ISSN 1478-7008

ENGLISH HERITAGE

Greenburn Copper Mine, Cumbria

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and Stewart Ainsworth

SURVEY REPORT

Archaeological Investigation Report Series AI/6/2001

GREENBURN COPPER MINE
CUMBRIA

Archaeological Investigation Report Series AI/6/2001

NMR No: NY 20 SE 9
NGR: NY 2901 0217
RSM: -

Surveyed September to November 2000
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English Heritage 2001
ISSN 1478-7008

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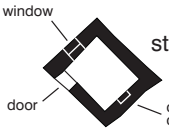
LIST OF ILLUSTRATIONS

Key to English Heritage plans in this report

ARCHAEOLOGICAL REMAINS

- trial working
- surface quarrying or mineral extraction
- chisel holes (selected instances only)
- artificial slope
- ore awaiting processing or waste resulting from processing
- spread of rubble or spoil
- processing building (or site of)



- standing stone-built structure
- battered stone-built walling
- collapsed or roughly constructed stone-built structure
- paving or other stone slabs (selected instances only)
- exposed floor or deliberately created surface
- revetment formed by one or two courses of stone
- intermittent revetment formed by one or two courses of stone
- site of water wheel
- metal fitting
- timber post
- socket for timber post
- horizontal timber post, beam or sleeper
- metalled track
- track (course inferred from earthworks)
- course of inclined tramway
- dam (or site of)
- course of leat
- course of leat (speculative)
- water lying in an archaeological feature
- drain constructed during the use of the mine
- erosion resulting from mining activity

NATURAL FEATURES

- approximate line of mineral vein
- rock outcrop
- stream
- stream (interpolated from OS mapping)
- contours (at 5m intervals)
- natural erosion or steep scarps
- limit of boggy ground

nb: for clarity, the natural accumulation of boulders along the bed of the stream is not shown

MODERN FEATURES

- drain
- fence
- permanent survey marker (brass rivet)
- National Grid at 100m intervals, (except where otherwise indicated)

ENGLISH HERITAGE

1. INTRODUCTION AND BACKGROUND TO THE SURVEY

Between late September and mid-November 2000, English Heritage undertook an archaeological field investigation intended to identify, interpret and record the surface remains associated with Greenburn Mine in Cumbria. The analytical survey was requested and partly funded by the National Trust, which owns the property, and was intended to inform the conservation and long-term management of the site. The mine occupies a remote location 3kms west-south-west of the hamlet of Little Langdale, in the parish of Coniston in the South Lakeland district. Until 1930, when the land was bought and bequeathed to the National Trust by Beatrix Heelis (Beatrix Potter), it formed part of the estates of the Pennington family; it now lies within the Lake District National Park. Although now within Cumbria, prior to the redefinition of county boundaries in 1974, the area lay just inside the northern border of the county of Lancashire. The main processing area, on which the investigation focussed, is centred at National Grid Reference NY 2901 0217.

The mine is regarded as an outlier of the Coniston Copper Mines and was known for parts of the 19th century as New Coniston Mine and Great Coniston Mine. The site was first mined for copper in the later 17th century; it was worked intensively from *c*.1845 until around 1861 and then less successfully by a succession of companies until *c*.1885. Further extraction was carried out between 1906 and 1917 and there was an intermittent presence on the site between *c*.1924 and 1942, although a minimal amount of work was done. Most of the buildings were constructed before 1861 in the period of the mine's most intensive use and some are fairly well preserved. The remains of a number of pieces of equipment for processing the ore also survive *in situ* and the complex as a whole is widely regarded as one of the best preserved copper mines in the Lake District.

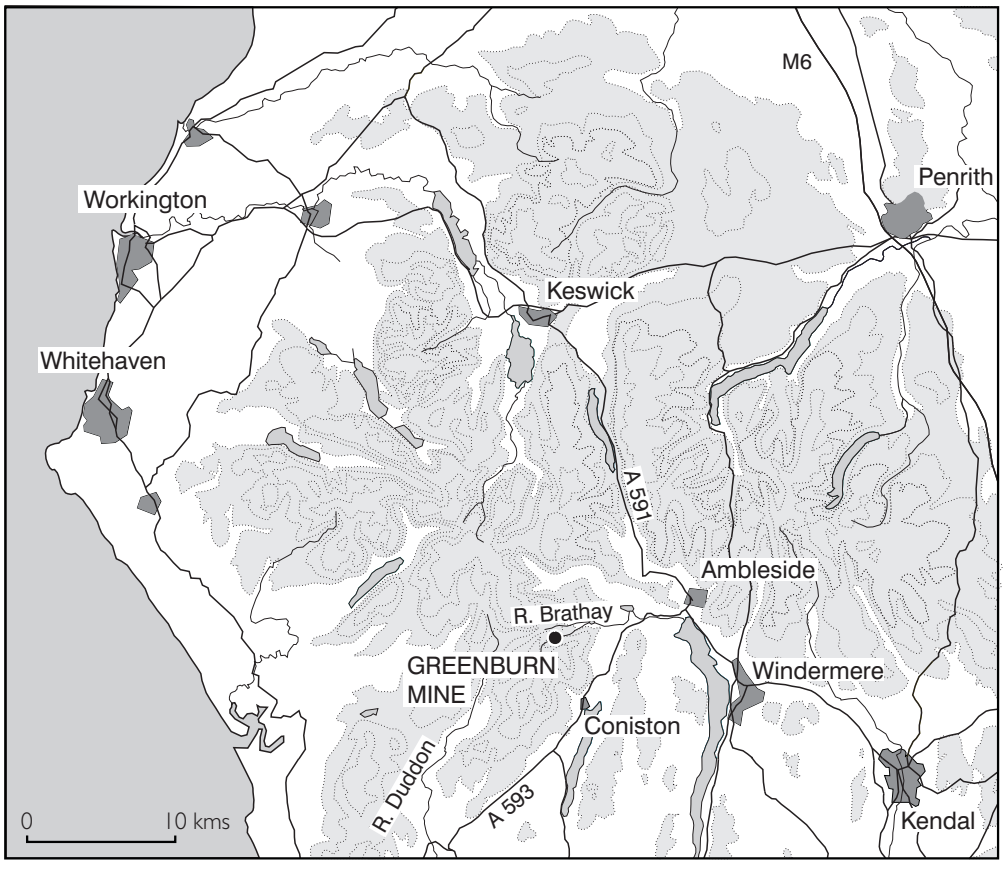


Figure 1. Location map

The detailed fieldwork carried out by English Heritage, which was limited to an area of 6 hectares (15 acres) around the main processing area, was carried out at Level 3 standard (as defined in RCHME 1999, 3-4) and was supported by basic documentary research. In addition, a more rapid field investigation (at Level 2 standard) was undertaken of the rest of the complex, which extends across an area of approximately 26 hectares (64 acres). Due to safety considerations, English Heritage did not carry out any survey of the workings below ground: unauthorised entry into the mines themselves is illegal and potentially dangerous. Certain structures around the processing area are also unstable and are particularly risky in wet weather, while other remains are situated in boggy or precipitous locations that are not easy to reach on foot. Therefore, although the mine lies within the Lake District National Park and public access to the site is not restricted, visitors are advised to approach with caution.

At the time of the field investigation, the remains were not protected as a Scheduled Ancient Monument, although their importance had been noted in the course of English Heritage's 'Monuments Protection Programme' (Hedley and Cranstone unpublished 1995). The site as a whole is recorded in the Sites and Monuments Record for Cumbria as 03153. The well preserved building range which includes the mine office is recorded in the National Monuments Record as NY 20 SE 9; this serves as a parent record for the other remains, the references to which are listed in Appendix 1.

2. GEOLOGY, TOPOGRAPHY AND LAND USE

The main processing area of the mine lies next to the Greenburn Beck, at an altitude of 260m above sea level, mid-way along the Greenburn Valley, which marks the northern edge of the Tilberthwaite Fells. The valley, which is of glacial origin, extends from west-south-west to east-north-east; it is fairly broad but with steep sides, particularly on the south, where the summit of Wetherlam reaches an altitude of 763m above sea level. The Greenburn Beck is a fast-flowing stream fed by several small tributary streams around the western end of the Greenburn Valley; it discharges into the River Brathay to the east. Part of its course was diverted by the creation of Greenburn Reservoir.

Detailed studies of the solid geology in the environs of Greenburn Mine have been undertaken in the past (British Geological Survey 1998; see also Dewey and Eastwood 1925). The 'native' rocks are coarse volcanic ashes and breccias (granites and similar conglomerates) of the Borrowdale Series. There are also grey slates of the Birker Fell and Wet Side Edge types. In the Greenburn Valley, the strata lie nearly vertical, in a arrangement known as the Greenburn Thrust. Nearby, most notably on Betsy Crag 1.7kms to the east, slate has been intensively quarried and mined as a building material; a little quarrying was undertaken at Greenburn to obtain building stone for the early mine buildings (see Section 5.2). Five named mineral veins (also termed 'lodes' in the 19th century) follow more or less the same alignment as the Greenburn Valley: from north to south these are the Low Gill Vein, the Sump Vein, the Gossan Vein, the Pave York Vein and the Long Crag Vein (see Figure 4). The lines of the northernmost three veins can be mapped quite precisely by the outcrops and trial extractions along them and can be seen to run nearly parallel to each other, with a number of shifts caused by faulting (see Figure 9). All five veins contain copper ore and were mined at different dates to varying degrees, the workings lying both east and west of the main processing area. The ore in Low Gill Vein, Sump Vein, Gossan Vein and Long Crag Vein is in the form of Chalcopyrite, or copper pyrites ($CuFeS_2$), while that in the Pave York Vein is in the form of Cuprite, or oxide of copper (CuO_2) (Blundell 1994, 1-2). Different processing techniques were applied to these different forms of ore at different dates.

A thin deposit of glacial sand and clay covers the valley floor and sides, but numerous small outcrops of rock remain exposed, mostly *roches moutonnées*, scoured by glacial action into characteristic whale-backed forms. Towards the western end of the valley, a layer of peat up to *c.*1m deep formed in a hollow scoured out by the glacier. This boggy area is annotated 'Peat Moss' on the Ordnance Survey First Edition 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850; see also Figure 3). The upper layers were partly dug away and largely submerged when the Greenburn Reservoir was constructed, but where erosion and quarrying have taken place around the edges of the reservoir, the peat beds are still exposed. These deposits may well contain well-preserved organic material indicative of early prehistoric environmental conditions.

The upper reaches of the Greenburn Valley are open fell typical of the region, with broad expanses of raised bog on the valley floor above the processing area of the mine. Apart from those areas affected by the mining activity, the land has seen no intensive land-use and is today lightly grazed by sheep. Lying within the bounds of the Lake District National Park, the land is open to the public and the footpaths along the southern side of the valley, which originally served the mine workings, are well used by walkers. Vehicular access along the Greenburn Valley is controlled by the National Trust and is difficult even by 4-wheel drive.

3. HISTORY OF RESEARCH

Most previous studies of Greenburn Mine have comprised brief outline histories which touch upon the character of the ore deposits and the effectiveness of the attempts at extraction (Postlethwaite 1913, 119-20; Dewey and Eastwood 1925, 68-9; Shaw 1970, 119; Marshall and Davies-Shiel 1977, 148; Holland 1987, 164-6; Adams 1988, 152-4; Blundell 1991; 1994). Both Postlethwaite and Adams reproduce copies of 19th-century drawings of the site, but none of the historians has fully referenced the original documents on which their accounts are based. Many of the relevant documents are to be found in the archives of the former landowners, the Pennington family, which are held in the Whitehaven branch of Cumbria Record Office. Those parts of the archives which were regarded as potentially informative were examined by English Heritage and the details of the documents are presented in Section 9.2 (thanks are due to Mr E Holland and Mr J Adams for information concerning their whereabouts).

The mine has been subject to even less investigative fieldwork. Major's article includes a large-scale sketch plan of the processing area, which identifies some of the best preserved features (Major 1969, 54-5). Eric Holland's (1981, 99-110) *Coniston Copper Mines, a field guide*, based on fieldwork carried out by the author in the 1970s, gives a much fuller account of both the surface and underground remains, based primarily on his own accurate observations and well-informed inferences. In

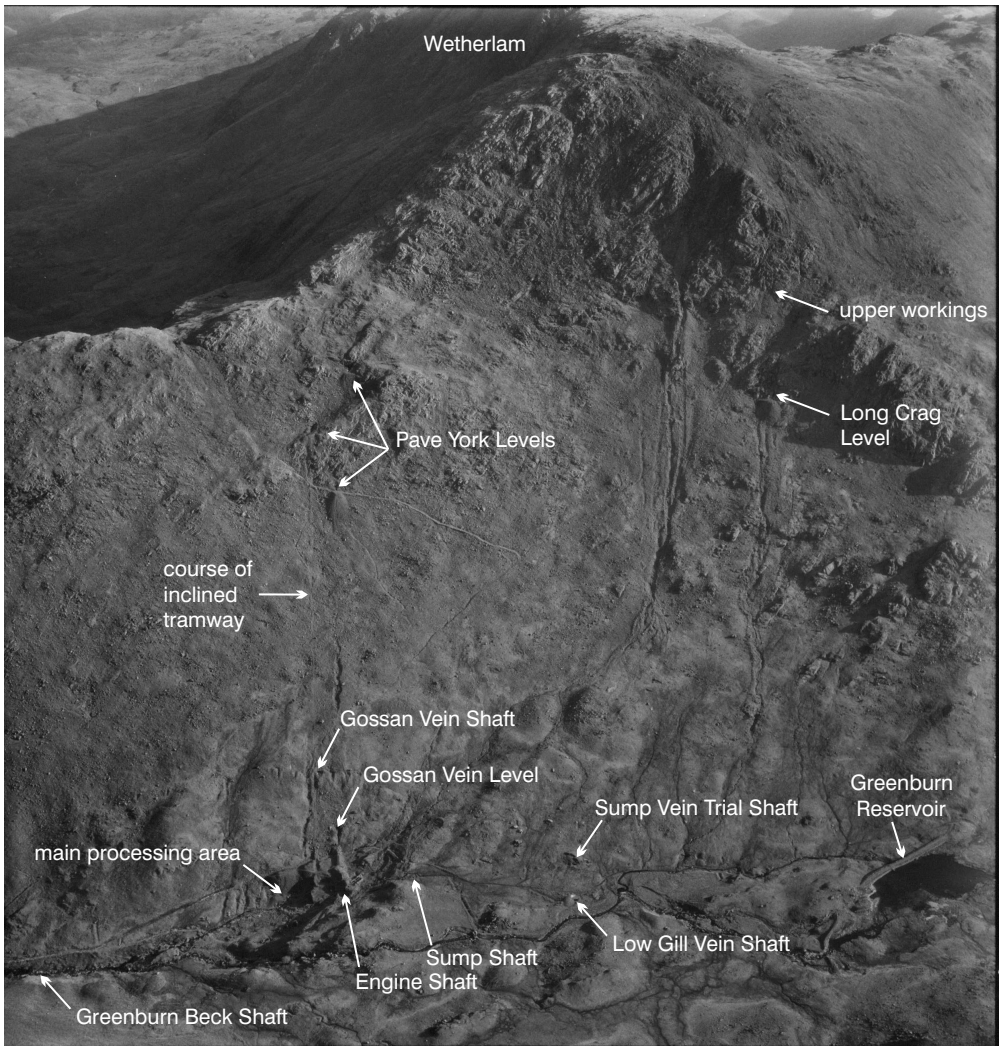


Figure 2. RCHME oblique aerial photograph taken from the north on 15 April 1997, showing some of the principal components of the mining complex (copyright English Heritage NMR)

addition to plans of several of the workings below ground, the guide includes a useful plan of the complex as a whole, made by a 'pace and compass' survey (Holland 1981, fig 48). This survey was later used as the basis for a reconstruction drawing of the processing area seen from the north-east (Holland 1987, fig 35). It should be noted that this drawing conflates structures of different periods and omits certain buildings identified by the English Heritage fieldwork. Throughout this report, most of the names used for convenience to refer to the various mine shafts and levels are those first applied by Holland.

The English Heritage survey was the first thorough investigation of the surface remains and resulted in the first accurate large-scale analytical plan of the complex, at 1:500 scale. The accompanying documentary research was limited to a review of the secondary sources and some primary sources, particularly maps and plans. The detailed investigation followed an initial assessment carried out in November 1995 by Lancaster University Archaeological Unit for English Heritage's Monuments Protection Programme, which concluded that the high standard of preservation was potentially conducive to the interpretation and display of the remains (Hedley and Cranstone 1995). In the wake of this assessment, the Royal Commission on the Historical Monuments of England (RCHME) carried out specialist aerial photography of the site in April 1997, producing a series of black and white and colour aerial photographs (Figure 2). Black and white vertical aerial photographs produced by four non-specialist sorties, made in August 1945, April 1957, June 1957 and March 1972, are also held in English Heritage's National Monuments Record, but these images are at smaller scales and not particularly informative (RAF 1945a; 1945b; 1957a; 1957b; Ordnance Survey 1972).

4. DOCUMENTARY EVIDENCE FOR THE MINE

What scant documentary evidence there is for early extraction in the Greenburn Valley points to a relatively brief but fairly productive phase of work in the late 17th century. A declaration of a sale of equipment by William Monson and William Thompson to the landowner Sir William Pennington, dated 28 February 1690, refers to '…all the Hutts or houses W^{ch} were erected for our use & are still standing on the Fell att Greenburn' (Cumbria CRO D/Pen/46/file 83-89/document 85). This would seem to imply a reasonably intensive and prolonged period of activity, for the term 'house' is regularly applied to storage buildings, such as, for example, a 'copper house' or 'powder house'. Records of the ore extracted and weighed up at Greenburn survive for 18 March 1694, for the period between June and December 1694, and for December 1696, totalling 50cwt (2.5 tonnes), 519cwt (26.4 tonnes) and 88cwt (4.5 tonnes) respectively (Cumbria CRO D/Pen/46/file 83-89/document 84). The quantities extracted between 13 June and 22 September 1697 range from 56lbs (25.4kgs) to 88cwt (4.5 tonnes), totalling some 50 tonnes (Holland 1987, 57). Although these figures would again seem to imply a determined and quite productive effort, the records do not specify the degree to which the ore had been processed when it was weighed, so it is difficult to make secure inferences about the nature or extent of the extraction.

Between 1717 and 1757, a series of documents (listed in Section 9.2) refer to copper mining in Tilberthwaite, but it seems more likely that this term denotes the mines at Tilberthwaite specifically, rather than the Manor of Tilberthwaite, whose area included the Greenburn Valley. In May 1799, Sir John Pennington offered a lease for a period of twenty years to George Wilson and William Mitchell to prospect and mine Little Langdale and Tilberthwaite, which certainly included the Greenburn Valley (Cumbria CRO D/Pen/46/file 102-106/document 102). In July of the same year, he offered a similar lease to William Roe (Cumbria CRO D/Pen/46/file 90-99/document 104). On 14 February 1826, he signed a lease to Michael Knott and John Taylor, again referring to Little Langdale and Tilberthwaite (Cumbria CRO D/Pen/46/file 90-99/document 106). However, in each case there is no further record of what work - if any - was done.

Writing for the third edition of his book on Lakeland mining, which was published in 1913, James Postlethwaite stated that the 19th-century mine had been opened about sixty-five years earlier and an approximate date of 1845 has been accepted by later historians (Postlethwaite 1913, 105). There is some circumstantial support for Postlethwaite's recollection: a lease for the mining rights at Greenburn was initially drafted in 1845, but apparently not signed or fully dated at that time due to a problem raised by the solicitors concerning the precise limits of the area in question. The lease was therefore put aside and was eventually re-used and signed on 10 August 1853 by John Barratt, James Hambleton and Joseph Mason (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see also Holland 1987, 148).

In any event, the First Edition of the Ordnance Survey 6-inch map, surveyed in 1847-8, indicates that by 1848 at the latest Engine Shaft and Long Crag Level were in operation, with a network of tracks and footpaths serving them (Ordnance Survey 1850; Figure 3). The alchemical symbol for copper, an open circle with a vertical cross joining its base, is used to mark the shaft, with the cross corresponding most closely to the actual position on the ground. The same symbol appears close to the annotation 'Greenburn Mine & Works'. This may denote the position of another working, perhaps already disused by 1848, which was presumably sited to exploit the

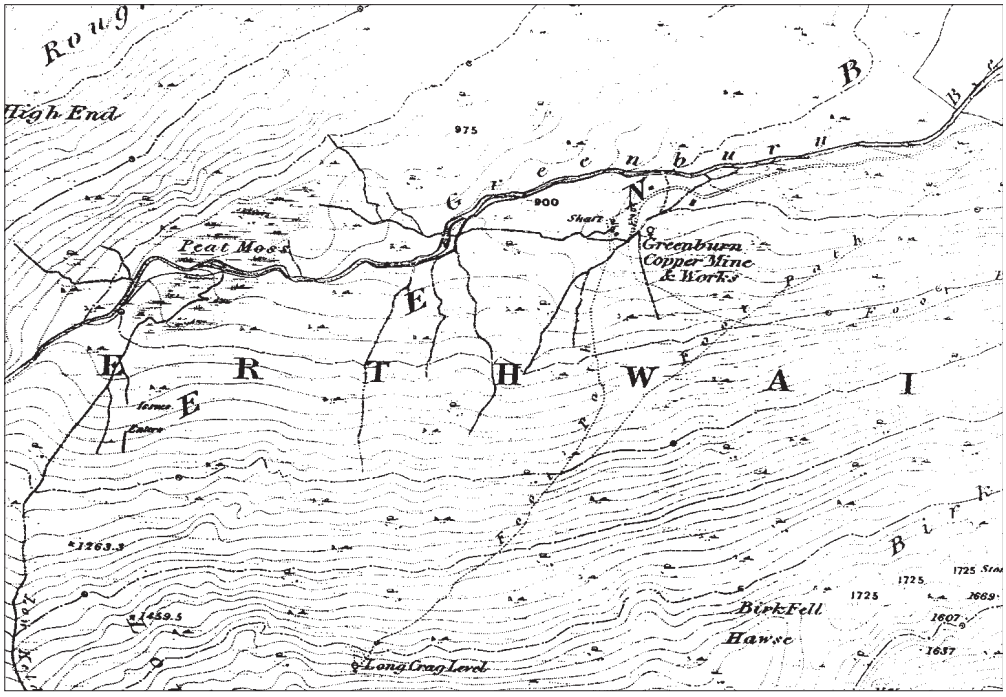


Figure 3. Greenburn Mine as mapped in 1847-8 (reproduced from the 1850 Ordnance Survey map)

Gossan Vein. The entrance to this possible working would subsequently have been overlain by spoil tipping from Engine Shaft and it is therefore referred to in Section 5.1 as the Buried Gossan Vein Level. The same symbol is depicted immediately south of Engine Shaft; this may indicate the existence of an early trial shaft, but its site is now concealed by the upper epsiodes of the Sump Vein south spoil tip. The map also shows buildings that can almost certainly be equated with the extant dry store and explosives store. These are depicted almost precisely correctly in terms of their true plan positions, though on slightly twisted orientations. A line on the map depicts what must be a leat, or artificial water channel; much of its course can be identified on the ground, generally lying within 7m of the line on the map (referred to as Leat 2 in Section 5.5). The existence of such a leat implies that a water wheel was in existence at that date, but none is explicitly marked, although the annotation 'water wheel' appears elsewhere on the map sheet, for example at the main Coniston Copper Mines. Two rectangular structures immediately south of Engine Shaft were apparently associated with the terminus of the leat and one seems likely to have been associated with a water wheel. These buildings, numbered 3 and 4 in Section 5.6, can no longer be identified by surface survey, for their sites now lie beneath the latest phases of the Sump Vein south spoil tip. Somewhat further to the east, three more rectangular buildings were depicted on the map: one of these (numbered 11 in Section 5.6) probably corresponds to a poorly preserved drystone building that remained in use into the later 19th century, but the other two (numbered 5 and 6) can no longer be identified on the ground.

