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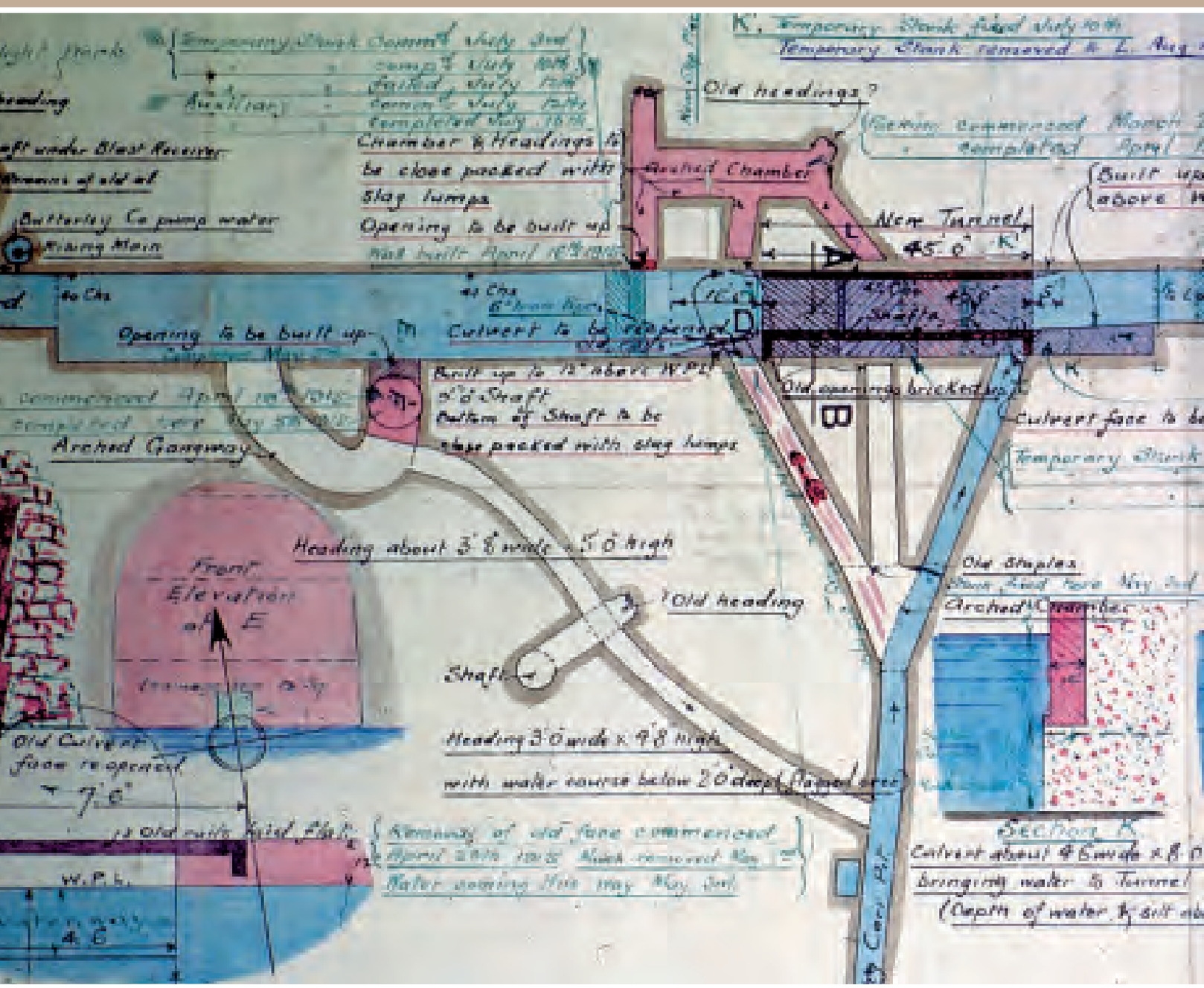
BUTTERLEY ENGINEERING SITE, BUTTERLEY HILL, RIPLEY, DERBYSHIRE DESK-BASED ASSESSMENT OF THE IRONWORKS AND UNDERGROUND CANAL WHARF

Rebecca Pullen



ARCHAEOLOGICAL SURVEY AND INVESTIGATION

ENGLISH HERITAGE

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BUTTERLEY ENGINEERING SITE
BUTTERLEY HILL, RIPLEY
DERBYSHIRE

DESK-BASED ASSESSMENT OF THE IRONWORKS AND UNDERGROUND CANAL WHARF

Rebecca Pullen

NGR: SK 4012 5171

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SUMMARY

This report presents research into the nature and significance of remains at the Butterley Engineering Site, a prominent former ironworks and mineral extraction site near Ripley, in the Amber Valley, Derbyshire. The site was established in 1790 and continued in operation through a series of expansions and redevelopments during the 19th and 20th centuries, until the Butterley Company went into receivership in April 2009.

Following recent demolition of all post-1948 buildings and partial development of the site for residential housing, the surface remains include two early 19th-century Grade II Listed Buildings associated with the administrative functions of the company, and an imposing sandstone retaining wall incorporating the partial remains of two 19th-century blast furnace structures. Additionally, the Butterley Tunnel on the Cromford Canal passes directly under the former furnace bank, at which point a series of subterranean features associated with extraction, and loading and unloading survive. These include a wharf or 'wide hole' where boat traffic could continue to pass while loading and unloading took place, vertical loading shafts to the surface, an underground roadway to Carr Pit Colliery, and several adjoining culverts, tunnels, shafts and old headings. Although subject to later alterations, these underground remains appear to represent the earliest surviving elements associated with the ironworks. At present the canal tunnel is in an unstable condition and is only partially navigable.

CONTRIBUTORS

The research, illustrations and report were prepared by Rebecca Pullen of English Heritage's Archaeological Survey and Investigation Team, Cambridge. Tony Calladine, Caroline Skinner and Rebecca Carter of English Heritage's Designation Team provided information and support. Wayne Cocroft commented on the text.

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ARCHIVE LOCATION

The digital archive is currently held on the English Heritage server, Cambridge.

DATE OF RESEARCH

The research was primarily undertaken during January and February 2010.

Cover image: Detail from 1915 Midland Railway plan of the Butterley Tunnel showing the 'Proposed Shortening of Wide Hole' © British Waterways Technical Directorate, Leeds, reproduced by kind permission (BWTD doc ref 10/564 ext ref 16126)

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INTRODUCTION

In March 2009, a Scheduling Request was submitted to English Heritage (EH) by Derbyshire County Council (DCC) for the Butterley Engineering Site (NMR SK45SW39, DHER 24733). The request called for particular consideration of blast furnaces, foundries, buried remains, vertical shaft links to the Cromford Canal (NMR LINEAR81) in the Butterley Tunnel running below the site, and its underground wharf. In January 2010, English Heritage's Archaeological Survey and Investigation Team (Cambridge) were asked to undertake background research into the nature and significance of the site on behalf of the EH Designation Team.

This report brings together information from existing documentary sources in order to clarify and expand on current understanding of the form and function of the Butterley Ironworks complex and its practical association with the Cromford Canal. The history and legacy of the Butterley Company and elements of the manufacturing complex itself are well documented (ie Mottram and Coote 1950, Riden 1990, and Christian 1990). This report focuses specifically on the surviving early elements on the site: the smelting and casting facilities and the underground canal wharf. It should be noted that due to access and safety constraints the author was unable to undertake a site visit or tunnel inspection, and so research was undertaken as a desk-based exercise. Although much detail has been extrapolated from documentary sources, it is acknowledged that the nature of some structural relationships and aspects of site phasing remain unclear.

Following recent demolition of all post-1948 buildings, the site consists of an imposing sandstone retaining wall incorporating the remains of three 19th-century blast furnaces, several buildings associated with the later manufacturing and administrative functions of the Company, including two early 19th-century Grade II Listed Buildings (LB79107, 79108), and an underground wharf on the Cromford Canal with vertical shaft links to the surface, along with a series of adjoining subterranean features associated with iron ore and coal extraction, and the loading and unloading of material for the iron production process. These underground remains appear to form the earliest surviving elements associated with the ironworks. At the time of research the site was owned by Coast Properties and Finance Ltd and was thought likely to be subject to a scheme of residential development. The canal tunnel is owned and maintained by British Waterways, and is not currently accessible as it is in an unstable condition and only partially navigable. At present there are no Scheduled Monuments on the site or within its immediate surroundings.

Location

The Butterley Engineering site is situated at NGR SK 4012 5171, on the north edge of Ripley in the Amber Valley, Derbyshire (Figure 1). The line of the Cromford Canal passes directly underneath the site on an east-west alignment through the Butterley Tunnel, and Butterley Reservoir which used to provide water to service the canal is situated immediately northwest of the site (Figure 2). West of the site is Butterley Hill with the suburb of Hammersmith beyond; land to the east of the site remains largely open. To the south-east the site borders Butterley Hall and Estate; formerly the grounds covered

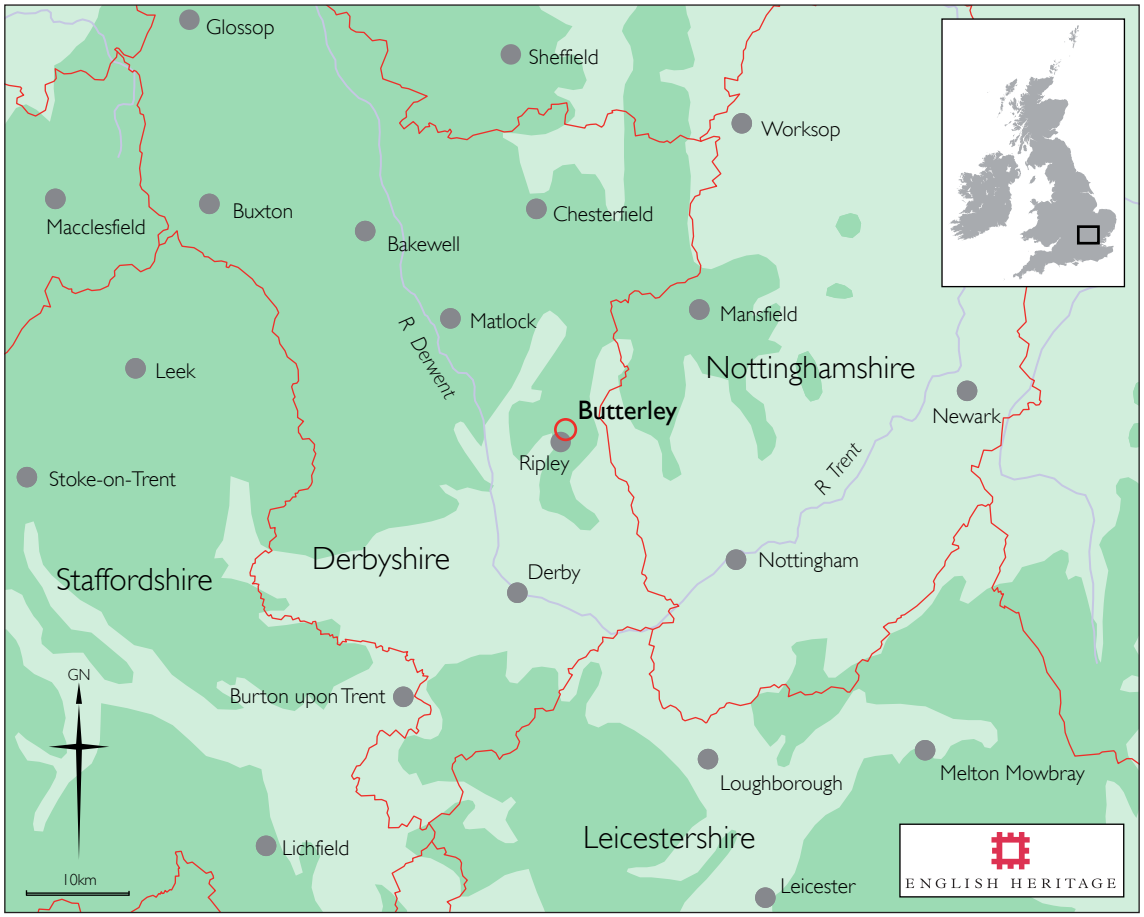

Figure 1: Location map. Drawn by Rebecca Pullen and Magnus Alexander, © English Heritage

a greater expanse encompassing the site of the engineering works. Butterley Hall now houses the headquarters of Derbyshire Constabulary.

Land-use, Topography and Geology

The site is effectively divided into two distinct areas separated by the imposing stone retaining wall bisecting the works on a near north-south alignment. The eastern portion of the site sits at *c.*115m above Ordnance Datum (OD), and consists of a higher level expanse that once contained the railway stockyard, paint shop and some administrative buildings. It was from this higher level that materials for the smelting process were loaded into the top of the blast furnaces which formed an integral part of the retaining wall. Since 2005, this higher area has been largely developed for residential use. At the base of the retaining wall the ground level is some 10m lower than it is to the east (*c.*105m above OD). This area housed the foundries and fabrication (assembly) sheds, along with more administration buildings.

The Butterley Tunnel measures some 2.8km and runs approximately WNW-ESE, passing directly beneath the ironworks site and enclosing a now disused section of the Cromford Canal. It cuts through a geological make-up of Pennine Middle Coal Measures, predominantly comprising sandstone, interspersed with mudstone and siltstone, and with

subordinate beds of coal and ironstone, and localised superficial alluvial deposits (BGS 1972). This soft sedimentary geology reportedly caused some difficulties to the cutting of the tunnel (Nixon 1969, 273). Construction of the tunnel included the excavation of several adits into the hillside, along with the sinking of thirty-three shafts and subsequent tunnelling at the correct level, giving a number of different faces on which to work the coal and iron ore reserves (Schofield 1988, 107). The coalfields around Butterley were heavily exploited; three collieries were located close to the Butterley tunnel, of which one, Butterley Carr Pit colliery, was worked with the assistance of small boats. (Farey 1817, 337).

Partway along the tunnel, some 0.83km east of its western portal, the canal passes directly under the ironworks, and at this point the waterway widens to allow for an underground wharf (this broadened section is known as a 'wide hole') where boats could be directly loaded and unloaded with coal, iron stone and limestone for transportation or for smelting in the Company's furnaces.

