, William Henry's nephew, and others in the 1870s (section 4.2 above). This seems to have coincided with a switch from large-scale re-investment of profits to taking money out of the business for personal benefit. For example, William Henry demolished the family's main residence, Sedgwick House, located near to the Old Sedgwick factory, upon his father's death and replaced it with a fashionable, Gothic, pile by the Lancaster architectural practice of Austin and Paley, completed in 1868 (Tyler 2002, 50 and 53 top). Shortly after being brought in to learn the business, Weston also built a sizeable house, Enyeat (unfortunately since demolished and now known only from a few historic photographs), for himself in Endmoor as befitted his wealth and position. This lack of visible major investment in the decade after 1864 may well have been linked to the marked decline in the price of gunpowder that reportedly followed the end of the American Civil War (Jecock *et al* 2005, 220).

7.2.3 Renewed investment and compliance with the 1875 Explosives Act, 1875-95 (Fig 132)

Demand for blackpowder, and the production of it, reached a peak in Britain in the 1870s but declined thereafter as newer, improved forms of explosives began to challenge gunpowder's position as the explosive of choice (Cocroft 2000, 67). At Gatebeck the 20 years from the middle of the 1870s to 1895 seem to mark a period of renewed investment after the apparent lull of the late 1860s/early 1870s. Interestingly, however, the evidence suggests that the investment was directed as much toward cost-cutting, diversification and the development of new markets as increasing productive output. The period opens with improvements to the factory's transport links with the laying of the Gatebeck Tramway; the same year, the passage of the 1875 Explosives Act imposed new safety obligations on all gunpowder manufacturers but at the same time created business opportunities in cartridge manufacture; in 1880 the company diversified into barrel-making and opened a new cooperage on the site of a redundant bleachery in Gatebeck hamlet capable of handling external as well as internal orders; in 1882 it expanded by taking over the rival Lowwood Gunpowder Company and sometime between 1881 and 1896 built four new incorporating mills at the Low Works; at least parts of the factory had electric lighting by 1888. The period has been taken as ending in 1895, but this is a fairly arbitrary cut-off date, largely chosen because it comes immediately prior to major investment in another effort at diversification that the company was about to make in developing the High Works (section 7.2.4 below), and also because we possess in the 1896 OS map a very good plan record of how the Low Works looked at this time. Indeed, the phase diagram (Fig 132) produced to illustrate this period is based almost entirely on the 1896 map, the only exceptions being the press houses and expense magazine, the positions of which have been taken off the 1911 map because of probable errors in the portrayal of the features in 1896 (Expense Magazine, section 6.2.3 above), and the cooperage, the portrayal of which is based on the draft 1898 factory plan (CRO(K) WDB/35/680c) in order to emphasise the point that the site had been developed and expanded by Wakefield's after acquisition in 1880.

Although the idea of the Gatebeck Tramway connecting the factory to the canal wharf at Crooklands and railway station at Milnthorpe, was floated as early as 1874, the line was not built until 1875 and did not open until January 1876. The gauge was 3 feet 6 inches. According to Tyler, tramlines within the works were built to a narrower gauge. If correct, this raises the possibility that the two parts of the system originated at different dates, with the internal system probably earlier than the line to wharf and station. Although the present investigation has found the case

for different gauges unconvincing (section 4.2 above), it is nevertheless theoretically possible that a network of tram lines did exist within the factory before 1875, for Wakefield's local competitors were all introducing similar systems around this time: Elterwater perhaps as early as 1867 (Tyler 2002, 176), Lowwood in 1869 (Jecock *et al* 2005, 181), New Sedgwick by 1874 (Dunn *et al* 2003, 115), and Blackbeck *circa* 1885 (Dunn *et al* 2005, 115-16). All that can be said for certain given the current evidence, is that Gatebeck's internal tram network existed by 1881 (section 6.2.9 above).

The 1875 Explosives Act brought in a new licensing system for all places where explosives were manufactured, administered by central Government acting through the newly formed Explosives Inspectorate at the Home Office. Existing works were required to apply for a continuing certificate, to obtain which a large-scale plan of the factory had to be submitted to the Inspectorate showing the position and function of each building. This was so that the Inspectorate could check the spacing between buildings, and ensure everything conformed to legal requirements and/or best practice. Provision of blast protection generally halved the permitted distance (Patterson 1986, 12-13; Cocroft 2000, 99-100). Although a few (unspecified) buildings at the Low Works were proscribed by the Inspectorate as a result of the application process, the factory was duly issued with continuing certificate no. 19 in April 1876 (section 4.2 above). Other consequences of the Act were that plans for all new buildings and changes to the physical form or function of existing buildings and structures had to be approved by the Inspectorate by the issuing of amending licences, and that it was now illegal to produce blasting cartridges except on licensed premises. Low Gatebeck received three amending licences in the 5 years after it was awarded its continuing certificate (Explosives Inspectorate 1881, 1). Although their remits are unknown, it is probable that at least two authorised the construction of one or more new buildings producing blasting cartridges and the conversion of another (the old store magazine) into a house where the cartridges could be packed into boxes, since most if not all these new buildings were operational by 1880. It is likely that women were now employed at the factory for the first time, for the gunpowder industry appears to have deemed cartridge-packing a largely female trade.

Besides cartridge manufacture, 1880 also saw the company diversifying into the production of barrels and crates for sale on the open market in addition to its own requirements, and opening a large sawmill and cooperage complex on the site of a former bleachery in Gatebeck hamlet (section 4.2 above). This enabled it to convert its existing sawmill (building 20) at the Low Works into a millwrights' or mechanics' shop (section 6.2.6 above). Since the conversion pre-dates August 1881, it may have been this building that was the subject of the reported third amending licence. A number of wooden buildings depicted by the 1858 OS map close to the sawmill, and which it has been argued were probably timber stores, were no doubt no longer needed and were demolished at this time or soon after.

In July 1881, the works suffered one of its commendably rare fatal accidents when the northern press house blew up. The resultant report by Major Ford, HM Inspector of Explosives, makes it clear that parts of the site were well wooded by this time (Explosives Inspectorate 1881, 1), indicating that Gatebeck Plantation as shown on later maps was already established. It was a recognised fact that tree cover was particularly effective in limiting the fallout of débris and therefore the risk of the explosion communicating to neighbouring process houses when, inevitably, buildings blew up.

The late 1870s/early 1880s saw difficult trading conditions for at least one Cumbrian blackpowder manufacturer – Lowwood (Jecock *et al* 2005, 29) – and in November 1882,

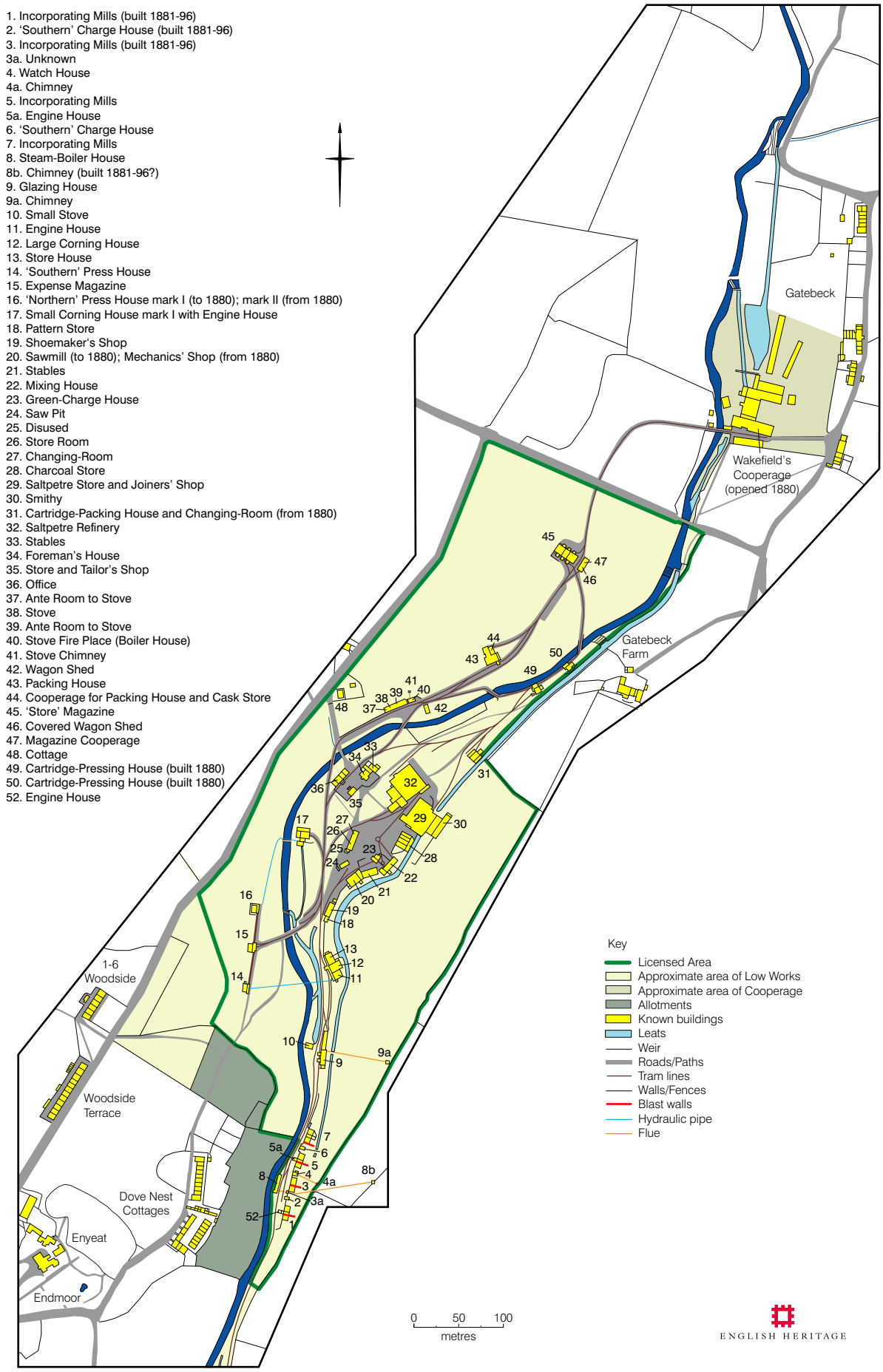

Figure 132: Phase diagram of Gatebeck Gunpowder Works, circa 1875-95 (Drawn by Philip Sinton, © English Heritage)