The physical remains themselves suggest that the operation prospered in the period after 1848, and greatly expanded; however, other than the lease of 10 August 1853 mentioned above, no documentary evidence that explicitly refers to this important phase is known to survive. Most secondary sources, including Postlethwaite, agree that John Crossfield & Co of Ambleside held the lease until 1861 and was responsible for the major development of the site (*contra* Marshall and Davies-Shiel 1977, 148), but no primary documentary evidence explicitly relating to this company has been located.

On 6 May 1864, the lease was taken on for a period of twenty-one years by David Dunlop, an entrepreneurial merchant from Glasgow, who subsequently sub-let the tenancy to a series of companies (Cumbria CRO D/Pen/Bundle 60/document not numbered). A prospectus for the New Coniston Copper Mining Co, probably printed soon after March 1868, reproduces a report by a mining engineer named Captain S Vivian, dated 7 December 1865, which assesses the condition of the mine and its remaining resources (Cumbria CRO D/Pen/46/file 90-99/document not numbered; see also Adams 1988, 152). Captain Vivian, summarising the mining work done up to that date, records that Engine Shaft had been sunk into the Sump Vein to a depth of 120 fathoms (219.4m), yielding around £14,000 worth of ore, the implication being that this work had been completed by previous tenants, presumably Crossfield & Co. The Pave York Vein had yielded 'several tons of ore near the surface' but Vivian does not record which of the three levels had been worked, nor precisely when. Long Crag Level had proved almost equally productive, but had been abandoned on account of the great effort required to reach the workings. The existence of Low Gill Vein had been proved, but no further work had been carried out. Vivian states that shortly before the time of writing, the Gossan Vein Shaft had been sunk for a depth of about 5 fathoms (9.1m) before flooding forced work to be abandoned. He adds that due to the promising quality of the vein, work on the Gossan Vein Level was in progress, with the aim of resuming mineral extraction early in March 1866. These fairly precise dates for the work on the Gossan Vein are of key importance in fixing the sequence of phases of activity that can be inferred from the physical remains. Captain Vivian also writes that '…the pumping, crushing and cleaning of the Ores are all done by water power, which saves a vast expense over steam'. Although he does not refer to the Greenburn Reservoir specifically, it is referred to and depicted elsewhere in the prospectus and a note appended to the report in 1868 states that no work other than the extension of the Gossan Vein Level had been carried out since 1865. This confirms that the reservoir had been built by December 1865, and therefore probably before 1861. Holland (1987, 166) speculates that the death of David Dunlop in 1866 left the mine deeply in debt to his estate, so that much less work was done in the wake of Captain Vivian's report than had been anticipated.

In about 1868, the New Coniston Copper Mining Co took over the lease, producing the printed prospectus mentioned above for limited circulation to potential investors, along with a share application form (Cumbria CRO D/Pen/46/file 90-99/document not numbered; D/Pen/46/file 83-89/document not numbered). The prospectus was apparently circulated with two separate sheets of drawings; neither is dated, but the fact that both refer to the New Coniston Mine has led previous historians to accept that they were both surveyed and drawn up at about the same time that the prospectus was written, that is, soon after March 1868. However, there is some evidence that the drawings may not be contemporary in origin either with the prospectus with which they were eventually circulated, or with each other, given that the style of the script, scale and north arrow differs between the two sheets. The first sheet has a small-scale sketch plan of the entire area covered by the lease, known as the 'sett', showing the location of Engine Shaft and the main processing area in relation to the five mineral veins (Cumbria CRO: D/Pen/46/file 90-99/document not numbered; see Figure 4). This plan was almost certainly made before the tenancy of the New Coniston Copper Mining Co, for the original annotation refers to 'Greenburn Copper Mine'. The second sheet comprises three drawings, which were not necessarily all drawn at the same date as each other (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figure 5). At the top of the sheet is an accurately surveyed large-scale profile/section drawing through Engine Shaft and Sump Vein Shaft. Immediately below this is a large-scale schematic plan of the associated buildings on the surface,

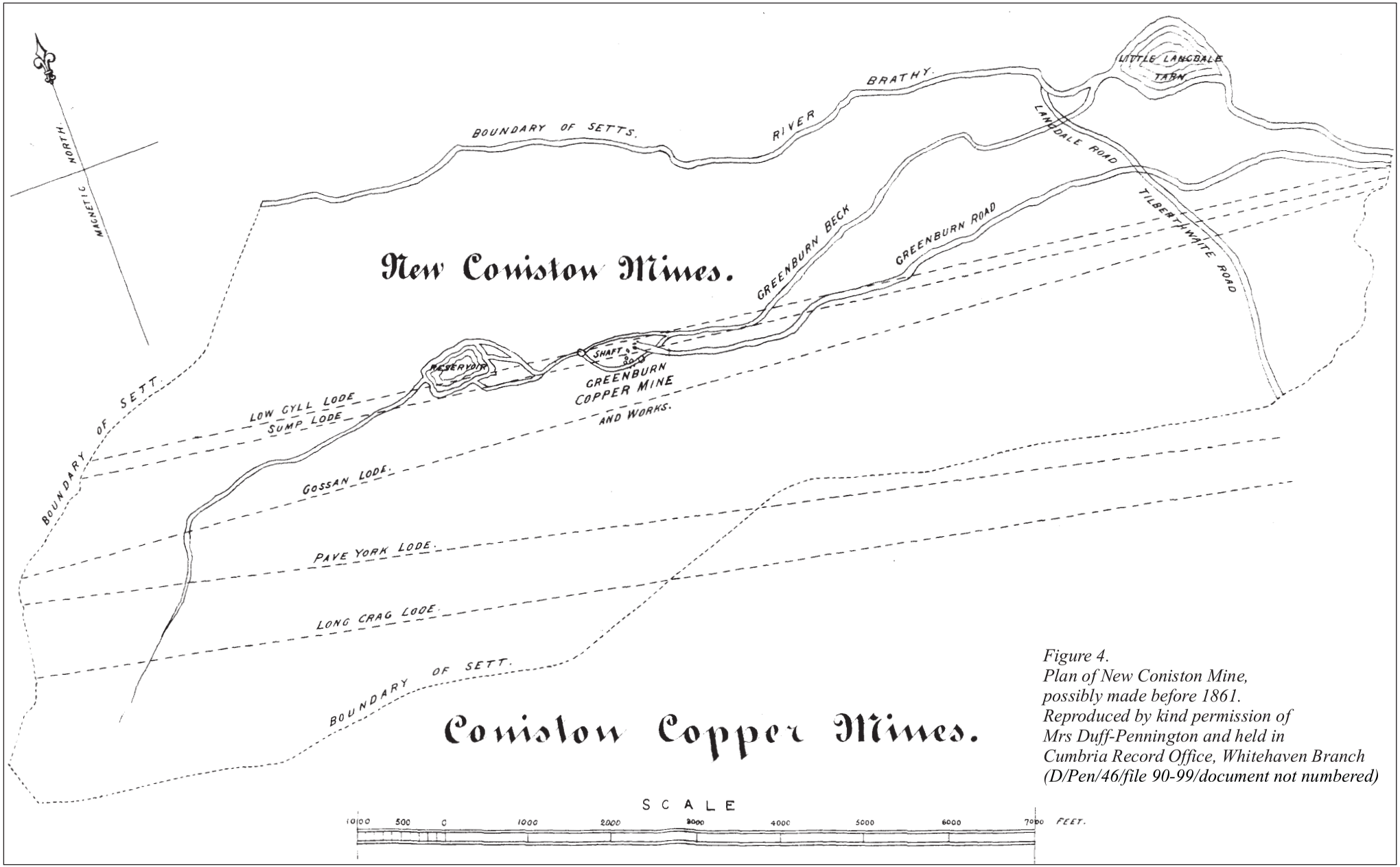


Figure 4.
Plan of New Coniston Mine, possibly made before 1861. Reproduced by kind permission of Mrs Duff-Pennington and held in Cumbria Record Office, Whitehaven Branch (D/Pen/46/file 90-99/document not numbered)

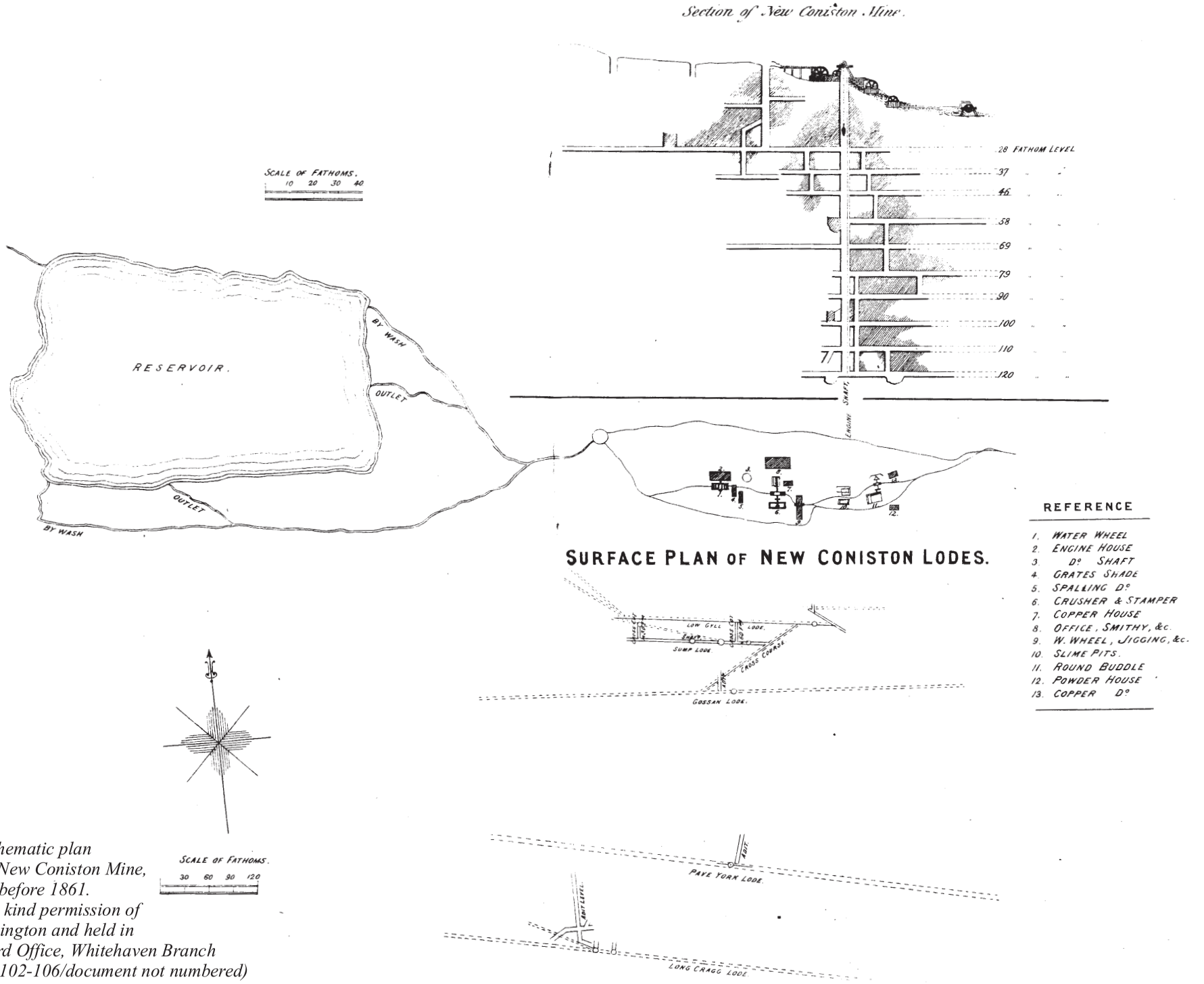


Figure 5.
Large-scale schematic plan and section of New Coniston Mine, possibly made before 1861. Reproduced by kind permission of Mrs Duff-Pennington and held in Cumbria Record Office, Whitehaven Branch (D/Pen/46/file 102-106/document not numbered)

drawn in the same style, which was probably produced at the same time. Four water wheels are portrayed on both drawings and the sites of all these can be precisely identified on the ground. A key to the plan sheds light on the functions of most of the buildings identified by the English Heritage field investigation. The note appended to Captain Vivian's report of December 1865, mentioned above, states that no further work had been carried out by 1868, so it is almost certain that all the features depicted were built prior to 1861. Below these two drawings, and slightly impinging on the large-scale plan, is a plan at a smaller scale of all five veins and the workings on them; this drawing is less carefully executed and more schematic in style, with a title in a different script. The different style and cramped positioning of this lower plan hints that it may have been a later addition. It is the only plan to mark the Gossan Vein Level, which may indicate that this survey alone was carried out after 1866, when work on that level was completed. In summary, there is little doubt that everything depicted on the two sheets, with the exception of the Gossan Vein Level, was in existence before 1861. With the exception of the putative later addition, the drawings may well represent contemporary records of the state of the complex, made prior to 1861 during the most intensive and profitable phase of the operation, under the management of Crossfield & Co. If so, the drawings must have been re-used by the New Coniston Copper Mining Co in 1868 as being still the most accurate depictions available, with the addition of a new plan of the workings to bring the original surveys up to date.

The prospectus includes two more reports, dated 11 February and 11 March 1868, by Captain William Jeffrey and Captain Benjamin Gribble respectively, both mine engineers. Both favourably compared the ore reserves, especially those in the Pave York Vein, to those in the main Coniston Copper Mines. Neither report adds much to the description given by Captain Vivian, but in his description of the Pave York Vein, Captain Jeffrey states that 'The level which has been driven in this Lode is at a depth of 30 fathoms', that is, approximately 55m below the surface. Although this figure is somewhat inaccurate, it corresponds more closely to the altitude of the Pave York Middle Level than to that of the Bottom Level. The depiction of the level on the small-scale plan of the workings thought to have been added *c.*1868 also most closely matches the Middle Level as mapped by Eric Holland (1987, fig 51). Since the prospectus states that no work other than the extension of the Gossan Vein Level had been completed since December 1865, it follows that the level must correspond to the '…small amount of work' on the Pave York Vein mentioned by Captain Vivian. It is not impossible that the work was begun in 1864 and discontinued prior to December 1865, but it seems more likely that it would have been carried out prior to 1861. This adds circumstantial support to the hypothesis that the small-scale plan of the sett was made before 1861, for it shows no workings other than Engine Shaft (Cumbria CRO: D/Pen/46/file 90-99/document not numbered; see Figure 4).

Although Captain Jeffrey's report recommends '…some little alteration' of the machinery, it seems unlikely that any major changes would have been completed by the New Coniston Copper Mining Co, for in the event, no production statistics were submitted, which suggests that little or no extraction was undertaken (Blundell 1994, 3). Eric Holland (1987, 147-8) proposes that it may have been this company to which the Reverend Ellwood was referring when he wrote in the *Transactions of the Cumberland and Westmorland Association* for 1885-6 of '…a swindling concern of a bogus mining company'. His description of the mine itself is no more complimentary:

> *…a bepuffed and worthless old copper mine in the neighbourhood which had already had 3 or 4 crops of unhappy dupes.*

The lease was taken on in 1872 by the Langdale Mining Co, and on 10 April 1873 by the Great Coniston Mining Co (Cumbria CRO D/Pen/46 file 102-106/document not numbered). It seems that the earlier equipment had been left on site, for the Great Coniston Mining Co acquired it from the estate of David Dunlop, at a cost in cash and shares that left the directors in a precarious financial position (Holland 1987, 166). The company evidently failed to get the necessary financial backing, for somewhat later in 1873 the Greenburn Mining Co was formed under the management of Captain I S Williams. Captain Williams was to remain manager of the mine under successive companies until 1881. In a report dated 15 August 1874, Thomas Lawn, a well known mining engineer from Furness, informed the agent for the Pennington family that he had visited Greenburn with Captain Williams and one of the directors (Cumbria CRO D/Pen/46/file 90-99/document not numbered). He states that the company was at that time engaged in driving an adit towards the Pave York Vein '…at a deeper level', that is, the Pave York Bottom Level. He believed this scheme would be successful, but his visit apparently followed a complaint to the landowner, for Lawn added:

> *I find there would not have been any damage done to fish in the river if it had not been for an accident to some Barrels of acid which had been damaged on their delivery at the Mines, their contents ran into the River when the water was very low. The stone tanks are perfectly secure. There are two reservoirs into which the water is conveyed. On its being drawn off the said tanks it is then allowed to run gradually into the river.*

The implication is that the stone tanks had only recently been installed and were involved in the processing of the ore from the Pave York Vein. However, no production statistics were submitted and in 1875, a new company was formed, under the directorship of Messrs McGowan and Cooper, the last recorded tenants of the 19th century. Although the company held the lease until *c*.1885, the lack of production statistics suggests that little extraction can have been achieved. It is perhaps significant that James Postlethwaite, in preparing the first edition of his account of mining in the Lake District published in 1877, makes no mention of Greenburn Mine, for he would quite probably have mentioned it if the work then in progress had appeared at all promising.

Despite the fairly prolonged desertion of the site, the Second Edition of the Ordnance Survey 6-inch scale map, revised in 1889, does not mark any part of the mine as 'disused' (Ordnance Survey 1891; Figure 6). Although the ancillary building outside Long Crag Level is annotated as a 'Ruin', Captain Vivian's report indicates that no work had been carried out there for at least twenty-four years, and it may have been as much as forty years. From the depiction on the map, it would appear that the other features, including the reservoir and the dams and leats that served the processing area, remained intact. However, comparison of the depiction with that on the First Edition map, with the plan thought to have been made before 1861 and with the textual references to other features, suggests that the revision work was far from thorough and that the Second Edition map is unreliable as a source (see Figure 8). Certain workings documented as having been commenced at various dates before 1885 are omitted altogether: Gossan Vein Shaft and Gossan Vein Level, together with all three workings on the Pave York Vein. Apart from the addition of a single building (referred to below as Building 16), the depiction of the main processing area on the First Edition map was also replicated precisely, despite the fact that the two large and two small water wheel pits depicted on the large-scale schematic plan had been built, almost certainly before 1861. The largest of the two spoil tips associated

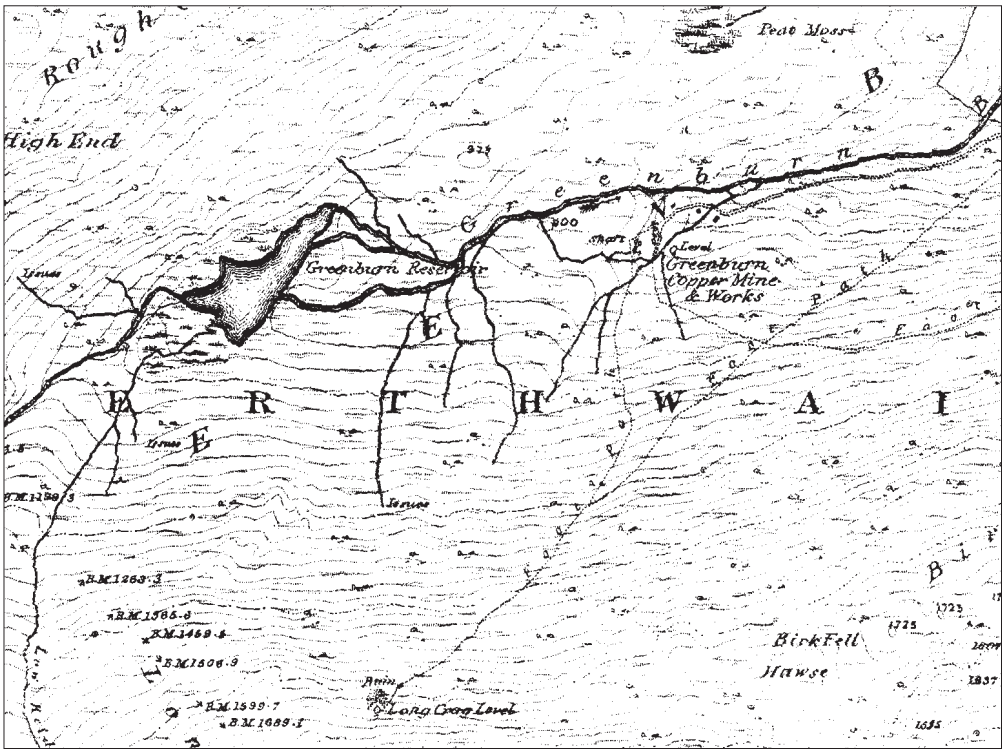


Figure 6. Greenburn Mine as mapped in 1889 (reproduced from the 1891 Ordnance Survey map)

with Engine Shaft is physically overlain by - and therefore predates - the tip associated with the Gossan Vein Level, which almost certainly originated in 1865-6, yet all the tips are first depicted on the Third Edition map. Acceptance of the map evidence at face value would lead to the conclusion that most of the extraction took place at some point between 1889 and 1912: a conclusion which is at odds with both the physical evidence and other documentary sources. The map even omits the large range comprising accommodation, office and smithy, which is also indicated on the large-scale schematic plan thought to have been made before 1861, which bears dates of 1871 and 1876 and which was undoubtedly still intact in 1889. Field evidence suggests that many of the other processing buildings known to have been constructed by 1861 were light-weight timber and corrugated iron structures. Their omission and the absence of any annotations of 'Water Wheels' (which appear elsewhere on the map sheet) are easier to explain away, for all these may well have been dismantled for re-use elsewhere by 1889. Greenburn Reservoir, which was built before 1861, is portrayed, but some doubt hangs over the accuracy of the depiction (see Section 5.5). The map accurately depicts the western stretch of the leat associated with the construction of the reservoir (numbered 3 in Section 5.5), which is shown on the plan thought to have been made before 1861 and remains a prominent earthwork. However, for the eastern stretch of the leat, the Second Edition map replicates the depiction of the eastern end of the earlier Leat 2 as shown on the First Edition and this conflicts with the evidence provided by analysis of the physical remains.

Given that the revision work undertaken by the Ordnance Survey for the Second Edition 6-inch scale map is generally considered to be exemplary, the quality of the mapping at Greenburn Mine is an interesting issue. It seems more likely that most of the inaccuracies in the map are due to the conventions employed for the revision work, or to time constraints, rather than to actual errors. The overall impression is that while large features of obvious significance were mapped fairly accurately, little effort was made to seek out features not marked on the First Edition. In addition, wherever features shown on the First Edition corresponded even roughly to what was encountered on the ground, the depiction was replicated, even if the specific features

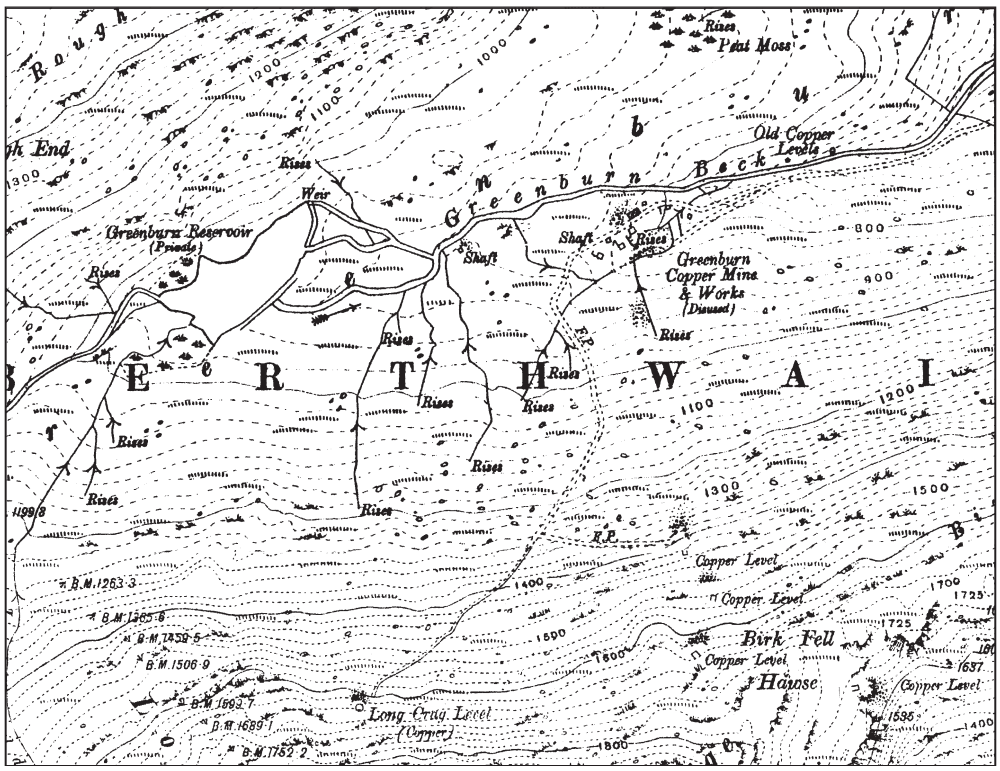


Figure 7. Greenburn Mine as mapped in 1912 (reproduced from the 1920 Ordnance Survey map)

no longer existed. In contrast, at the main Coniston Copper Mines, where the components of the mining complex had also been radically modified in the four decades since the First Edition, the map revision was thorough, making numerous minor amendments in addition to the major changes. In any event, the depiction of Greenburn Mine must be treated with caution as a source of evidence, for it is demonstrably misleading as to the existence and condition of a number of features.