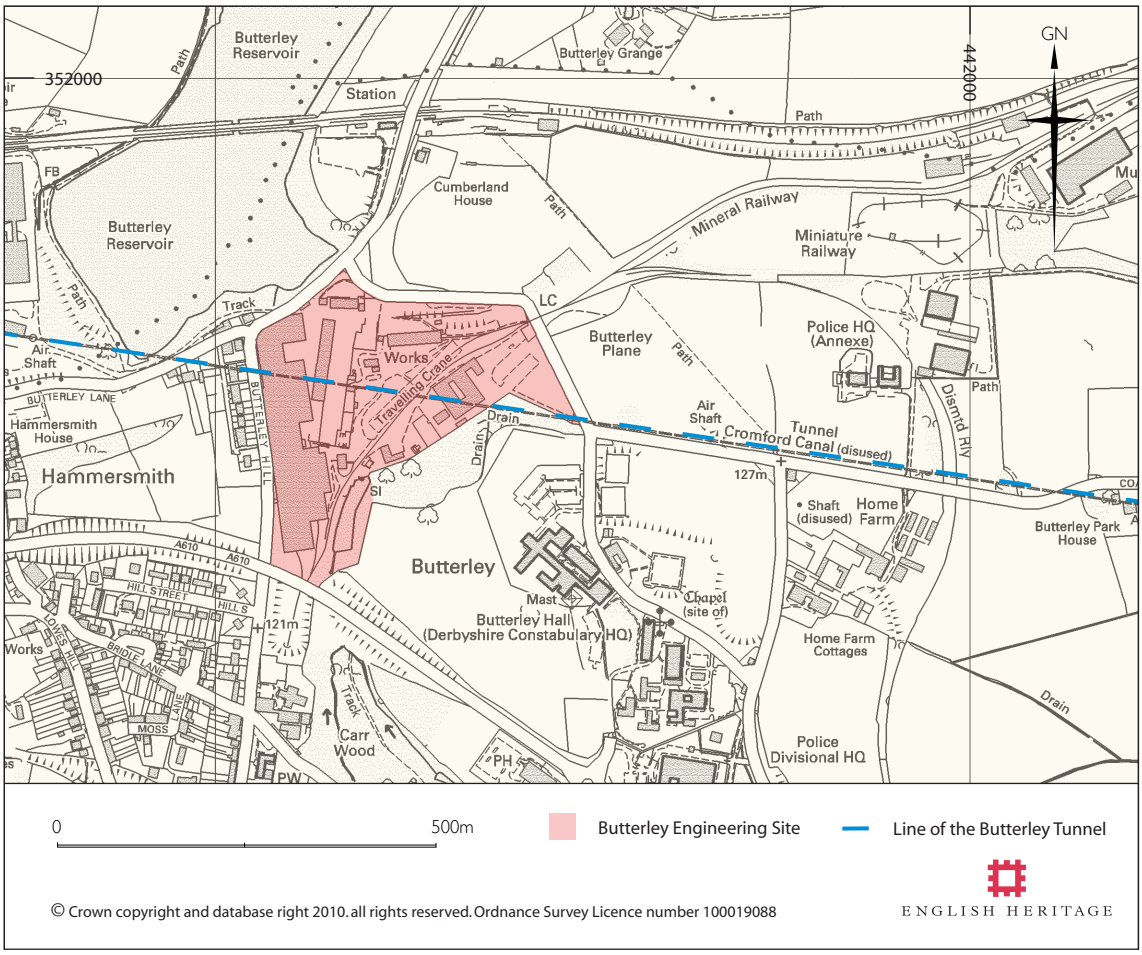

Figure 2: Area of investigation. Drawn by Rebecca Pullen, © English Heritage

PREVIOUS RESEARCH

Prior to this research exercise, a number of other reports investigating the nature and significance of historic structures and archaeology surviving on the Butterley Ironworks site had been produced:

- 2003 Desk-Based Assessment, ARCUS
- 2005 Building Recording Report by JSAC
- 2007 Desk-Based Assessment, MAP Archaeological Consultancy Ltd
- 2007 Watching Brief, ULAS
- 2009 Listing Advice Report, English Heritage

The structural remains of the ironworks buildings were appraised as part of a desk-based assessment undertaken by ARCUS in 2003, during building recording by John Samuels Archaeological Consultants (JSAC) in 2005, and again by MAP Archaeological Consultancy Ltd in 2007. Additionally, an archaeological watching brief was undertaken by University of Leicester Archaeological Services (ULAS) during the capping of former vertical loading shafts connecting to the Butterley Canal Tunnel (Farnworth-Jones and Boucher 2007).

In their rapid building appraisal of 2003, ARCUS identified 20th-century office buildings, along with some steel-framed semi-prefabricated 1920-30s buildings formerly used as garages, and the remnants of railway sidings from the movement of raw materials and loading of furnaces in this eastern zone (Bell and Jessop 2003, 7). ARCUS recommended further building recording should be undertaken in this area in advance of demolition, and in 2005 JSAC undertook a program of basic building survey across this north-east portion of the site taking in a substantial travelling crane mechanism and rails along with all extant structures (Slatcher 2005). Since 2005, the upper eastern portion of the site has been redeveloped for the provision of housing.

The 2007 report by MAP identified ten structures standing on the lower western portion of the site, of these two are Grade II Listed Buildings (Buildings 4 and 5), and the majority of the other structures are included within the curtilage of the listed buildings (Figure 3). This group of structures was recently reviewed by English Heritage for a listing assessment where it was advised that no further structures on the site should be recommended for listing (English Heritage 2009).

The structures identified were as follows (numbering system retained from MAP 2007 desk-based assessment, as used in the EH 2009 listing advice report):

Structure 1 This refers to the substantial sandstone retaining wall running approximately north-south down the centre of the former ironworks site footprint. The structure measures some 14m high and forms a furnace bank incorporating the remains of two 19th-century blast furnaces the southern of which has been largely demolished (Figure 4). The fabric of the wall and furnaces is affected by vegetation and sapling regeneration, and shows signs of structural instability with large cracks visible in places. In their 2007 desk-based assessment, MAP recommended that these

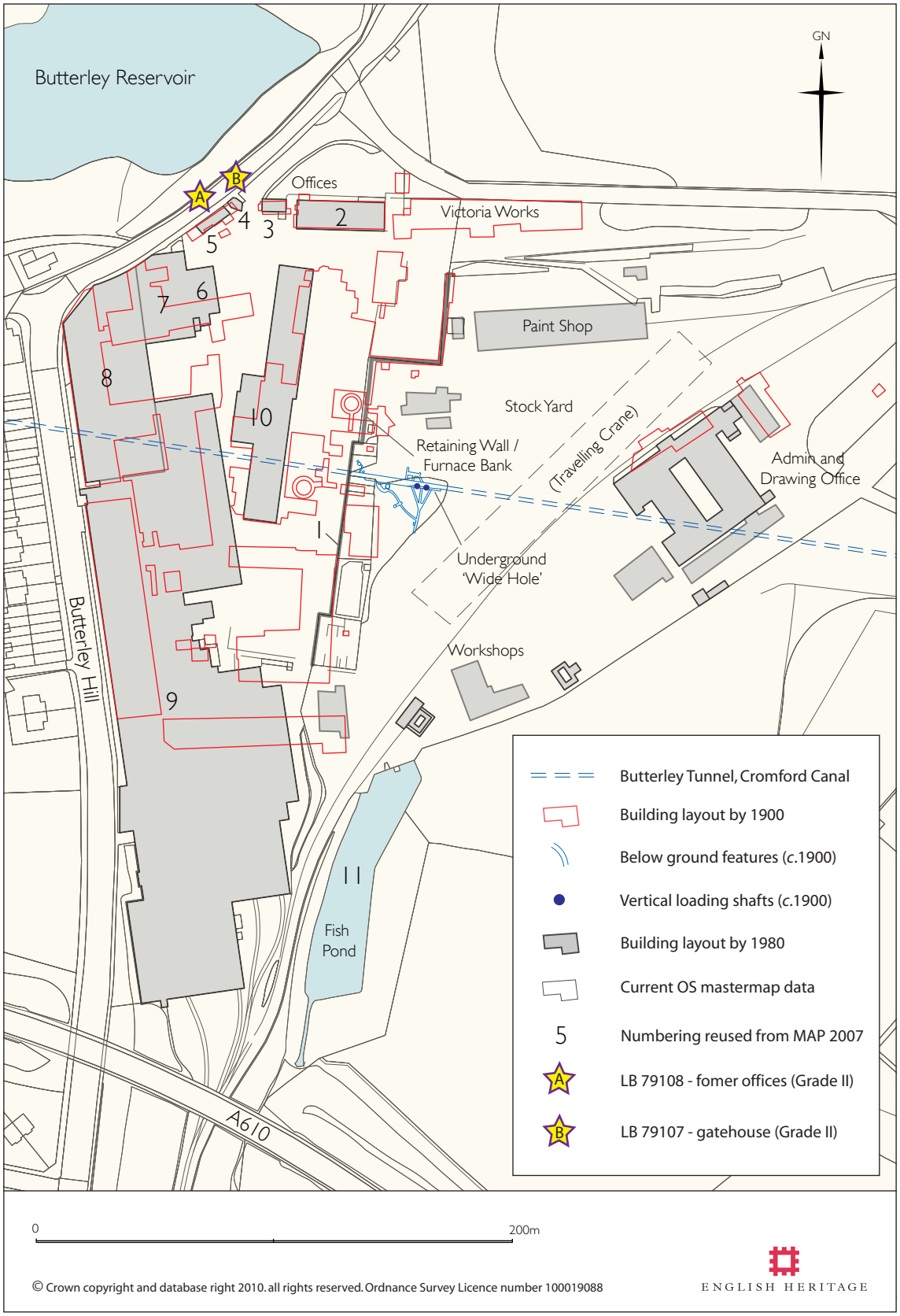

Figure 3: Butterley Engineering site, showing building numbers and the main phases of development. Drawn by Rebecca Pullen, © English Heritage

Figure 4: Remains of the two blast-furnaces incorporated within the retaining wall at the Butterley Ironworks ('Structure 1'), looking north-east (after Palmer and Neaverson 1992, 103, figure 115). Reproduced by kind permission, © Marilyn Palmer

structures required further detailed RCHME Level II/III recording, and inspection by a structural engineer to assess any need for consolidation.

Building 2 A two and a half storied sandstone building with slate roof, lying within the curtilage of the Listed Buildings. In 2007 it was still being used as a reception and offices.

Building 3 A three storey sandstone building with hipped slate roof lying within the curtilage of the Listed Buildings; thought to be of mid 19th-century date it has seen much later alteration. In 2007 it was in a state of disuse having formerly been used as offices.

Building 4 This is a Grade II Listed Building (LB 79107). An octagonal two storied sandstone gatehouse with a hipped slate roof. MAP (2007, 20), recommended that full recording to RCHME Level II be undertaken prior to any interior or exterior refurbishment.

Building 5 This is a Grade II Listed Building (LB 79108). A two storey sandstone building with hipped slate roof, formerly an office block later converted to a lavatory block; its construction is integral to the boundary wall. MAP (2007, 20), recommended that full recording to RCHME Level II be undertaken prior to any interior or exterior refurbishment.

Building 6 A two storey brick-built block with a slate gable roof, thought to be a canteen dating from 1941, it lies within the curtilage of the Listed Buildings.

Building 7 Two gabled structures, ancillary to the large adjacent structure; the western structure is a two storey sandstone attachment to the open plan 19th-century Building 8; the exterior walls showed traces of Second World War camouflage paint. The eastern structure is a slightly larger brick-built two-storey storage building, dated to 1941. This ancillary structure lies within the curtilage of the Listed Buildings.

Building 8 A much altered stone building with a 20th-century brick extension to its southern end. The open plan interior is equipped with central travelling cranes and their arcaded gantry supports; this is likely to represent a former foundry or assembly workshop. This building is thought to be the earliest surviving part of the manufacturing complex which forms a range running the length of the western side of the site. This building lies within the curtilage of the Listed Buildings.

Building 9 A substantial mid- to late-20th century purpose built steel frame building.

Building 10 A large late 20th-century modern steel unit

Structure 11 Pond, originally part of the parkland features, later incorporated in to the Butterley Works during site expansion in the 1860s.

Yellow Coal Measure Sandstone is thought to represent the earliest building material used in the above ground structures at the site; following this a secondary period of construction using pinkish or darker red sandstone is visible. Subsequently, later buildings were erected using combinations of brick, concrete, steel-framing, and corrugated iron (Bell and Jessop 2003, 10).

It is understood that all post-1948 structures on this western portion of the site have now been demolished, or are currently subject to demolition, and that Amber Valley Borough Council advised on and monitored the work.

It is also worth noting that although a program of building recording on the eastern side of the site was undertaken by JSAC in advance of development and following recommendations made by ARCUS in their 2003 report, it was buildings in the western half of the complex that were particularly highlighted by ARCUS as worthy of further investigation and recording to RCHME Level II/III (namely Structure 1, Building 4, and Building 5). As far as is known, targeted recording has not been commissioned in the area to the west deemed to represent the historic core of the ironworks, and currently subject to partial demolition activities.

HISTORICAL BACKGROUND OF THE SITE

The history and achievements of the Butterley Company have been extensively documented through several publications, most notably; Mottram and Coote's work of 1950 '*Through Five Generations: The History of the Butterley Company* ', Riden's 1973 '*The Butterley Company 1790-1830'* and 1990 revised edition, and Roy Christian's 1990 book '*Butterley Brick: 200 years in the making*'. The following section will outline the main aspects in the history and development of the site.

Little is known of the site itself in the Prehistoric or Romano-British periods, and only occasional isolated finds are recorded from the immediate surroundings.

Butterley is a hamlet in the Parish of Ripley, formerly associated with the manors of Ripley and Pentrich, and the hundred of Morleston and Litchurch in Derbyshire. Although there are no archaeological sites of medieval date attributed to the footprint of the ironworks, Lorde de Grey noted a sea coal mine at Butterley in 1430 (Anon 1953, cited in MAP 2007, 10). Additionally, nearby Butterley Hall (LB 24715, Grade II) and its chapel are believed to be built on the site of a medieval manor house that was a former grange of Darley Abbey (MAP 2007, 11).