Wakefield's took the firm over. The precise reasons why Wakefield's agreed to buy Lowwood are not known. The second half of the 19th century and early decades of the 20th were a time of consolidation and rationalisation of the explosives industry nationally (Cocroft 2000, 67), and Wakefield's may have viewed the acquisition as an opportunity to acquire cheap extra productive capacity at the same time as reducing competition. What is very apparent, however, is that the company brought much improved organisation and management to Lowwood, suggesting that it was a well-run affair while Lowwood's difficulties were more the result of internal failures than any general economic downturn (Jecock *et al* 2005, 222-4). Indeed, Wakefield's raised its own productive capacity even further at or shortly after the acquisition, erecting an additional four incorporating mills at Low Gatebeck before 1896 (section 4.2 above). This was a time when other gunpowder producers in Cumbria were similarly installing extra capacity: Blackbeck increased its complement of incorporating mills from seven to eight between 1881 and 1898 (Dunn *et al* 2005, 52), Elterwater from ten to twelve between 1859 and 1897, most probably around 1878-82 (Jecock *et al* 2003, 20-2 and 110), and New Sedgwick from eight to nine between *circa* 1875 and 1889 (Dunn *et al* 2003, 42).

It has been argued in this report that the erection of the new Gatebeck incorporating mills necessitated the re-siting of the chimney to boiler house 8 that provided steam to run the mills' auxiliary engines (section 6.2.3 above). It may also have been the occasion that the new stove complex (buildings 37-40) was constructed on the west bank of the Peasey Beck in order to be able to handle the increase in throughput of powder. A considerable amount of extra workers' housing was put up in both Endmoor and Gatebeck in this phase (section 6.2.11 above), but this may have been primarily to accommodate the large workforce now employed at the Gatebeck Cooperage. The draft of the 1898 factory plan (CRO(K) WDB/35/680c) indicates that tenants at Low Cottages in Endmoor were provided with allotments.

Other recorded investment at the works in this phase includes the advent of electric lighting (section 4.2 above) and the installation of an auxiliary steam engine at the small corning house (section 6.2.3 above) which probably also powered pumps sending hydraulic power to the northern press house. It is not known where and how electricity was generated at this early time, although by 1909-11 (and possibly earlier) it was by a Pelton wheel (or similar device) driven by pressurised water piped down from a reservoir the company built in 1895 to the east of the factory at Fall Beck (section 4.2 above).

By the early 1890s the company was reportedly employing two research scientists to develop a range of safety powders for use in coal mines susceptible to fire damp (section 4.2 above). The employment of research scientists indicates the degree to which the Wakefield company, unlike its Lakeland competitors, was prepared to invest in, and be forward-thinking in developing, new markets as its traditional stock-in-trade – blasting powder – came under increased competition from other forms of explosive. It is a moot point, however, where this research was carried out. A laboratory existed at the Low Works from at least 1881 until 1898 (section 6.2.6 above), but its proximity to other buildings makes it an improbable candidate as the theatre of this research, and it has been suggested in this report that the laboratory was more likely used for checking the quality of saltpetre or the finished powder instead.

7.2.4 New markets and the opening of the High Works, 1896-1903 (Fig 133)

Recorded developments at Gatebeck in the decade or so after 1895 almost entirely concern the construction and opening of the factory's northern extension, the High Works, which is

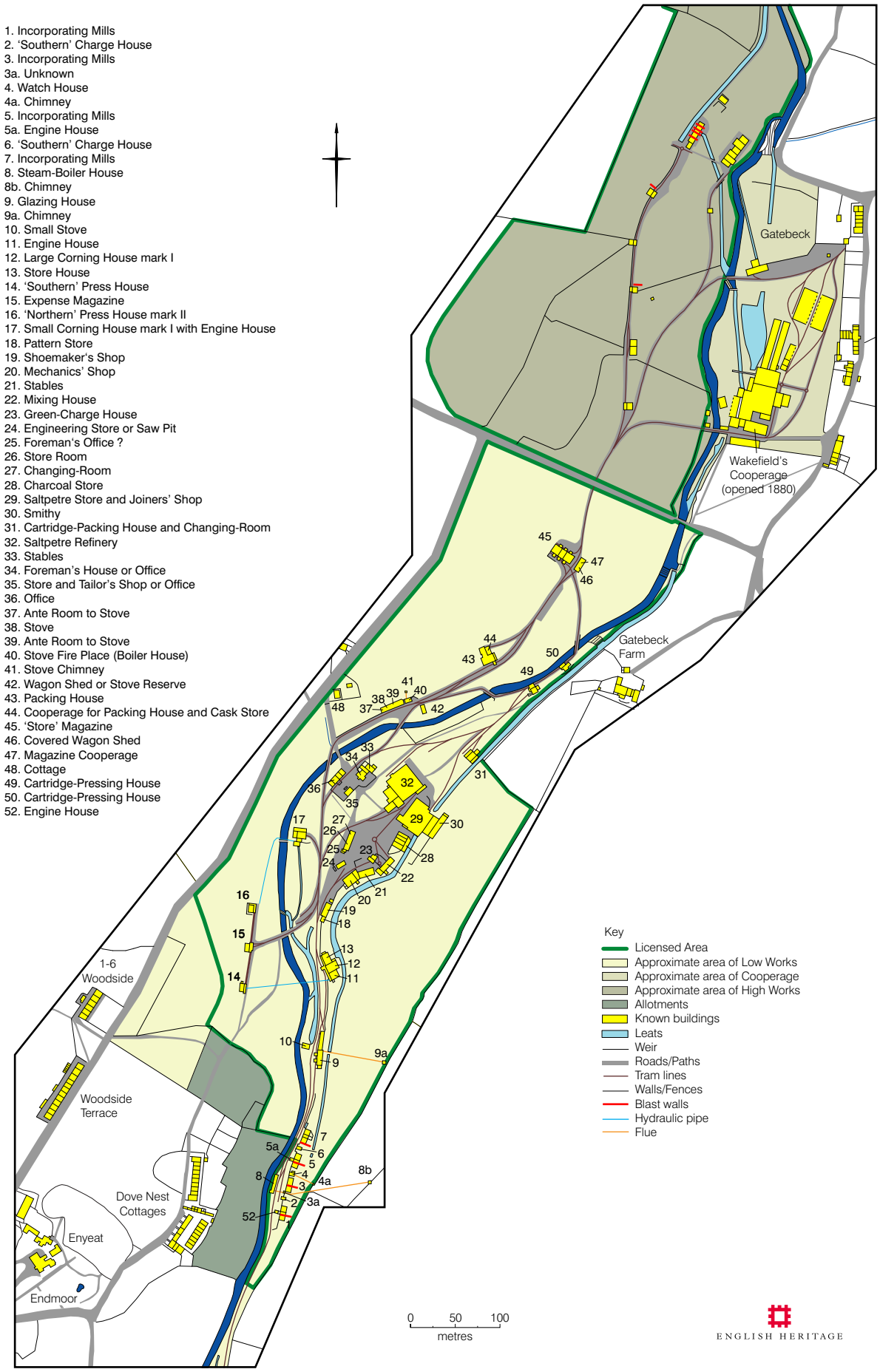

Figure 133: Phase diagram of Gatebeck Gunpowder Works, circa 1896-1903 (Drawn by Philip Sinton, © English Heritage)

beyond the remit of the present report. (For a more considered discussion of the history and evolution of Gatebeck High Works, see Oswald *et al*, in prep). However, in brief, the site was built specifically to manufacture the company's new range of safety powders and was equipped with its own mixing house, incorporating mills, powder press, corning house, glazing house, stove, packing house and magazines, etc. At least to begin with it was a completely separate operational unit run by a subsidiary company, although by the 1930s the specialist powders were no longer being manufactured and the Low and High Works were being managed by the then owners, ICI, as a single entity. The High Works opened in 1898 but had undoubtedly been several years in the planning and construction, for map evidence shows many of the buildings existed by 1896. Indeed, the need to provide a means of powering the High Works powder press may well have been a material factor behind Wakefield's decision to construct the Fall Beck reservoir the previous year (section 4.2 above). For the present report, however, the story of the High Works has been taken as starting in 1896 since this is the date of the earliest map depiction of it (on which Fig 133 is based). The selection of 1903 as the phase's terminal date is somewhat arbitrary, chosen largely because it is the year that Wakefield's adopted limited liability status, but it does have the advantage of enabling differences in the depiction of the High Works on the 1896 and 1911 OS maps to be reflected on separate phase diagrams (compare Fig 134). It is not known how rapidly after 1896 these changes were introduced.