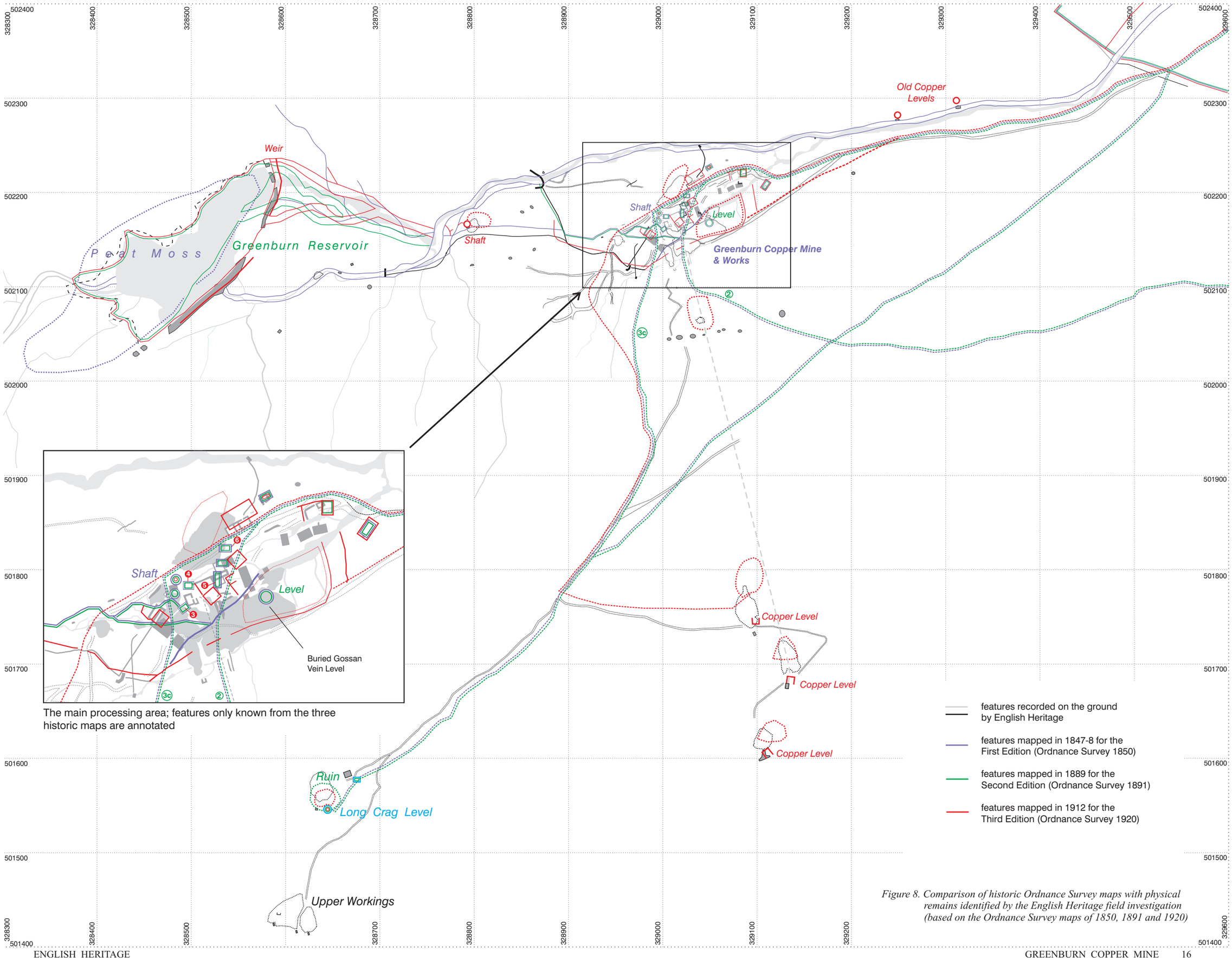
The Greenburn and Tilberthwaite Syndicate took on the lease in May 1906, concentrating their effort on the cuprite ore in the Pave York Vein (Adams 1988, 154; Blundell 1994, 4). The physical remains from the subsequent period, which include an inclined tramway from the Pave York Middle Level and an ambitious trial on the Low Gill Vein, suggest that there was considerable commitment and capital investment in the venture. In 1906, the workforce of five produced 14 tons (14.2 tonnes) of ore, which, after smelting, returned 1 ton of metal worth £84. In 1907, the workforce expanded to seven; they produced 32 tons (32.5 tonnes) of ore, but it must have been of poorer quality (*c*.5% copper content), since it only fetched £132 despite an unchanged market value. It was presumably this set-back which led to the suspension of extraction in 1908 and the reduction of the workforce to three. In 1909 and 1910 there was only a caretaker on site. Once again, it is probably significant that James Postlethwaite, who was writing for the third edition of his account of mining in the Lake District at about that date, does not end his summary of the work done at Greenburn with some comment on the current state or future prospects of the mine, as he did in other cases (Postlethwaite 1913, 119). By 1911, the mine was officially listed as 'not worked' and by the following year 'abandoned' (Blundell 1994, 4).

The Third Edition of the Ordnance Survey 6-inch map, revised in 1912, marks the complex as 'Disused' (Ordnance Survey 1920; Figure 7). This term is important, for it indicates that the mapping took place before the Langdale Silver, Lead and Copper Co took on the lease late in 1912, and therefore that it in effect depicts the state of the mine under the Greenburn and Tilberthwaite Syndicate some four years earlier. Unlike the revision of the survey for the Second Edition map, the Third Edition made

amendments which accurately portrayed changes actually made before 1889, depicting all the main stone buildings identified by the field survey, including for the first time the range comprising the accommodation block, office and smithy, as well as the two largest water wheel pits, the loading bay and the major spoil tips (see Figure 8). Those structures shown on the large-scale schematic plan thought to have been made before 1861 which field evidence suggests were constructed in timber and corrugated iron are not depicted. Given the accuracy of the rest of the map, this can be taken to mean that these buildings no longer stood. Importantly, the map depicts a gap in the line representing the leat that had formerly served the main water wheel (both numbered 3 in Section 5.5). The position of this gap corresponds to a small earthen bank identified in the course of the field investigation, which indicates that the channel had been deliberately blocked at some point during the tenancy of the Greenburn and Tilberthwaite Syndicate. Beyond the gap, the line marked on the map corresponds to a narrow drainage channel identified on the ground, which eventually leads back to the channel of the blocked leat and so discharges into a tributary stream. There is no indication that the water was directed anywhere near the water wheel that the leat had formerly served, nor that the timber structure that would have carried the launder still stood. It can therefore be inferred that after *c*.1885 water was no longer used to power the processing machinery, but what succeeded it is unclear. The map contains one further piece of information which is of key importance in dating the inclined tramway, whose course is recognisable on the ground. Two short gaps are portrayed in the tributary stream on the southern side of the valley. The western gap corresponds to the point at which the stream passes through a culvert beneath the spoil heap produced by work in the Gossan Vein Level, while the eastern gap corresponds to the point at which the embankment of the tramway crosses the stream. This represents strong evidence that the tramway was not built after *c*.1908.

In the winter of 1912-13, the Langdale Silver, Lead and Copper Co took on the lease, initially employing a workforce of three. In 1912, 14 tons (14.2 tonnes) of copper ore were mined, producing 1 ton of metal (Blundell 1994, 4). It is uncertain where this extraction took place, but it seems likely to have been the Pave York Vein, despite the probable removal of the inclined tramway some years before. In 1917, despite a rise in the market value of copper to £125 per ton due to shortages caused by the First World War, the company surrendered the lease.

Between 1924 and 1926, the Greenburn and Tilberthwaite Mining Co was formed under the directorship of William Mathias, a former stockbroker, B G Blunt, a retired civil servant, James Brown, a retired planter and H Foster-Williams, a local mine engineer. Blundell (1994, 4) suggests that most of the efforts at extraction were concentrated in the Tilberthwaite area. In the 1970s, a former employee recalled how at Greenburn a skeleton staff, lead by Foster-Williams, had gone to great lengths to convince potential investors who were visiting the site that it was already a hive of industry (Holland 1987, 270). As the guided tours progressed, the workers would change their appearance and act out different tasks at different locations around the complex for the benefit of the visitors. These desperate measures did not succeed; following a decision to liquidate taken at an Extraordinary General Meeting on 22 November 1940, the last company to work Greenburn Mine was finally dissolved in December 1942. The earliest available aerial photographs indicate that by August 1945 all the buildings had lost their roofs and that certain structures were already falling into ruin (RAF 1945a & b).



The main processing area; features only known from the three historic maps are annotated

Figure 8. Comparison of historic Ordnance Survey maps with physical remains identified by the English Heritage field investigation (based on the Ordnance Survey maps of 1850, 1891 and 1920)

5. DESCRIPTION AND INTERPRETATION OF THE REMAINS

5.0 SUMMARY

For an overview of the principal remains described in Section 5, see the annotated aerial photograph, Figure 2. A key which applies to all the English Heritage plans is included at the front of this report. Figure 9 shows the complex as a whole, while Figure 10 depicts the main processing area and its environs, which were investigated and recorded in greater detail (reduced from the original survey at 1:500 scale). Textual descriptions of the individual components of the complex are in many cases accompanied by an extract from the original survey and by an interpretative illustration or photograph where appropriate. Features investigated in less detail are described more briefly and are generally illustrated only by photographs. Where appropriate, the documentary evidence for the history of the feature under consideration is summarised. Altitudes on the plans and in the text are given in metres above Ordnance Datum, that is, mean sea level.

In the following sections, the surviving remains are described according to categories which broadly correspond to activities that occurred in the sequence from the mining of the copper ore to its processing: copper extraction, slate quarrying, spoil dumping, transport, water management and ore processing. The ancillary buildings relating to the mining operation are described in a separate section. Within each category, the individual components are described according broadly to the chronological order in which they are thought to have originated, rather than by geographical location; this is intended to clarify the more complex arguments concerning the chronological sequence of the remains. The evidence for the development of the complex over time has mostly been overlooked by previous investigations and is discussed further in Section 6. Five broad phases have been identified by the English Heritage field investigation:

- the late 17th century
- the period immediately after *c*.1845
- the period before 1861, under Crossfield & Co
- the period from 1864 to 1885, under various companies
- the period from 1906 to 1940, primarily under the Greenburn and Tilberthwaite Syndicate

Section 5.1 describes features relating to copper extraction. No investigation was undertaken below ground by English Heritage, but the survey examined the entrances of six major shafts and nine levels (or adits) which exploited the five mineral veins, along with various features directly associated with the entrances. The possible existence of another working, here called the Buried Gossan Vein Level, can be inferred from map evidence, but it can no longer be identified on the ground. With the exceptions of Long Crag Level and Engine Shaft, the precise names used originally to denote the workings are not known; most of the names used in this report for the sake of convenience are those applied by Eric Holland's (1981, 99-110) *Coniston Copper Mines, a field guide*. In addition to trials in the immediate vicinity of the major workings, fourteen more isolated minor trials of the deposits were also

identified; these are described more briefly. To summarise: several of the workings, including Greenburn Beck Level, Sump Vein Level, Engine Shaft and Sump Vein Shaft, and perhaps the Buried Gossan Vein Level, are thought to have originated in the late 17th century; Long Crag Level became active *c.*1845, but work there was soon abandoned; work in the period before 1861 concentrated on Engine Shaft, but work in the Pave York Top and Middle Levels was also undertaken; the work from 1864 to *c.*1885 concentrated on the Gossan and Pave York Veins; after 1906, only the Pave York Middle Level was worked seriously, although Low Gill Vein Shaft and Sump Vein Trial Shaft were started and soon abandoned.

Section 5.2 describes the evidence for stone quarrying, which took place on a small scale in several places around the complex. Quarrying and mining of slate were explicitly forbidden by the terms of the leases, but good quality building stone would have been essential for certain structures; quarrying was probably carried out in three areas *c.*1845, that is, before the copper mining itself began to produce sufficient waste rock. A fourth instance of quarrying was probably undertaken before 1861 to obtain large blocks of stone to build a dam.

Section 5.3 concentrates on the spoil tips in the immediate vicinity of the main processing area. These linear mounds of blasted rock, known as 'finger dumps', are unremarkable in themselves, but analysis of the sequence in which they built up contributes significantly to an understanding of how the mining operation as a whole developed over time. The Gossan Vein north and south spoil tips, which were both produced by work in Engine Shaft, predate the Gossan Vein spoil tip, which was produced by the work in Gossan Vein Level in 1865-6.

Section 5.4 describes the main track giving access to the mine, which was constructed *c.*1845. In due course, numerous other tracks and footpaths were constructed in order to transport ore or quarried stone to the processing area, as the pattern of activity around the complex changed. An inclined tramway, thought to have been built *c.*1906 to bring ore down from the Pave York Middle Level, is also described.

Section 5.5 describes features relating to the management of water. In the period immediately after *c.*1845, and probably earlier, water wheels were used to power machinery and a reliable flow of water was also essential to the process of washing and refining the ore. A few poorly preserved features probably relate to these early periods of the exploitation of the site. Most of the major structures that can be identified through analysis of the surface remains were probably built in a single episode in the period before 1861 and are depicted on the large-scale profile and plan thought to have been made before that date (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figure 5). In addition to Greenburn Reservoir, these include a series of dams, leats (artificial channels) and four stone-built 'wheel-pits' constructed to hold water wheels. The timber or wrought iron water wheels themselves were probably removed for re-use or for scrap *c.*1885, but their sizes can in most cases be gauged fairly accurately. Undoubtedly, there would also once have been several more artificial water channels, formed by small wooden ducts resting lightly on the surface, but only one such duct now survives. From *c.*1906 onwards, water power seems not to have been used; it is possible that a steam engine may have been brought to the site, although there is no clear supporting evidence for this theory. Nonetheless, due to the location of the complex, the control of water remained important: the leat that had formerly supplied the water wheels was deliberately blocked *c.*1906 and a number of channels were probably dug at the same time to drain the boggy area above the processing area.

Section 5.6 describes features relating directly to the processing of the ore. Most of the remains identified relate to the period of the mine's most intensive use prior to 1861, but there are clues to the sequence of processing both before and after that phase. The coarse blocks of ore-bearing rock were broken up by hand on 'spalling floors' before being taken to the crushing mills powered by the water wheels. The sites of these floors can be identified from the spreads of waste material that accumulated around them. An early floor (Spalling Floor 1), which may have been in use in the late 17th century, seems to have been associated with two buildings (numbered 1 and 2); the vesitigial surviving traces suggest that they were constructed in timber. The processing arrangements in the period immediately after *c.*1845 are unclear due to the impact of later modifications, but the sites of several buildings (numbered 3 to 6) can be identified from map evidence. The main spalling floor (Spalling Floor 2), which was built at some point between 1848 and 1861, occupied the top of a massive platform built of waste rock, overlooking sheds housing the more complex equipment for refining and washing the ore. Although none of these timber-built sheds survives, the floor surfaces and thus the plans of the principal structures can still be discerned. The large-scale schematic plan thought to have been made before 1861 sheds light on their functions at that date (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figure 5). The only processing machinery surviving in reasonable condition is a battery of 'stamps', or vertical hammers used to pulverise the ore, which may have remained in use until *c.*1885. Two 'precipitation tanks', constructed with large stone slabs, and a timber-built settling tank were probably first used *c.*1873 and were almost certainly re-used for some time after *c.*1906. These stone tanks would have held acid, which was used to bring about the chemical separation of the copper from the barren rock. Once processed, the ore was kept in a building known as a 'copper house', which lay adjacent to a loading platform from which horse-drawn carts could remove it for sale and subsequently smelting.

Section 5.7 describes the remains of the ancillary buildings associated with the mining operation. A stone-built range, built before 1861, comprised two-storeyed accommodation for the miners, a small office and a smithy. The range occupied the site of an earlier building, probably built soon after 1847, which may have served similar functions. Nearby was a stone-built dry store, certainly built before 1848, with an adjoining toilet block added at a later date, probably before 1861. At a distance from the main areas of activity stood a stone-built storeroom in which explosives were kept, also built before 1848. These buildings are all now in ruinous condition, but retain many minor architectural details which shed light on their use and development, most having probably remained intact well into the 20th century.

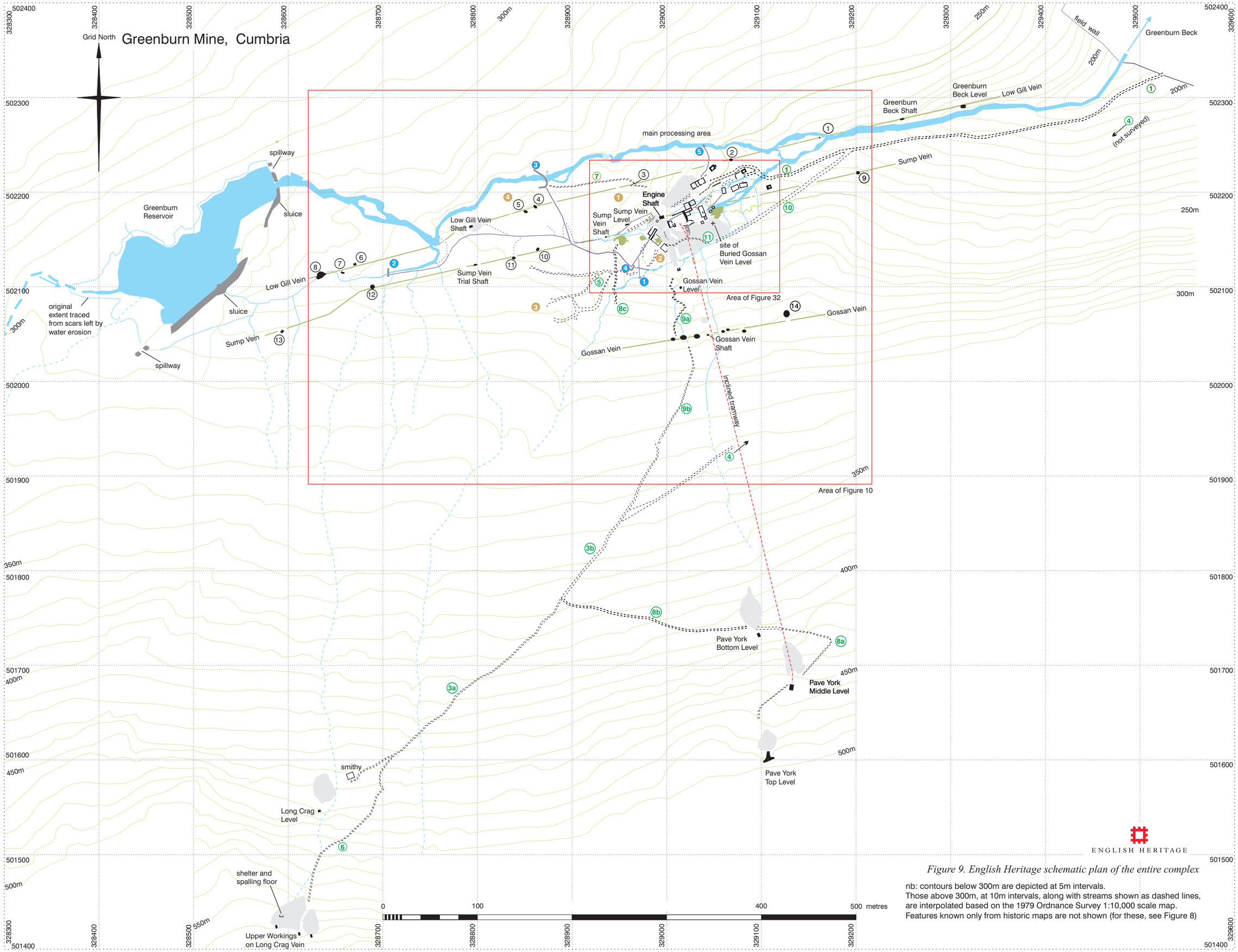


Figure 9. English Heritage schematic plan of the entire complex

nb: contours below 300m are depicted at 5m intervals.
Those above 300m, at 10m intervals, along with streams shown as dashed lines, are interpolated based on the 1979 Ordnance Survey 1:10,000 scale map.
Features known only from historic maps are not shown (for these, see Figure 8)

Grid North

Greenburn Mine, Cumbria

328650 328700 328800 328900 329000 329100 329200

502300 502200 502100 502000 501900

290m 285m 280m 275m 270m 265m 260m 255m 250m 245m 240m 235m 230m

Greenburn Beck

Low Gill Vein

Low Gill Vein Shaft

Sump Vein

Sump Vein Trial Shaft

limit of detailed survey

Sump Vein Shaft

Sump Vein Level

Spalling Floor 1

Spalling Floor 2

Engine Shaft

ST01

ST02

accommodation, office & smithy

dry store

Loading Bay 2

Loading Bay 1

Sump Vein north spoil tip

explosives store

precipitation tanks

site of Buried Gossan Vein Level

Sump Vein south spoil tip

Gossan Vein spoil tip

inclined tramway

Gossan Vein Level

Gossan Vein Shaft

Gossan Vein

limit of detailed survey

inclined tramway

(40m)

0 10 50 100 200 metres

Figure 10. English Heritage plan of the part of the complex surveyed in detail, reduced from the original at 1:500 scale

5.1 COPPER EXTRACTION

Greenburn Beck Level (Figure 9)

NGR: NY 2931 0229; NMR number: NY 20 SE 10

The entrance to the level (Figure 11) lies immediately adjacent to the northern bank of the Greenburn Beck, *c*.2m above the normal height of the stream, at an altitude of 205m. The entrance itself is partially blocked, but where clear the tunnel is 1.8m high and 1.3m wide. According to a plan surveyed by Holland (1981, fig. 47), the level divides into two branches which extend for a maximum of *c*.110m underground, following a geological fault which probably marks the line of the Low Gill Vein. Greenburn Beck Level and Greenburn Beck Shaft were first mapped as 'Old Copper Levels' in 1912, by which date they had apparently long lain disused (Ordnance Survey 1920). Other than this, there are no documentary references to the working, nor is there any evidence for the use of the large-bore triangular chisels widely used in the later 19th century. Given the inaccessible position of the entrance and the difficulty that would have been involved in transporting any ore uphill to the extant processing area, it seems likely that the level represents an early working, perhaps of late 17th century date. It is presumably broadly contemporary with Greenburn Beck Shaft.