Following the dissolution of Darley Abbey, the Manor of Ripley was sold; the area encompassing the Butterley site was bought by the Zouche family of Codnor Castle in 1542. In the 1580s the Zouche family brought blast-furnace iron smelting technology to the area with the building of a furnace in Codnor Park; however these early Codnor furnaces were only in use for a few decades (Riden 1990, 6). By the early 17th century, the Park Estate at Butterley seems to have become detached from the Hall when the land was sold to the Bate family of Derby (Riden 1990, 19). The land at Butterley changed hands several times throughout the 17th and 18th centuries. Upon leasing the Estate from John Spateman of Morton in 1661, William Horne also acquired the rights to mine coal and carry away coal from the site (Riden 1990, 49). It is thought that pits in Butterley had been producing coal in excess of 1000 tons per annum since the early 17th century (Nef 1932, cited in Nixon 1969, 74). At this point the landscape around Butterley was still predominately under agricultural use.

Construction of the canal began in 1787. In 1790, Outram and Beresford purchased a 200 acre area of the Butterley Estate, including Butterley Hall at its southern extent; they planned to run the canal under the park in a long tunnel. Outram had been the assistant to the notable engineer William Jessop for the development of the Cromford Canal designed to link Cromford with the Erewash Canal at Langley Bridge. In 1791, Outram and Company successfully negotiated with the canal company to have an underground wharf integrated into the tunnel directly was to pass beneath the proposed furnace location (Cromford Canal minutes of 10 November 1791, *cited in* Schofield 1988, 110). The canal with its tunnel and 'wide hole' was completed in 1793, and opened in 1794; at the time of its building it was the third longest canal tunnel in the World, after Sapperton and Dudley, measuring *c.*2.7km (2,966 yards) (Schofield 1988).

Rich coal and ironstone seams exposed duing the cutting of the tunnel did not go

unnoticed (Schofield 1988, 110). Consequently, the newly founded Benjamin Outram and Co, the result of a partnership between Benjamin Outram, Francis Beresford, William Jessop and John Wright, established The Butterley Works in 1790. At first, the partnership developed primarily as a mining operation, but it quickly expanded to include an ironworks, and transport links to serve these enterprises; it was to dramatically alter the character of the area.

Smelting on the site began with a single cold-blast furnace, built in 1791 for the production of iron. By 1797, brick and tile making was added to the partnership's portfolio, and additional blast furnaces were built in 1806 and 1810. Derbyshire Record Office holds the accounts for the Butterley Furnace from March 1810 to March 1811 (DRO Ref D503/47/2) (see MAP 2007, 12-13). In 1807, communication links to the site improved with the opening of the Derby to Alfreton Turnpike skirting round the north of the site.

Farey (1815, pages un-numbered, cited in MAP 2007, 13), described the Butterley Company as producing '…pipes, rollers, wheels, cylinders, shaft and steam engines and weighing machines, as well as cast iron rails and wagons'. Engineer William Brunton was an engineer for the Butterley Company between 1808 and 1821 during which time he pioneered locomotive and marine engine manufacture at Butterley (Hayman 2005, 91)

In the 1820s, the Company's expanded further by building a second ironworks at nearby Codnor Park where they already owned lime-kilns and a forge. Around this time the Company also began constructing Ironville, a large village of purpose-built company housing intended to encourage the efficiency of the workforce with its spacious layout and large gardens. Ironville grew throughout the century, registering a population of some 1500 in 1870 (Gaskell 1979, 441). Unfortunately, much of the model village at Ironville has now gone.

By 1835, the Butterley Ironworks had expanded to cover a twelve acre site, and the Company was believed to be the largest coal owner, and the second largest iron producer in the East Midlands. Pigot's 1835 Commercial Directory of Derbyshire describes the Butterley Company as an Iron Masters and Founders, manufacturing pig, bar, plate, hoop and rod iron, and steam engines. As well as being noted as a manufacturer of pig iron and a range of rolled and cast iron products, the Company was known to specialise in a number of areas, including bridge castings for roads, canals and early railways, along with structural iron roof trusses, cast-iron rails for early railways, and cast-iron water and gas pipes (Hayman 2005, 90-1). The Pigot's directory also lists Langley and Portland collieries as belonging to the Company, and a number individuals working for the Company (Lockie 1996):

- George Goodwin, agent to the Butterley Iron Company
- Peter Brown, agent to the Butterley Company
- Anthony Brown, George Outram, and George Stanley, bookkeepers to the Butterley Company
- Major Jessop, Henry Jessop esq., and William Jessop esq., gentry, occupants of Butterley Hall

In 1862 the Midland Railway line was constructed crossing the centre of Butterley Reservoir to the north of the ironworks, and by 1863 the Company was rolling the largest masses of iron of any foundry in the country (MAP 2007, 16). An 1835 map of Butterley Hall Estate held by Derbyshire Record Office (DRO D503/73/210) shows the Butterley Works (labelled '30') but does not depict any further details of furnaces or foundries on the site (see MAP 2007, 32, figure 4), whereas a further Estate map from 1865 (DRO D503/74/210) labels the land of Outram, Wright and Beresford and shows a greatly expanded works with railway lines to the north (see MAP 2007, 33, figure 5) No detailed cartographic depictions of the works were identified pre-dating the 1880 Ordnance Survey map; on this basis the extent to which structures dating from the 1790s and early 1800s were reused and modified or demolished remains somewhat unclear. On the 1882 OS map, three blast furnaces are visibly depicted, and the onsite network of tramways for moving raw materials, machinery and products is prominent (Figure 5).

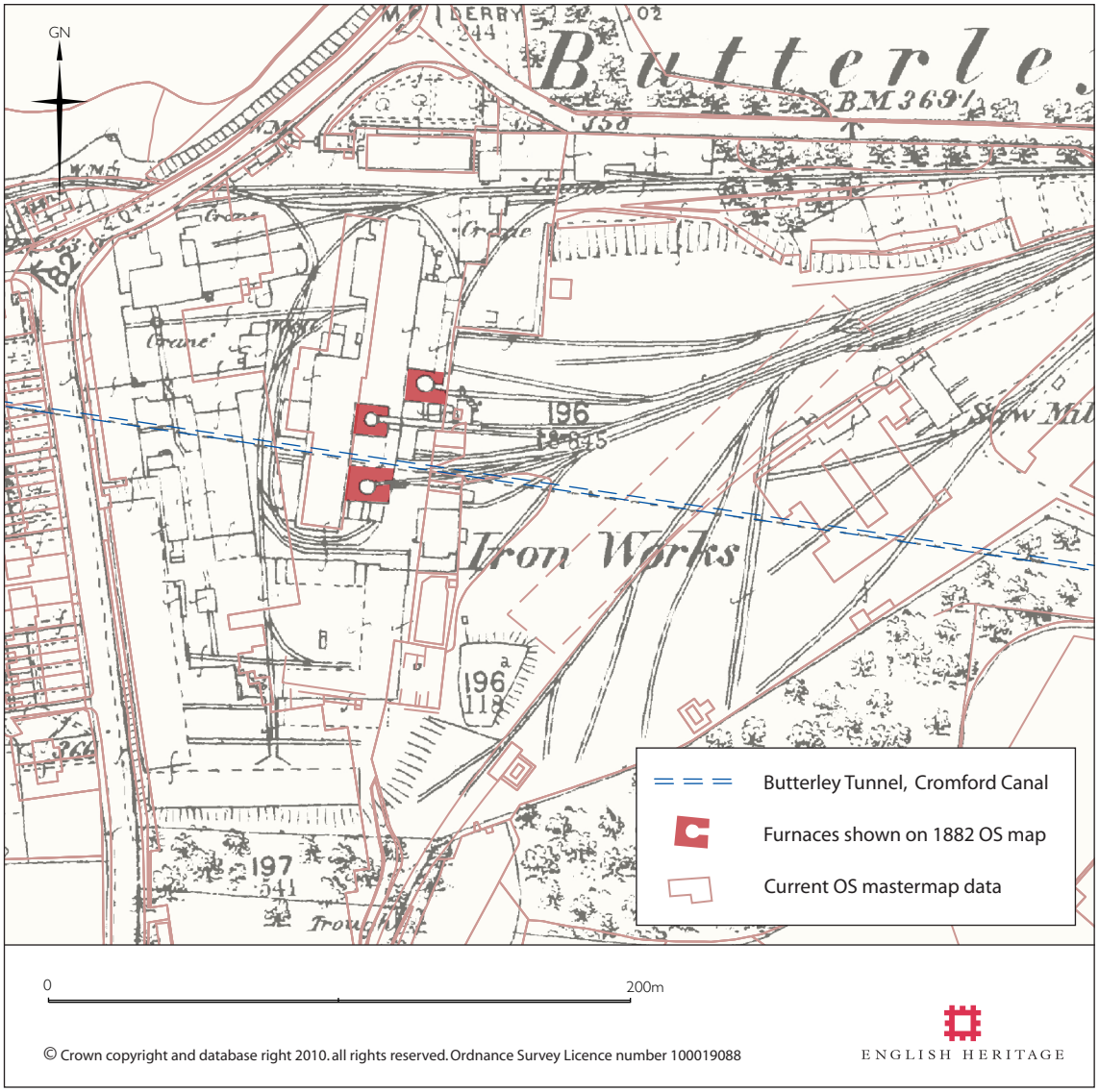

Figure 5: Extract from 1882 1:2500 scale Ordnance Survey map, showing the location of three blast furnaces at the Butterley Works. Drawn by Rebecca Pullen, © English Heritage

The 1892 and 1900 OS maps show a very similar layout (Figure 6), the works and its associated transport links had become very extensive, with a network of railway lines fanning out on the eastern side of the site, and serving the furnaces, foundry and associated workshops. The ongoing expansion of the site is depicted on subsequent OS maps, though significant change is not apparent until sometime between 1921 and 1938 when buildings to the south and west of the site undergo large-scale alteration or rebuilding. By the 1950s, the Butterley Company employed approximately 10,000 workers and had again altered the size and layout of buildings on the site (see Figure 6).

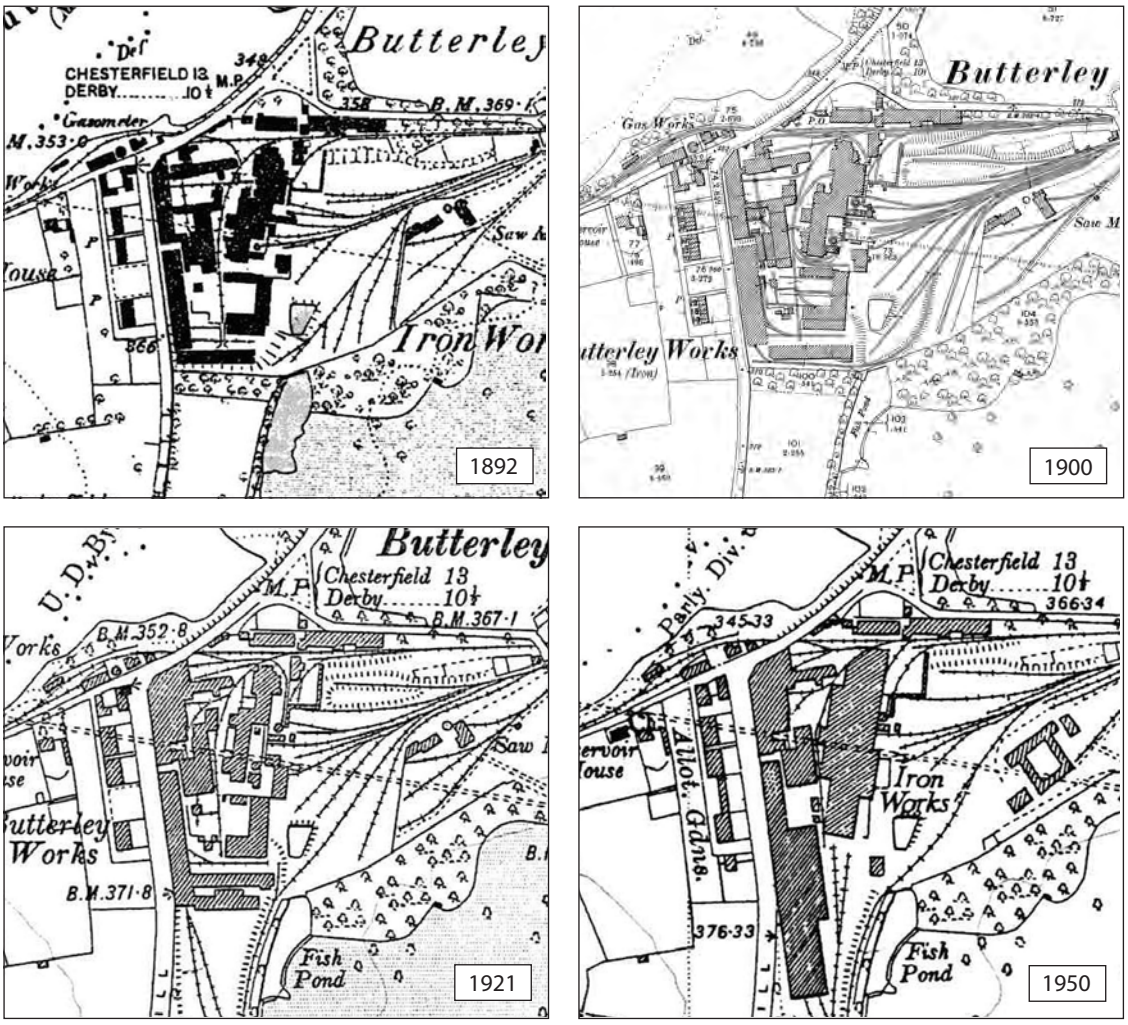

Figure 6: Extracts from the 1892, 1900, 1921 and 1950 Ordnance Survey maps

In 1968, the Company was sold, and subsequently was restructured to form engineering, brick-making and aggregates businesses. A final phase of rebuilding by the Company took place in the 1980s with partial demolition followed by the erection of huge new steel sheds along the western edge of the site in 1985. In 2005, much of the eastern side of the site, encompassing the higher ground covered by internal railways, had been redeveloped for housing. Butterley engineering occupied the majority of the ironworks site until April 2009, when it closed. Since November 2009, demolition works have begun on all post-1948 structures in advance of redevelopment.