7.2.5 The early 20th century, 1904-17 (Fig 134)

There is very little evidence for events at the Low Works between 1904 and 1917 when Wakefield's combined with other gunpowder manufacturers to form Explosives Trades Ltd (section 4.2 above). For example, the 1911 OS map (on which Fig 134 is largely based) shows that while a number of new buildings had been erected at the High Works since 1896, the Low Works – at least in plan – was virtually unchanged. That is not to say there were no developments at the Low Works, however, for the 1923 factory plan does portray (a few, minor) new buildings and also records that others had undergone a change of function since 1898 or been structurally altered or extended since 1911 (section 4.2 above); the problem lies in knowing which of these changes pre- or post-date 1917. For the purposes of Fig 134, it has been assumed that all structural changes recorded by the 1923 plan post-date the creation of Explosives Trades unless there is evidence to the contrary. This means that the only developments at the Low Works attributable to the phase are small-scale improvements in the field of power supply. For example, although parts of the factory had had electric lighting since at least 1888, this was reportedly extended to the incorporating mills in 1913, two of which were also electrically powered by this date. This may have been in consequence of the company's recorded purchase of two Pelton wheels in 1909 and 1911, one of which was used to generate electricity, and raises the possibility that the installation of an auxiliary electric motor in a new building (no. 9b) associated with the glazing house (recorded on the 1923 factory plan) pre-dates 1917 also; unfortunately, there is no hard evidence that this is so. By 1931 both corning houses also had electric motors on stand-by if the need arose, but the installation of these dates to 1923 or later (section 7.2.6 below).

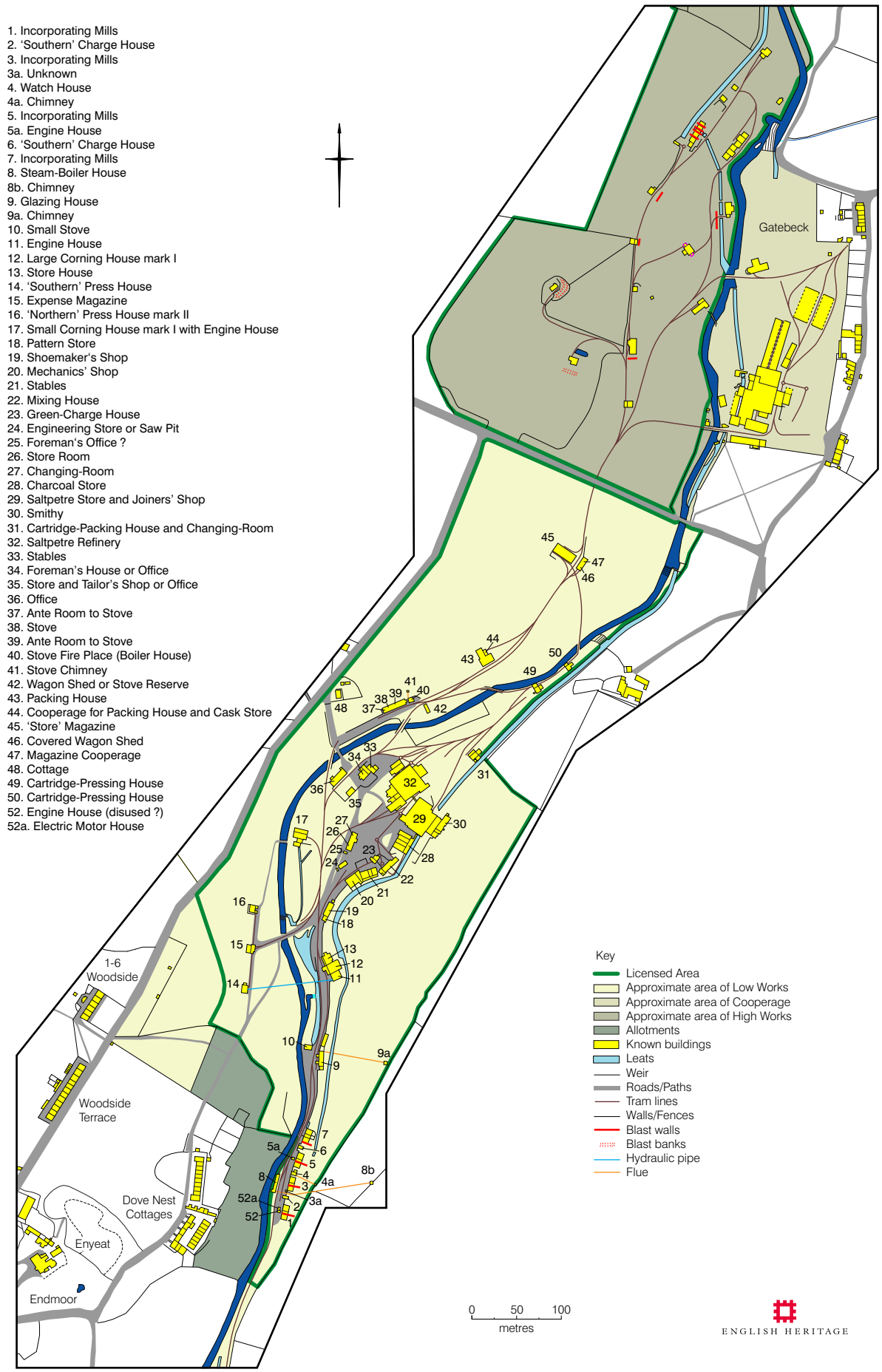

Figure 134: Phase diagram of Gatebeck Gunpowder Works, circa 1904-17 (Drawn by Philip Sinton, © English Heritage)

Off-site during this phase a sixth terrace of workers' housing, nos. 7-12 Woodside, was constructed in Endmoor, suggesting perhaps that the company was still taking on extra workers and needed to provide accommodation for them. The terrace is not depicted on either the 1911 OS map or 1923 factory plan, but it has been argued in this report (section 6.2.11 above) that the traditional style of the housing indicates the terrace was erected prior to the Great War, most probably, therefore, between 1911 and 1914. The omission of the terrace from the 1923 factory plan is probably best explained by the latter plan being based on the pre-War map.

7.2.6 Post-War Difficulties: the formation of Explosives Trades & Nobel Industries Ltd, 1917-26 (Fig 135)

In 1917, the four remaining Cumbrian gunpowder companies merged as part of a new national concern called Explosives Trades Ltd, which in 1920 became Nobel Industries Ltd (section 4.2 above). The merger was in response to overcapacity in the explosives industry generally brought about by the gearing-up of production levels to meet wartime demands. Elsewhere in England, factories voluntarily went into liquidation as part of an agreed programme to address the problem of oversupply - for example Chilworth closed in 1920 (Cocroft and Tuck 2005, 231) - but the process of rationalisation did not directly affect the Cumbrian blackpowder factories until 1928. Before then, in 1926, Nobel Industries became a division of Imperial Chemical Industries (ICI).

There is very little that can meaningfully be said about developments at Low Gatebeck in the 9 years it was under the control of Explosives Trades and Nobel Industries. The 1923 factory plan provides us with a very good record of the layout and function of buildings around the middle of the period (the accompanying phase plan (Fig 135) is accordingly based on that plan, and therefore shows the works as it was in mid-1923 rather than earlier), but otherwise the only reasonably well documented event is the blowing up of the mark I large corning house in May 1923 and the construction of the replacement, mark II, building. English Heritage has been able to demonstrate from detailed recording of the archaeological evidence (section 6.2.3 above) that this mark II house is of very much the same design as others subsequently erected by ICI at the Oare and Marsh Gunpowder Works in Kent in 1926 and at Lowwood in 1928-9 (Jecock *et al* 2005, 112). The 1923 plan records a number of other, presumably recent, changes and additions, but is our only real source of evidence for many of them, particularly since several of the buildings no longer survive and their sites now built over. These changes comprise: the presence of 'power houses' at the mixing and glazing houses (suggesting that both were now driven by water-turbines); a new fire-engine house, building 27a; a new cartridge-pressing house, building 50c, replacing the condemned building 50a-b; a second charcoal store, building 53, at the southern end of the works; and a new general store and cycle shed, buildings 54 and 55 (variously, sections 6.2.2, 6.2.3, 6.2.4 and 6.2.6 above). Some or all of these developments could date to before the creation of Explosives Trades (section 7.2.5 above), but it has been assumed for purposes of Fig 135 and the present discussion that all post-date 1917.