Figure 11. View of the entrance to Greenburn Beck Level from the south-east

Greenburn Beck Shaft (Figure 9)

NGR: NY 2925 0228; NMR number: NY 20 SE 11

What was termed the Low Gill Vein Trial Shaft by Eric Holland is here called the Greenburn Beck Shaft for clarity. The mouth of the shaft lies on the northern bank of the Greenburn Beck, at an altitude of 221m. The opening is 2.7m long by 1.2m wide and follows the alignment of the Low Gill Vein from east-north-east to west-south-west; it is largely concealed by an overhanging juniper bush. Other than

the annotation 'Old Copper Levels' on the Third Edition map revised in 1912, there are no documentary references to the working (Ordnance Survey 1920). There is no evidence for the use of the large-bore triangular chisels commonly used in the 19th century. As with the Greenburn Beck Level, with which the shaft is presumably broadly contemporary, the difficulty that would have been involved in transporting any ore uphill to the extant processing area hints that the shaft represents an early trial, perhaps dating to the late 17th century. Work was evidently abandoned at an early stage, for the shaft is flooded, which indicates that it does not connect with the Greenburn Beck Level which lies 16m beneath.

Sump Vein Level (Figure 14 a)

NGR: NY 2896 0217; NMR number: NY 20 SE 12

The level, which lies at an altitude of 260m, cuts into the natural slope at an oblique angle for *c*.21m west-south-westwards along the line of the Sump Vein (Figure 12). The form of the cutting, whose sides are revetted by low drystone walls, suggests that hand-pushed tram trolleys were used to remove the spoil. At the point where the cutting becomes deeper than head height, a tunnel with a rectangular profile begins. This extends for only 3m before it opens out to the surface again for a few metres more, beyond which it terminates. Immediately to the west of this, on the same alignment, the vein has been pursued at a higher level by hacking an irregular quarry into the outcropping rock (marked by the upper ranging rod in Figure 12). This suggests that the level was effectively a trial intended to test the quality of the ore. There are no explicit documentary references to this work, but it seems likely that it would have become redundant when Engine Shaft and Sump Vein Shaft were sunk, so a relatively early date is probable. A few chisel holes are visible, but all are small-bore circular holes, distinctly different from the large-bore triangular holes left by the 19th-century work. In summary, both the exploitation of the surface exposure and the tools used are consistent with a date before *c*.1845, perhaps in the late 17th century.

Figure 12. View of Sump Vein Level from the east

Engine Shaft (Figure 13 a)

NGR: NY 2899 0217; NMR number: NY 20 SE 13

History

The First Edition 6-inch map surveyed in 1847-8 depicts Engine Shaft using the alchemical symbol for copper - an open circle with a vertical cross joining its base - accompanied by the word 'Shaft' (Ordnance Survey 1850). This probably indicates that the shaft was in active use *c*.1848 and therefore probably from *c*.1845 onwards. There is circumstantial evidence, discussed in Section 6, that it may have originated in the late 17th century and at the same date as Sump Vein Shaft, since it was common to sink two shafts in parallel to improve ventilation and to allow emergency access. The plan and section thought to have been made before 1861 shows that the surviving structures associated with the shaft had already been built by that date, probably under the tenancy of Crossfield & Co (Cumbria CRO D/Pen/46/file 102-106/ document not numbered; see Figure 5). Captain Vivian's report of December 1865 records that the shaft had been sunk to a depth of 120 fathoms (219.4m), yielding £14,000 worth of ore (Cumbria D/Pen/46/file 90-99/document not numbered). The section drawing is reproduced by Postlethwaite (1913, 120), suggesting that the shaft was not deepened further. Apparently contradicting this evidence, he remarks that by that date about £25,000 worth of ore had been extracted. Notwithstanding this, other documentary evidence suggests that Engine Shaft was not worked intensively, if at all, after 1861: the first-hand accounts of 1865, 1868 and 1874 scarcely mention the Sump Vein, but instead suggest that work was being concentrated on the Gossan and Pave York Veins. In December 1865, Captain Vivian stated that the shaft was '…in good working order', and the physical remains hint that limited trial work may have been undertaken after David Dunlop took on the lease in the preceeding year. However, three years later Captain Jeffrey commented that it was flooded to a depth of 10 fathoms (18.2m) and that the ore reserves were exhausted above that depth. The Second Edition map suggests that Leat 3, which had supplied Water Wheel 3, was essentially still intact in 1889, although part of the course of the leat as depicted on the map is probably incorrect, as discussed in Section 5.5 (Ordnance Survey 1891). However, the absence of the annotation 'Water Wheel' suggests that the wheel itself may already have been removed, which would have rendered the shaft's essential pumping and winding gear inoperable. The Third Edition map shows that the leat had been deliberately blocked by 1912; given the documented sequence of tenants, this almost certainly means *c*.1906 (Ordnance Survey 1920). The physical remains support the conclusion reached from the documentary evidence: there is no evidence for any tipping after the accumulation of the Gossan Vein spoil tip in 1865-6. Two wall-like stacks of spoil constructed in a late episode of work in the Gossan Vein, at some point after 1866, effectively blocked the tramway that had been used to transport material from Engine Shaft. In summary, Engine Shaft was probably effectively disused by 1861, not worked at all after 1865 and abandoned by *c*.1885 at the latest.

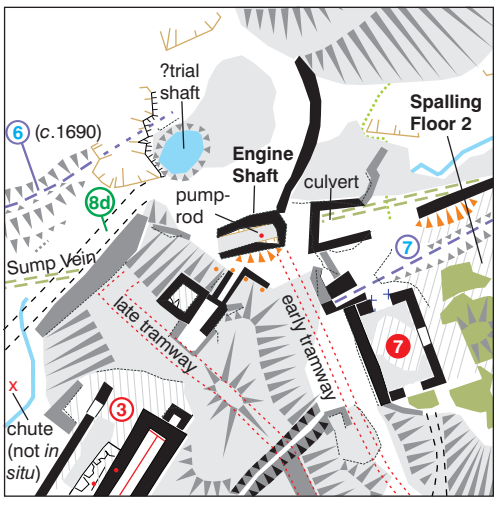


Figure 13 a. Plan of Engine Shaft and its environs

Description

Engine Shaft exploited the productive Sump Vein and was the most intensively used of the workings. The mouth of the shaft lies at an altitude of 258m and is blocked 1.2m below the surface by rubble. Much of this was probably dumped deliberately to seal the shaft when it was abandoned. However, it is possible that there has been natural collapse in the relatively recent past, for Eric Holland, writing in the 1970s, mentions the presence of a cast-iron rising main from the pump, with an attached box for carrying run-off, neither of which are still visible (Holland 1981, 99). The mouth of the shaft is roughly rectangular, some 4m long by 1.2m wide, and is aligned from east-north-east to west-south-west, following the orientation of the mineral vein. On

Figure 13 b. View of the mouth of Engine Shaft from the north-east

the northern side of the opening, natural rock can be seen just above the rubble that blocks the shaft, surmounted by a low drystone revetment wall. The other sides of the shaft, as far as they are visible, are also revetted by walls, which show signs of instability. Holland suggests that where the shaft passed through the 'stopes', or worked-out voids, it would have been formed by a timbered passage, divided into two. The large-scale profile/section thought to have been surveyed before 1861 indicates that the western half would have housed the cables carrying the 'kibble', or bucket, while the eastern half would have contained the pumping gear and a ladder to allow the miners to descend (Cumbria CRO: D/Pen/46/file 102-106/document not numbered).

The water pumped out of the working was directed into a culvert just below the level of the mouth of the shaft, which discharged onto the surface 3m to the east. From there, it may have been channelled to wash the ore in the stamps in Building 10. The culvert remains virtually clear and the walling around the exit is well-preserved. A pump-rod, which is probably the uppermost of a continuous series still *in situ*, projects vertically from the top of the rubble at the eastern end of the shaft, standing to a maximum height of 1.8m above the rubble. The cast-iron rod is circular in cross-section, with a diameter of 5cms. The eye at the top end is on exactly the same alignment as the pit of Water Wheel 3, which indicates that it was lifted by a mechanism powered by that wheel, probably a reciprocating beam pivoted midway between the shaft and the axle of the water wheel. In order to reduce the strain on this main beam, the weight of the pump rods would have been counter-balanced by a 'balance-bob'. This would have comprised a smaller beam, pivoted close to ground level, with a counter-weight formed by a timber box filled with rubble, which dipped into a pit (Jones 1996, 14 and fig 22). Balance-bobs were commonly aligned at 90 degrees to the main beam, but at Engine Shaft, the beam seems to have been on the same alignment, presumably at a lower height (Holland 1981, 103). This is inferred primarily from the physical remains, but there is nothing to suggest any different arrangement on the large-scale schematic plan thought to have been surveyed before 1861 (Cumbria CRO: D/Pen/46/file 102-106/document not numbered). To the south-west of the shaft is a platform 2.4m square and surfaced with large slabs, apparently built to support heavy machinery. Next to this, a narrow passage aligned on the shaft (marked by the upper ranging rod in Figure 13 b) terminates in a quadrangular pit whose sides are revetted by less carefully constructed drystone walls. Next to the mouth of the shaft, four rotting timber posts, no longer upright but roughly *in situ*, probably represent part of a timber superstructure above the shaft, which would have supported the winding wheel, as shown on the profile accompanying the large-scale plan. The transfer of power to the mechanisms associated with Water Wheel 3 and Engine Shaft is discussed in Section 5.5 (see Figure 28 a). The large quantity of waste rock removed via the shaft would have been transported in hand-pushed tram trolleys to the Sump Vein north and south spoil tips (see Section 5.3). The ore-bearing material would also have been moved along the tramway running above Spalling Floor 2 (see Section 5.6).

Immediately north of Engine Shaft, a small platform has been blasted into the slope. Documentary evidence casts no light on its function and it may well relate to earlier work on the Sump Vein. Near the centre of the platform, a shallow depression, partly filled with rubble, may be a backfilled trial shaft. It was flooded at the time of the English Heritage investigation, suggesting that it is not of great depth and does not connect with Engine Shaft. The First Edition map shows a second alchemical symbol for copper immediately to the south of Engine Shaft, its site now concealed by the Sump Vein south spoil tip. This may represent another trial shaft; both would presumably have been abandoned before Engine Shaft became active, so they may have originated at an early date, perhaps in the late 17th century.

Sump Vein Shaft (Figure 14 a)

NGR: NY 2894 0215; NMR number: NY 20 SE 14

Documentary evidence gives no clear indication of when work began on Sump Vein Shaft. The shaft connects with Engine Shaft at a depth of 28 fathoms (51.2m) below the surface, which may indicate that the two were sunk at roughly the same time. This technique was commonly used throughout the post-medieval period, both to allow access in the event of an emergency and to improve ventilation below ground. This supports Holland's (1981, 102) conclusion that the shaft is of 'early' origin, that is, *c*.1845 or even earlier, although it is not marked on the First Edition map. The shaft seems to have been associated with Spalling Floor 1 (see Section 5.6), which suggests that at an early stage, perhaps before 1845, Sump Vein Shaft acted as a major winding shaft for bringing ore to the surface. The absence of spoil in the vicinity appears to contradict this inference, but Captain Vivian's report records that the ore in the Sump Vein lasted '… all the depth from near the surface', so it possible that very little waste rock was extracted. Sump Vein Shaft had evidently been superseded as the main access to the workings below ground by Engine Shaft by 1848 at the latest.

The mouth of the shaft, at an altitude of 268m, is a quadrangular cutting into the natural rock, which is visible only a few centimetres below the turf. The opening is 1.6m long by 1.1m wide, its long axis following the same alignment as the mineral vein, roughly from east-north-east to west-south-west. The mouth of the shaft, which is partially blocked by an iron bar, opens into a void. Approximately 10m to the north-east, a natural crevice in the surface of the rock has been enlarged artificially to create an irregular elongated pit on the same alignment as the shaft. Two horizontal timber 'axles' are set into sockets cut into the sides of the pit, placed 1.2m apart (Figure 14 b). Each is formed by a segment of a roughly shaped thin circular wooden post, 60cms long. The purpose of these is uncertain, but it seems most likely that ropes may have passed around them, perhaps from a hand-powered winch on the same axis. The timber axles usually lie just below the surface level of the water in the pit and may be abnormally well preserved due to the damp conditions; it seems unlikely that they are of 17th-century date, but since the shaft seems to have been used little in the period before 1861, or subsequently, it is possible that the they were put in place as early as *c*.1845.

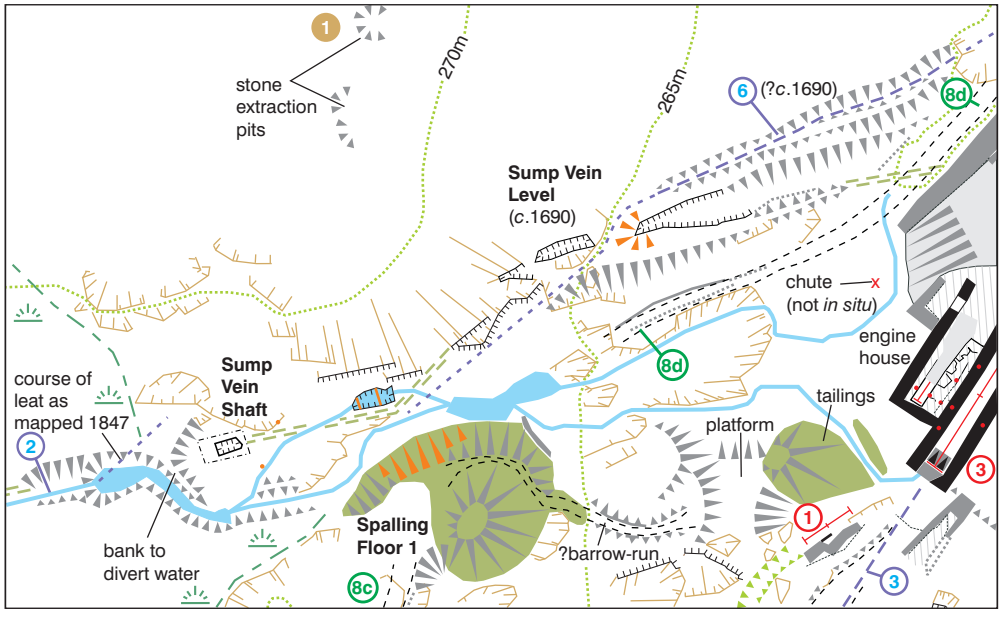


Figure 14 a. Plan of Sump Vein Shaft and Sump Vein Level

Figure 14 b. View towards Sump Vein Shaft from the east with the 'winch' in the foreground

Immediately to the west of the shaft, a culvert and low earthen bank divert the residual flow of water along the channel of Leat 2 around the southern side of the mouth of the shaft. The Second Edition map shows that Leat 2 itself passed to the north of the shaft, probably along a timber launder, of which no trace can now be identified on the ground. A broader and deeper depression on the line of the leat, which forms part of the culvert, is probably the product of erosion by the flow of water. However, it lies on the same alignment as the shaft and may represent an artificial feature, such as a pit for another hand winch. If this tentative suggestion is correct, such a winch may have powered winding gear in the shaft. Such a simple mechanism would tend to suggest an early date, perhaps before the 19th century.

Buried Gossan Vein Level (Figures 3 and 23)

NGR: NY 2904 0216; NMR number NY 20 SE 45

Near the foot of the southern slope of the valley, within the limits of the area buried beneath the Sump Vein south spoil tip, the First Edition 6-inch scale map surveyed in 1847-8 depicts the alchemical symbol for copper - an open circle with a vertical cross joining its base (Ordnance Survey 1850; see Figures 3 and 8). The symbol is used widely elsewhere on the map sheet, but without much more extensive fieldwork, which is beyond the scope of the English Heritage investigation, its precise significance remains uncertain. In some instances, the symbol is accompanied by a name, for example 'Long Crag Level', or simply with the word 'Shaft', clearly indicating that a mine working was present. In other instances, as in this case, it is depicted without annotation. It is possible that this indicates the existence of a level that was not in active use at the time of the mapping, or a minor working not large enough to term a 'level'. In this instance, the presence of the Sump Vein south spoil tip hinders any interpretation, but the position of the symbol coincides with a bulge in the line of the spoil tip; this may hint at the presence of an underlying mass, such as the spoil heap of an earlier working. The symbol was subsequently interpreted by the Ordnance Surveyors themselves as a working, for the symbol appears on the Second Edition map revised in 1889, but this time with the annotation 'Level' (Ordnance Survey 1891). However, this is difficult to reconcile with the physical evidence, which strongly suggests that the area would have been buried beneath the spoil tip at some point before 1861. The Second Edition map does not depict the Gossan Vein Level, although this is documented as having been completed by 1866. It is quite possible, given the other inaccuracies evident on the Second Edition map, that the symbol depicted on the 1847-8 survey was mistakenly thought to apply to the Gossan Vein Level and that the precise position of the working in relation to the symbol was not verified.

Long Crag Level (Figure 9)

NGR: NY 2864 0155; NMR number: NY 20 SE 15

History

The First Edition 6-inch map surveyed in 1847-8 indicates that work at Long Crag had already begun by that date, although there is no proof that they were in active use at the time of the survey (Ordnance Survey 1850; see Figure 3). Both the entrance to the level and the ancillary building just downslope are shown, *c*.11m east of their true position. Captain Vivian's report of 7 December 1865 states that work had been abandoned prior to that date due to the inaccessibility of the site (Cumbria CRO D/Pen/46/file 90-99/document not numbered). The Second Edition map revised in 1889 does not mark the level as 'disused', but the ancillary building is annotated as being a 'Ruin' (Ordnance Survey 1891; see Figure 6). The spoil tip downslope from the level was portrayed - the only instance at Greenburn Mine where this was done as part of the revision work for the Second Edition.

Description

The entrance to the level lies on a steep slope at an altitude of 468m, with a small shelter of drystone construction standing just outside it (Figure 15 a). This was probably intended to give protection while blasting was taking place. The entrance is reached from the west via a substantial platform built using waste rock. Holland's (1981, fig 53) plan of the level below ground indicates that the main tunnel follows a fairly straight line southwards into the hillside for *c*.157m to reach the vein, where it branches out into a number of drives to the west and east.

Approximately 40m downslope and to the north-east of the entrance to the level, a small building served as a smithy, and probably as a store and shelter, for the miners who worked at Long Crag (Figure 15 b). The building comprises a single rectangular room some 6m by 5m internally with a doorway on the north, facing downslope.

Figure 15 a. View of the entrance to Long Crag Level from the north-east

Figure 15 b. View of the smithy and store below Long Crag Level from the north-west

There is no evidence that the building was part of a longer range divided into two, as suggested by Holland's sketch plan (1981, fig 53). The structure is dilapidated, standing to a maximum height of 0.6m. A large number of round-headed roof slates lie in the vicinity. There is strong evidence that the building held a smithy: the threshold is pock-marked with shallow triangular chisel holes, as is that of the smithy on the valley floor. Smithing waste was noted in the north-west corner of the interior and a dilapidated structure which may represent the remains of a raised hearth lies mid-way along the western wall.

Upper workings on Long Crag Vein (Figure 9)

NGR: NY 2861 0142; NMR number: NY 20 SE 16

The upper workings on Long Crag Vein were not recorded on any historic maps. Since the complex was in active use when the the First Edition of the 6-inch scale map was surveyed, their omission from that map can probably be taken to mean that they were not begun until after *c*.1847, though they can be assumed to be broadly contemporary with work in Long Crag Level. Their omission from later Ordnance Survey editions probably stems from their small size and inaccessible locations. The entrance to what was apparently the main level lies at an altitude of 565m, with an extensive spread of waste material spilling downslope from it. The mouth is almost entirely blocked by a single large slab of stone, but it is unclear whether this was deliberately placed, or has collapsed naturally. A second cutting, a few metres to the west, appears to have been abandoned at an early stage. A third, more inaccessible level lies some 15m to east of the main level and slightly upslope; the volume of spoil is not great, suggesting that work was abandoned after a fairly short time. However, this is probably the working recorded by Holland (1981, fig. 54) as running southwards for *c*.6m to reach the vein, before it branches to the west and east. A short distance downslope to the north-west of the workings, stands a small rectangular shelter, now dilapidated, constructed with low drystone walls which probably supported a timber superstructure of which no trace survives. The shelter was apparently open on the north, facing on to a level platform which was evidently used as a spalling floor for the primary dressing of the larger lumps of ore.

Pave York Top Level (Figure 9)

NGR: NY 2911 0160; NMR number: NY 20 SE 19

No workings on the Pave York Vein are shown on the First Edition 6-inch map surveyed in 1847-8, which would seem to indicate that no attempt was made to exploit it until after 1848 (Ordnance Survey 1850). Captain Vivian's report of December 1865 states that '…a small amount of work' on the vein had been completed by that date, the implication being that this had been done by Crossfield & Co during the period of the mine's most intensive use, prior to 1861 (Cumbria D/Pen/46/file 90-99/document not numbered). As described below, Captain Vivian was probably referring to both the Top and Middle Levels. Despite this, no workings are shown on the Second Edition map revised in 1889 (Ordnance Survey 1891). Given normal mining practice and Captain Vivian's use of the phrase 'near the surface', it seems most plausible that the vein was first tested where it is most clearly exposed, that is, at Pave York Top Level. The cave-like form of the main opening, with its numerous short exploratory tunnels, is entirely consistent with an initial trial. Although Captain Vivian and later Captain Gribble commented on the excellent appearance of the vein, it is clear that no intensive work was done at this level either by Crossfield & Co or subsequently.

The entrance to the level is formed by a T-shaped open cutting blasted southwards into the steep southern side of the valley at an altitude of 487m (Figure 16). From the eastern arm of this cutting, three short tunnels branch out to the south and east, the longest only a few metres long, with a shallow shaft giving access to further small trials below (Holland 1981, fig 52). From this lower level, a shaft which descends to the Pave York Middle Level some 40m below seems to have acted as a 'smoke hole', or shaft dug primarily to ventilate the lower working. The tip of spoil immediately outside the entrance forms a small level platform, which was presumably at one stage accessible along Track 8a, although the precise route is now unclear. Given the small size of the working, it seems unlikely that the route would have been used for a prolonged period.

Figure 16. View of the entrance to Pave York Top Level from the north

Pave York Middle Level (Figure 9)

NGR: NY 2913 0168; NMR number: NY 20 SE 18

History

In his description of the Pave York Vein, written in February 1868, Captain Jeffrey states that 'The level which has been driven in this Lode is at a depth of 30 fathoms', that is, *c*.55m below the point at which the vein outcrops on the surface (Cumbria D/Pen/46/file 90-99/document not numbered). Although this figure was probably an estimate, given that it falls *c*.8m lower than the altitude of the Pave York Middle Level, it is accurate enough to indicate which of the two lower levels he was referring to. A single level is also depicted on the small-scale plan of the workings thought to have been added in about 1868 to the more detailed drawings (Cumbria D/Pen/46/file 102-106/document not numbered). This too, with a shaft marked on the line of the vein to the west of the main level, most closely matches the Middle Level as mapped by Eric Holland (1987, fig 51). The prospectus states that no work other than the extension of the Gossan Vein Level had been completed since 1865, so the level must have been part of the '…small amount of work' on the Pave York Vein mentioned by Captain Vivian. Although no workings on the Pave York Vein are shown on the small-scale plan of the sett thought to have been produced before 1861, it is uncertain how far this can be relied on (Cumbria D/Pen/46/file 90-99/document not numbered). It is not impossible that the work was begun in 1864 and discontinued prior to December 1865, but it seems more likely that it was carried out prior to 1861 and was simply omitted from the plan of the complex, or that the plan was made well before 1861. None of the three workings on the Pave York Vein that existed by 1874 are depicted on the Second Edition of the 6-inch scale map revised in 1889, but all are shown on the Third Edition revised in 1912 (Ordnance Survey 1891; 1920). Work on the Middle Level was resumed between 1906 and 1908 under the tenancy of the Greenburn and Tilberthwaite Syndicate. During this period the inclined tramway was probably constructed and almost 49 tonnes of ore were extracted (Blundell 1994, 4). However, the quality of the ore proved much poorer than the enthusiastic reports of Captain Vivian and Captain Jeffrey had suggested.