Timeline

1787 Construction of canal commenced

1789 Cromford Canal Company formed – William Jessop appointed principal engineer

1790 Francis Beresford and Benjamin Outram purchased Butterley Hall and its 200 acre estate from the ironmaster Horne

Benjamin Outram and Company was established by Outram, Beresford, Jessop and Wright as a coal and iron enterprise at Butterley

1791 Benjamin Outram took over construction of the canal from insolvent contractors

First ironworking forge with a cold-blast furnace constructed over the canal tunnel at the Butterley Works (Riden 1990, 19, 53)

1792 Driving of the Butterley Tunnel underway

10 December, first partnership deed signed binding the four signatories for sixty years in equal shares (Mottram and Coote 1950, 47; Riden 1990, 15)

1793 Cromford Canal and Butterley Tunnel completed

1794 Butterley Tunnel opened

1797 Company also began producing brick and tile

1802 Traffic through Butterley Tunnel had increased to a point where was it required to be regulated through the tunnel by law (Hadfield 1966, 52)

1805 Benjamin Outram died

1807 Opening of the Derby to Alfreton turnpike, this ran past the main gates of the Butterley Works

April, the company was renamed the Butterley Company (Riden 1990, 34)

1810 Butterley Company established the nearby Codnor Park Ironworks (Reedman and Riden 1971)

1813 Carr Colliery described as 'worked out' (Riden 1990, 19)

1814 William Jessop (senior) died

1817 By now Carr Colliery has disappeared from the Butterley Company accounts (MAP 2007, 13)

9-10 June 1817, The Pentrich Riots/Pentrich Revolution – a skirmish of the post-Napoleonic depression, involving rioters invading the ironworks in a search for weapons; they were confronted by the factory agent and a few constables, three senior were killed during the uprising (MAP 2007, 13). A plaque above the door on the gatehouse commemorates the revolution

1826 Masons were sent into the tunnel by the Butterley Company to patch and repair brickwork that was already decaying rapidly (Ratner 2009, 22)

1827 Butterley Company was employing almost 1,500 staff (Nixon 1969, 60)

1830s By the 1830s the Butterley Company was believed to be the largest coal owner and the second largest iron producer in the East Midlands

1835 By 1835 the Works had expanded to cover a 12 acre site and hot-blast technology had been adopted

1838 The original 1791 blast furnace was rebuilt, presumably on the same footprint (Riden 1990, 53-4)

1840s Competition from railways began to undermine the canal trade

1845 Butterley rising main pump and shaft installed adjacent to the north wall at the west end of the wide hole (Greenwood 2003, 18)

1852 Cromford Canal was sold to MBMMJR (Hadfield 1966, 186)

1860 Use of the vertical loading shafts between the Butterley Works and the canal wharf below thought to have ended (Greenwood 2003, 12)

1862 Midland Railway line constructed to the north of the site

1870 The Cromford Canal became part of Midland Railway

1887 The Butterley Company became a Limited Liability Company (Mottram and Coote 1950, 92)

1889 Butterley Tunnel closed after suffering a collapse, four years of repairs followed

Midland Railway's Heanor and Ripley Branch opened

1890 Midland Railway's Heanor and Ripley Branch was extended to Butterley

Butterley Tunnel extended at its west end with the building of the Midland Railway

1893 Butterley Tunnel reopened

1900 6 June, Butterley Tunnel permanently closed due to further partial collapse

1904 Government commissioned survey by Rudolph de Salis considered the tunnel to be beyond economic repair

1907 Partial collapse in 1907 during repair works is documented in a letter dating from March of that year, held in the British Waterways Archives (transcribed by Potter 2009b, 21)

H Eustace Mitton and Sir Francis Fox explored the tunnel and found collapsed sections of roof and shafts (Mottram and Coote 1950, 94; Greenwood 2003, 13-33)

1909 In response to the Royal Commision survey of 1904, Midland Railway sought an Act of Abandonment and passage through the canal was finally stopped

1915 Plans drawn for 'wide hole' to be narrowed and strengthened (BWTD doc ref 10/564 ext ref 16126)

1920 Butterley rising main pump removed (Greenwood 2003, 18)

1937 Announcement of intention to close the Cromford Canal

1938 Cromford Canal closed

1944 Cromford Canal officially abandoned by Act of Parliament

1947 Cromford Canal taken over by British Waterways

Nationalisation of the coal industry

1950s By now the Butterley Company employed some 10,000 workers

1962 Cromford Canal entirely abandoned

1965 Butterley Company closed down and dismantled its Codnor Park Works (Nixon 1969, 57)

1968 Butterley Company was sold to Lord Hanson for £4.7million, and was split into Butterley Engineering, Butterley Brick, and Butterley Aggregates (MAP 2007, 17)

Butterley Hall was sold and became the headquarters of Derbyshire Constabulary

1979 20 September, Robin Witter (1979) undertook an inspection and photographic record of Butterley Tunnel

1985 Following a phase of building demolition on the site in the 1980s, new huge fabrication sheds erected along the westernmost edge of the site

2003 DBA undertaken by ARCUS (Bell and Jessop 2003)

2004 Proposal put forward for redevelopment of part of the Butterley Works site – the initial planning application was rejected by local planning authority, the application went to appeal so an Enquiry was held

In response to the Enquiry, Friends of the Cromford Canal (FCC) requested an opinion of historical value from the Inland Waterways Sub-Panel regarding the former underground wharf (Cragg 2004a; 2004b)

2005 Since 2005 the Victoria Works buildings at the north of the site and all buildings and associated structures on the eastern half of the site have been redeveloped as residential housing (MAP 2007, 17)

Building Recording report produced by John Samuels (Slatcher, 2005)

2006 Tunnel explored and photographed by Tina Cordon (2006)

2007 Watching Brief undertaken by ULAS (Farnworth-Jones and Boucher 2007)

DBA undertaken by MAP Archaeological Consultancy Ltd. (MAP 2007)

2009 Butterley Engineering occupied the site until April 2009

Statutory inspection by an independent Reservoir Engineer led to discussions and action by British Waterways to partially renew mechanisms associated with water inlet from Butterley Reservoir (*see* Potter 2009b)

March, Derbyshire County Council submitted a scheduling assessment request

April, English Heritage listing assessment advice report submitted

November, demolition of post-1948 structures underway

DESCRIPTION AND INTERPRETATION

As described earlier in this document, several previous investigations have already assessed and reported on the surviving buildings of the Butterley Engineering site, now largely demolished.

The following description and interpretation of the remains aims to outline current understanding of the canal tunnel and underground wharf, vertical shaft links to the canal, blast furnaces, foundries, and any potential for buried remains.

Butterley Tunnel, Cromford Canal

The Butterley Tunnel was opened in 1794; at the time of its construction it was the third longest canal tunnel in the World, after the Sapperton and Dudley tunnels, measuring *c.*2.7km (2,966 yards). The canal was supplied by water from Butterley Reservoir on the hill above the tunnel, and entered the canal via an adit to the tunnel (*for the location of inlet culvert see the 1880 site plan of the Works in* Greenwood 2003, 34, figure 2).

The tunnel is currently some 2.8km long (one and three quarter miles / 3,063 yards), having been extended twice at its west end; initially for the building of the Midland Railway in 1890, and latterly for the construction of the modern A38 road.

The tunnel was driven simultaneously from both ends through various coal measures lying beneath the Butterley estates (Greenwood 2003, 8). The surrounding area had already been subject to extensive mining in the form of shallow 'bell pits', though by the later 1800s methods were turning to longer wall mining which would eventually lead to the closing of the tunnel by associated subsidence. The Butterley Works themselves escaped subsistence through the purposeful retaining by the Company of a large pillar of coal underneath the complex (Greenwood 2003, 8).

The tunnel was brick lined throughout, and remained entirely unsupported by other means until problems of instability and collapse began in the late 19th century. In an inspection account by the Inland Waterways Protection Society from 1959 (Watson 2009, 23), construction of the tunnel is described as '…interesting, having permanent centring for the brick vault in the form of stout planks supported on curved railway-line sections built into the tunnel sides', and suggests that this attests to earlier attempts to repair damage caused by subsidence. In total, thirty-three vertical shafts were sunk to assist drivage during the tunnels construction, although only four were kept open as airshafts following its completion (Greenwood 2003, 8). As the tunnel was constructed prior to the successful use of steam driven pumps for ventilating deep shafts or long tunnels (and long before industrial electric fans were available), the depth to which the heading could be driven was directly governed by the necessary provision of ventilation shafts. According to Greenwood (2003, 8), many of the vertical shafts at Butterley were narrow in diameter compared to the standard airshafts of some 9ft (2.7m), but they were adequate for air passage and as escape routes. Along with airshafts along the line of the tunnel, two loading shafts were sunk directly from the Butterley Works to an underground wharf on the Cromford Canal (Greenwood 2003, 8-9).

Likewise, the canal itself was of a narrow gauge at 2.7m wide (9ft), and with only 2.4m (8ft) clearance above the water level; because of this, boats on the Cromford Canal were smaller than average, and the lack of towpath meant that boats were navigated by 'Legging', a tiring, slow and dangerous method requiring two individuals to lie braced sideways on the top of the boat while walking along the walls of the tunnel to propel the boat. The long narrow nature of the tunnel necessitated regulation of traffic in a one-way system alternating in direction of flow every three hours. At the time of its opening boats could only enter the east portal between 5am and 6am or 1pm and 2pm, and the west portal between 9am and 10am or 5pm and 6pm, and could not take more than three hours in transit. By 1802 tunnel use had increased, and to compensate the tunnel was also worked at night, allowing boats to enter the east portal between 9pm and 10pm, and the west portal between 1am and 2am (Hadfield 1966, 51-2; Potter 2003, 67).

Boats associated with the Butterley Works would have been used to transport limestone to the works, coal and iron ore from the mines, and products from the manufacturing process (Greenwood 2003, 10). Use of the canal and its tunnel diminished somewhat with increasing reliance on tramways and full scale railways which could provide greater speed and carry larger loads; by 1844 Butterley had some 96.5km (60 miles) of internal railways with locomotives and rolling stock, a coverage that continually increased and by 1880 lines spread to almost all of their works and mines (Greenwood 2003, 11).

According to Riden (1990, 15), the Partnership had

> '…power to extract minerals from wherever it wished at Butterley, except under buildings or within 10 yards of any house. Likewise it would erect whatever buildings, furnaces, forges, limekilns, houses or steam engines it wished on the estate as long as none were within 200 yards of Butterley Hall'.

Limestone, required in the furnaces to act as flux improving fusibility in the process, was brought to the Butterley ironworks by barges travelling south-east along the Cromford Canal from the Crich-Cliff lead mines (Mottram and Coote 1950, 49). Nixon (1969, 80) suggests that for every 1 ton of iron smelted in the Butterley furnaces, 1 ton or more limestone was required as a flux.

The tunnel was closed in 1900, and passage through the canal was finally stopped by Act of Abandonment in 1909 following a government commissioned survey by Rudolph de Salis in 1904 which declared the state of the tunnel to be beyond economic repair. However, maintenance continued until the 1920s as a requirement to maintain water levels, and many sections were piped to retain flow in the event of further collapse (Greenwood 2003, 12).

The tunnel has since been explored and photographed a number of times. In September 1979, Robin Witter inspected the tunnel and provided fifteen colour photographs with descriptions available on the Friends of the Cromford Canal (FCC) website (Witter 1979). More recently, Tina Cordon explored the tunnel between October and November 2006; her photographic report is published on-line comprising 122 colour photographs with brief descriptions of location, function and condition (Cordon 2006). In

conjunction with Des Greenwood's 2003 publication on the Butterley Tunnel, personal accounts from tunnel inspections in 1907 (*see* Greenwood 2003, 18-24; Potter 2009a), and 1959 (Watson 2009), and early 20th-century Midland Railway plans of the tunnel, these records comprise the majority of the known corpus of information relating to the wide hole in Butterley Tunnel.

Description of the tunnel interior by Witter and Cordon suggest that much of the tunnel walls are lined with a mixed lime and ironstone flow-stone, and the water is heavily silted with deep rust-coloured deposits. Distance along the tunnel is marked by iron plaques labelled with the number of 'chains' travelled from the eastern portal (Witter 1979; Cordon 2006); one chain is equivalent to 22 yards (66ft) which represents about 20m. Many sections have been strengthened with wooden shoring, horizontal iron roof braces, or iron hoops. Cordon (2006) suggests that marks on some of the shoring timbers hint that they were reused railway materials. The tunnel height dimensions change several times along its length, and brick patching is visible in a number of places (Witter 1979; Cordon 2006). Cordon also noted leaks in the wall fabric suggesting that the water level in the tunnel was lower than that of the surrounding water table.

The canal tunnel is now owned and maintained by British Waterways, and is not presently accessible as it is only partially navigable and in an unstable condition. Beyond the east end of the portal the tunnel was partially filled with limestone rubble and water during repairs in 1909 and water was carried through this section in pipes (Greenwood 2003, 30). This rubble remains in place between the 43 and 50 chain marks (Witter 1979) (Figure 7). After a short stretch of this rubble surface, a collapsed section exists somewhere around the 55 chain marker (*c.* 1.7km from the west portal), east of the eastern end of the underground wharf, and so access to the wide hole and associated features is only possible by entering the tunnel from the western portal (Cordon 2006).

Figure 7: Limestone infill in the Butterley Tunnel, (after Witter 1979, image 13) © Robin Witter, reproduced with permissions

Canal tunnel and 'wide hole' with underground wharf

In his 2003 publication focussing on the Butterley Tunnel, Greenwood (2003, 9), quotes a passage from page 83 of the Canal Company's minute book of November 1791, stating that

> '...at their own convenience and cost they [Outram and Co] were to construct a 'Wide Hole' within the tunnel beneath their property, with access for the canal to pass. Along with the Wide Hole all such shafts, navigable cuts and culverts as required for carrying out their business'.

Greenwood (2003, 49), defines a wide hole as a widened section of canal, often triangular and some 30-40ft across, allowing barges to turn or for several boats to be moored over night. In the case of Butterley, the wide hole represents a section of the tunnel widened to allow boats to lay up for loading at an underground wharf while other canal traffic could continue to pass through the tunnel. The Butterley wide hole was 4.5-5m (15-16ft) across, allowing for the berthing of two of the 7ft wide boat to pass side by side if one was loading (Greenwood 2003, 22) (Figures 8 and 9).

In slight disagreement with Greenwoods description, in his 1979 account of entering the tunnel, Robin Witter describes the tunnel as widening to around three times its previous width (ie 25ft or 7.6m), at the point where the wide hole begins some 825m (900ft) east of the western portal.