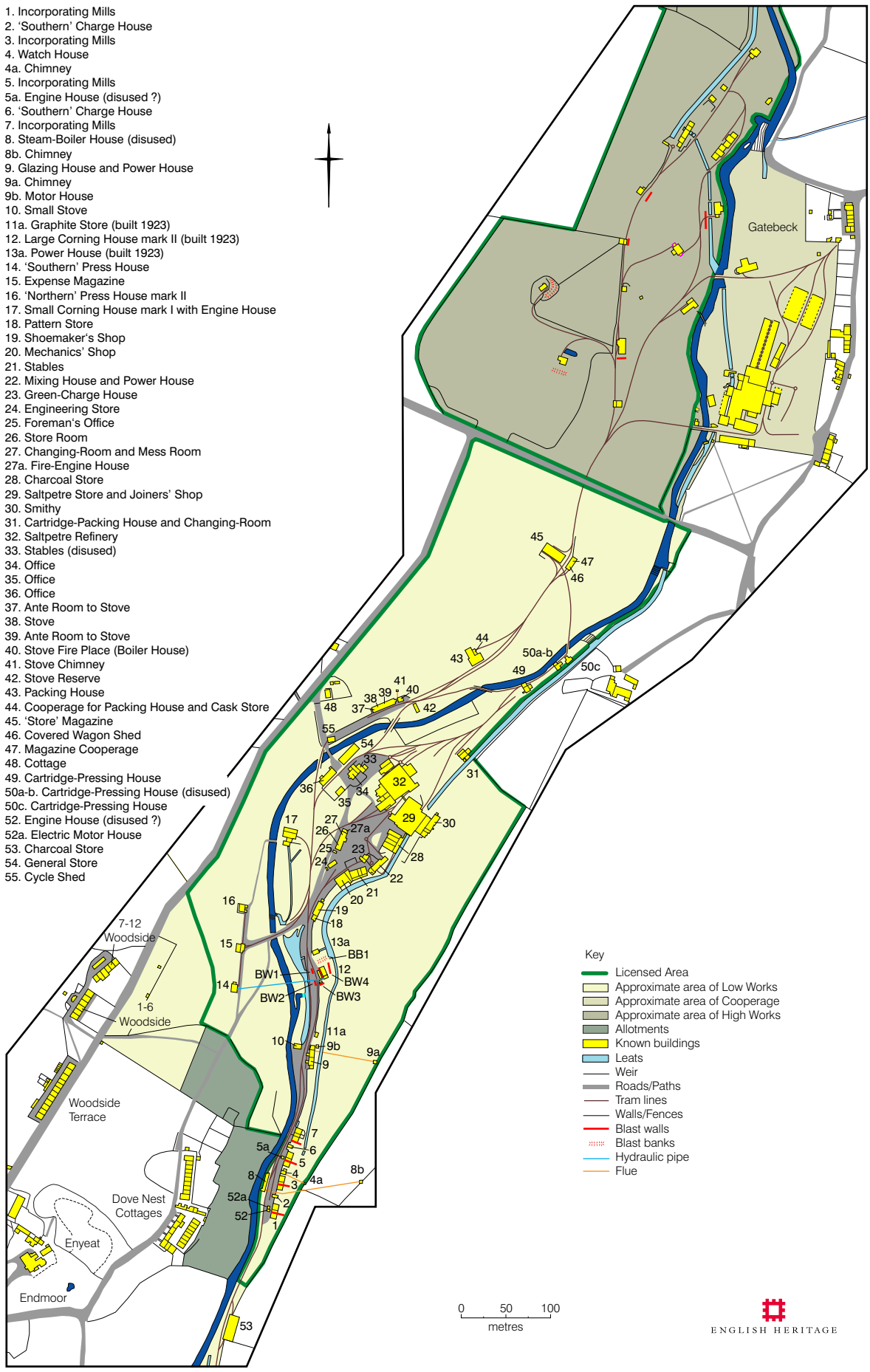

Figure 135: Phase diagram of Gatebeck Gunpowder Works, circa 1917-26 (Drawn by Philip Sinton, © English Heritage)

7.2.7 Modernisation and Rationalisation: the ICI years and closure, 1926-36 (Fig 136)

In 1926 Nobel Industries became part of the new conglomerate, ICI, who ran and managed the factory for ten years until closure in September 1936. Since direct cartographic evidence for the layout of the works during this period is lacking, Fig 136 is based on the 1923 factory plan informed by archaeological and other documentary sources as available.

There is no formal record of ICI's strategy for either the blackpowder industry nationally, or the North of England Gunpowder Group (into which the five Cumbrian factories were organised) in particular; nor indeed is there information on whether, and if so how, that strategy was modified over time. But within four years of ICI's formation, both Blackbeck and Elterwater had been closed and the decision taken to concentrate blackpowder manufacture at fewer sites (Imperial Chemical Industries 1929, 339; Dunn *et al* 2005, 131-2; Jecock *et al* 2003, 24). If the ICI historian (Imperial Chemical Industries 1929, 342) is read at face value, of the three North-of-England-Group factories that remained open it was only Lowwood that received large-scale investment to modernise and re-equip at this time (see also Jecock *et al* 2005, 230-4). However, the present survey has produced evidence to indicate that a substantial amount of money was put into updating and improving Gatebeck Low Works, too. Some of the evidence (section 6.2.3 above), such as re-equipping the stove house to be heated by hot air rather than steam, is entirely documentary; some, such as the existence by 1931of the existence at the incorporating mills of edge-runner mills with iron rather than stone bedplates and runners, is also circumstantial (that is, we cannot be sure if the investment was made by ICI or previous owners). In yet other cases, such as the fact that sometime between 1923 and 1931 the mark I small corning house was replaced by a house of the same, standardised, design as the large corning house, the evidence for investment is almost entirely archaeological (the motive behind the reconstruction of the small corning house appears to have been modernisation and/or a need to increase corning capacity pure and simple, for the new mark II house was identical in size, and presumably therefore output, to its so-called 'large' neighbour). It is possible that ICI was also responsible for sanitary improvements carried out at some of the workers' housing in Endmoor (Dove Nest or Low Cottages, section 6.2.11 above).

Despite investing in the Low Works, however, ICI was unable to prevent a continued decline in demand for blackpowder, and in September 1936 finally bowed to the inevitable and closed the Gatebeck factory, having closed Lowwood and New Sedgwick the previous year. It is perhaps fitting that the last of the factories to close was the successor to Old Sedgwick where gunpowder manufacture in Cumbria had begun 168 years previously.

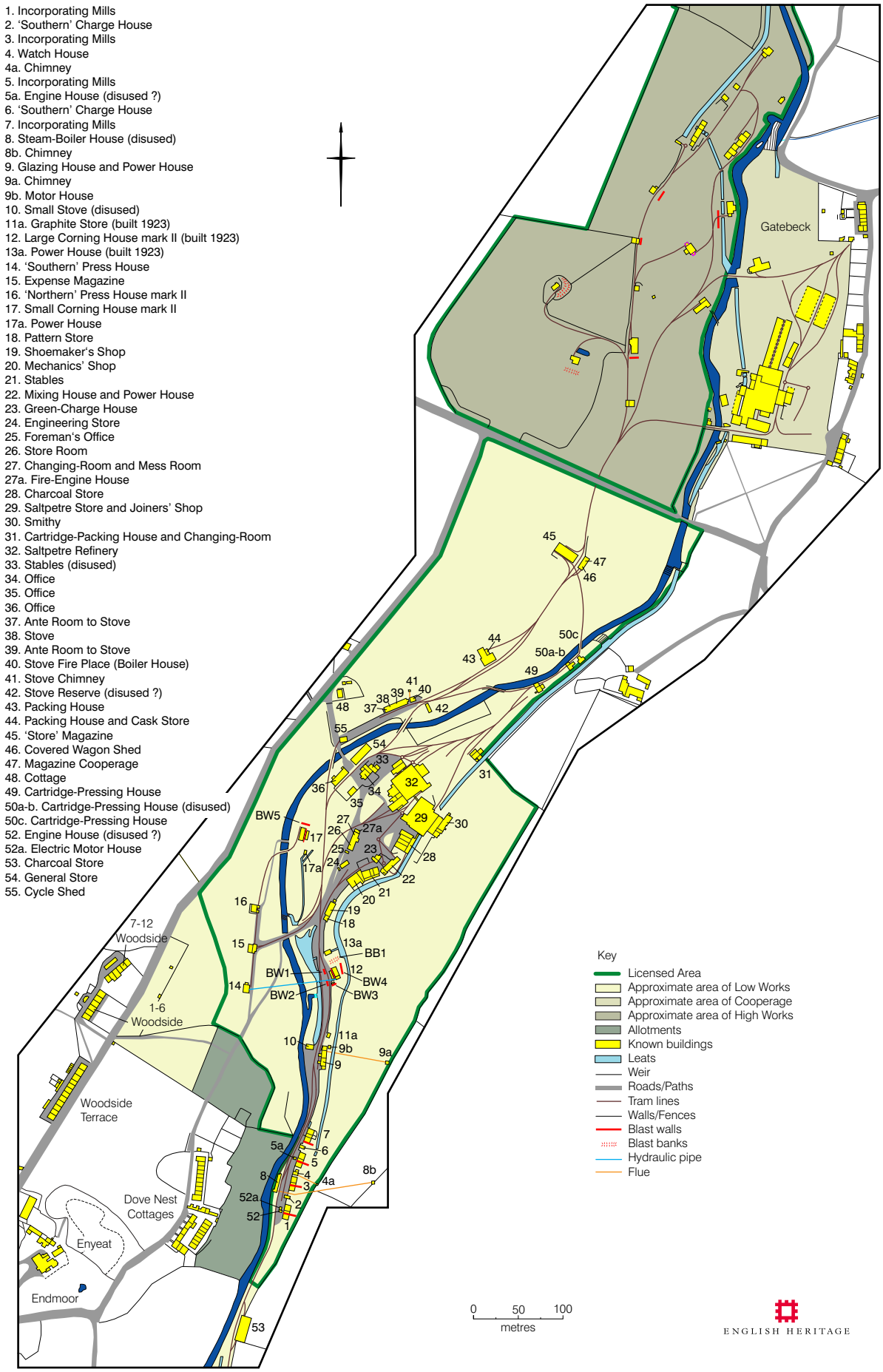

Figure 136: Phase diagram of Gatebeck Gunpowder Works, circa 1926-36 (Drawn by Philip Sinton, © English Heritage)

8. SURVEY METHODOLOGY

The main site plan was produced using total stations and tapes because of the dense tree cover across most of the site. However, differential Global Positioning System (GPS) equipment was used to position the survey within Ordnance Survey National Grid.

In total, a network of 24 survey stations was established across the site using a Trimble 5600-series total-station theodolite. This consisted of a primary baseline traverse supplemented by two link traverses and a spur station. Before any observations were taken, station 1 - which lay in more open terrain at the north end of the traverse and could be expected to have good satellite visibility - was selected to act as a local base station from which to bring in National Grid (NG) coordinates using a dual-frequency Trimble 4800-series GPS receiver and the OS network of active GPS stations. NG coordinates were successfully computed using Trimble Geomatics Office (TGO) software and the OSNT02 transformation, employing broadcast rather than precise ephemeredes; the standard Chi-square test was passed after a single iteration of the adjustment routine using an alternative scalar weighting strategy. Differential-GPS surveying relative to station 1 was then undertaken to log NG coordinates for station 2 and provide the bearing necessary to carry coordinates round the rest of the traverse, and also for station 22 at the southern end of the baseline to provide a check on the overall accuracy of the survey. Station 1 was permanently marked by a nail hammered into tarmac, but stations 2 and 22 and indeed all other stations in the network were marked by wooden pegs only. Unfortunately, by the time the theodolite survey reached the southern end of the baseline, station 22 had been disturbed or obscured by agricultural operations and could not be relocated; no check on the overall NG accuracy of the survey was therefore possible. Points of archaeological and topographical detail were observed by radiation from each station set-up, and coded with line and point information before being loaded into an AutoCAD file. All theodolite data were processed using Trimble Geosite Office software, with distance measurements reduced by a local scale factor of 0.99966, or -340ppm.