Figure 17. View of the entrance to Pave York Middle Level from the north

Description

The level was sited on the line of Track 8a, which had probably originated as a footpath serving the Pave York Top Level. The position of the Middle Level was probably an important factor in the decision to redevelop it in 1906, for it is the easternmost of the three, lying directly up the hillside above Spalling Floor 2, so that the inclined tramway could descend straight there from the mouth of the level. The pre-existing track, once broadened and improved, would also have allowed access to the upper stretch of the tramway (numbered 8b Section 5.4). The level cuts roughly south-westwards into the steep southern side of the valley, extending for *c*.57m to meet the vein before branching to the west and east (Holland 1981, fig 51). At some point, a 'smoke hole', or shaft constructed primarily to ventilate the mine, was driven to connect with the Pave York Top Level some 40m above. Holland records that some of the wooden rails for a tramway, perhaps relating to the later period of the level's use, remain *in situ*. The entrance to the level, at an altitude of 448m, is formed by a cutting whose sides are revetted by low drystone walls. An amorphous heap of stone to the east of the entrance may represent the dilapidated remains of a blasting shelter similar to those noted outside Long Crag Level and Gossan Vein Level (in the foreground in Figure 17). The tip of spoil immediately outside the entrance forms a large level platform. Small pieces of copper ore, presumably extracted *c*.1906, are scattered across this surface. The well-preserved condition of a paved drain for carrying run-off water from the mine suggests that it was constructed in this later phase of activity. At the lip of the spoil tip, adjacent to the point at which the inclined tramway would have begun its steep descent, an iron fitting is fixed into a large stone block set into the ground. Part of the spoil tip below the platform and along with it a section of the tramway, have been severely eroded by a water channel.

Gossan Vein Shaft (Figure 18 a)

NGR: NY 2904 0205; NMR number: NY 20 SE 20

History

Captain Vivian's report of 7 December 1865 (Cumbria CRO D/Pen/46/file 90-99/document not numbered) states that work was in progress on Gossan Vein Level, because Gossan Vein Shaft had flooded having been sunk to a depth of about 5 fathoms (*c*.9m). This implies that the shaft had been started and abandoned shortly before December 1865, certainly after David Dunlop took on the lease in 1864. Captain Vivian was of the opinion that the quality of the ore was high and Captain Gribble concurred in 1868, commenting that the vein was '…of a very kindly nature'.

Description

The mouth of Gossan Vein Shaft, which lies at an altitude of 285m, is an opening *c*.0.9m square cut directly into the natural rock at the rear of a shallow cutting; it is flooded to the top. The overburden, together with the waste rock produced by blasting, was tipped downslope, probably from hand-pushed tram trolleys, to create a single fairly large 'finger-dump'. The eastern edge of this spoil heap was pushed aside to create a cutting for the inclined tramway (marked by the two ranging rods in Figure 18 b). Although Track 2 was depicted on both the First and Second Editions of the 6-inch scale map, it seems likely that the route was already used by the time of the Second Edition; all trace of it seems to have been erased by the later activity.

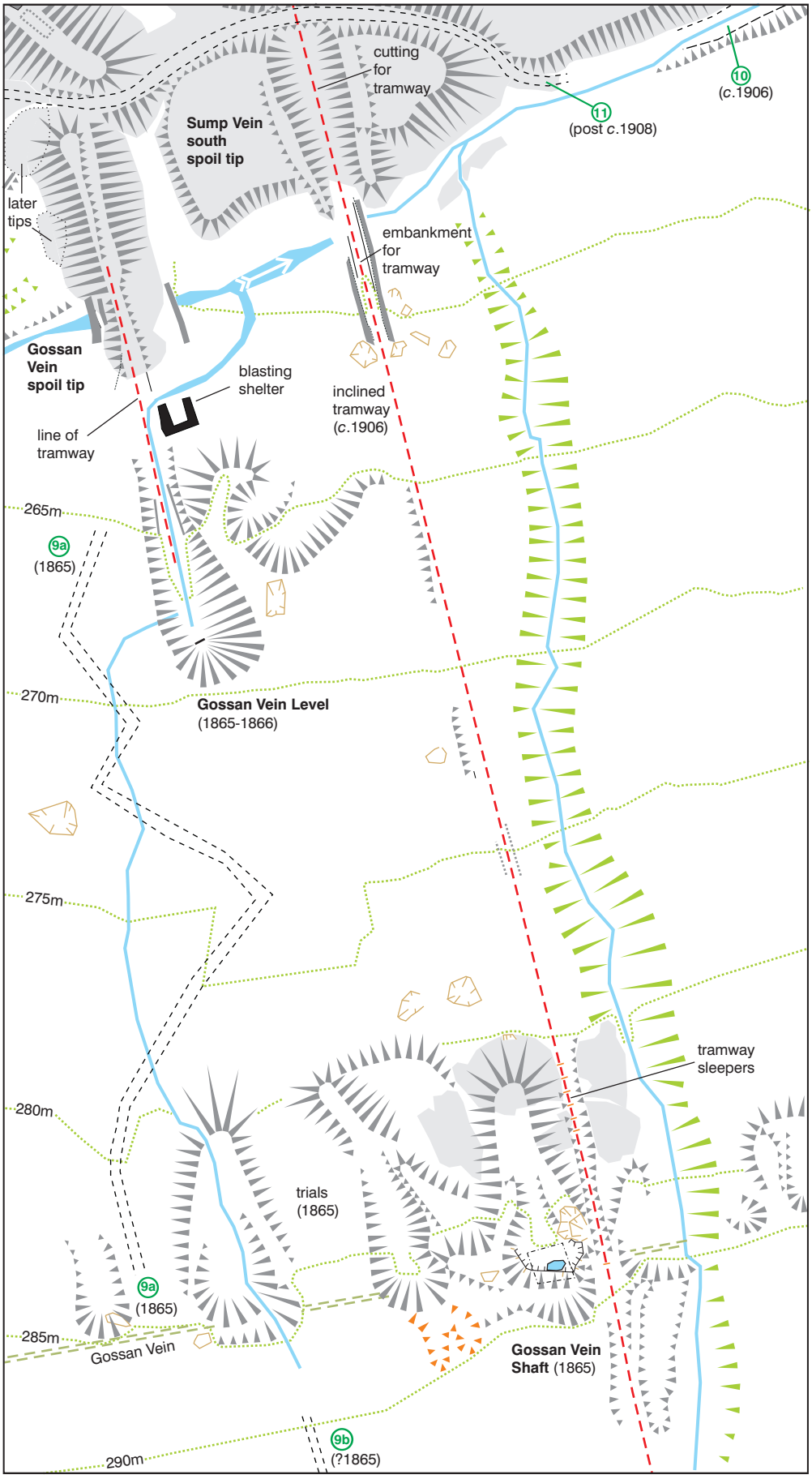


Figure 18 a. Plan of Gossan Vein Shaft and Gossan Vein Level

Figure 18 b. View of the complex from the south, with Gossan Vein Shaft in the foreground

It was probably during the initial phase of work on the shaft that three trials were made on the slope immediately to the west of the Gossan Vein Shaft and another four on the slope immediately to the east (none of which are numbered). These are a series of shallow cuttings, of differing size, but all smaller than that dug for the Gossan Vein Shaft itself, which are spaced at fairly even intervals a few metres apart. The spoil from each was dumped to either side and directly downslope. All seem to have been abandoned almost immediately, apparently even before the overburden had been fully removed. Track 9a, a minor footpath which zig-zags up the steep slope, probably gave access to the various workings. Some 50m further east is an isolated trial of similar form but somewhat larger size (Trial 14). This appears by its more weathered condition to be of earlier date, and may have been worked *c*.1845 (see below).

Gossan Vein Level (Figure 18 a)

NGR: NY 2901 0210; NMR number: NY 20 SE 21

History

The Gossan Vein Level is the most precisely dated of all the work undertaken at Greenburn Mine and provides a fixed point in the relative sequence that can be inferred from the physical remains. Captain Vivian's report of 7 December 1865 states that at the time of writing, work was in progress on the Gossan Vein Level, with the intention of reaching the vein itself early in March 1866 (Cumbria D/Pen/46/file 90-99/document not numbered). A note appended to the report in 1868 states that the extension of the level was the only work undertaken in the intervening three years. Captain Vivian was of the opinion that the quality of the ore was high and Captain Gribble echoed this conclusion in 1868. Despite this, the field evidence would suggest that the level must have been abandoned without any major extraction having taken place at that time. There is no documentary evidence for any further work having been carried out, but a series of small tips on the Gossan Vein spoil tip suggest that there may have been a brief period of renewed activity, probably at some point before *c*.1885 (see Section 5.3).

Description

The Gossan Vein Level lies directly downslope from the Gossan Vein Shaft, at an altitude of 264m. The entrance to the level, which was driven southwards straight into the hillside, is formed by an open cutting some 16m long and up to 4.5m deep; both sides are revetted for part of this distance by low drystone walls (Figure 19). The narrow floor of the cutting has been eroded by a stream that drains out of the level and the western side has been disturbed by the growth of a rowan tree. The opening of the tunnel itself is a low and irregular rock-cut arch; this would presumably have been enlarged somewhat had the level ever gone into profitable production. Holland (1981, 107) records that below ground the level is *c*.55m long, and in good condition, with remnants of wooden sleepers for a hand-powered tramway on the floor. It was almost certainly planned to extend the tramway as far as Spalling Floor 2 in the event of the discovery of major deposits of ore, but it seems that this never occurred. As a result, it only served to dump waste rock on the Gossan Vein spoil tip. As discussed in Section 5.3, the physical evidence is consistent with the main part of the spoil tip having been produced in a single episode of work, which can confidently be equated with the drive completed between December 1865 and about March 1866. This offers an important fixed point in the sequence of tips that can be inferred from the physical remains.

Immediately to the north-east of the cutting, there are signs of further digging, probably undertaken as initial exploratory work. An earthen mound probably represents the overburden removed prior to the start of blasting into the solid rock. In the lee of this mound, on its northern side, a stone wall 1.3m high describes three sides of a rectangle, with the open side facing northwards away from the mouth of the level (in the foreground on Figure 19). The structure, whose internal area is only about $2m^2$, could conceivably have been roofed and functioned as a small store, but given its design and siting, it seems more likely to have given protection to the miners responsible for carrying out the blasting. Similar shelters were noted near Long Crag Level, Low Gill Vein Shaft and possibly Pave York Bottom Level.

Figure 19. View of the entrance to Gossan Vein Level from the north

Pave York Bottom Level (Figure 9)

NGR: NY 2910 0174; NMR number: NY 20 SE 17

History

The evidence that Pave York Middle Level was begun before February 1868, and probably before 1861, has been presented above. Thomas Lawn's report of August 1874 states that the Great Coniston Mining Co, which had held the lease since 1873, was then engaged in work on the vein '…at a deeper level' (Cumbria D/Pen/46/file 102-106/document not numbered). The inferrence to be drawn is that the company had started work on the Pave York Bottom Level in 1873. The Second Edition of the 6-inch scale map revised in 1889 is unhelpful, since it neglects to portray any of the three workings on the Pave York Vein known to exist by that date (Ordnance Survey 1891). The Third Edition map portrays all three levels to within a few metres of their true plan positions, but the depiction of the spoil tip outside the Bottom Level is much less accurate, lying some 30m too far north (Ordnance Survey 1891). However, there is no documentary or physical evidence that the level was worked after the tenancy of the Great Coniston Mining Co.

Description

The level was evidently sited so as make use of Track 8, which had formerly served Pave York Top Level and Middle Level. It is possible that the route was improved to form Track 8b at this time, but it seems more likely that this took place *c*.1906. The level cuts approximately south-eastwards into the steep southern side of the valley, according to Holland's (1981, fig 50) survey work extending in a straight line for *c*.108m to meet the vein, where it branched to the west and east. The entrance, which lies at an altitude of 409m, is formed by a short cutting whose sides are revetted by low drystone walls (Figure 20). The tip of spoil immediately outside the entrance forms a small level platform.

Figure 20. View of the entrance to Pave York Bottom Level from the north

Low Gill Vein Shaft (Figure 21 a)

NGR: NY 2879 0216; NMR number: NY 20 SE 22

The mouth of the Low Gill Vein Shaft is large and the surrounding wall is well-built. Given that amendments were made nearby for the Second Edition of the 6-inch scale map, the lack of any depiction of the shaft must indicate that it was begun after 1889 (Ordnance Survey 1891). However, the working is marked on the Third Edition revised in 1912 (Ordnance Survey 1920). Since the complex had lain disused for four years when the revision was carried out, it can be inferred that the work was very probably begun *c.*1906, under the auspices of the Greenburn and Tilberthwaite Syndicate. The appearance of the shaft and the careful preparatory work undertaken strongly suggest that a serious and prolonged attempt at extraction was anticipated.

The mouth of the shaft, which lies some 15m south of the Greenburn Beck at an altitude of 275m, is flooded almost to its top. It is rectangular, 3.3m long by 1.8m wide, with its long axis following the alignment of the mineral vein roughly from east-north-east to west-south-west. The sides are formed by well-constructed drystone walls, with a stone-lined gulley to allow water to run off in the north-east corner. The spoil was dumped immediately to the east of the shaft to form a mound 1.3m high; the fairly small quantity indicates that work on the shaft must have been abandoned only a few metres below the surface. To the west of the shaft, a small quantity of quartzite, potentially bearing copper ore, was separated out from the rest of the spoil and broken into smaller pieces.

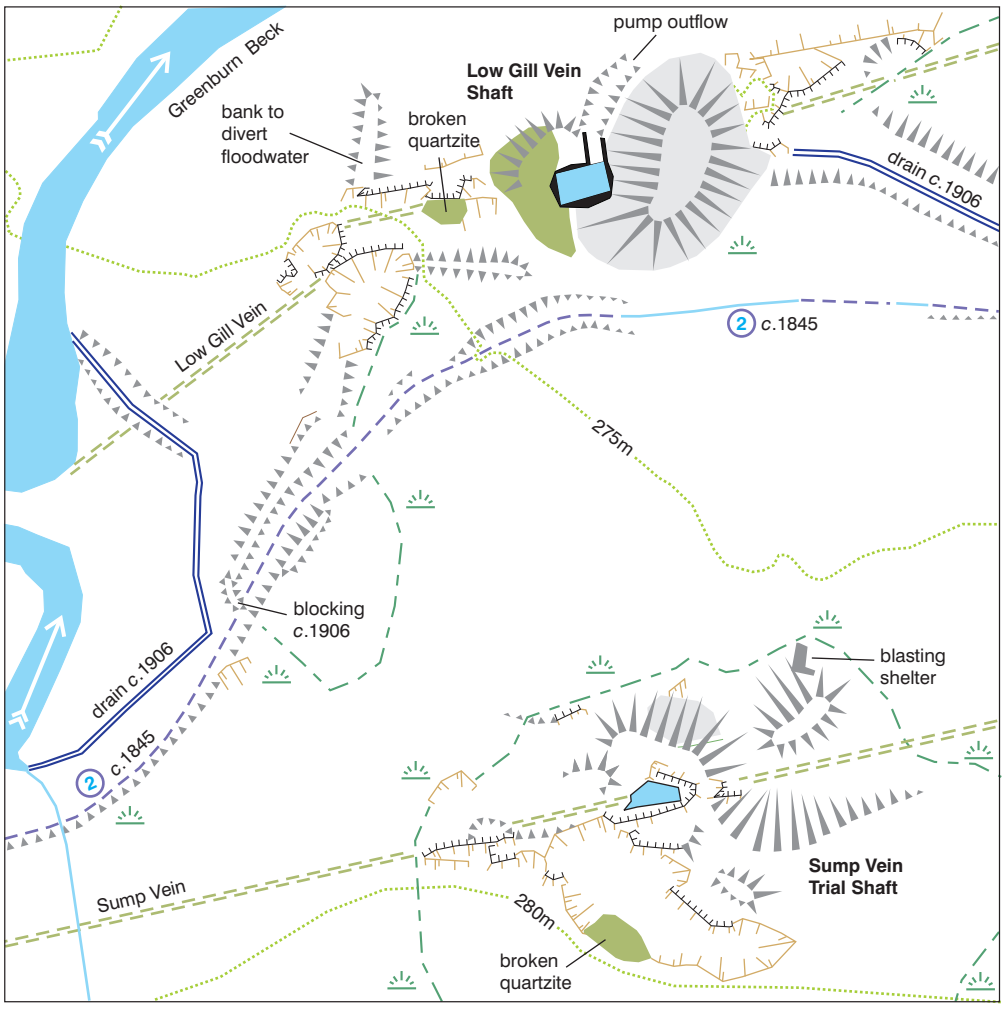


Figure 21 a. Plan of Low Gill Vein Shaft and Sump Vein Trial Shaft

Figure 21 b. View of the mouth of Low Gill Vein Shaft from the west

The shaft was not only sited close to the Greenburn Beck, but also on the western edge of an extensive area of raised bog; as a result, flooding was evidently a problem. Upstream from the shaft, the course of Leat 2, long disused by *c.*1906, was deliberately blocked and a drainage channel was dug to allow any water that did accumlate in the former leat to flow back to Greenburn Beck. A low embankment was also constructed following a natural ridge to the west of the shaft, presumably to divert any water in the event of the Beck overflowing its banks.

Had mineral extraction been more successful, the transport of the ore to the main processing area across the intervening boggy area would have posed considerable problems. This may well account for the construction of a series of drainage channels feeding into the channel that had formerly been part of Leat 2 (see Section 5.5).

Sump Vein Trial Shaft (Figure 21 a)

NGR: NY 2880 0212; NMR number: NY 20 SE 23

Like nearby Low Gill Vein Shaft, this trial was very probably carried out at some point between 1889 and 1912, probably *c.*1906, under the auspices of the Greenburn and Tilberthwaite Syndicate. However, in this case there are no indications that any serious attempt at extraction was anticipated. The shaft is located mid-way along the side of an outcrop where the mineral vein is exposed on the surface, at an altitude of 277m. Small-scale quarrying along the same line had already been carried out, perhaps at an earlier date. It seems that overburden was removed to expose an additional stretch of the surface deposit immediately to the east, at about the same time that the shaft was dug. The shaft itself, which is flooded almost to its top, is roughly rectangular, some 3.3m long by 1.8m wide, with its long axis following the alignment of the mineral vein roughly from east-north-east to west-south-west (Figure 22). Spoil was dumped to form a mound 1.0m high immediately to the north of the shaft; the small quantity indicates that the shaft cannot be more than a few metres deep. A small quantity of quartzite, potentially bearing copper ore, was removed to the level surface of the outcrop immediately to the south and broken into smaller pieces.

Figure 22. View of the mouth of Sump Vein Trial Shaft from the west

On the northern side of the mound of spoil created by the removal of overburden from the surface exposure to the east is a small L-shaped structure formed by a roughly constructed wall 0.3m high. The siting of this structure, on the side of the mound away from the shaft, suggests that it was built to provide protection for the miners while blasting was taking place.

Minor trials (Figure 10)

NMR number: NY 20 SE 24

In addition to the workings already described, numerous minor trials were identified in the course of the survey, the largest of which are numbered 1 to 14. It seems likely that more may await discovery beyond the limits of the area investigated, particularly in the area south and west of Greenburn Reservoir. The trials, many of which could have been completed by one or two workers in a single day, were probably in most cases intended to test for the presence and quality of the mineral veins and do not indicate that more prolonged work was anticipated. Those sited at points where the mineral veins are exposed on the surface take the form of small-scale quarrying into the rock outcrops, following the line of the vein. Those sited away from rock outcrops, usually on the projected line of the veins between proven deposits, generally take the form of shallow cuttings, driven into slopes at right angles to the line of the vein, and therefore known as 'cross-cuts'.

The only document to shed any light on the date of these workings is the cross-section through Engine Shaft and Sump Vein Shaft thought to have been made before 1861, which also depicts two shallow shafts further to the west (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5). The depiction of these is evidently schematic, for the two shafts can only correspond to Trials 10 and 11, which are actually cross-cuts. For the remainder, dating is reliant on the form and condition of the earthworks. The small-scale quarries sited where the vein is exposed on the surface (namely Trials 1, 3 and 8) together with Trial 2, where it would have been necessary to remove some overburden, may be amongst the earliest attempts at

extraction, perhaps dating to the late 17th century. The cross-cuts similar in form to Trials 10 and 11 are perhaps more likely to have been made in the 19th century. Within this category, it is possible to distinguish pairs of cross-cuts located in close proximity to each other: Trials 4 and 5, 6 and 7. These in particular, and to a lesser extent the more isolated Trial 13, are sufficiently similar in form to Trials 10 and 11 to suggest that they may have been completed in the same episode of work, at some point prior to 1861. The remaining three cross-cuts, Trials 9, 12 and 14, are not only somewhat anomalous in form, but appear by their more weathered condition to be of somewhat earlier date. Trials 9 and 14, like Greenburn Beck Level and Greenburn Beck Shaft, lie to the east of the main processing area and so are very unlikely to have been undertaken after the remodelling of the complex at some point before 1861. These may therefore have been completed in the period immediately after *c.*1845.

Trial	Vein	NGR	Alt.	Description	?Date
1	Low Gill	NY 2916 0226	229m	preparatory work for shaft	17thC
2	Low Gill	NY 2907 0223	243m	preparatory work for level	17thC
3	Low Gill	NY 2896 0221	269m	quarried outcrop	17thC
4	Low Gill	NY 2886 0218	272m	cross-cut	19thC
5	Low Gill	NY 2885 0218	273m	cross-cut	19thC
6	Low Gill	NY 2867 0212	278m	cross-cut	19thC
7	Low Gill	NY 2866 0212	282m	cross-cut	19thC
8	Low Gill	NY 2864 0211	280m	quarried outcrop	17thC
9	Sump	NY 2920 0222	235m	cross-cut	19thC
10	Sump	NY 2886 0214	273m	cross-cut	pre-1861
11	Sump	NY 2884 0213	274m	cross-cut	pre-1861
12	Sump	NY 2869 0210	279m	cross-cut	19thC
13	Sump	NY 2859 0205	289m	cross-cut	19thC
14	Gossan	NY 2913 0207	285m	cross-cut	19thC

5.2 STONE QUARRYING (Figure 9)

NMR number: NY 20 SE 25

Although the mining and quarrying of stone and slate were explicitly forbidden by the terms of all the surviving lease agreements, the field survey recorded widespread evidence for the quarrying concentrated in the area overlooking the processing area (see Figure 10). In most instances, this must have been done solely to obtain building material, but it is possible that some of the larger outcrops were blasted open with the secondary purpose of testing for the presence of the ore veins.

Quarry 1

NGR: NY 2894 0218

On the slope 75m to the north-west of the main processing area, a number of outcrops have been broken up. One of these lies on the line of the Low Gill Vein (Trial 3). In the vicinity are a group of shallow pits, of irregular shape and size, but the largest no more than 3m in diameter; some are associated with low mounds of spoil. These were first identified by Eric Holland (1981, 102) and are typical of the depressions left when large earthfast boulders have been prised out of the ground (known as stone extraction pits). In one instance, half of such a boulder remains *in situ*, with part of a triangular chisel hole visible in the broken edge. This probably indicates that although the technique is relatively crude, the quarrying took place in the 19th century.