Greenwood (2003, 18, figure 11) depicts the wide hole in plan and annotates that it starts in the west at the 40 chain mark, and that the wide hole and tunnels linked to Carr Pit were located about 15m below the surface west of the furnace bank retaining wall, and nearer 30m (100ft) below the higher ground to the east. The wharf would have been connected to the above ground tramways by a crane lift operating through the vertical loading shafts.

Following the expansion of the railways in the 19th century, use of the wharf in the Butterley tunnel declined, and although limestone from Crich quarries continued to be transported by boat, use of the loading shafts to the wharf is thought to have ended around the 1860s (Greenwood 2003, 12). The tunnel was closed in 1900 with all passage ceased in 1909. Despite this, considerable maintenance and alterations were undertaken in 1915 to block off several adjoining shafts and passages, and to narrow the eastern end of the wide hole. Figure 9 shows a plan of this segment of the tunnel recording the progress of works by a detailed sequence of annotation. Remodelling of the wide hole to remain navigable from the western end. Investigation of the wide hole by Witter in 1979 and Cordon in 2006 identified a significant block of newer brickwork narrowing a portion of the wide hole along the southern tunnel wall and blocking off the base of the loading shaft pair. Neither account gives any detail about the landing facilities of main wharf area, though it appears to have been on the south side of the tunnel, probably at the western end where the two high arched entrances are clearly visible (the eastern entrance is now blocked); these are the two dry roadway tunnels identified by Witter (1979) and discussed further in the next section. Masonry quoins were noted at the water level on the projecting corner at the 40 chain mark where tunnel narrows (Figure

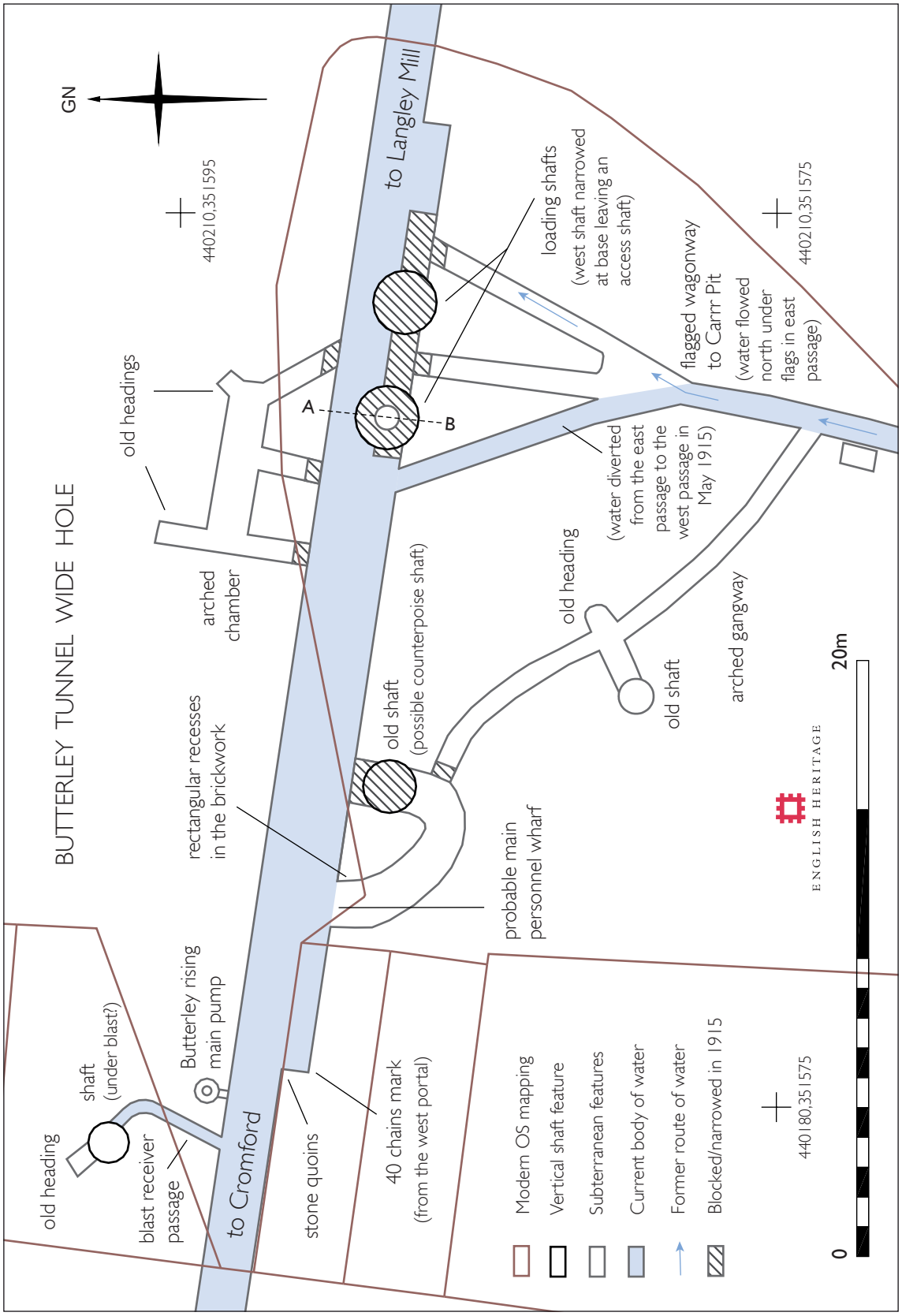

Figure 8: Interpretive diagram of Butterley Tunnel wide hole as it is thought to survive (adapted from Midland Railway plan of 1915; Witter 1979; Greenwood 2003; Cordon 2006; Farnworth-Jones and Boucher 2007), Drawn by Rebecca Pullen © English Heritage

M.R. BUTTERLEY TUNNEL.

PROPOSED SHORTENING OF "WIDE HOLE."

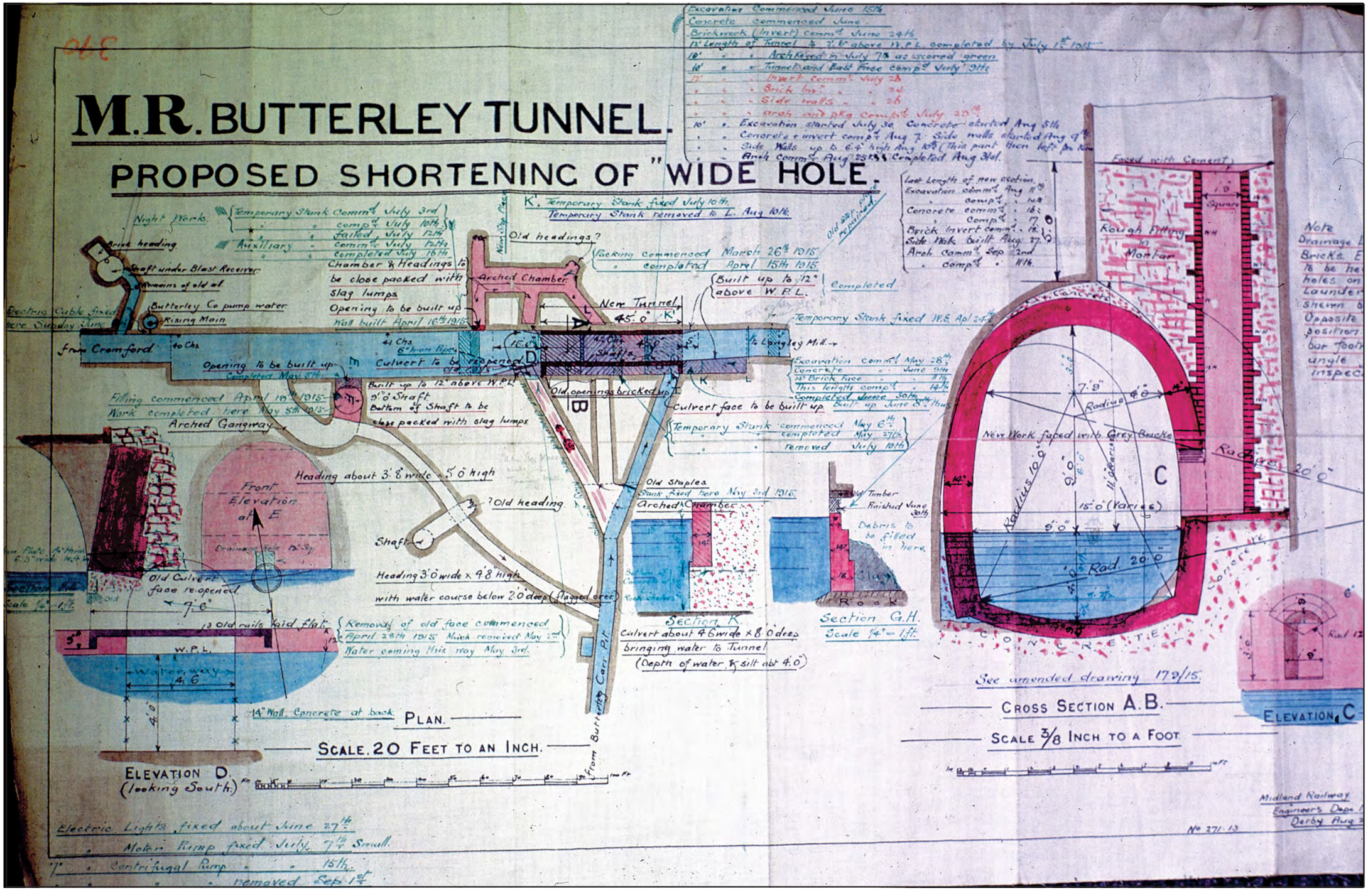

Figure 9: Midland Railway Plan showing the 'proposed shortening of the wide hole', with annotations from 1915 detailing progress of the work

Photographed by Hugh Potter, © British Waterways Technical Directorate, Leeds (BWTD doc ref 10/564 ext ref 16126) reproduced by kind permission

10). Rectangular recesses in the brickwork within the sides of the open entrance are suggestive of some form of supported loading platform or walkway (Figure 11). It could be tentatively suggested that this was for loading and unloading people, rather than the crane system for hoisting materials through the loading shafts to the east.

Figure 10: East facing internal elevation of the wide hole, showing stone quoins protecting the projecting west corner, looking west (after Witter 1979, image 11), © Robin Witter, reproduced with permissions

Figure 11: Rectangular recesses in the brickwork, main personnel unloading point, looking south-east (after Cordon 2006, images 67 and 69), © Tina Cordon, reproduced with permissions

Horizontal links to the tunnel: adits and branch tunnels

To maintain the water level the canal was fed by adit from Butterley Reservoir. The coalfields around Butterley were heavily exploited; one of the company's collieries, Butterley Carr Pit, was worked with the assistance of small boats using a short branch tunnel running south from the wide hole (*see* Figures 8 and 9). Riden (1990, 190) describes Carr Colliery as 'worked out' by 1813, and Farey (1815, 192; 1817, 337, 343-4), implies that use of boats in this branch tunnel had ceased by at least 1815. Additionally, several inlets carried ochre-laden mine drainage waters drained water away from Butterley Carr Pit into the subterranean canal (Greenwood 2003, 8-9).

In his illustrated report of an inspection of the tunnel interior Witter (1979) describes and photographs an adit in the north wall of the tunnel connecting to Butterley Reservoir, some 550m (600yards) from the western portal; he noted wooden slats braced horizontally at equal distances along the bottom of a *c.*18m long brick-lined feeder tunnel with water visible cascading down in the distance. Cordon (2006) records Witter's slats as iron beams.

Although, Witter does not discuss a second adit from the reservoir, Greenwood (2003, 34, figure 29), marks a second adit from the reservoir ending at a point between two blast furnaces close to the supposed west end of the wide hole, and labelled 'reservoir suction' to satisfy the need for water in the smelting process. It is unclear whether this sump for the furnaces had any physical connection to the tunnel itself. A second curving passage carrying water used in the tuyeres for cooling the blast away from the furnace and into the tunnel, via an opening in its north wall close to the west end of the wide hole, is described in a 1907 account of a tunnel inspection by Mitton (*see* Greenwood 2003, 18). This feature is described as a blast receiver tunnel and photographed in some detail by Cordon (2006), showing that the base of a vertical shaft under the site of a former furnace still survives, along with some surviving iron fittings in the floor, and a very short section of tunnel continuation beyond (Figures 12 and 13).

Figure 12: Low entrance to blast receiver passage in north wall of tunnel, looking north (after Cordon 2006, image 59), © Tina Cordon, reproduced with permissions

Figure 13: Low entrance to blast receiver shaft, seen from inside shaft, looking south-east (after Cordon 2006, image 64) © Tina Cordon, reproduced with permissions

A little further east in his exploration, Witter (1979) describes reaching the western end of the wide hole within the south wall of which are two dry roadway tunnels of substantial dimensions; the western tunnel appeared to curve away to the east, while the entrance to the easternmost of the pair was bricked-up. Greenwood believes these to curve round to join each other, and that the eastern opening represents a possible old counterpoise shaft blocked off in 1915 at the same time as the narrowing and strengthening of the wide hole (2003: 18-9) (see Figures 8 and 9). It was in this western opening that recesses in the brick were noticed, possibly capable of supporting some form of platform. Cordon further explored this pair in 2006, confirming their joint nature, and noting the blocked entrance to a narrow arched gangway leading to the Carr Pitt access wagonway.

Tina Cordon (2006) records several of these side tunnels or arched gangways in her explorations which were more thorough than those undertaken by Witter in 1979. Although most points can be tied in with plans of the wide hole section of the tunnel, it is not always clear precisely which elements of the complex of galleries he is describing. From beside the blocked loading shaft bases three passages once led to the main Carr Pitt access tunnel, the easterly two are now blocked, but Cordon was able to enter the western passage and from there access the Carr Pitt tunnel and the gangway leading back to the western pair of openings (Figure 14) (see Figures 8 and 9).

According to the annotated Midland Railway plan of 1915 and Greenwood's interpretation (2003, 18, 22), there should be a group of three gallery entrances blocked in the north wall opposite the position of the loading shafts; it is unclear from the text and images in Witter and Cordon's accounts whether this is the case.