Plots of the observed data at a variety of scales between 1:100 and 1:500 were taken back into the field for checking, and missing detail added using standard graphical techniques of offset and radiation. New information was digitised into the main AutoCAD file.

Survey of upstanding masonry was undertaken using reflectorless electromagnetic distance measurement (REDM) equipment to record basic building elevations which were then enhanced by hand in the field using tape, measuring stick and booked data. All data were subsequently drawn up electronically in the office within a Microstation environment.

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WD/W/6.3 Bundle etc relating to premises at Gatebeck, including foundry and bleach works 1781-1843

WDB/35/SP271 Sales particulars of lands to be sold at auction, 8 April 1854

WDB/35/680a-h Plans of Gatebeck powder factory, Preston Patrick, showing layout and use of buildings

WQ/O/15 Kendal Order Book 1839-76

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Paper copy of plan, entitled 'Plan of Gatebeck Factory, HO/D 15-67', traced 22 August 1923, and annotated 'Factory No. 19 Westmorland. Plan to Amending Licence No 2851', signed by 'R A Thomas, Lt Col, HM Inspector of Explosives, 25 September 1923.'

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Westmorland Gazette, 4 February 1865, nd

Westmorland Gazette, 13 May 1865, page 5

Westmorland Gazette, 1 August 1874, page 3

Westmorland Gazette, 7 July 1877, page 5

Westmorland Gazette, 23 July 1881, page 5

Westmorland Gazette, 30 July 1881, page 8

Westmorland Gazette, 11 Nov 1911, nd

Millbrook Caravan Park Company Collection (Platt & Fishwick, Solicitors, Wigan):

1. Agreement dated 15 Feb 1910 between LNWR Co and WH Wakefield & Co Ltd relating to water accommodation from Crooklands Beck.

2. Conveyance dated 31 Mar 1937 between Jacob Wakefield and Nobel's Explosives Co Ltd for £6250.

3. Conveyance dated 13 Mar 1939 between Nobel's Explosives Co Ltd and O L Spedding Esq, of freehold land and premises being the site of the Gatebeck Gunpowder Works, for £3,500.

4. Conveyance dated 3 Apr 1939 between O L Spedding and Henry Proctor of a plot of land [field no. 210] at Gatebeck, for £150.

5. Conveyance dated 6 Apr 1939 between O L Spedding and Henry Nelson of a cottage ['Holmleigh'] situate at Gatebeck, for £270.

6. Conveyance dated 17 Apr 1939 between O L Spedding and Stephen Wood of Kaker Mill of plot of land formerly site of Gatebeck Tramway, for £20.

7. Conveyance dated 18 Mar 1943 between O L Spedding and Westmorland Bakeries Ltd of plot of land ['Saw Mill'] at Gatebeck, for £800.

8. Conveyance sated 9 Aug 1949 between O L Spedding and Norman Jackson of plot of land at Gatebeck.

9. Sale by O L Spedding, dated 12 July 1950, of land and buildings situate at Gatebeck.

10. Lease dated 3 Dec 1956 of 21.240 acres of land at Endmoor and derelict buildings thereon, to Westmorland County Council for a Civil Defence Training Ground, for 21 years from 1 Apr 1956.

11. Further conveyances variously dated between 1957 and 1966.

NMRC, Swindon:

Air Photographs Library

Library no. 3864 RAF/106G/LA/195 frames 1058-9, 24 Mar 1945

Library no. 8 RAF/106G/UK/653 frames 4091-2, 13 Aug 1945

Library no. 1073 RAF/541/525 frame 3393, 14 May 1950

Library no. 10051 OS/70312 frame 70, 27 Aug 1970

Edward Patterson Collection (PAT01)

Box 3

1. Original typescript of ICI's Manufacturing Method Book (MMB) for Gatebeck

2. Colour photographic prints taken 5 October 1978 and April 1979 (scanned as OP04662-87)

3. Blueprint of powder press

Photo Library

NMR AA035260 Copy negative from Brian Gregg private archive, showing Cooperage workers at Gatebeck Gunpowder Works

NMR AA035261 Copy negative from Brian Gregg private archive, showing the Cooperage at Gatebeck Gunpowder Works

NMR AA035262 Copy negative from Brian Gregg private archive, showing horse-drawn gunpowder van in transit between Gatebeck and Basingill

NMR AA035283 Copy negative from David Willacy private archive, showing the Gatebeck Gunpowder Works 'management team' outside bldg 34

APPENDIX 1: LIST OF RECORDED ACCIDENTS AND EXPLOSIONS AT GATEBECK (LOW AND HIGH)

It was only with the passing of the Explosives Act in 1875 that the reporting of fires and accidents involving explosives at gunpowder works became a statutory requirement (Cocroft 2000, 99). As a result, major incidents after 1875 are often recorded and analysed in great detail in a series of special reports prepared by Her Majesty's Explosives Inspectorate. Before that date, the only accident record we have for most of the Cumbrian blackpowder factories is local newspaper coverage of the more serious incidents - chiefly those involving fatalities when a coroner's inquest had to be held – and this is true for Gatebeck. From 1876, even non-fatal minor explosions were noted briefly in the Explosives Inspectorate's annual reports. It has not been possible to consult this latter report series at first hand, but Patterson (1986, table II) has compiled statistical data from it for explosions which occurred in incorporating mills whilst in motion, and these are included in the table below. Other explosions caused by the incautious removal of trod from stationary mills - hard, adherent, powder which accumulated on the mill bed and edge-runners during incorporation - were not listed by the Inspectorate, and so only feature below when fatalities resulted which were reported elsewhere. What the figures reveal is that explosions in incorporating mills were frequent, but did not regularly result in injury or major loss of life because the dangerous nature of the process was appreciated, and the mill-keepers retired to the safety of the watch house after setting the mills in motion. In simple numerical terms, deaths were much more likely in other buildings: press houses, glazing houses, etc.

Patterson (1995, 41-3) has compiled fatal accident statistics for all seven factories which operated in the county. In this, he treats the Low and High Works at Gatebeck as a single concern, an approach replicated here and in the table below. According to him, if Basingill and Old Sedgwick are omitted as being unrepresentative - only incorporation was undertaken at the former (Hunt and Goodall 2002) and there are few data for the latter (Jecock and Dunn 2002, 50) - Gatebeck had the best safety record, averaging 9.5 operational years per death. However, Patterson's published total of 9 deaths for Gatebeck includes one fatality (24 July 1874) that happened at Basingill (the accident was actually on 25 July; Hunt and Goodall 2002, 52) and omits four fatalities that occurred from what might be termed non-gunpowder specific workplace causes (in 1859, 1864, 1865 and 1910). Even with this revised figure of 12 fatalities, Gatebeck's record at 7.08 years per death is very much in line with the bulk of the other Cumbrian blackpowder factories, namely Elterwater at 8 years per death, Lowwood at 6.5 years per death (Jecock *et al* 2005, 249, *contra* Patterson) and New Sedgwick at 6 years per death. All four sites compare very favourably to the fifth Cumbrian manufacturer - Blackbeck – which incurred 36 fatalities (*contra* Patterson's figure of 33) during a relatively short operating life of only 69 years, with the corning houses exploding nine times (Dunn *et al* 2005, 15 and 141-5).

(NB. n/d in the table overleaf indicates that no details are currently available)

Date	Site	Cause	Damage	Casualties	References
3 March 1859	Incorporating mill	Man dragged into wheel-pit	none	1 man killed	*Westmorland Gazette*, 5 March and 7 May 1859
3 May 1859	Mixing house	Explosion/fire caused by spontaneous combustion of charcoal	n/d	2 men killed	*Westmorland Gazette*, 7 May 1859; Explosives Inspectorate nd, Appendix C, 15; Patterson 1995, 32n
8 December 1864	Saltpetre refinery	Fall into a vat of boiling saltpetre	none	1 man killed	*Westmorland Gazette*, 4 February 1865
10 May 1865	Disused combined press/corning/ glazing house	Small explosion caused by accidental ignition of powder dust during building work	Minor damage to building	1 man killed	*Westmorland Gazette*, 13 May 1865
1867	Mixing house	Fire caused by spontaneous combustion of charcoal	n/d	No injuries	Explosives Inspectorate nd, Appendix C, 15
1876	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1876	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
2 June 1877	Incorporating mill	Small flash or explosion caused by removing trod from mill	none	1 man killed	*Westmorland Gazette*, 7 July 1877
1877	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1877	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
21 July 1881	Northern press house	Explosion – cause not established	Building destroyed	2 men killed	*Westmorland Gazette*, 23 and 30 July 1881; Explosives Inspectorate 1881
1882	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1883	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1885	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II

1886	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1889	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1895	Incorporating mill	n/d	n/d	n/d	Patterson1986, table II
1896	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1906	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1906	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table I
6 November 1906	Shed near to stove house	Fire	Building destroyed	None	*Westmorland Gazette*, 10 Nov 1906
1910	Gatebeck Tramway	Dragged behind horse	None	1 man killed	Tyler 2002, 77
10 November 1911	No. 2 incorporating mill, High Works	Explosion caused by removing trod from one mill communicating to adjoining mills	Range of 4 incorporating mills destroyed	1 man killed	*Westmorland Gazette*, 11 and 18 Nov 1911
1914	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1914	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1915	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1915	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1915	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1917	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1917	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1919	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1919	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1919	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1919	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1920	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II

1920	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1921	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1921	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1921	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1922	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1922	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1922	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1922	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1922	Incorporating mill at High Works	n/d	n/d	n/d	Patterson 1986, table II
1922	Incorporating mill at High Works	n/d	n/d	n/d	Patterson 1986, table II
17 May 1923	Large corning house	n/d	Building destroyed	2 men killed	*Westmorland Gazette*, 19 May 1923
1926	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1926	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1927	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1927	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1928	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1928	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
1928	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II
21 April 1928	Incorporating mill at High Works	Explosion in one mill communicating to adjacent mills; precise cause not established	Range of 4 incorporating mills destroyed	none	Patterson 1986, table II and 25-6
1929	Incorporating mill	n/d	n/d	n/d	Patterson 1986, table II

APPENDIX 2: THE ARCHIVE AND PHOTOGRAPHIC RECORD

An archive of field survey plans and site photography, plus supporting background information such as the overall Project Design and selected correspondence, has been deposited with the NMRC in Swindon under Collections reference AF00239, where it is available for public consultation upon request. Survey data also exists digitally as a series of AutoCAD files, currently held at the English Heritage office in York but ultimately to be archived in the NMRC; these are also publicly available upon request.