Quarry 2 (Figure 24)

NGR: NY 2898 0213

Immediately to the west of the main processing area, a considerable quantity of outcropping rock has been removed, to a maximum depth of about 1.5m. Dating evidence is provided by the relationship of the quarrying to Track 5e. The track was built before Leat 1, which was in turn built before Leat 4, which was in turn built before 1861 (see Section 5.4); so the fact that the track passes through the quarried area implies that the quarrying must have taken place earlier still, although this may represent a very short interval of time. There is little evidence for the widespread use of quarried stone for the buildings thought to have been constructed *c*.1845, but some specialised structures such as water wheel pits may have required the quarrying of larger, flatter slabs. It seems likely that the quarrying was carried out in order to provide building material for these structures.

In one place where the quarrying has produced a level surface, a discontinuous band of stones forms a small enclosure abutting the quarried face. This seems to mark the site of a tent.

A little quarrying also took place immediately to the south-west of Leat 3 and this also appears to predate the construction of the leat. However, while it may be part of the more extensive quarry, it is possible that the extraction was undertaken separately immediately prior to the construction of the leat in order to obtain material for its building or reinforcement.

Quarry 3

NGR: NY 2888 0208

On the slope 150m to the south-west of the main processing area, a number of small outcrops have been removed, or blasted and only partially removed. The widespread use of large-bore triangular chisels to make shot-holes suggests that the work was carried out in the 19th century. More precise evidence is provided by the association of the various quarries with Track 5e, since most of this route seems to have been in use well before 1861, but soon after extraction had started at Quarry 2 (see Section 5.4). It seems likely on the basis of this evidence that the quarrying took place *c*.1845, as the easily accessible outcrops exploited by Quarry 2 were exhausted.

Quarry 4 (Figure 26)

NGR: NY 2885 0219.

Some 130m to the north-west of the main processing area, a knoll formed by a large outcrop has been heavily blasted. At least two of the resulting blocks were used to form Dam 3, built at some point between 1848 and 1861, but much of the rock was apparently left in place. There is no clear evidence for a track suitable for carts or sledges approaching the knoll, and the transport of heavy slabs towards the processing area would have been severely hampered by the intervening stretch of boggy ground. It is therefore possible that although the blasting is similar in appearance to Quarry 3, it was undertaken somewhat later, both to obtain material for Dam 3 and to test for the presence of the Low Gill Vein. However, the mineral vein is visible where it outcrops along the southern edge of the knoll, and it has been tested there by two minor trials (numbered 4 and 5).

5.3 SPOIL DUMPING

This section deals with the major spoil tips in the immediate vicinity of the processing area: the Sump Vein north and south spoil tips, and the Gossan Vein spoil tip. For the most part, these comprise coarse, angular fragments of waste rock produced by blasting below ground. Although of little interest or archaeological importance in themselves, a sequence of dumping can be distinguished which sheds light on how the complex as a whole evolved (Figure 23). The two largest tips relate to Engine Shaft: one on the north side of the valley, and the other on the south, here called the Sump Vein north and south spoil tips. Both comprise several phases of linear 'finger-dumps', whose form is characteristic of tipping from hand-pushed tram trolleys. A smaller tip of similar form relates to Gossan Vein Level, and is here termed the Gossan Vein spoil tip. The first phase of this finger-dump can be dated with considerable confidence to between December 1865 and February 1866 (see Section 5.1), offering a fixed point in the relative sequence that can be inferred from

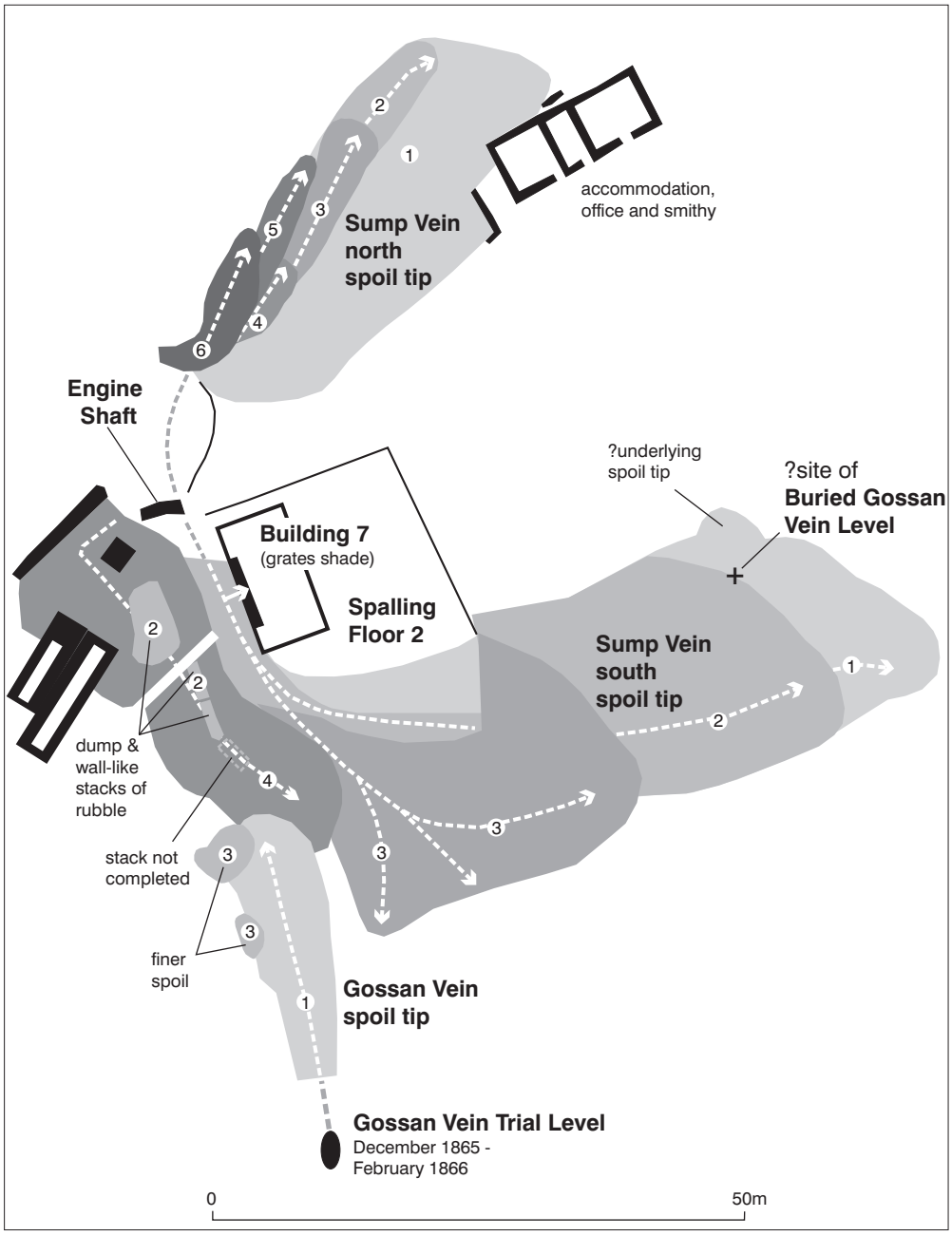


Figure 23. Schematic plan of spoil dumping in the vicinity of the main processing area

the physical remains of the tips. The field evidence thus contradicts the impression created by the Second and Third Editions of the 6-inch scale map, revised in 1889 and 1912 respectively (Ordnance Survey 1891; 1920). The spoil heaps are only shown on the Third Edition map, from which it would generally be inferred that they originated in the intervening period, perhaps *c.*1906. Although spoil tips at the main Coniston Copper Mines and indeed at Long Crag Level were portrayed in some detail on the Second Edition map, it seems that they were omitted in the immediate vicinity of the main processing area. It is not entirely clear why this was done, but the omission is consistent with other inaccuracies on the Second Edition map.

Sump Vein north spoil tip

The Sump Vein north spoil tip represents a sequence of at least six finger-dumps, numbered 1 to 6 on Figure 23, although in practice, the six episodes may correspond to only one or two phases of intensive extraction. The lowermost spread of tipping (1) is heaped up to a depth of *c.*2m against the rear of the accommodation block and office, and is therefore later than that building, which is known to have been built at some point between 1847 and 1861 (see Section 5.7). The subsequent pattern of dumping suggests that care was taken not to put too much pressure on the rear wall of the building. Given this, and the smaller size of the Sump Vein north tip, it is reasonable to infer that it was used for a briefer period than the south spoil tip.

Sump Vein south spoil tip

The Sump Vein south spoil tip represents a sequence of at least four finger-dumps, numbered 1 to 4 on Figure 23. There is no evidence for when the first episode of tipping took place, but it is reasonable to assume that it may have been at about the same date as the first episode of the north spoil tip, that is, at some point before 1861. As described in Section 5.1, a bulge in the southern slope of the tip may testify to the presence of an underlying mass, which may be a spoil tip extending northwards from the Buried Gossan Vein Level. The possible existence of this working is inferred from a symbol marked on the First Edition 6-inch scale map surveyed in 1847-8, whose plan position falls just to the south of the bulge recorded during the English Heritage fieldwork (Ordnance Survey 1850). The first three episodes were evidently deposited from tramways that started at the same height as Engine Shaft. The platform on which Spalling Floor 2 lies had evidently been built by the time the second episode of tipping took place, for the western wall of Building 7 originated as a revetment to retain the spoil (see Section 5.6). Indeed, the walls and presumably the core of the platform itself are built almost entirely of spoil, which must have been created by relatively early extraction.

The fourth episode was evidently delivered to a height *c.*2m above the top of the shaft, presumably onto a timber superstructure level with the platform that supported the pumping and lifting gear in Engine Shaft. This significant change in the established *modus operandi* suggests that the spoil may have been the product of a later episode of work carried out after Crossfield & Co had surrendered their lease in 1861, perhaps a trial undertaken after David Dunlop took over the lease in 1864. The reason for the decision not to continue with the earlier system of dumping is unclear, but if the waste was produced by a trial in 1864 or 1865, it is possible that it was deliberately placed with the imminent work on Gossan Vein Level in mind, for the top of the finger dump lies at almost precisely the same height as the Gossan Vein spoil tip. The southern end of this latest episode of the Sump Vein south spoil tip is also physically overlain by the northern end of the first episode of the Gossan Vein

spoil tip, so the former must have been completed before December 1865, as described below. In other words, the Sump Vein north spoil tip and the first four episodes of the south spoil tip, which together represent the vast majority of the waste material on the site, were certainly deposited prior to December 1865 and the principal structures associated with Engine Shaft were in existence before most of the dumping took place. In practice, this means that all the major building work and extraction was carried out before 1861, that is, probably under the tenancy of Crossfield & Co.

As the final phase of the Sump Vein south spoil tip accumulated, a narrow passage extending obliquely through the width of the tip was left open, its sides formed by crudely built battered drystone walls holding back the rubble on either side. The purpose of this passage remains unclear. Its relationship with the spoil tip suggests that it relates to an arrangement predating the tipping, which it was important to maintain. The passage was apparently deliberately kept clear even when the wall-like stacks of rubble thought to result from work in the Gossan Vein Level were constructed, at some point after 1866. The western end of the passage is at ground level, but the eastern end is some 2m above the surface of the earlier tramway along which ore and spoil would have been transferred from Engine Shaft, which suggests that whatever passed through the passage could have done so without interrupting the movement of the trolleys. The passage is too narrow to have functioned as a footpath; there is no evidence that a leat passed through it and it seems unlikely to have transferred power from Water Wheel 3, for example via cables, given that it lies on a different alignment.

Gossan Vein spoil tip

The first phase of the Gossan Vein spoil tip, numbered 1 on Figure 23, is dated fairly precisely to the winter of 1865-6 by Captain Vivian's report. It is essentially a single finger dump, whose relatively small size is consistent with the length of the level driven to reach the mineral vein. In other words, it would appear that little extraction took place on the vein itself and therefore that the deposits were not as rich as had been hoped. As noted above, the height of the top of the finger dump is the almost precisely the same as that of the fourth episode of the Sump Vein south spoil tip, which may have been deposited in 1864 or 1865 (numbered 4). This is unlikely to be coincidental, and probably indicates that the tramway was designed to deliver any ore to Spalling Floor 2 by the same route previously used to carry ore from the timber superstructure above Engine Shaft. This may have been the consideration behind the decision to dump material from Engine Shaft at a higher level in the first place.

The final episode of the Sump Vein south spoil tip is surmounted by a wall-like stack of coarse rubble 1.8m high, which actually comprises two conjoining segments, and a more irregular heap which is apparently contemporary (both numbered 2); these seem to result from a brief episode of extraction in Gossan Vein Level at a later date. The key evidence leading to this conclusion is the existence of a discontinuous alignment of stones immediately to the south-east of the main stack; this appears to represent the lowermost course of a similar wall-like stack, which was left unfinished. It can be inferred from this that the material was brought from the south, that is, from the Gossan Vein Level: it was initially thrown across the narrow passage through the Sump Vein south spoil tip, then stacked more tidily increasingly close to its source, as space diminished. Stacking the ore on the line of the tramway that had once served Engine Shaft would effectively have prevented its further use, suggesting that the shaft was disused. However, it appears to have been important not to block

the narrow passage through the fourth episode of the Sump Vein south spoil tip. It is possible that the wall-like stacks and the less structured dump are contemporary with a series of spreads of finer material on the western side of the Gossan Vein spoil tip (numbered 3), and that all this material represents a single phase of extraction. The finer material seems to have been extracted without major blasting; in total, there is no more than four or five trolley loads. In summary, it is probable that the work was a minor trial carried out at some point after 1866.

5.4 TRANSPORT

Tracks (Figures 8, 9 and 10)

Track 1 (NMR number: NY 20 SE 26)

Throughout the use of the mine, Track 1 provided the only means of vehicular access to Greenburn Mine from outside the valley. It was therefore the route along which equipment was brought to the site and along which copper ore was taken away for smelting. It is possible that parts of the extant track follow an earlier path which served the 17th-century workings, but there is no surviving physical evidence to support this speculation. In fact, on its descent to the lower ground, part of the extant track is forced to climb several metres in order to skirt a field wall, which was probably built following the Parliamentary Acts of Inclosure in the earlier 19th century. This relationship not only suggests that the track itself was built in the 1840s, but lends support to the theory that the 19th-century mining began in earnest at about that time. The First Edition 6-inch scale map surveyed in 1847-8 indicates that the route was certainly in existence by 1848 (Ordnance Survey 1850). It is the only track shown on the plans thought to have been made before 1861 and is called 'Greenburn Road' on the small scale plan of the mining sett (Cumbria CRO: D/Pen/46/file 90-99/document not numbered; see Figure 4). In order to carry heavily laden horse-drawn carts, the track was well constructed, surfaced with stones and tailings from the crushing mill and with a slight revetment bank on the downhill side where appropriate. Wherever necessary, covered drains were constructed in order to prevent erosion of the metalled surface by minor streams. From the processing area, the trackway leads eastwards for 1.5kms, to a point where it joins a track that had probably been built somewhat earlier to serve the slate workings on Betsy Crag. Most of this section maintains a fairly gentle downhill gradient, although there is a short uphill stretch, as mentioned above. From the junction with the track from Betsy Crag, the route turns back on itself at an acute angle and runs obliquely across the contours to reach the valley floor. From there, it heads north, crossing the Greenburn Beck by a hump-backed stone bridge to join the public road to Little Langdale.

Immediately to the east of the processing area, the trackway crosses the tributary stream, protected by a series of crudely built rubble weirs. Just to the north of the crossing, a short branch of the trackway (numbered 1a) turns towards Loading Bay 2 (see Section 5.5). Prior to the construction of Loading Bay 2 at some point between 1848 and 1861, this branch may have been somewhat longer, for discontinuous stetches can be traced continuing for *c*.30m further to the west, terminating adjacent to a low wall that may represent part of an earlier loading bay (Loading Bay 1). The First Edition map indicates that close to Loading Bay 1, the main part of the track (numbered 1b) bent to the south-west, giving access to the centre of the main processing area. From there, it was continued up the southern side of the valley by the minor footpath referred to as Track 2 (Ordnance Survey 1850; see Figures 3 and 8). Despite its evident importance, Track 1b is very difficult to identify on the ground. If the map depiction is slightly inaccurate, it may be marked by a fragmentary series of scarps, perhaps corresponding to the embankments along the sides of the track. There are two reasons for the poor condition of this section. Firstly, the pattern of activity on the processing area evidently changed dramatically in the period of the mine's most intensive use before 1861 (see Section 5.6). Secondly, part of this area has been heavily disturbed by the creation of a broad irregular channel. It seems likely that this was dug out deliberately at some point, probably after *c*.1885, possibly to improve drainage once the main water wheels had become redundant. According to the First

Edition map, another minor branch of the track (numbered 1c) continued westwards for a few metres to join the minor footpath referred to as Track 3 (Ordnance Survey 1850; see Figures 3 and 8). The terminus of the track was apparently broadened at a later date to create a turning area outside the range comprising the accommodation, office and smithy. This section remains fairly well-preserved.

Track 2

Track 2 was depicted on the First Edition 6-inch scale map surveyed in 1847-8 and annotated 'Foot Path', but much of its course has been disturbed by later activity and the remainder can no longer be identified with confidence on the ground (Ordnance Survey 1850; see Figures 3 and 8). The footpath apparently served to link Greenburn Mine with the copper mines at Tilberthwaite, 1.5kms to the south-east (centred at NGR NY 298 009). It evidently started at the terminus of Track 1b, climbed straight up the southern hillside for about 500m, then turned south-eastwards, crossing the contours obliquely to intersect with Track 4. Tipping on the Sump Vein south spoil tip, work on the Gossan Vein in 1865-6, and work on the inclined tramway *c.*1906, would each have played a part in masking or erasing the surface remains of this lower part of the trackway. From the intersection with Track 4, the footpath headed eastwards along the contours towards Tilberthwaite. The English Heritage field investigation did not extend as far as this area.

The Second Edition map revised in 1889 also portrayed the track, precisely replicating the depiction on the First Edition (Ordnance Survey 1891; see Figures 6 and 8). However, given that the Second Edition neglected to depict the Gossan Vein Shaft and Level, which had certainly been completed by the time of the revision and lie very close to the line of the track, it is impossible to be certain that the route was actually still in use. The fact that it was not depicted on the Third Edition map revised in 1912 strongly suggests that it was not used after *c.*1885 (Ordnance Survey 1920).

Track 3

Track 3 was clearly constructed in order to connect Long Crag Level with the processing area; it was depicted on the First Edition 6-inch scale map surveyed in 1847-8 and annotated 'Foot Path' (Ordnance Survey 1850; see Figures 3 and 8). The upper and central sections of the track (3a and b), which descended the valley side obliquely, are relatively easy to trace on the ground. The upper section of the route (3a), beyond the point where Track 8b diverges, is a minor footpath; this stretch probably best reflects the original form of the track. Although narrow, the footpath is relatively well-defined and this probably explains why it was mapped for the Third Edition 6-inch scale map revised in 1912, since it was almost certainly wholly disused by that date (Ordnance Survey 1920). Although extraction at Long Crag Level ceased before December 1865, the central part of the route (3b) was re-used by Track 8 in order to allow access to the Pave York Levels and was probably further improved *c.*1906 in order to allow access to the inclined tramway. The condition of this stretch as it can be seen today is essentially the product of these later modifications.

At the lower end of the stretch numbered 3b, the track bent sharply northwards to descend to the valley floor. The bend in the track was recorded by the English Heritage field survey, but very little of the stretch of the track below this point (numbered 3c on Figure 8) can be traced on the ground. Part of the route was buried beneath the Sump Vein south spoil tip at some point before 1861, although the Second Edition 6-inch scale map revised in 1889 misleadingly replicates the depiction on the

First Edition (Ordnance Survey 1891; see Figures 6 and 8). Much of the remainder of the route is simply too ephemeral to identify with confidence. Although the eastern part of Track 5e appears to coincide with its line, there is no physical evidence that this track, as far as can be recognised from the earthwork remains, crossed the tributary stream at the point indicated on the map; rather, it seems to have been linked exclusively with the transport of material from Quarry 3.

Track 4

Track 4 was depicted on the First Edition 6-inch scale map surveyed in 1847-8, annotated 'Foot Path' (Ordnance Survey 1850; see Figures 3 and 8). It evidently allowed Track 3 to be reached from Track 1 without passing via the main processing area. There is no evidence that the ore in the Long Crag Vein was taken elsewhere for processing, so the route probably allowed a more gentle ascent to the workings, but was not generally used for the descent. Only a short stretch of the track east of the intersection with Track 3 was identified on the ground by the English Heritage field survey. The plan position of this stretch differs markedly from the position depicted on the First Edition map, but there is no question that they are the same route. As it approaches the line of the inclined tramway, the course of the track becomes too ephemeral to trace; the area east of the tramway was not investigated on the ground.

The Second Edition map revised in 1889 precisely replicated the depiction on the First Edition (Ordnance Survey 1891; see Figures 6 and 8). However, given that the Second Edition neglected to depict the workings on the Pave York Vein, which had certainly been completed by the time of the revision and lie reasonably close to the line of the track, it is impossible to be certain that the route was actually still in use. The fact that it was not depicted on the Third Edition map revised in 1912 strongly suggests that it was not used after *c.*1885 (Ordnance Survey 1920).

Track 5

Track 5 appears to have been associated with the removal of stone quarried as a building material at the outcrops collectively described as Quarry 3 (see Section 5.2). Holland (1981, 103) suggests that sledges may have been used, rather than horse-drawn carts, and these may indeed have been much more practical over the more boggy sections of the route. One of the eastern branches of the track (numbered 5e) is overlain by Leat 1, which is in turn cut by Leat 4, built at some point before 1861 (see Section 5.5). The same branch of the track passes through and therefore post-dates Quarry 2, although it seems unlikely that this relationship represents a very long interval of time. In short, although not shown on the First Edition map, Track 5 was probably in use for a brief period while the first 19th-century mine buildings were being erected, *c.*1845. The western end of the track comprises three main branches (5a - c), each of which gives access to an area of quarrying. The northernmost branch (5a) runs along the contours for nearly 100m and the other two branches descend the contours obliquely to join it. The eastern end of the route also divides, presumably to supply the quarried stone to different parts of the complex. Both branches (5d and 5e) appear to be heading for the site of Building 3, which may been associated with Water Wheel 2; its wheel-pit, like that of the better preserved Water Wheel 3, may originally have been surrounded by flat slabs obtained by quarrying. The southern branch (5e) passes through Quarry 2 and, as described above, may have formed part of Track 3, although the physical evidence does not support this conclusion. In either case, if Track 5e did continue towards the valley floor, the overlying spoil tips have concealed its course beyond this point.

Track 6

Track 6 is a narrow footpath which links the Upper Workings on Long Crag Vein with Track 3a, joining it just below the smithy associated with Long Crag Level. Neither the track nor the Upper Workings are shown on the First Edition 6-inch scale map surveyed in 1847-8, so it seems likely that the route originated at some point after 1847 and was used during the relatively brief period that the Upper Workings remained active. Although amendments were made to the depiction of Long Crag Level for the Second Edition map revised in 1889, neither the track nor the workings were shown (Ordnance Survey 1891). Notwithstanding this, it seems most probable that both were used in the period before 1861; the omission from the map of all the workings on the Pave York Vein suggests that the surveyors did not seek out less obvious features not shown on the First Edition, so the lack of any record of the inaccessible Upper Workings cannot be taken as evidence that they did not exist.

Track 7

Track 7 is a minor footpath that connects the processing area with Dam 3; it must therefore have originated before 1861 and gone out of use by 1885, yet it is not depicted on the Second Edition 6-inch scale map revised in 1889 (Ordnance Survey 1891). The path would have allowed access to the main sluice gate that controlled the water supply to Dam 4.