At Butterley, mineral and waste rock extraction took place using a series of specially constructed branch canal tunnels; for example Carr Colliery was first worked by a tunnel for small boats leading off Butterley Tunnel, though later like other pits on the estate

it relied on railways to transport its coal (Riden 1990, 51). This juxtaposition of canal tunnels with mining works and the construction of wharves and connecting galleries eventually caused problems of subsidence and often weakened the tunnel itself (Roberts 1980, 5, 10). In the case of Butterley, subsidence led to closure of the tunnel which is now highly unstable (Roberts 1980, 10).

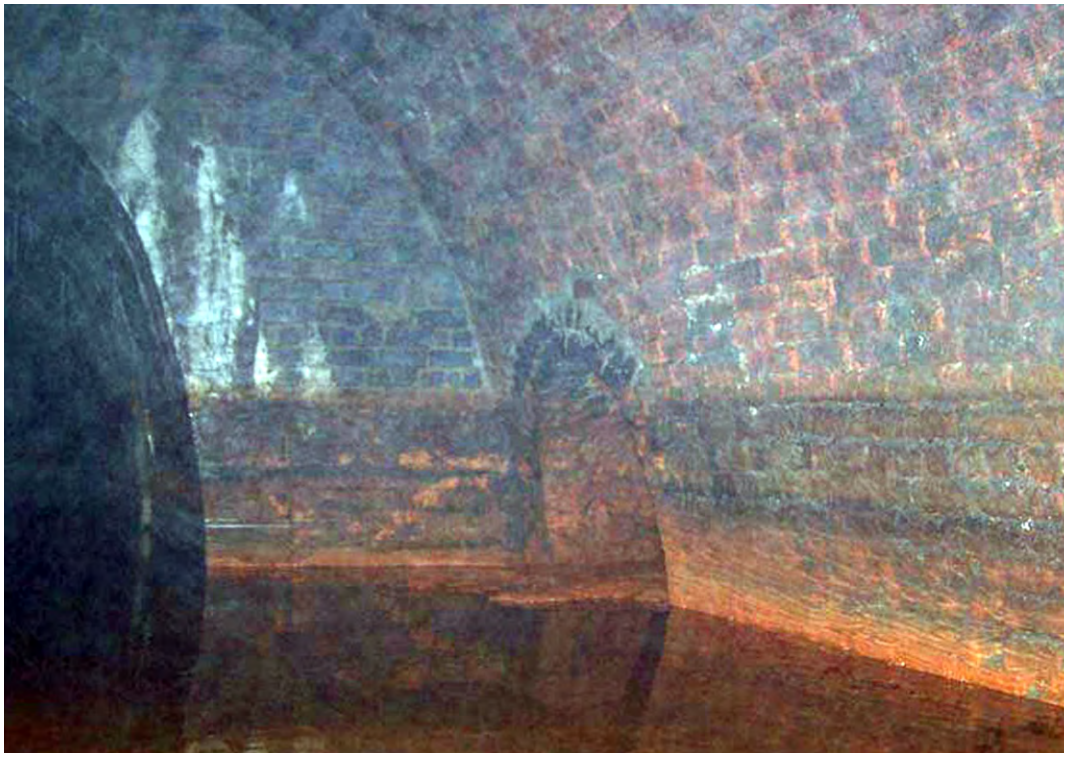

Figure 14: Remaining open entrance to Carr Pit wagonway, seen in south wall of tunnel, just west of narrowed section of the wide hole, looking south-east (after Cordon 2006, image 79), © Tina Cordon, reproduced with permissions

Vertical shaft links to the canal

As previously mentioned, in addition to the four open airshafts retained to ventilate the canal tunnel, the Butterley Tunnel was also punctured by two vertical loading shafts sunk directly from the Butterley Works down to the underground wharf, providing direct access to the canal (Greenwood 2003, 8). Several additional shafts appear to have connected into the canal and its branch tunnels close to the wide hole, for example the blast receiver shaft discussed in the previous section, which drew water used for cooling away from the blast and back into the canal.

As described by Rees (1819, pages un-numbered, cited in Roberts 1980, 11), at the Butterley Works ore for the furnace along with coals for fuel were drawn up through these shafts from the mining and transport system below. In all probability, limestone brought by barge from Crich quarries to the north-west would also have been unloaded at the wharf and hauled up to the works through these shafts to be used as a flux in the furnaces.

The goods were transported vertically in containers to and from the canal boats to tram wagons that were transported to the Butterley Works on top of the hill. The lifting system initially used a water bucket counter balance system subsequently replaced by steam engines; is the set up has been described at some length by Farey (1817, 340-1):

> 'In the Coke Yard on the E side of Butterley Furnace, two large Shafts descend to a recess for Boats, adjoining the Canal Tunnel, thro' which the large Tram boxes of Coals, Ironstone, Limestone, Fluor, &c. are drawn up, for the use of the Works; and Pig Iron and Cast Goods, &c. are lowered into the Boats below, to be sent off by the Canal. Formerly, a large water bucket, supplied from a Reservoir, descended in another Shaft, as a counterpoise for drawing or lowering Goods in these Shafts, but a very complete *Whimsey* Steam-engine has been substituted; guide chains descend the drawing and lowering Shafts, to steady the frames that suspend the Tram-boxes; which last are held suspended over the Shaft, while a Stage is slid over it, on which a pair of Wheels, and a Horse attached to them by shafts, have been backed; the Tram-box is then lowered and placed on the Wheels, the stage is slid again off the Shaft, and the Horse then proceeds with the Tram-box and its contents, to any part of the Works, and returns in like manner to the other Shaft, with Goods that are to be lowered in the like manner and sent off.'

A cross section diagram of the wide hole and an associated loading shaft I the annotated 1915 Midland Railway Plan shows, depicts the proposed narrowing of the wide hole at the east end, and shows the original profile of this section as a faint arc, with the new layout resulting in a narrowing of the loading shaft for inspection access only and the insertion of a small arched opening at the base where the shaft exits into the tunnel (*see* Figure 9) (*for a simplified version of the cross section see* Greenwood 2003, 23, figure 16). The position of the shafts in relation to the original wide hole profile would have allowed goods to be loaded directly into the barges without need for an adjacent unloading platform (Greenwood 2003, 24).

Although limestone from the quarries at Crich continued to be transported to Butterley by boat after the expansion of the railways and the opening of the Derby to Alfreton turnpike, use of the loading shafts to the wharf is thought to have ceased around the 1860s (Greenwood 2003, 12).

In her exploration of the tunnel in 2006, Tina Cordon recorded base of a shaft thought to be the western example of the loading shaft pair. She described it as a narrow shaft with twelve iron rungs set into the wall at 14 inch (0.36m) intervals allowing access up through a square hole and into the wider base of the loading shaft (Cordon 2006) (Figures 15 and 16). This description matches the proposed remodelling of the wide hole and narrowing of shafts, relating to the 1915 wide hole shortening modifications; the arched doorway giving access to the lower iron rungs is shown in 'Elevation C' on the Midland Railway plan (*see* Figure 9) (*see* Greenwood 2003, 24).

Figure 15: Entrance to narrowed vertical shaft, showing iron rungs (after Cordon 2006, image 82), © Tina Cordon, reproduced with permissions

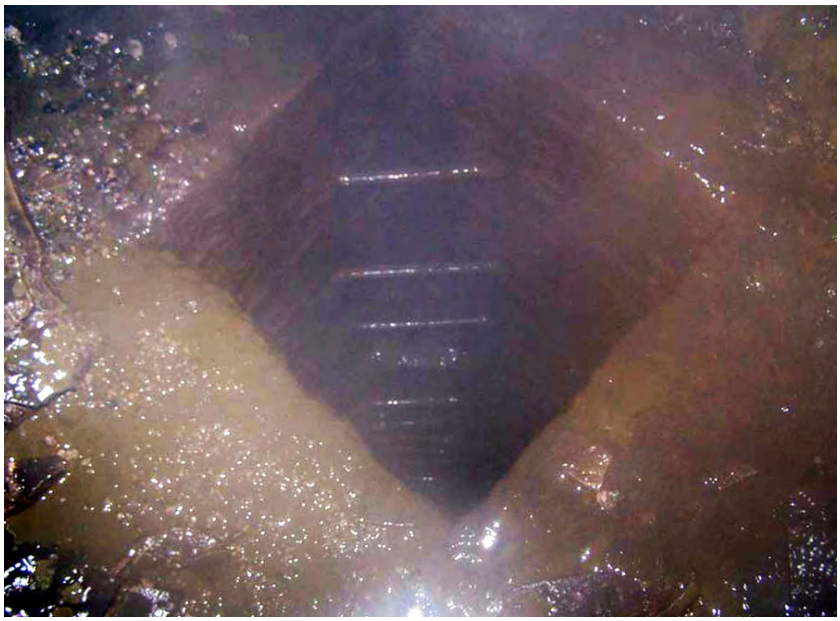

Figure 16: Western loading shaft looking down through the narrowed square opening (after Cordon 2006, image 85), © Tina Cordon, reproduced with permissions

Two vertical shafts connecting the canal tunnel to the ground surface above were exposed during groundworks in 2007, and recorded in a watching brief undertaken by University of Leicester Archaeological Services (ULAS). The upper portions of the shafts were photographed and approximately located by ULAS; the report describes the two shafts as measuring 2.13m (7ft) in diameter, and spaced at 4m apart centre to centre. The shaft itself was constructed of yellow sandstone blocks, each measuring approximately 0.26m x 0.18m x 0.07m, and bonded with a grey dry lime mortar with small white inclusions. A later 1.5m high domed cap had been constructed over the shaft opening, built using a stretcher bond construction of red bricks bonded with a pinkish dry lime mortar with small black and white inclusions (Farnworth-Jones and Boucher

2007, 6-7) (Figure 17). During the 2007 watching brief, the upper 8.5m of composite superstructure was demolished in order to insert a concrete cap over the mouth of the shaft at the level of the surrounding bedrock.

Figure 17: Domed brick capping on a shaft exposed during archaeological watching brief (after Farnworth-Jones and Boucher 2007, 7, figure 4), © ULAS, reproduced with permissions

The ULAS report describes the pair of shafts as formerly being used for the construction and ventilation of the Butterley Tunnel. These shafts are potentially those that were used for the loading and unloading of containers, and if so would once have had associated headgear mechanisms present at their tops (Farnworth-Jones and Boucher 2007), and may represent the two loading shafts labelled by Greenwood (2003, 18), and described as having been blocked in 1915 with the narrowing and strengthening of the wide hole. However, in his conclusion, John Boucher states that despite being of approximately the right diameter and location, the orientation and internal features were not as expected. 'The two shafts found are clearly not the loading shafts to the tunnel wide hole. Whether they pre-date or post-date the canal construction is impossible to say' (Farnworth-Jones and Boucher 2007, 13). This puzzle still needs to be untangled.

Greenwood suggests that three vertical shafts may have existed for loading purposes, along with two counterpoise shafts, though it is unclear which shafts he is attributing to these functions, other than the paired loading shafts in the south wall of the wide hole. These two principal loading shafts were thought to have been within the stockyard rather than under the foundry (Greenwood 2003, 44).

An addition to shafts associated with the wide hole, Greenwood suggests a further shaft was sunk from the interior of the old brass foundry (Building 8) close to where the tunnel runs underneath; nothing of this is mentioned in the recent building appraisals.

Butterley Ironworks

Blast furnaces

In the early 19th century, Farey (1815, cited in Riden 1990, 51), noticed slag on the Butterley Hall estate, suggestive of earlier ironworking. This is most likely from a bloomery as there is no evidence for a charcoal-fired blast furnace at Butterley.

Clear physical evidence for the towering blast furnaces at Butterley currently exists in the form of two furnace structures incorporated into the 14m high stone retaining wall cutting north-south across the centre of the site. Previous investigations into the Engineering Works have referred to these integrated features as 'Structure 1' (MAP 2007; Hawkins 2009), and Greenwood (2003) refers to these as being in the position of the original blast furnaces from 1791. The northernmost of the two furnaces survives largely intact, and has recently been used to house a modern electricity sub-station under the archway in its front (west-facing) elevation. Further south along the retaining wall are the largely demolished remains of a second furnace of similar size and design. Greenwood (2003, 41), suggests that the southern furnace had the front section of its original cast house removed to make way for a new furnace built in around 1820.

According to Riden (1990, 53-4), only a single cold-blast furnace was constructed for smelting when the works first opened; he suggests this was built around 1791, based on the existence of a re-used inscription stone marked 'B.O. 1791' incorporated into the fabric of the northerly of the two surviving later furnaces within the high stone retaining wall (Structure 1), though nothing of the original furnaces survives. The extant furnace remains are themselves dated by a plaque just above the re-used stone, stating 'Rebuilt 1838' (Riden 1990, 53).

There appears to be a degree of confusion surrounding the subsequent sequence of furnace construction. Greenwood's plan (2003) indicates two early furnaces from 1791, apparently sharing the footprint of the surviving furnace bank. Riden (1990, 53) describes a second blast furnace being added sometime between 1796 and 1805, and a third about 1805-6. Other records have suggested that a second cold-blast furnace was constructed in 1806, and a third in 1810. Further research is required to piece together a definitive account of furnace construction and upgrades at the Butterley Ironworks site.

An engraving on an 1801 bill of exchange represents the earliest depiction the ironworks (Figure 18). It is thought to show a single furnace, with a three-bay casting house in front and a charging-house on the bank behind, along with other ancillary buildings and chimneys, and Butterley Reservoir in the foreground (Riden 1990, 53).

The following diary extract describes the furnaces and foundry at the Butterley site, as of Sunday 5 January 1806, according to George Mushet, assistant and younger brother to the manager of the nearby Alferton ('Riddings') Ironworks (Healey 1982, 19):

> 'I gratified my curiosity by taking a peep at the exterior of this extensive works, where ruin, confusion, and desolation seemed to exist in this rude mass of architecture. The works consists of 3 blast

Figure 18: Detail from an 1801 Bill of Exchange showing the Butterley ironworks (after Riden 1990, 50 figure 2), reproduced with permissions

> furnaces, 2 of which are presently at work. The casting houses run out in front of the furnaces. They are filled from a level coke yard. Their burden of cokes, 16 cwt to the charge and 14 cwt of Ironstone. 2 barrows containing 8 cwt each formed one Charge. The new furnace went 11 to 12 of these in one shift, the furnace 7 to 8. The rest of the buildings are moulding shops, Smith shops & etc and various workmen's houses & etc struck into the form of a circle round the blast furnaces, having in the front of the Casting house a square piece of ground for Pig iron yard.'