The main photographic record of the site was taken by an English Heritage photographer, Bob Skingle, using a Hasselblad H2D high resolution digital camera as photographic job number 2K/09092. Each photograph has been allocated an individual NMR digital photograph (DP) number, and many have been reproduced in some form in this report. Other 'snapshot' digital photography was taken during the course of investigation by Christopher Dunn, Simon Taylor, Tony Berry and Marcus Jecock using either Nikon 5700/5400 5-megapixel or Canon PowerShotG2 4-megapixel digital cameras; plans in the CRO(K) were photographed by Abby Hunt using a Fuji FinePix 1400Zoom digital camera. All these snapshot images (and others not reproduced in this report) are currently retained at English Heritage's office in York, but should ultimately also be available through the NMR.

APPENDIX 3: ADDENDUM TO ENGLISH HERITAGE'S REPORTS ON THE OLD SEDGWICK AND BASINGILL GUNPOWDER WORKS, CUMBRIA

Since the reports on the Old Sedgwick and Basingill gunpowder works were published (Jecock and Dunn 2002; Hunt and Goodall 2002), additional documents have come to light which shed new light on the development of both factories and also show that their accident records were not quite so spotless as previously thought: the plan of the Wakefield family's Sedgwick estate surveyed by John Williamson in 1796 - calendared in the CRO(K) as WD/W/11.3 but which could not be located in the search room at Kendal in 2001-2 when the research for those reports was being carried out - has been found, while Mike Davies-Shiel has provided English Heritage with references in his possession to pre-1875 accidents reported in local newspapers.

The Williamson plan depicts both the Old Sedgwick factory and its Basingill outstation in some detail. Although individual buildings are not named or identified by function, the importance of the document lies in the fact that it pre-dates all previously known maps and plans by almost 60 years, and thus provides a record of the layout of the factories at a much earlier stage of their development (in the case of Basingill only 6 years after that outstation opened). In the case of Old Sedgwick, the plan confirms the overall conclusion of the report that the factory changed relatively little with time, for it indicates that the complement and configuration of buildings in 1796 was much the same as when the works closed in the 1850s (compare Jecock and Dunn 2002, figs 4, 5 and 13), the principal differences being demolition of and/or changes to a cluster of small buildings (of uncertain function) at the centre of the site, alterations to the corning house (buildings 16-18 on Jecock and Dunn 2002, 30 Fig 9) and the construction of building 32 (possibly the heading-up or packing house) towards the northern periphery which did not exist in 1796. For Basingill, however, the plan suggests that the phasing of the incorporating mills previously put forward needs revising. Whereas it was previously suggested (Hunt and Goodall 2002, 40-3) that mills 1 and 2 were the earliest, with mills 4 and 5 added most probably between 1814 and 1820 when Isabella Wakefield laid out a romantic garden that partly incorporated the factory, the Williamson plan demonstrates the opposite: that mills 4 and 5 are the original pair with mills 1 and 2 added after 1796.

Davies-Shiel's trawling of 19th-century local newspaper reports has significantly increased our knowledge of the safety records of both Old Sedgwick and Basingill (Jecock and Dunn 2002, 50; Hunt and Goodall 2002, 52-3). The published Old Sedgwick report contained reference to a single accident and the Basingill report mostly listed accidents that occurred after 1875. It is now clear that there was a succession of incidents throughout the lifetime of both works, although overall their safety records are still substantially better than other Cumbrian blackpowder factories. The following need adding to the lists of recorded incidents at both sites:

Old Sedgwick

Date	Site	Cause	Damage	Casualties	References
15 March 1816	Incorporating mills	Taking lighted candle into mill	None	1 man died of his burns	*Westmorland Gazette*, 16 March 1816

28 June 1839	Saltpetre refinery	Fire in flue spreading to building	Building destroyed?	None	*Westmorland Gazette*, 30 June 1839; *Kendal Mercury*, nd
14 July 1839	'2 gunpowder sheds'	n/d	Buildings destroyed	None	*Westmorland Gazette*, 21 July 1839
17 September 1842	n/d	n/d	n/d	n/d	n/d
15 April 1843	n/d	n/d	n/d	2 men blinded	n/d
20 August 1845	Incorporating mills	n/d	n/d	n/d	*Westmorland Gazette*, 25 August 1845?
19 April 1847	Preparing house and/or incorporating mills?	n/d	Buildings destroyed	None	*Westmorland Gazette*, 24 April 1847
28 October 1848	Incorporating mills	n/d	n/d	n/d	*Westmorland Gazette*, 31 October 1848

Basingill

Date	Site	Cause	Damage	Casualties	References
September 1844	Incorporating mills 1 and 2?	Unknown	2 mills destroyed	1 man killed	*Westmorland Advertiser*, 16 March 1816
28 October 1863	Incorporating mill	Unknown	Not specified	1 man injured	*Westmorland Gazette*, 31 October 1863
10 October 1868	Incorporating mills	n/d	n/d	none	*Kendal Mercury*, 17 October 1868

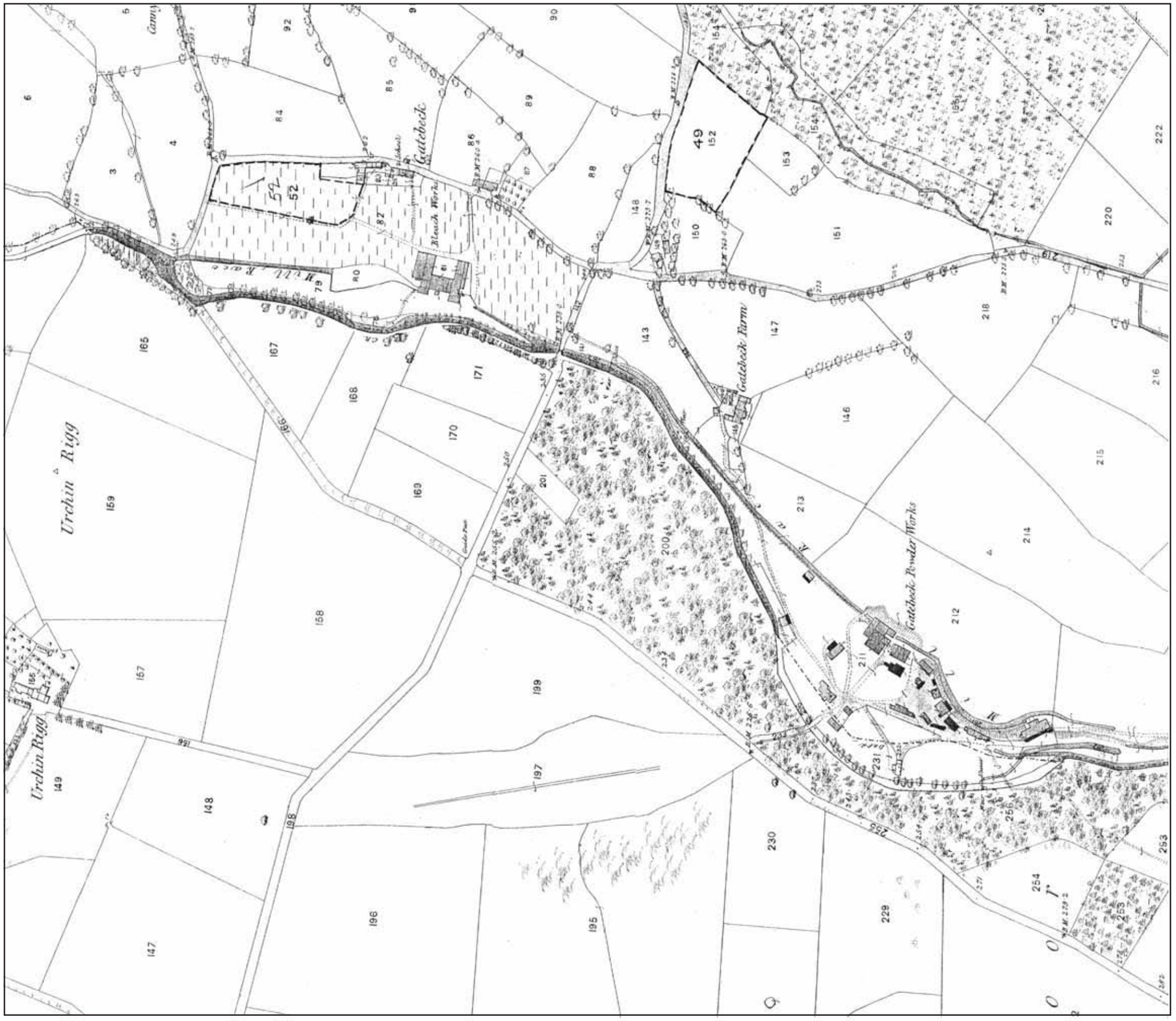

Figure 137.
Gatebeck Gunpowder Works as mapped at 1:2500 scale in 1858. (Reproduced at c.1:5000 scale from the 1858 Ordnance Survey map)