Track 8

With the wholescale transformation of the complex in the period before 1861, in particular the accumulation of the Sump Vein south spoil tip, the lower stretch of the earlier route between the main processing area and the southern side of the valley, Track 3c, would have become unusable. The new route, Track 8, probably originated as a minor footpath connecting Pave York Top Level and subsequently with Pave York Middle Level with the main processing area. The Top Level was very probably worked before 1861 and the Middle Level was certainly worked before 1868 and probably before 1861; therefore, the track also probably originated before 1861. The same route would also have served Pave York Bottom Level, which was probably begun *c*.1873. The Second Edition of the 6-inch scale map, revised in 1889, is unhelpful, for it neglected to portray any of the workings on the Pave York Level or the track that must have served them, but instead precisely replicated the depiction on the First Edition map (Ordnance Survey 1891; see Figures 6 and 8). The more thorough mapping undertaken for the Third Edition map, revised in 1912, resulted in a more-or-less accurate depiction of the route (Ordnance Survey 1920; see Figures 7 and 8). The fact that it was depicted hints that this route, like Track 10, may well have been used *c*.1906 to facilitate the construction of the inclined tramway.

All that can now be identified of the early track are slight traces (numbered 8a) east of the course of the inclined tramway and above Pave York Middle Level. This is due to the fact that the stretch between Track 3b and the inclined tramway (numbered 8b), together with Track 3b itself, was apparently broadened and improved *c*.1906 to allow access to the inclined tramway during its construction. In this form, the track was mapped for the Third Edition revised in 1912, although the plan position is slightly inaccurate and the depiction shows the broader section extending only as far as Pave York Bottom Level, rather than to the line of the tramway just beyond (Ordnance Survey 1920; see Figures 7 and 8). Little can be identified on the ground of the central section of the route below the line of Track 3b, so it seems unlikely that

the route can have been used intensively or over a prolonged period. The stretch that can be traced between Spalling Floor 1 and the tributary stream on the southern side of the valley (numbered 8c) indicates that the plan position shown on the Third Edition map is also inaccurate, lying up to 20m too far west of the actual line of the track (see Figure 8). The fragmentary remains of a low revetment wall (numbered 8d) correspond fairly closely to the northern edge of the stretch of track running north-eastwards from Spalling Floor 1, as this was mapped in 1912 (Ordnance Survey 1920). Apart from this, the only physical evidence of this section of the route is the northern end of the latest episode of dumping on the Sump Vein south spoil tip, which terminates in a roughly built revetment wall, presumably allowing the track to pass. A terrace cut into the southern side of the Sump Vein north spoil tip (numbered 8e) marks the line of the track in its descent to the terminus of Track 1c.

Track 9

Track 9a is a narrow footpath which appears to have been used to reach Gossan Vein Shaft and the numerous cuttings probably dug in the initial exploratory phase of work; it must therefore have been used for a very brief period. The footpath, which ascends the steep slope in a series of zig-zags, can be traced as very slight and discontinuous earthworks. An even narrower path (numbered 9b) seems to have carried on to the south of the Gossan Vein Shaft to join up with Track 3b.

Track 10

Track 10 is a broad and well-constructed metalled track which branches southwards from Track 1 and climbs obliquely across the contours at a constant gradient. It is not shown on the Second Edition of the 6-inch scale map revised in 1889 and it is almost inconceivable that such a major feature would have been omitted if it existed, even given the other demonstrable omissions from the map (Ordnance Survey 1891). It was certainly built before 1912, for it is depicted on the Third Edition map revised in that year (Ordnance Survey 1920; see Figure 7). The documented sequence of tenants at this time suggests that in practice it was very probably built before *c.*1908. It therefore seems most probable that the track was constructed *c.*1906, when the Greenburn and Tilberthwaite Syndicate took on the lease. Like Track 1, the trackway is broad enough and sufficiently well constructed to have allowed use by horse-drawn carts. However, the location of the western end of the track, which is poorly defined due to erosion by minor streams, cannot be accounted for in terms of the movement of ore. Although Track 11 does continue westwards beyond this point, that path is demonstrably of later origin. It seems likely that the primary function of the track was to allow materials and equipment for the construction of the inclined tramway to be carried up to the foot of the tramway, probably *c.*1906 (see below). It may also have served to transport heavy equipment, perhaps including a steam engine, to Spalling Floor 2, where processing seems to have taken place at that time.

Track 11

Track 11 is a narrow footpath which meanders across the Sump Vein south spoil tip, heading westwards from the upper end of Track 10 to the valley floor immediately west of the processing area. The destination and purpose of the track are unclear. It seems unlikely to have been involved in the transport of ore, for it climbs over the Gossan Vein spoil tip without signs of any serious attempt at making the route more direct or even. The path overlies the course of the inclined tramway, which indicates that it originated late in the history of the mine, very probably in 1912 or even later.

Inclined tramway (Figures 9 and 32)

NGR: NY 2913 0168 - NY 2902 0217; NMR number: NY 20 SE 27

The construction of the inclined tramway, linking the Pave York Middle Level with Spalling Floor 2, was a major feat of engineering (see Figure 2). There are no documentary references to the tramway, but it was probably constructed *c*.1906, when the Greenburn and Tilberthwaite Syndicate took on the lease. Several pieces of complex circumstantial evidence point to this conclusion. Firstly, neither the tramway itself, nor Tracks 8 and 10, which apparently were respectively improved and built from scratch to give access to the tramway during its construction, are depicted on the Second Edition of the 6-inch scale map revised in 1889 (Ordnance Survey 1891). However, the tracks are shown on the Third Edition map revised in 1912 (Ordnance Survey 1920). Various other features known to have been constructed prior to 1889, including Pave York Middle Level itself, were not depicted on the Second Edition, but it is highly unlikely that the tramway would have been omitted, had it existed, given that tramways were mapped elsewhere, for example at the main Coniston Copper Mines. It is even more unlikely that Tracks 8 and 10 would have been omitted, since both survive even today as well-constructed routes. Secondly, the Third Edition map shows two short gaps in the tributary stream on the southern side of the valley. The western gap corresponds to the point at which the stream passes through a culvert beneath the Gossan Vein spoil tip, while the eastern gap corresponds to the point at which the embankment of the tramway crosses the stream. From this evidence, it can be inferred that the tramway must have been dismantled by 1912, leaving only the embankment to be mapped. Thirdly, documentary sources indicate that the Greenburn and Tilberthwaite Syndicate was engaged in work on the Pave York Level, which was initially fairly productive. Fourthly, the scale of the construction of the tramway suggests considerable investment and in this respect, the undertaking is comparable to the careful and extensive preparatory work completed prior to the sinking of Low Gill Vein Shaft, which was almost certainly begun *c*.1906. Lastly, and most significantly, the 'jetty' that forms the lower terminus of the tramway was built in the same constructional episode as an ore chute which evidently allowed crushed material to be moved down to the precipitation tanks (see Section 5.6). The surface of the chute is covered with fine material containing tiny pieces of cuprite ore, similar to that scattered outside the Pave York Middle Level (see Section 5.1). This indicates that the ore had been finely crushed on Spalling Floor 2, prior to being fed into the tanks. The sequence of processing therefore by-passed Building 9, which had housed the crushing mill until at least 1868. This suggests that the crushing mill may have been absent by the time the tramway was constructed. The most plausible context for its removal is the abandonment of the mine *c*.1885, so it is highly probable that the tramway was constructed *c*.1906 and was removed for re-use elsewhere prior to 1912, and possibly as early as 1908, when production at Pave York Middle Level ceased.

The tramway ran in a straight line down the southern side of the valley, descending some 190m over 500m, that is, at an average gradient of *c*.40%. According to Eric Holland, the rails would have been wooden, reinforced with iron strips (Holland 1981, 108). However, none now survive and given that a series of timber sleepers do survive, it is possible that Holland's assertion is mistaken: the rails may in fact have been cast iron, which may have been removed for re-use elsewhere. The course of most of the upper end of the tramway can be traced as a low embankment passing through a narrow gap in the bracken; sections that are more difficult to trace may have been supported on timber trestles. Towards the lower end, where the course

makes an almost imperceptible deviation to pass around the Gossan Vein Trial Shaft, the tramway passed through a shallow cutting. Mid-way along this cutting, a series of at least six timber sleepers, spaced at intervals of about 1.2m, survive *in situ* (see Figure 18 a). The surface remains are potentially misleading, for the sleepers are partially buried beneath spoil from the Gossan Vein Shaft, suggesting that they are of earlier date. In reality, this results from the slumping of the spoil heap after the digging of the cutting through the loose material. Below this, the final approach to the processing area levels out: it is carried across the tributary stream on an embankment 1.1m high, built with spoil presumably obtained from the Sump Vein spoil tip, and revetted with low drystone walls. As noted above, this feature appears to be represented on the Third Edition map by a gap in the line of the stream (Ordnance Survey 1920). Next, it passes through a cutting dug to a depth of 1.2m through the upper levels of the south spoil tip. Immediately beyond this, an abrupt change of alignment in the course of the tramway strongly suggests that the track divided, allowing the trolley to be directed along one of two routes. To the west, a ramp appears to have carried the tramway straight down onto Spalling Floor 2. To the east, a well-constructed drystone 'jetty' would probably have carried the track onto a timber trestle 2.7m above the height of Spalling Floor 2. The weathered appearance of the jetty is potentially misleading in terms of its date, for, like the embankment to the north, it was constructed using angular fragments of rock presumably obtained from the Sump Vein south spoil tip, which had already been exposed for about fifty years. The existence of the trestle is inferred from a tip of ore-bearing rock on the floor *c*.3m beyond the end of the jetty. This arrangement would have allowed access beneath the tramway to the top of the ore chute built in the same episode (see Section 5.6).

Inclined tramways of this type, which were powered solely by gravity and are therefore termed 'self-acting', were often built with two parallel tracks, so that the descending full trolley was partly counterbalanced and thus braked by the ascending empty trolley (Jones 1996, 195). Where there was a single track, as at Greenburn Mine, there was usually a short section of double track mid-way up the line to allow the two trolleys to pass each other. However, there is no clear evidence that this was the system used at Greenburn; it is possible that the descent of the full trolley was mechanically braked in some other way.

5.5 WATER MANAGEMENT

Dams and leats

Dam 1 and Leat 1 (Figure 24)

NGR: NY 2897 0211; NMR number: NY 20 SE 28

Dam 1 and its associated leat are amongst the earliest identifiable remains relating to water management. They are not whown on the First Edition of the 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850), but Leat 1 cuts through the surfaces of Tracks 5d and 5e, which were probably in use during the construction of the first 19th-century buildings on the site *c*.1845 (see Section 5.4). Leat 1 is itself cut by - and therefore predates - Leat 4, which was constructed before 1861, as described below. It is possible that that the dam and leat were built immediately after *c*.1845 and became redundant before 1848, or that they were too insignificant to map in 1847-8, or that they were built shortly after 1848.

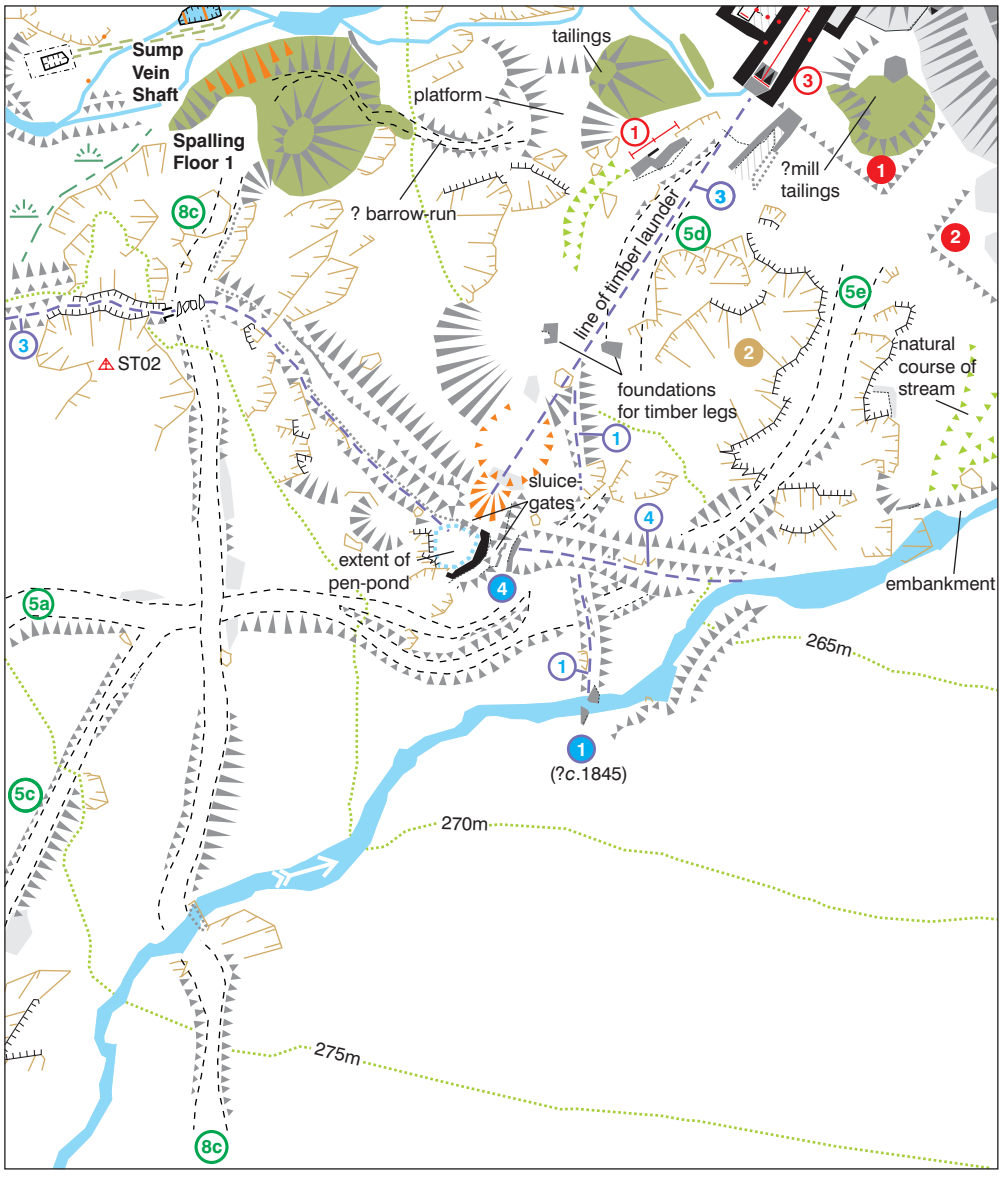


Figure 24. Plan of Dams 1 and 4, and Leats 1, 3 and 4

All that survives of Dam 1 are a few displaced blocks of stone in the course of the minor tributary stream on the southern side of the valley, at an altitude of 267m. Leat 1 can be traced for *c*.22m as a narrow channel of minimal depth with a more prominent embankment on the eastern side, running northwards from Dam 1. Beyond this, its course is impossible to discern, probably because the topography necessitated the use of a raised timber launder to maintain the same gradient. The tributary stream can never have supplied a very powerful volume of water and the arrangement may therefore have rapidly become redundant.

Dam 2 and Leat 2 (Figures 10)

NGR: NY 2871 0212; NMR number: NY 20 SE 29

Leat 2 must have been constructed soon after *c*.1845, for its channel is depicted as a line on the First Edition of the 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850). The prospectus of 1868 and the accompanying plans, thought to have been made before 1861, indicate that the Greenburn Reservoir and Leat 3 had been constructed by 1861, making Leat 2 redundant (Cumbria CRO D/Pen/46/file 102-106/document not numbered). The Second Edition of the 6-inch scale map revised in 1889 suggests that the eastern part of Leat 3 re-used the channel of Leat 2, but the plan thought to have been made before 1861, together with the physical remains, show that this was almost certainly not the case (Ordnance Survey 1891).

The First Edition map indicates that Dam 2 was located on what is now a tributary stream, but was then, before the creation of Greenburn Reservoir, the main channel of the Greenburn Beck (Ordnance Survey 1850). The dam, at an altitude of 276m, is poorly preserved, surviving only as an amorphous earthwork and a heap of stones. It may have been a weir, designed to raise the water level, rather than a dam. Stone may have been quarried from an outcrop immediately upstream. Leat 2 follows a sinuous course eastwards from the dam for *c*.310m overall, falling *c*.10m over that distance, at an average gradient of 1 in 30. It was almost certainly constructed to supply Water Wheel 2, whose position is not explicitly marked on the First Edition map, but can be inferred from the position of Building 3 in relation to the line of the final stretch of the leat. For *c*.70m at its western end, the course of the leat can be traced as a scarp running parallel to the southern edge of the tributary stream, with a ledge formed by a discontinuous course of stones adjacent to it. This presumably served to support a timber launder, of which no trace survives. The next *c*.50m, where the channel passes through a spur of slightly higher ground, is formed by a fairly broad ditch up to 0.6m deep. On the western side of the spur, where the ground begins to rise, the ditch has been deliberately blocked and diverted along a drainage channel, which was probably dug at the same time as the other drainage channels, *c*.1906 (see below). Beyond the end of the ditch, where the leat passes for *c*.40m across a level stretch of boggy ground, it is traceable only as a vestigial earthwork and intermittently as a narrow water-filled channel. For a further 70m, it has been recut as a drain, and as a result is more easily identifiable as a sharply-defined earthwork; four more drains, probably dug *c*.1906 and described further below, discharge into it. To the east of this section, the leat was overlain by Leat 3, which crosses it obliquely from the north-west. Beyond this, the leat can be traced for a further 26m as a narrow watery channel. Immediately west of Sump Vein Shaft, the leat is cut into by a much deeper culvert which serves to divert the flow around the mouth of the shaft. This is evidently a later modification, for the First Edition map indicates that the leat turned north-eastwards, passing the mouth of the shaft on the north and then continuing eastwards. None of this stretch of the leat can be traced on the ground, presumably because it was formed by a wooden launder.

Greenburn Reservoir (Figure 9)

NGR: NY 2848 0205 - NY 2858 0222; NMR number: NY 20 SE 31

Although the Greenburn Beck never runs dry, its flow diminishes in summer and can increase suddenly and potentially destructively after rainfall. The prospectus of *c*.1868 comments that the reservoir '…contains an abundance of water, supplying the requisite power all the year round'. The First Edition of the 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850; see Figure 3 and 8) shows the lie of the land prior to the creation of the reservoir. The chosen site was a stretch of peat bog in a hollow scoured out by glacial action, lying some 450m west of the main complex and some 25m higher, at an altitude of *c*.290m. This provided not only a suitable topographic situation, but also a ready supply of building material in the form of peat. The large-scale plan thought to have been made before 1861 portrays the reservoir schematically as a roughly rectangular body of water, indicating that the dam had been constructed during the period of the mine's most intensive use (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5). The Second and Third Editions of the 6-inch scale map revised in 1889 and 1912 respectively differ from each other somewhat in their depiction of the extent of the reservoir (Ordnance

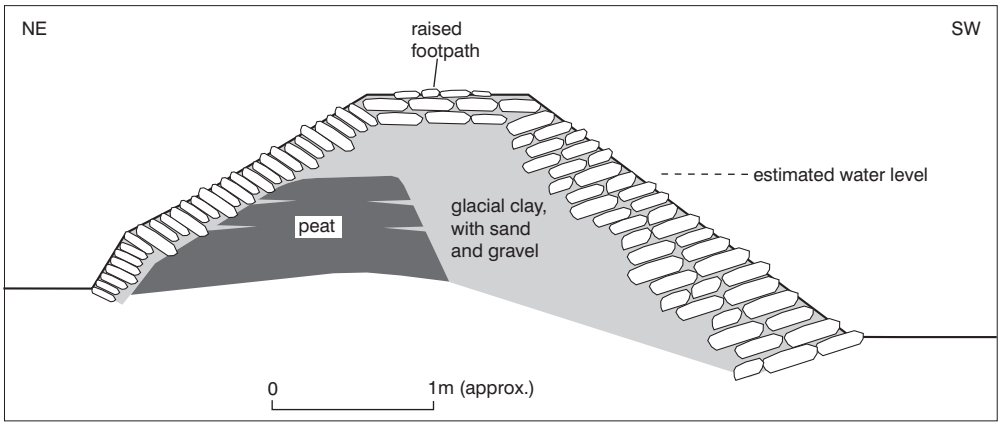


Figure 25 a. Cross-section through the dam of Greenburn Reservoir

Figure 25 b. View of Greenburn Reservoir from the east

Survey 1891; 1920; see Figures 6, 7 and 8). On the west, both maps correspond closely to scars created by water erosion which were recorded on the ground by the English Heritage investigation. On the east however, the Second Edition does not explicity depict the dam at all, but only shows the edge of the water, and this lies some distance to the west of the extant dam, corresponding closely to the edge of the 'Peat Moss' depicted on the First Edition map. On the Third Edition map, both the dam as it is today and the projected extent of the full reservoir are depicted accurately. At first sight, the discrepancy between the two maps would seem to lead to the conclusion that the dam mapped in 1889 was destroyed and then rebuilt on a different line at some point before 1912, presumably during the two years that the mine was occupied between 1906 and 1908. Such a massive investment of time and money would seem to be in stark contrast to the small quantity of ore that was actually extracted by the Greenburn and Tilberthwaite Syndicate, but the possibility cannot be dismissed out of hand, given the other major investments in preparatory work carried out in this period. However, even if the scenario is accepted, the two map depictions present a logical impossibility: that following the putative rebuild, the water level was raised so that a greater area was flooded on the eastern side, but without changing the extent at all on the west, despite the fact that the land on that side rises more gently. This may support the hypothesis that when the revision for the Second Edition map took place, the water level was low (the map appears to show that it was low at Levers Water, the reservoir that served the main Coniston Copper Mines). While it would have been easy to map the actual edge of the water on the east where the slope is steeper, it may have been safer on the west to map the edge of the boggy ground. Alternatively, given the other errors on the map, which seem to result from an attempt to minimise the amount of revision work, it may be that the edge of the 'Peat Moss' depicted on the First Edition was erroneously taken to correspond to the line of the dam. Although clearly schematic, the depiction on the large-scale plan thought to have been made before 1861 provides some support for this possibility, for it depicts a sharp bend mid-way between the northern and southern outflow channels (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5). This is much sharper than the gradual change of angle on the ground, but arguably corresponds more closely to the layout as it can be seen today than it does to the depiction on the Second Edition map, which shows no angle change at all. Neither theory adequately accounts for the lack of any depiction of the dam itself on the Second Edition map, whether the extant one or an earlier structure. The dam eventually burst following a storm in the winter of 1979-80 (Blundell 1994, 4). Although Eric Holland (1981, 102) records that a destructive deluge of water was released, the breach is located in a fairly low stretch of the dam, so the damage could have been far more serious.

The dam comprises two stretches of walling crossing the low ground to the north and south-west of a knoll of higher ground in the middle of the valley floor, forming a total span of *c*.220m. The reservoir, some 1.5 hectares (3.7 acres) in extent and up to *c*.5m deep when full, would have had a capacity large enough to supply the water wheels all year round. At its highest, mid-way along the south-western stretch, the dam stands nearly 6m high, with an estimated width of 10m at the base. At the point where the Greenburn Beck has burst through, where the dam is only 1.2m high, a cross-section through the earthwork has been exposed (Figure 25 a). This shows that the dam was built in a single episode: the turf was removed prior to the construction of a bank of peat sods, over which a layer of glacial clay was deposited, thicker on the upstream side, and this was then covered with a battered facing of flat boulders. Thin smears of sandy clay between the layers of peat and amongst the boulders indicate that all three elements of the structure were buillt up simultaneously in a single constructional episode. On top of the dam, additional stones were laid to form a

slightly raised footpath. All the construction materials were probably obtained from the area flooded by the reservoir. Spillways, stone-lined channels built to allow excess water to overflow without damaging the dam or the workings downstream, were sited at both ends of the dam. There were two sluice gates, of which the more northerly survives intact (in the foreground on Figure 25 b); the more southerly is indicated on the Second Edition 6-inch scale map, and its site can be identified as a pier-like projection on the upstream side of the dam. The northern sluice, which released water into a channel to return it to the Greenburn Beck and so down to Dam 3, was evidently regularly used, for the channel is deeply eroded. In contrast, the more southerly sluice cannot have been used regularly, for there is no erosion.