If this is to be believed, then there were three furnaces at Butterley by 1806, presumably with the third 'new' furnace having only recently been constructed. According to Riden (1990, 19), these initial cold-blast furnaces were constructed of local freestone; they each measured 12.2m (40ft) high and with a 4m (13ft) basal diameter and were powered by steam-driven blowing engines.

The values presented in the table below (Table 1), when compared to equivalent data collected by Riden (1990, 30) for other smelting sites in Derbyshire, Nottinghamshire and Leicestershire, show that by 1830 Butterley Ironworks was unmatched in its output, and only the adjacent site at Codnor Park, also owned by the Butterley Company, had as many furnaces built. The table also suggests that the site saw some element of change in use or rebuilding of furnaces during the mid-late 1820s.

Table 1: Butterley Ironworks Blast Furnace Statistics, 1796-1830 (after Riden 1990, 30, table 2), where dashes appear data was not available

Year	Furnaces standing	Furnaces in blast	Reported annual output
1796	1	-	936 tons
1805	2	2	1,766 tons
1810	3	3	-
1823	3	-	2,639 tons
1825	2	2	3,000 tons
1830	3	-	3,981 tons

According to Greenwood (2003), original pair of blast furnaces was replaced by two furnaces sited immediately east of the original structures, the southern of this pair dates to around 1820. Again, there is a degree of confusion between sources as to the sequence of furnaces construction and rebuilding. The large furnace bank, dated by a stone inscribed 'Rebuilt 1838', remains as a prominent feature, surviving as large rectangular sandstone superstructures incorporated into the existing high retaining wall that bounds the present Ironworks site to the east. It is unclear whether the original furnaces stood on the same spot as the later rebuilt furnace bank.

In 1828, the vastly more efficient 'hot-blast' technology was patented by James Beaumont Neilson; a large iron producing enterprise like the Butterley Company would want to move over to these new methodologies fairly swiftly, no doubt requiring further construction or adaption of their furnace facilities. It is thought that by 1830, hot-blast furnaces had replaced the original cold-blast furnaces at Butterley, which would have put the ironworks at the forefront of technology. Nationally, the hot-blast method only became widely adopted as a method of improving efficiency in the smelting process in the later 1830s (Espinasse 2004). Neilson's hot-blast method involves the blast being heated by hot gases taken from the upper part of the stove, or in stoves by producer gas and other fuels. The Monuments Protection Programme (MPP) report on the Iron and Steel Industries (Crossley 1992, 34), states that hot-blast apparatus rarely survives, making evidence of early installations of particular value.

A comprehensive account of a visit to the Butterley Ironworks, from the 1844 edition of *The Penny Magazine* of the Society for the Diffusion of Useful Knowledge, describes the three large blast furnaces on the site as 'huge clumsy erections' capable of either hot- or cold-blast methods (Knight 1844, 74):

> 'At the Butterley Works they [the furnaces] have a square horizontal section, and partake in their general appearance and construction much of the character of Egyptian buildings, especially in the opening which forms the lower mouth of the furnace. The furnaces area bout forty-five feet in height: they are built of stone quarried in the neighbourhood, and are lined internally with fire-bricks and cement capable of resisting heat.'

These furnaces could each hold around 120 tons of burning material at any time. At the base of the furnace structures had apertures on three sides holding tuyeres conveying

Figure 19: Engraving showing the feeding the furnace at the Butterley ironworks (after Knight 1844), copyright expired

compressed air, or hot gases in the hot-blast design, from a store in a blast-regulator. The blast-regulator at Butterley was a thirty-foot high iron cylinder, measuring nine feet in diameter (Knight 1844, 77).

The account further details the furnace charging method, and the hot-blast technology; it suggests that the ore, fuel and flux were brought to the furnaces by railway from the pits. The materials were then transferred in their necessary proportions (alternating between just coal, and iron ore mixed with limestone) into special carriages with a cylindrical vessel at one end of a long balance, the vessel has a loose bottom shaped as an upward cone which can be lowered to release the contents once it is suspended over the six-foot square mouth of the furnace (Figure 19) (Knight 1844, 76).

In 1848, the Company had six furnaces in blast, out of a total of twenty for all Derbyshire at this time, and producing nearly 21,000 tons of pig iron (Mottram and Coote 1950, 76). In a further technological leap, Bell and Jessop (2005, 5), state that the Company installed a plant for the manufacture of steel by the Siemens-Martin process in 1887, utilising haematite imported from Spain.

Following the nationalisation of the coal industry in 1947 the Company could no longer depend on supply of their preferred coal, and as a result its furnaces were converted to oil-firing which further reduced its self-sufficiency (Bell and Jessop 2005, 5). Presumably referring to the same alteration, Greenwood (2003, 40), states that by the mid 20th Century all blast furnaces on the site had been replaced by smaller Cupola furnaces (steel cylinders with internal refractory brick linings), though cupolas are mentioned in an

inventory for the site from 1813 (Bell and Jessop 2005, 4). By 1975 only the retaining wall and integrated furnace remnants remained as testimony the main casting foundries and furnaces (Greenwood 2003, 40).

The recent listing advice report for surviving structures on the Butterley site (Hawkins 2009, 3), suggests that:

> 'The surviving sections of retaining wall give some idea of the scale and character of what has been lost, but are not in themselves of such special interest as to compensate for the loss of buildings and structures central to an understanding of the site's industrial character, and the processes on which its reputation was founded'.

The MPP Report on the Iron and Steel Industries describes coke-fired blast furnaces of the later 18th and early 19th centuries as surviving in some number due to their robust construction, and often retaining elements of traditional earlier design. The report also suggests that structures of this period are disproportionately represented in the long-term history of coke-fired furnaces, with traditional stone-built structures surviving in greater number than those of 19th- and 20th-century origins, many of which were of iron construction and some were dismantled for scrap (Crossley 1992, 12-13). With this in mind, the surviving (partially derelict) 1838 rebuilt furnaces at Butterley may be of more interest than the 1790 structure that it replaced.

Foundries

The Butterley Company owned the ironworks at Butterley itself, along with those at nearby Codnor Park to the south-east, and all of the land between the two. Both sites had active blast furnaces, but the foundry at Butterley was used for casting pig iron on a large scale and direct casting of large components for civil engineering projects, whereas the works at Codnor Park were designed for the processing of pig iron into wrought iron in a finery, and for the processing of coal into coke before the introduction of hot-blast furnaces rendered this unnecessary (Knight 1844).

The casting process at Butterley would have involved forming moulds around a wooden pattern to leave accurate voids in a bed of sand (probably wet Green Sand mixed with coal dust), into which the molten iron was drained out of the blast furnaces to create one hundred or more oblong pigs of metal feeding from a central runnel or 'sow' from the furnace (Knight 1844, 77). For larger castings and for collecting molten metal to pour into pipe moulds and the like, liquid iron was directed into large pits in the foundry floor (Figure 20); a comprehensive account of a visit to the Butterley ironworks in 1844 gives the following description (Knight 1844, 74):

> 'When we…pass round to the front of one of the furnaces, we find all the busy and remarkable arrangements for casting the melted iron into sand moulds. A very large roofed shed extends in front of each furnace; and the floor of this shed or foundry has in it various earthen pits in which to make large castings; together with cranes for raising and shifting ponderous vessels filled with the melted iron.'

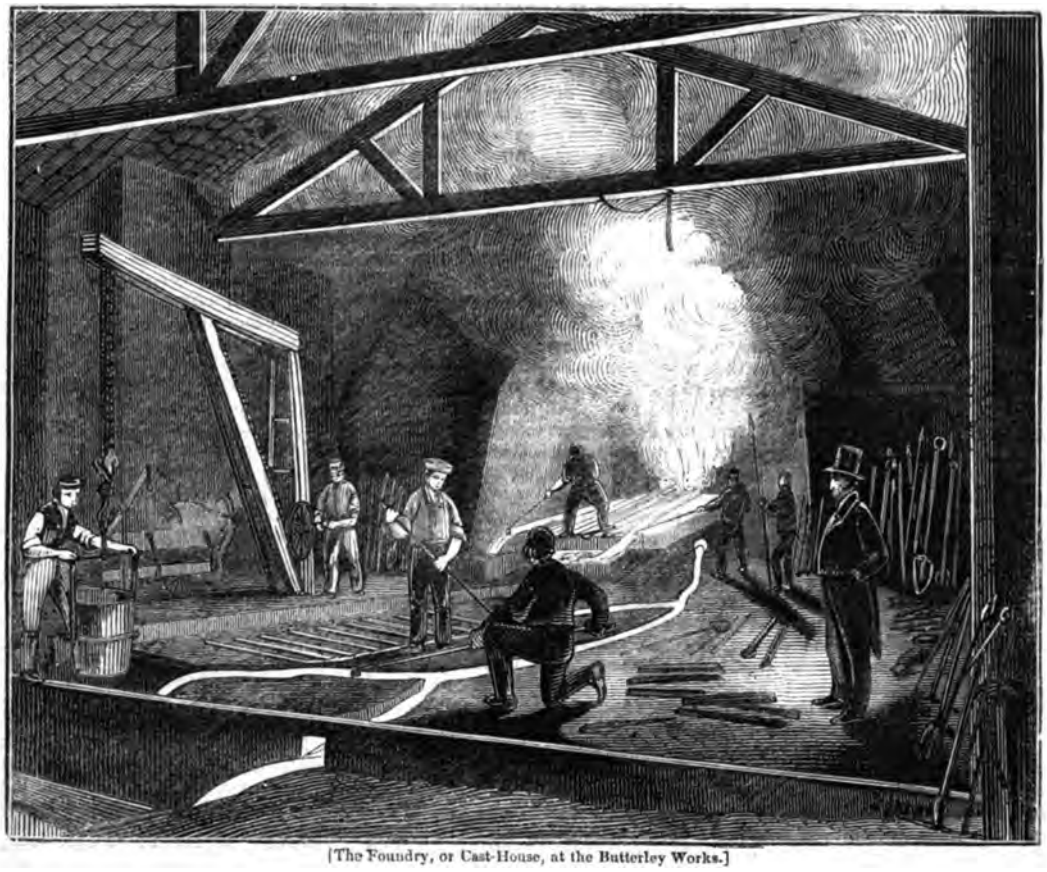

Figure 20: Engraving showing workers in the foundry at the Butterley ironworks (after Knight 1844), copyright expired

Waste slag from the process was tapped into rectangular iron moulds and removed for use in road construction or rough walling (Knight 1844, 77).

Buried remains

No evidence for the potential survival of buried remains has been encountered during the documentary research process (other than the structure of the canal tunnel itself and any associated shafts). The site has suffered significant disturbance in the past relating to construction of the canal tunnel, engineering works, internal railways, drainage activities, and more recent development for residential use.

There is little or no archaeological evidence pertaining to activity on the site prior to the medieval period, and any evidence of early small-scale extraction and ironworking practices prior to the establishment of the Butterley Works and the Cromford Canal are likely to have been heavily disturbed or destroyed by these later engineering activities.

An assessment of the site by ARCUS in 2003, reports that remnants of railway sidings for movement of materials by wagons were evident in the main stock yard, east of the central retaining wall (Bell and Jessop 2003, 7). They further suggested the possibility that sections of the track might survive; however, it is not thought that any track was noted buried or on the surface before redevelopment of the area began.

During an archaeological watching brief undertaken by ULAS in advance of development in 2007, the surviving upper remains of two vertical loading shafts were exposed and recorded before demolition and capping as part of the ground-preparation scheme. Description of the surrounding deposits is of a single horizon of disturbed ground consisting of mixed industrial waste presumed to relate to the former manufacturing activities of the Butterley Works (Farnworth-Jones and Boucher 2007, 6).

One possibility for buried deposits on the site relating to the industrial practice would be any remnant survival of the sand casting beds or large earthen casting pits in the foundry floor, and possible fragments of fired clay from the clay plugs used to seal the metal and slag 'taps', these stoppers were smashed out each time to release the contents of the furnace (*method described in* Knight 1844). However, due to the extent of expansion and rebuilding of the industrial buildings on the site, and more recent demolition practice in advance of development, it seems unlikely that undisturbed remnants of the sand casting beds or pitted foundry floor would survive.

Consideration should also be taken of the potential for waste by-products from the iron smelting process, including lime-rich slag, and metal spills, offcuts and turnings (Dungworth and Paynter 2006).

DISCUSSION AND CONCLUSIONS

Comparable sites

There are thirty-one canal tunnels with listed building status relating to some element of their structure; the majority of which are Grade II. Of these listed stretches of canal tunnel, one is in Derbyshire, and like the Butterley Tunnel it is in the Parish of Ripley and carries a length of the Cromford Canal, however it shares few other characteristics with the Butterley Tunnel. The unnamed canal tunnel is situated at Buckland Hollow some 2.7km west of the Butterley site, and is listed along with its high splayed embankment. It was built by William Jessop and Benjamin Outram of the Butterley Company in 1792, and is short barrel-vaulted tunnel around 27m (30yards) long. It is built of coursed squared stone with segmental arched entrances and a flagged tow path passing through the tunnel (LB 79112).

Canal tunnels associated with extraction

Of the 101 known canal tunnels in Britain, only five were directly associated with the extraction of minerals, having been adapted for mining purposes from conventional canal tunnels (Roberts 1977, 7-14, cited in Roberts 1980, 5). All five tunnels penetrate major watersheds and are characterised by the wide variety of minerals and strata encountered (Roberts 1980, 5). These five were:

- Dudley tunnels, Dudley Canal (coal and limestone)
- Lord Ward's tunnel, Dudley Canal (coal and limestone)
- Butterley tunnel, Cromford Canal (coal and ironstone)
- Harecastle tunnel, Trent & Merseyside Canal (coal and ironstone)
- Morwelldown tunnel, Tavistock Canal (copper, tin and arsenic)

Additionally, Roberts (1980, 10), suggests that the Butterley system may have functioned in a similar manner to the better known levels at the Worsley coalfield near Manchester (*see* Roberts 1981a; 1981b). The Duke of Bridgewater's underground canal tunnels at Worsley would have allowed the canal to directly connect with the mine, while also acting dually helping to feed the canal by draining the mine. The tunnel entrances and wharf at Worsley Delph are scheduled (SM GM17), and the entrance portals and sluice gates are Grade II Listed Buildings (LB 400033, 400034, 400036, 400037).