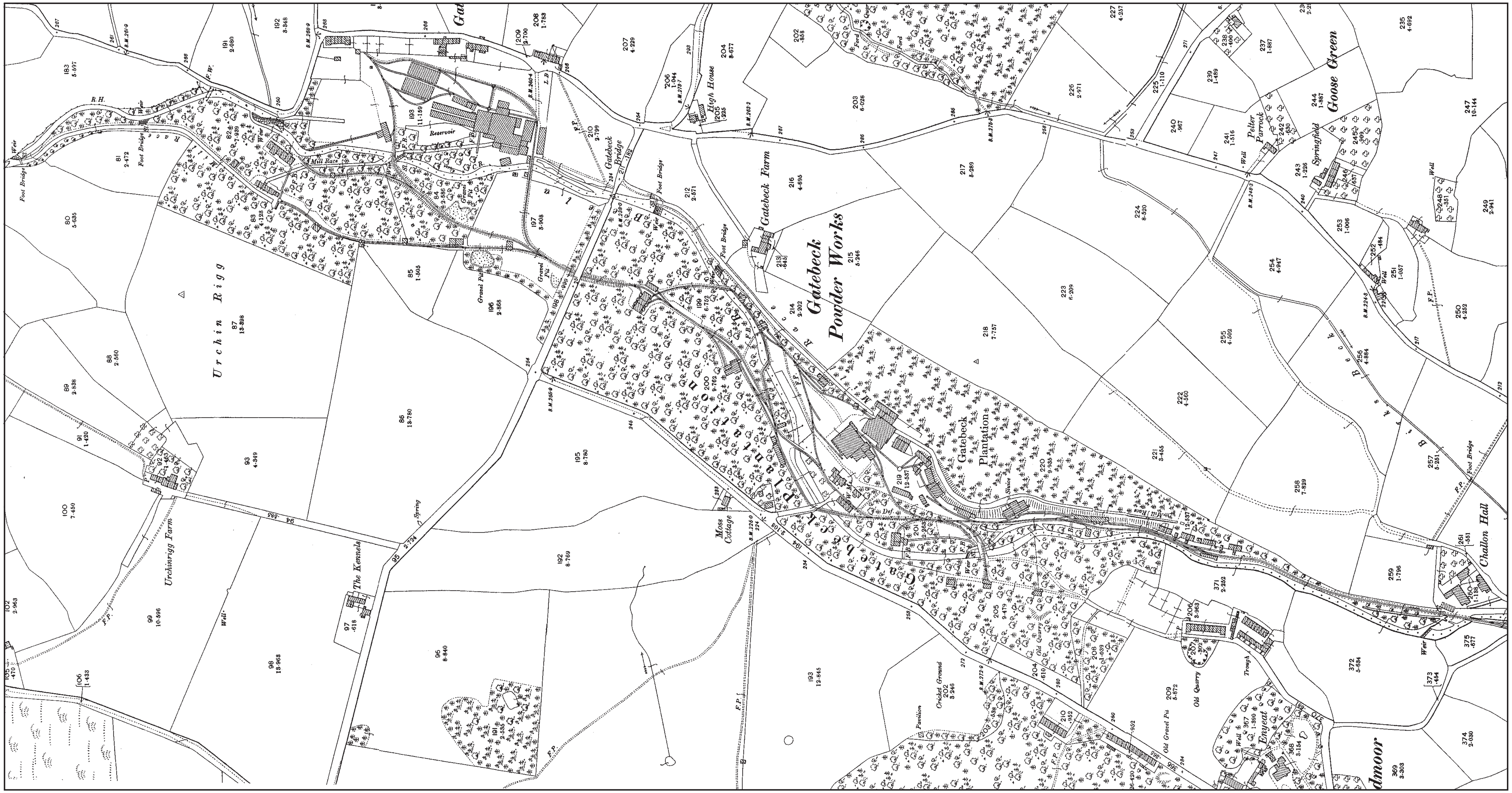

Figure 138.
Gatebeck Gunpowder Works
as mapped at 1:2500 scale in 1896.
(Reproduced at c.1:5000 scale from
the 1898 Ordnance Survey map)

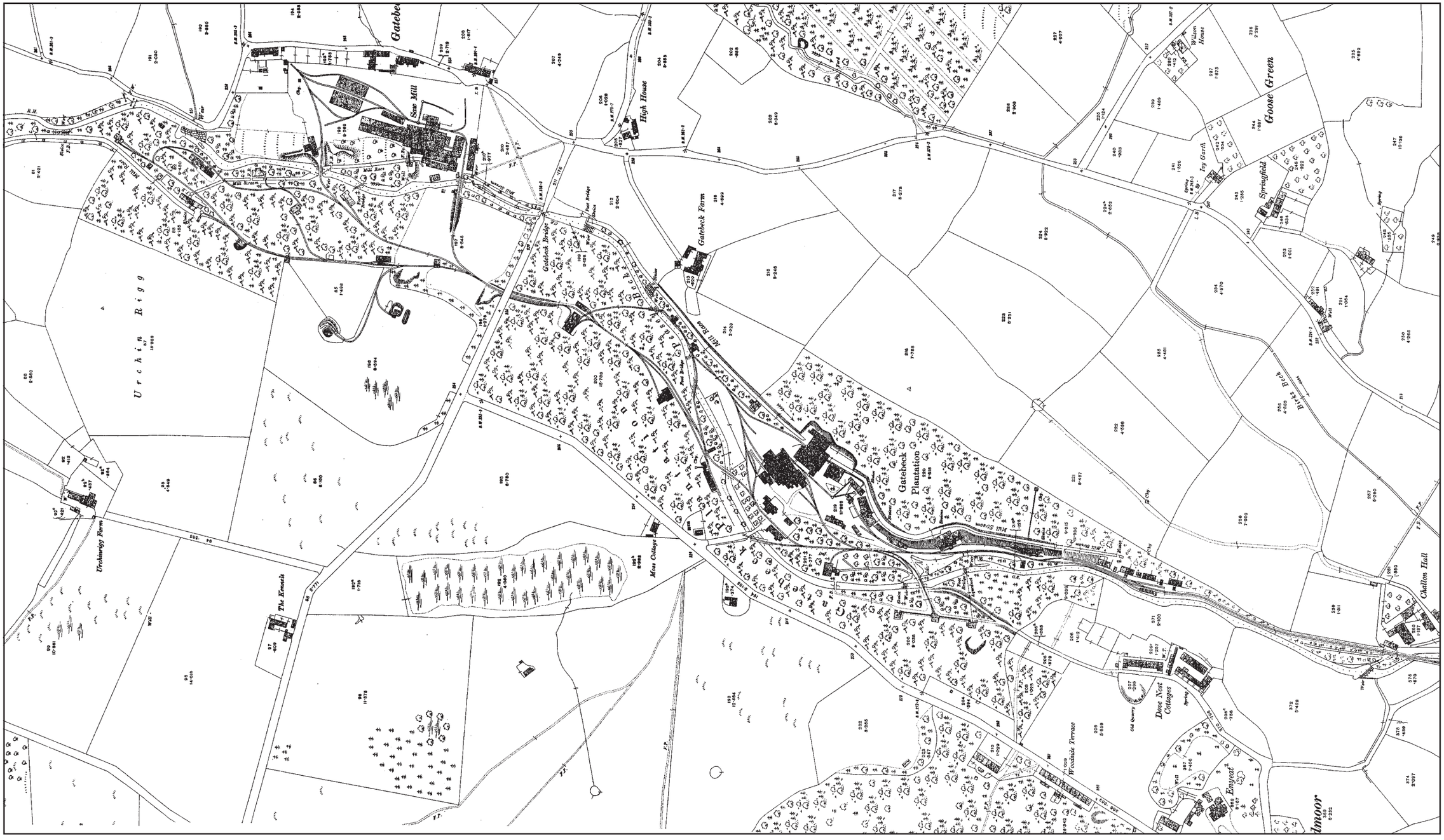

Figure 139.
Gatebeck Gunpowder Works as mapped at 1:2500 scale in 1911. (Reproduced at c.1:5000 scale from the 1914 Ordnance Survey map)