It is possible that further examples have come to light since Roberts' initial study. At Clay Cross Railway Tunnel, 10miles to north of the Butterley Tunnel, boring of the tunnel exposed iron and rich coal seams inspiring the formation of the Clay Cross Company; the northern portal of the tunnel is a Grade II Listed Building (LB 79408).

Canals with wharf/loading facilities underground

In 2004, Roger Cragg of the Institute for Inland Waterways Sub-Panel for Historical Engineering Works undertook an assessment of historical value of the underground wharf at Butterley tunnel at the request of the Friends of Cromford Canal. During consultation of the Sub-Panel's members and database, examples of five sites where

underground facilities were used in the loading and/or unloading of canal boats were encountered in addition to Butterley (Cragg 2004a; 2004b). These five were (*for more detailed descriptions see* Cragg 2004b):

- Brierly Hill on the Coalbrookdale Branch on the Shropshire Canal *(here the canal was at a high level and a pair of underground shafts were used to move goods down to or up from road and rail links at the River Severn level, before later being replaced by an inclined plane wagonway)*

- Worsley Mines near Manchester, on the Bridgewater Canal *(the Duke of Bridgewater's underground canal has 50miles of tunnel on four levels, inclined plane systems and numerous side branches which were used to transport vast quantities of coal directly out from the mines; work started in 1759 and use ceased in 1887)* The tunnel entrances and wharf are scheduled (SM GM17), and the entrance portals and a sluice gates are Grade II Listed Buildings (LB 400033, 400034, 400036, 400037)

- The Castlefield Terminal on the Bridgewater Canal (*here the canal terminated in an underground unloading wharf in a short dead-end tunnel*)

- Dudley Tunnels on the Dudley Canal (*tunnels were used to load and unload quarried limestone, and to reach Tipton Colliery*). The subterranean wharves appear to have been fronted by timber baulks adjacent to brick retaining walls, boats were secured by chains and rails, and narrow walkways of thick planks were supported by metal spikes hammered into the tunnel walls. Much of the tunnel network with its underground basins and wharfs is designated in the expansive area of scheduling covering the limestone quarrying and processing industry in Dudley, incorporating Wren's Nest, Mon's Hill, Castle Hill, and the Black Country Museum (SM 35127).

- Great Northern Railway Warehouse, Castlefield, Manchester, linking to the Manchester & Salford Junction Canal (*here goods came in and out at basement level via a tunnel branch from the Manchester and Salford Junction Canal*). This is a Grade II* Listed Building (LB 461733).

The first four of these examples differ from the Cromford system; where vertical movement of goods took place their tunnels were driven solely for that purpose (Cragg 2004b, 2-3). In this sense the Cromford system is almost unique.

A similar containerisation system of goods movement was used in the Grocers Warehouse at Castlefield in Manchester on the Bridgewater Canal in the 1760's, though the vertical distance travelled by the goods was far less (Farnworth-Jones and Boucher 2007, 4-5).

Other possible examples include Crooke Canal near Crooke village, Wigan, which apparently has an 18th-century tunnel connecting the canal to Taylor Pit Shaft and an underground wharf, though the entrance is now closed and silted-up. Unlike the example

at Butterley, this is a branch tunnel rather than a through tunnel on a main canal route.

Comparable ironworks with furnace remains

At Blists Hill on the Shropshire canal, three blast furnaces and two blowing houses are sited against the canal embankment and are associated with the Coalport inclined plane mentioned earlier. The furnace complex was built around 1840, a similar time to the furnace rebuilding at Butterley, and is one of very few survivors from this period. The group of furnaces and blowing houses are designated as Grade II Listed Buildings (LB 361859) and have Scheduled Monument status (SM WK339). The furnaces have stone and fire-brick hearth structures that would have been topped by iron shafts (Crossley 1992, 13).

Also in the Amber Valley near Ripley is the former Morley Park Ironworks site, located 3.2km south-west of Butterley Engineering Works, close to railway but not served by canal. The site consists of two of fairly dilapidated tall stone-built coke-furnaces. The furnaces are fenced off and all other associated ironworks structures have since been demolished. The northern furnace was built around 1780 and refurbished in 1818, and the southern example was constructed in 1825 along with a boiler house. The pair are designated as a Grade II* Listed Building (LB 79143), and as a Scheduled Monument (SM DR187). Derbyshire Archaeological Society (DAS), state that these are the only significant remains of 1790s iron industry in the county apart from Butterley (letter from D Fowkes of DAS to S Miles, December 2009). The MPP Step 3 report into the Iron and Steel Industries lists the Morley Park site as the only example of later iron industry in Derbyshire (Crossley and Hedley 1998).

Comparable sites subject to designation

To sum up, the following sites that share characteristics, particular to this enquiry, with the remains at Butterley are already subject to some form of protection by designation:

- Worsley Delph and Mines near Manchester on the Bridgewater Canal, tunnel entrances and wharf (SM GM17, LB 400033, 400034, 400036, 400037)
- Dudley Canal, tunnels, underground basins and wharfs (SM 35127).
- Great Northern Railway Warehouse, Castlefield, Manchester, with canal wharf in basement (LB 461733)
- Blists Hill blast furnaces adjacent to the Shropshire Canal (SM WK339)
- Morley Park Ironworks near Ripley, Derbyshire (SM DR187, LB 79143)

Significance and value

Assessment of significance

The Butterley tunnel is one of only five known British canal tunnels where associated mineral extraction took place (Roberts 1977, 7-14, cited in Roberts 1980, 5); and is one of only six known sites where underground shafts and/or an underground wharf was employed in the loading and unloading of canal boats (Cragg 2004b).

The Butterley Works sits *c.*4km from the Derwent Valley Mills World Heritage Site (WHS). The WHS stretches south from Matlock Bath for 24km ending at Derby City Centre; it encompasses a series of historic mill complexes, river weirs and associated settlements, transport networks, and notably, a 10km stretch of the Cromford Canal.

By the 1830s the Butterley Company was believed to be the largest coal owner and the second largest iron producer in the East Midlands, and by 1863 the Butterley Company was rolling the largest masses of iron of any foundry in the country (MAP 2007, 14-16).

The Butterley Ironworks remained in production from the late 18th century to the mid 20th century, and achieved a national reputation for the manufacture of large scale iron castings and components for the expanding railway network and civil engineering projects, notably including:

- St Pancras Station, London – the original steel roof spans for Barlow's recently renovated 247 foot wide single span terminal engine shed (Figure 21)
- Vauxhall Bridge over the River Thames
- All castings for the Croydon, Merstham and Godstone Iron Railway, and the Cromford and High Peak Railway
- And more recently, the modern Falkirk Wheel canal boat lift for British Waterways, reconnecting the Forth and Clyde Canal with the Union Canal

The Butterley Company is described as 'the first nationally important iron manufacturers' in the Cromford Canal Conservation Management Plan (northern section – Cromford to Ambergate); Jessop and Outram of the Butterley Company were also the first to develop and use internal railways or tramways to extend the reach of the canals, and were pioneering in the push towards wider use of railway transport (DCC 2007, section 5, Heritage Significance).

There is also evidence that the products and engineering prowess of the Butterley Company was also valued internationally. Correspondence from 1825 suggests that the partners also owned an ironworks in Calcutta, India, acquired in order to 'form a connection with the Butterley Ironworks at home' (unreferenced document, cited in Mottram and Coote 1950, 60). There are also suggestions of further international connections with potentially large manufacturing requests from Spain for Butterley built machinery; additionally another letter requests plans and estimates for a barge to be built

Figure 21: The Butterley Company stamp at the foot of one of the iron roof spans at St Pancras Station. Photographed by Rebecca Pullen, © English Heritage

for navigating the River Indus (Mottram and Coote 1950, 60).

The MPP report on the Iron and Steel Industries includes the following statement with regard to priorities and recommendations for the blast-furnace period (Crossley 1992, 45):

> '…in Landscape terms, there is merit in identifying blast-furnace sites where there is a relationship with supply activities. These comprise ore-mining, the quarrying of refractories and, hitherto neglected, woodlands where there are physical remains of past coppicing regimes, in the form of internal boundaries and place-names'.

In the case of the Butterley Engineering Works site, the blast furnace remains survive alongside supply activities in the form of the ore and coal mining shafts adjoining the canal in the Butterley Tunnel underneath the ironworks, and the canal's prior use for transporting limestone into the site for use as a flux in the smelting process.

In the 1998, the initial 1992 gazetteer of the MPP Step 3 report into the Iron and Steel Industries was greatly expanded and presented in more detail (Crossley and Hedley 1998). The pair of furnaces at Morley Park is the only site recorded for the later iron industry in Derbyshire in the document, and is deemed to be of exceptional national importance; it is unclear whether the structural furnace remains at Butterley had yet to be identified , or had not been considered for assessment.

Assessment of uniqueness

In his publication, *The Cromford canal, Portal to Portal: a short history of the Butterley Tunnel*, Des Greenwood (2003: 9), describes the system of two vertical loading shafts leading directly from the works site down to the underground canal wharf as '…somewhat unique in that although many works have canals passing through or spurs off for loading few, if any can boast a loading wharf 100ft below'.

Similarly, in 2004, Roger Cragg of the Inland Waterways Sub-Panel for Historical Engineering Works, undertook an assessment of historical value of the former underground wharf at Butterley tunnel at the request of the Friends of Cromford Canal (Cragg 2004b). After looking at the situation at Butterley and the nature of five comparable examples (as previously listed), Cragg (2004a) made the following statement about the underground wharfage facilities at Butterley in an unpublished report for the Friends of the Cromford Canal:

> 'It would appear…that the arrangement on the Cromford Canal whereby goods were loaded and unloaded at an underground wharf *in a through tunnel which formed part of the main line of the canal* was possibly unique, or extremely rare, and hence the recommendation of the Sub-Panel was that it had a high historical interest'.

The other elements of the site particularly focussed on here, namely the furnaces and foundries, although they were early in there late 18th century origin, they appear to have been largely rebuilt in the 1830s or demolished in more recent times.

Assessment of condition and intactness

The furnace remains at Butterley are in a state of partial demolition and continued slow decay. In addition, as an integral element of the 14m high stone retaining wall the structure could be under some degree of physical pressure from the higher ground to the east.

The condition of the tunnel is now deemed highly unstable, originally closed due to subsidence and weakening of structural integrity as a result of such close proximity to mineral extraction activity and the soft local geology, though it is reportedly navigable for a reasonable stretch if entered by the western portal.

Masons employed in 1826 by the Butterley Company to 'plug holes' and repair brick-work in the unstable sections of the tunnel described the tunnel make-up as being very decayed, and talked of using 'barrow mortar' to repair the walls (this may have been Portland Cement, or more likely, lime mortar) (Ratner 2009).

In 1915, the wide hole and underground wharf structures were subject to extensive consolidation and remodelling. The blocking off of shafts and side tunnels plus the shortening of the wide hole in the section immediately underneath the loading shafts has radically altered the feature by removing almost all functional aspects.

The upstanding brick caps on two vertical loading shafts were demolished in 2007 during ground preparation works prior to recent expansive development to the east of the surviving retaining wall; however, there is some debate as to whether these were definitely shafts associated with the canal beneath (*see* Farnworth-Jones and Boucher 2007).

Conclusions

The significant legacy of the Butterley Company and its founding engineers is clear, and could be viewed as of both regional and national importance. There is a strong contextual background; local associations with the history of the site, including company housing at Ironville, and its significant contributions to the technological advancement of British civil engineering and including some of its most iconic architectural and locomotive achievements.

There could be a threat to both the furnace remains and the canal tunnel beneath in that the potential effect of residential development on the structural integrity of the site is unknown. Considerable development has taken place on high ground above the surviving furnace bank and retaining wall, and further development is intended for the western portion of the site.

The 1838 rebuilt blast furnace structures surviving on the site are from a period where few survive and may be of greater value than the earlier examples they replaced (Crossley 1992, 13). The extant furnace remains are currently in a fairly poor condition with much of the stonework overgrown and showing signs of cracking. These structures are integral to a high retaining wall and as such are currently acting as buttresses to a huge amount of earth; for this reason they almost certainly require some form of consolidation or support. Although nothing remains of the early associated foundries, or any of their later incarnations, nonetheless, as the last standing testament pertaining to the great ironworking legacy of the site, the remains of the furnace bank warrant a degree of historical interest despite being a secondary build and in a state of some decay. Accurate metric survey and photographic recording of the footprint and elevations of the furnace remains would enhance present understanding of the structure and its condition.

The local historical society, the Friends of the Cromford Canal, place a high value on the canal and, in particular, on its underground wharf; they are campaigning for its protection and consolidation, with a view to future reopening of the entire canal. The wide hole in Butterley Tunnel along with its surviving passageways and vertical shaft links appears to be the remnants of a unique complex of structural features linking canal transportation with mineral extraction and commercial ironworking.

However, as previously discussed, the wide hole area has seen much alteration and repair work since its construction, and no longer retains any of its loading facilities as originally constructed. Navigation is currently only possible from the western portal and many areas of the tunnel appear unstable with areas of collapsed shoring and bulging brickwork noted in places (Cordon 2006). If it was ever to be reopened to the public it would require major consolidation and refurbishment; possibly including the devising of a scheme of ventilation, lighting and safe emergency exit routes.

The wide hole and associated features would benefit from a more targeted inspection. Both Witter and Cordon's accounts are thorough, but more specific location data would prove very useful as it is often unclear which elements they are describing. Future inspection should produce detailed annotation and alteration where necessary

on an existing plan, along with a photo locator plan and some located accurate metric measurements.

METHODOLOGY

This research was undertaken as a desk-based assessment; due to various constraints the author was unable to undertake a site visit or tunnel inspection. All discussion of site layout, dimensions and condition have been gleaned from archive material and published sources. It should also be noted that, owing to time restrictions, only the most significant documents from the large body of the primary sources relating to the Butterley Company, the Butterley Engineering Site, and the Butterley Tunnel were consulted.

All measurements given by ULAS for the location of the two observed shafts (Farnworth-Jones and Boucher 2007), for the base of shafts as described by Witter (1979) and Cordon (2006), along with those plotted by Greenwood (2003) from early 20th-century documentary accounts all tie together when plotted and measured as a vector drawing (see Figures 3 and 9). However, ULAS suggest that the co-ordinates for the loading shaft positions were given to them by the groundworks contractors and are thought to be inaccurate (Farnworth-Jones and Boucher 2007, 11).

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