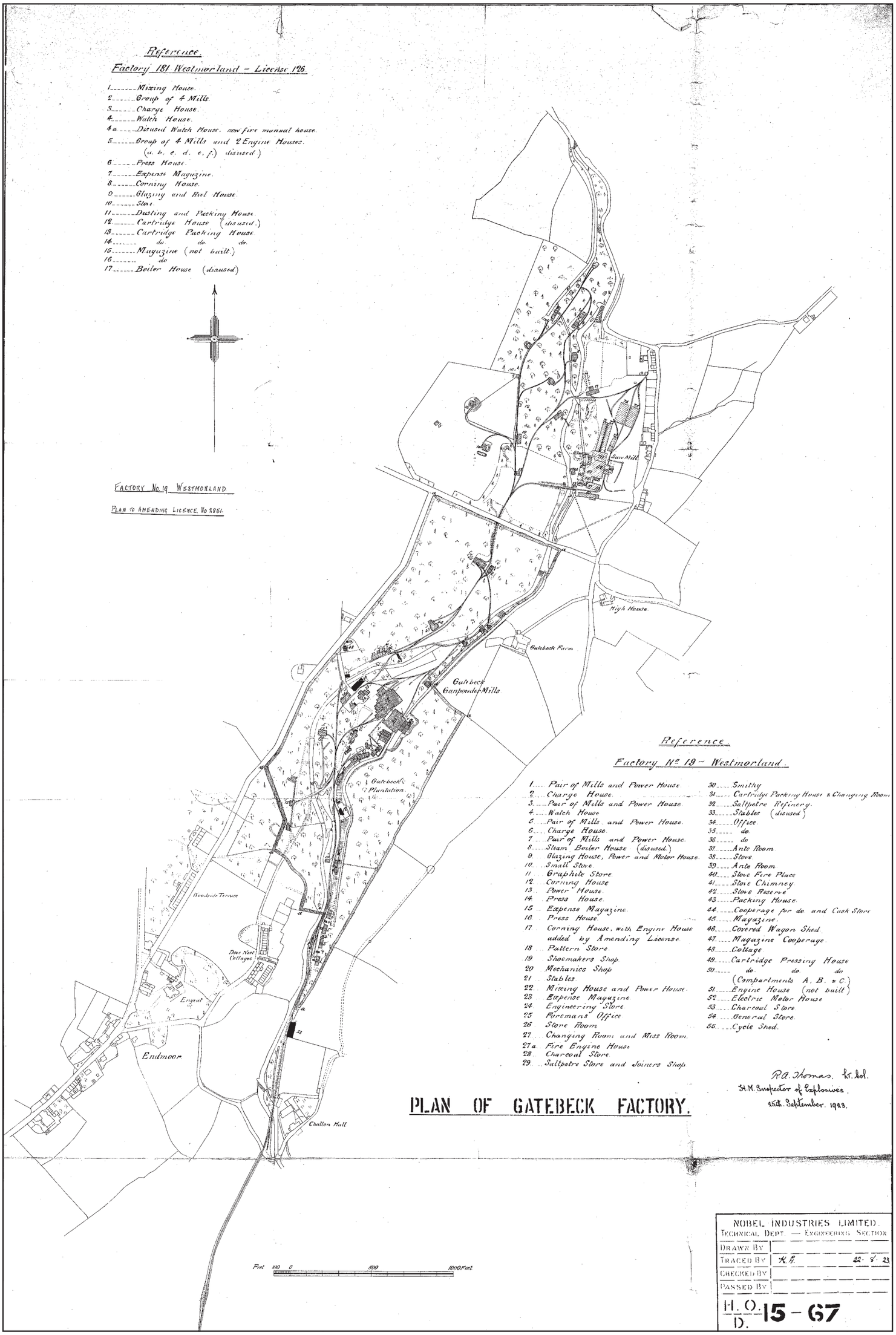

Figure 140.
Plan accompanying A/L no. 2851 (the '1923 factory plan'). (ICI plc, copyright reserved).

Figure 141. Plan of the large corning house and associated structures (© English Heritage)

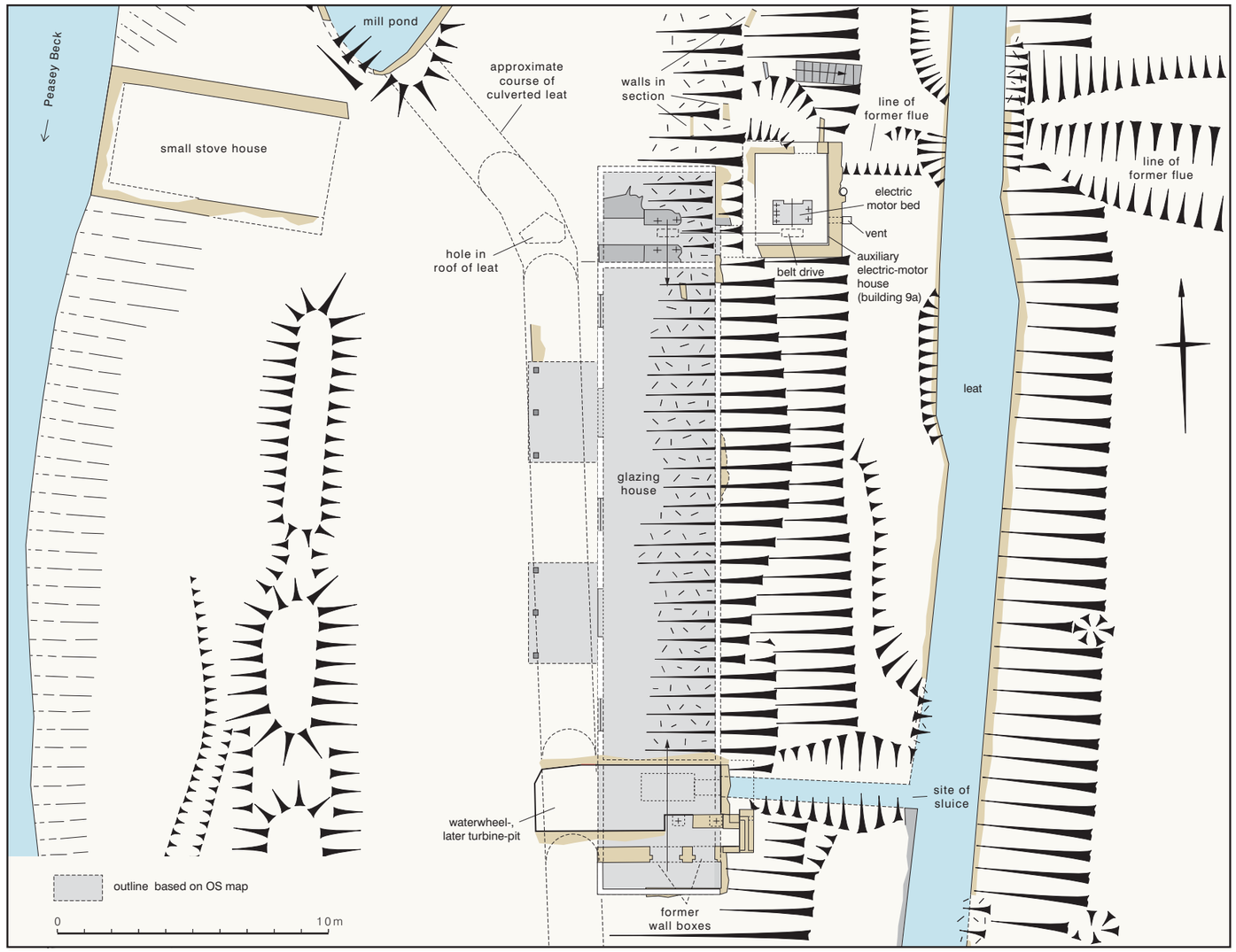

Figure 142. Plan of the glazing house and small stove house (© English Heritage)

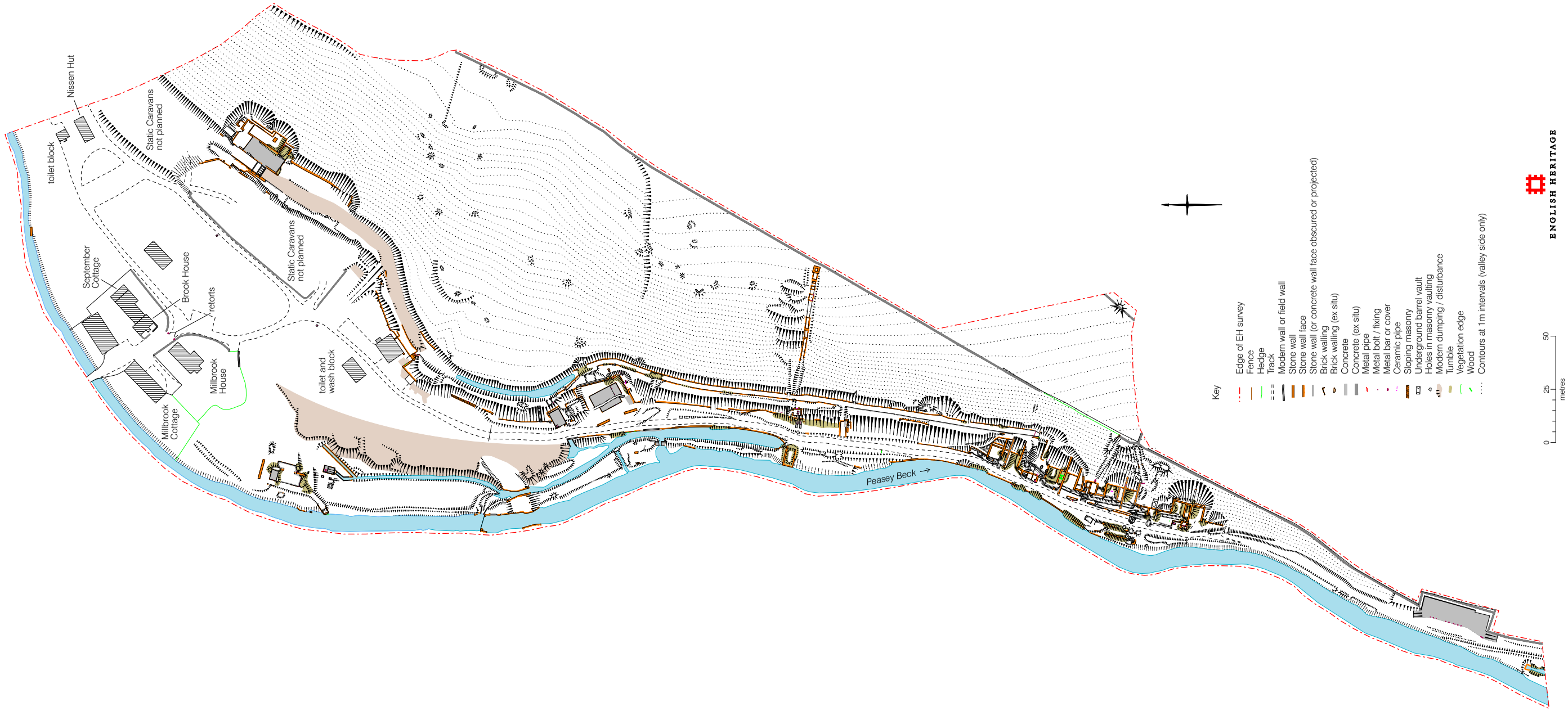

Figure 143.
English Heritage earthwork plan of Gatebeck Low Works, reproduced at 1:2000 scale
(© English Heritage)