Dam 3 and Leat 3 (Figure 9; see also Figures 24 and 26)

NGR: NY 2887 0221; NMR number: NY 20 SE 32

Leat 3 essentially replaced Leat 2, supplying water to the pen-pond formed by Dam 4 and from there to Water Wheel 3. The large-scale schematic plan thought to have been made before 1861 appears to represent the leat and the pool formed by the dam, indicating that they were broadly contemporary with Greenburn Reservoir and were constructed during the period of the mine's most intensive use (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5). The Second Edition of the 6-inch scale map revised in 1889 indicates that the leat was intact at that date, implying that the dam was also intact, although it is not shown (Ordnance Survey 1891; see Figure 6). However, while the western half of the leat was depicted accurately, the physical evidence strongly suggests that the map is misleading in duplicating the depiction on the First Edition map in its portrayal of the eastern half (see below). A gap in the line of the leat as shown on the Third Edition map revised in 1912 corresponds to a low earthen bank surviving on the ground, which entirely blocks the watercourse (Ordnance Survey 1920; see Figure 7). A line depicted immediately downstream of this blocking might be taken to represent a continuation of the leat, but it actually corresponds to a narrow drainage channel, which can also be identified on the ground. In the light of the documented sequence of tenants, it can be inferred that the leat is most likely to have been made inoperable *c.*1906 and therefore that it was not used after *c.*1885. This is an important inference, for it follows that none of the main water wheels in use during the period of the mine's most intensive use can have remained in operation after the mine re-opened in 1906.

There is some evidence that there was an earlier version of the arrangement depicted on the large-scale schematic plan thought to have been made before 1861. What may be part of an artificial channel some 20m long, marked on Figure 26 as Leat 3a, lies within the area that would have been flooded by the construction of Dam 3. No trace of whatever dam may have been associated with the leat can be identified, possibly because it was formed by a simple wooden barrier pushed out into the stream to divert the flow whenever necessary. There are also signs that the main stretch of Leat 3 was reinforced at some point. If so, the underlying earthwork may also correspond to an earlier version of the watercourse.

Dam 3, sited on the Greenburn Beck at an altitude of 272m, was designed to divert water released from the Greenburn Reservoir down the stream into Leat 3. The central section of the crescent-shaped span, some 35m long overall, is formed by an arrangement of large rocks, the gaps between which would presumably originally have been partially plugged by smaller stones to form a massive weir. Some of the large rocks are boulders more or less in their natural positions, but two seem to have

been obtained from Quarry 4, immediately to the south-west. At each end, the dam is formed by a bank of earth and stone up to 0.8m high. There is a spillway channel near the northern end; the outflow from this was powerful enough to erode an inlet in the northern bank of the stream and a subsidiary channel in the southern bank. Track 7 skirts this erosion, indicating that it took place while the dam was still in regular use. The site of the sluice, near the southern end of the dam, has been severely damaged by erosion. From this point, Leat 3 ran straight to the south-east for 65m, crossing the course of the earlier Leat 2. The northernmost stretch of the channel is unusually broad (some 2m wide) and has a relatively large embankment on the eastern side; the

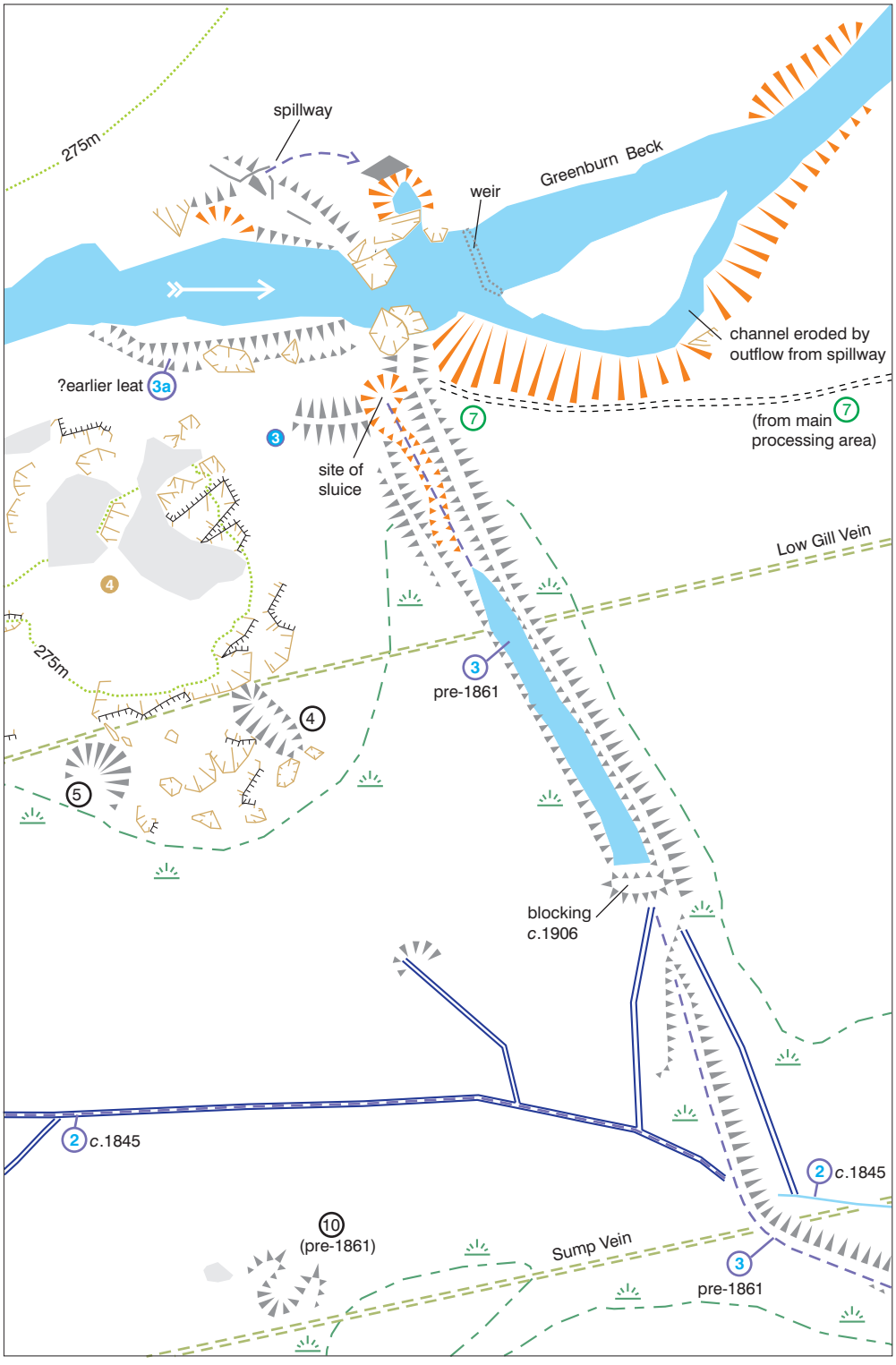


Figure 26. Plan of Dam 3 and the stretch of Leat 3 deliberately blocked c.1906

breadth of the channel and the strength of the earthworks suggest that the volume of water carried by the leat was much greater than that carried by Leat 2 and therefore potentially more powerful. However, the earthworks diminish abruptly, suggesting that the channel was continued by a timber launder. At a later date, the leat was deliberately blocked at the point of change by the construction of a low earthen bank, flooding much of the channel to the north-west. As mentioned above, the blocking is depicted as a gap in the line shown on the Third Edition map surveyed in 1912 (Ordnance Survey 1920; see Figure 7). Two much narrower channels were dug to drain the area to the south; all the drainage channels are described further below. One of these, which discharges into the former channel of Leat 2 and so back to the line of Leat 3, is also shown on the Third Edition map. As described above, in the light of the documented sequence of tenants it can be inferred that the blocking was done *c.*1906. Having crossed the course of Leat 2, Leat 3 turns eastwards, extending for a further 75m to reach the pen-pond formed by Dam 4. This stretch approximately follows the contours, although for a distance of 8m it is formed by a narrow channel blasted through a rock outcrop. From Dam 4, which would have served to calm the strong current, the flow would have been diverted whenever necessary into a timber launder that supplied Water Wheel 3. Little physical evidence for the launder survives, but Water Wheel 3 is clearly aligned on the sluice in Dam 4. A small pile of stones and a more carefully constructed platform *c.*1m square, lying on either side of the supposed line of the launder, probably served as foundations for the legs of a timber A-frame supporting the launder. Three pairs of legs are shown on the section drawing thought to have been made before 1861 (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5).

The physical remains suggest that Dam 3, Leat 3, Dam 4 and Leat 4 were constructed in a single episode, probably not long after the construction of Greenburn Reservoir. This seems to be the arrangement depicted on the large-scale schematic plan thought to have been made before 1861 (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5). Yet for the eastern end of Leat 3, the Second Edition map revised in 1889 precisely replicates the depiction of the eastern end of Leat 2 on the First Edition map, showing the channel diverging along the line of Leat 2 at the point where the two leats intersect. Although the Second Edition 6-inch scale map is probably reliable in terms of its record of the state of preservation of the later leat, the depiction of the course of the eastern end of the leat is apparently misleading (Ordnance Survey 1891; see Figure 6 and 8). Given that the complex remained unoccupied from *c.*1885 to 1906 and the Third Edition map indicates that Leat 3 was deliberately made inoperable *c.*1906 it is impossible to reconcile the depiction on the Second Edition map with the physical evidence surviving on the ground.

Dam 4 and Leat 4 (Figure 24)

NGR: NY 2896 0212; NMR number: NY 20 SE 30

Dam 4, at an altitude of 268m, essentially formed a small ‘pen-pond’ in which water from Leat 3 could be collected and calmed prior to its diversion, whenever necessary, into the timber launder that supplied Water Wheel 3 (described above as part of Leat 3). When the wheel was not in use, the water could be allowed to continue to run straight ahead along Leat 4, and so to return to the tributary stream on the southern side of the valley. Leat 4 thus served primarily as a by-pass channel, but is termed a leat in this report for convenience. Both the dam and the leat must be contemporary in origin with Dam 3 and Leat 3; all these features appear to correspond to the arrangement depicted on the large-scale schematic plan thought to have been made

Figure 27. View of Dam 4 from the north-west

before 1861 (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5). As noted above, Leat 4 cuts through the course of Leat 1, which may therefore have been in use soon after *c*.1845. As described above, the Second and Third Editions of the 6-inch scale map indicate that Leat 3 was still serviceable in 1889 but had been deliberately blocked by 1912 (Ordnance Survey 1891; 1920). In the light of the documented sequence of tenants, it was almost certainly blocked *c*.1906, and therefore cannot have been used after *c*.1885. Dam 4 and Leat 4 would also have become redundant as a result, although the leat continued to carry the flow from the drainage network to the west.

The dam is formed by a bank built of earth and stone, faced on the upstream side by a low stone wall (Figure 27). The area of the pond, which was increased slightly by digging and quarrying above the dam, would have been roughly 10m^2. The sluice that would have controlled the flow of water into the wooden launder has been severely eroded, apparently by water action. However, the stonework of the sluice that allowed the flow to continue into Leat 4 is better preserved (marked by the upright ranging rod in Figure 27). The channel of Leat 4 itself is well preserved as a shallow channel with an embankment along its northern side, extending for some 15m to the east of Dam 4 to allow the water to rejoin the tributary stream. Some 10m east of the confluence, the stream has been diverted from its natural course and passes into a conduit under the Gossan Vein spoil tip and then under the Sump Vein south spoil tip to emerge adjacent to Building 12.

Dam 5 and Leat 5 (Figure 41 a)

NGR: NY 2904 0225; NMR number: NY 20 SE 33

There is no documentary evidence for Dam 5 or Leat 5, but their likely date and function can be inferred from the physical remains. No trace of the dam actually survives, almost certainly because it was formed simply by a wooden board projecting into the Greenburn Beck, at an altitude of 250m. Leat 5 runs

approximately southwards from the site of the dam, running in an arc around the contours for a total of 36m. At its southern end, the earthwork becomes indistinct, probably because a wooden duct was used for this section. However, the minimal earthwork traces suggest that the channel turned to enter the smithy, described in Section 5.7. This suggests that the dam and leat were constructed at some point between 1847 and 1861 in order to supply water to the smithy.

Leat 6 (Figure 32)

NGR: NY 2898 0218

What appears to be part of a leat can be traced running for some 22m alongside the northern side of the cutting of the Sump Vein Level. The point of origin of the leat is uncertain, but may have been the somewhere close to Sump Vein Shaft, at an altitude of 268m. The destination of the leat is equally unclear, but may have been the level platform immediately north of Engine Shaft. The relationship to the Sump Vein Level and Sump Vein Shaft suggest that the leat may be of relatively early date, perhaps *c.*1845 or even earlier. The channel does not follow a constant gradient, suggesting that it is likely to have supplied water for a washing process, rather than to a water wheel.

Leat 7 (Figure 32)

NGR: NY 2901 0217

Leat 7, at an altitude of 255m, effectively formed both the tail-race of Water Wheel 3 and the head-race of Water Wheel 4. It can therefore be dated to the most intensive period of the mine's use, before 1861. Emanating from a culvert overlain by the upper levels of the Sump Vein south spoil tip, the leat ran for 20m parallel to the northern edge of Spalling Floor 2, directly to the edge of the wheel pit of Water Wheel 4. It is uncertain whether it was covered by the roof of Building 8. The channel can be traced as a slight earthwork, in places enlarged by erosion.

Leat 8 (Figure 32)

NGR: NY 2903 0218

Leat 8 seems to have carried water from the tail-race of Water Wheel 4 south-eastwards for 10m to the launder of Water Wheel 5 and to have been in use during the most intensive period of the mine's use, before 1861. Key evidence for its existence is the arrangement depicted schematically on the large-scale plan thought to have been made before 1861 (Cumbria CRO: D/Pen/46/file 102-106/document not numbered). The only physical traces of the leat are two fragmentary sections of rubble walling on an alignment between the two wheel pits. Water Wheel 5 is depicted as an overshot wheel as shown on the section drawing accompanying the large-scale plan. The difference in height between the projected base of Water Wheel 4 and the projected top of Water Wheel 5 indicates that the water must have been drawn off Water Wheel 4 at a height just below the level of the axle, rather than from the base of the wheel-pit.

Leat 9 (Figure 32)

NGR: NY 2905 0219

Leat 9 seems to have carried water from the tail-race of Water Wheel 5 north-eastwards for at least 20m and dates to the period of the mine's most intensive use. The large-scale schematic plan thought to have been made before 1861 suggests that the leat extended for *c*.50m to supply Water Wheel 6 (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5). Given the reliability of the plan on other issues, this can probably be accepted as an accurate portrayal of the arrangement when the plan was made. However, Leat 9 cannot be traced beyond Buildings 14 and 15, both of which were involved in the refining and washing of ore, so it is possible that the arrangement was modified at some stage. The leat was joined immediately east of Water Wheel 5 by the culvert that carried the small tributary stream on the southern side of the valley, as shown on the large-scale schematic plan. The first 6m of the channel can be traced fairly easily as a disturbed line of flat slabs which may have supported the channel. Beyond this, the line of slabs is discontinuous. The section drawing accompanying the large-scale plan is apparently more schematic in one respect: it shows the final section of the leat rising vertically to reach the top of Water Wheel 6. Due to the careful use of the natural slope, the leat in fact almost certainly maintained a constant gradient from the base of the wheel-pit of Water Wheel 5 to the top of Water Wheel 6.

Leat 10 (Figure 32)

NGR: NY 2906 0221

Leat 10, whose course is somewhat speculative, seems to have acted as a by-pass channel when water leaving Water Wheel 4 was not being directed into Leat 8 to supply Water Wheels 5 and 6. It is depicted as such on the large-scale schematic plan thought to have been made before 1861 (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5). The supposed course of the leat is inferred from discontinuous vestigial fragments of stone-built revetments and alignments of facing stones, extending in total eastwards for *c*.60m from the wheel-pit of Water Wheel 4. Some 5m north-west of Building 10, a well-preserved section of a wooden (pine) duct with a box-profile 8cms wide, lies partially buried on same alignment as the leat itself. This suggests that although the leat acted primarily as a by-pass channel, water may have been drawn off it at one or more points to serve other purposes.

Water wheels

Water Wheel 1 (Figure 24)

NGR: NY 2898 0215; NMR number: NY 20 SE 34

There is circumstantial evidence that a dilapidated drystone structure some 8m south-west of Water Wheel 3 at an altitude of 263m may represent the poorly-preserved remains of a wheel-pit for a small water wheel of relatively early date. All that can be identified with confidence is an irregular depression adjacent to a crudely constructed L-shaped wall surviving to a height of 0.9m, which may represent two sides of an enclosed wheel-pit for an overshot wheel, or an open-sided pit. It is difficult to be sure of the alignment of the structure, but it is roughly from west-south-west to east-north-east, lying across the contours. More convincing than the pit itself is a spoil heap adjacent to the northern side of the structure, which may represent waste material from the hand-dressing of over-sized lumps of ore immediately prior to crushing. The position of this mound in relation to Spalling Floor 1 (described further in Section 5.6), which lies some 25m upslope to the west, would be consistent with a crushing mill lying nearby. Given this evidence, it is possible that the water wheel was associated with the earliest recognisable processing sequence, possibly in the late 17th century.

Water Wheel 2 (Figure 8)

NGR: NY 2900 0216; NMR number: NY 20 SE 35

The depiction of Leat 2 on the First Edition 6-inch scale map surveyed in 1847-8 implies that there was a water wheel in existence by that date, although none is explicitly annotated on the map, as were several at the main Coniston Copper Mines (Ordnance Survey 1850). The depiction of the final stretch of Leat 2, which approaches Building 3 at right angles, is suggestive of a head-race, so Building 3 may have been an engine house lying immediately adjacent to the wheel-pit (see Section 5.7). No relevant physical remains can be identified on the surface due to later activity around Engine Shaft, but the map depiction is sufficiently accurate to estimate that the wheel-pit probably would have lain close to the extant Building 7.

Water Wheel 3 (Figure 28 a)

NGR: NY 2899 0216; NMR number: NY 20 SE 36

Water Wheel 3 was the largest wheel at Greenburn Mine and its site has been identified by previous studies of the remains. During the period of the mine's most intensive use, the wheel was vital to the operation of Engine Shaft, for which it powered the pumping and winding gear. It was first depicted on the large-scale schematic plan thought to have been made before 1861, adjoined on the north-west by a building annotated 'Engine House' (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5). Greenburn Reservoir, Dam 3 and Leat 3 are also depicted as integral to the arrangement, so all these features were very probably constructed in broadly the same episode, as part of the major redevelopment of the complex that heralded the most successful period of production. The section/profile drawing accompanying the plan is equally informative, for it gives a good idea of how the mechanisms of the pumping and winding gear may have been

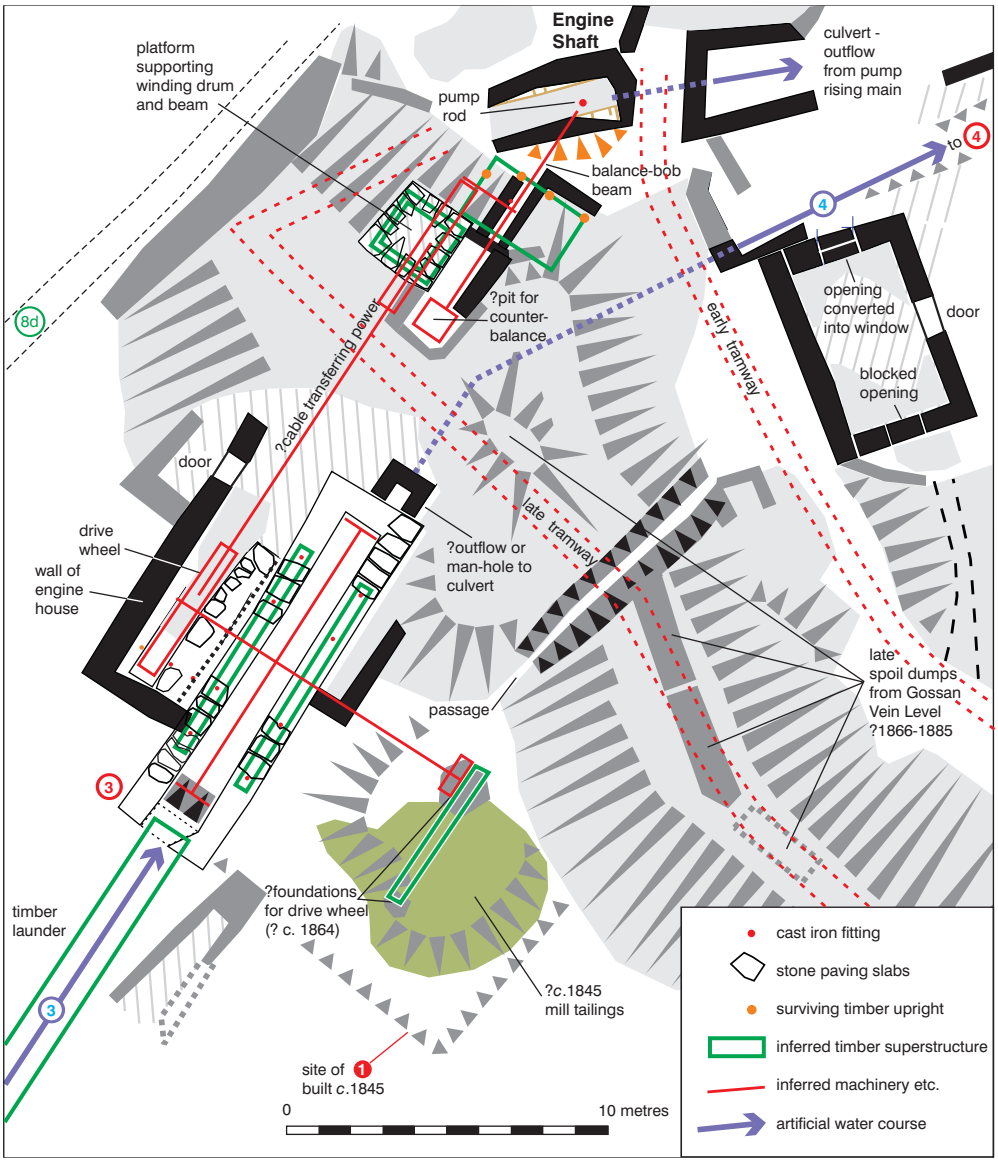


Figure 28 a. Interpretative plan of Water Wheel 3 and associated structures (enlarged from 1:500 scale)

Figure 28 b. View of the wheel pit of Water Wheel 3 from the south-west

powered by the wheel. The Second Edition of the 6-inch scale map revised in 1889 did not reflect any of the changes shown on the large-scale schematic plan and made no amendment to the depiction on the First Edition map, so is of little help (Ordnance Survey 1891). However, the depiction of Leat 3, though apparently inaccurate, suggests that this remained intact at that date, which implies that the wheel itself may have been operable. The Third Edition map revised in 1912 shows the wheel-pit and sheds important light on the date at which the wheel went out of use (Ordnance Survey 1920; see Figure 7). As described above, the map shows that Leat 3, which had supplied Water Wheel 3, had been deliberately blocked by 1912. In the light of the documented sequence of tenants, it can be inferred that the leat is most likely to have been made inoperable *c.*1906 and was therefore not used after *c.*1885. This is an important inference, for it follows that none of the main water wheels in use during the period of the mine's most intensive use was operable after *c.*1885 and that Engine Shaft must also have been effectively abandoned by that date.

The wheel-pit was sited at an altitude of 262m, oriented from south-west to north-east abutting the south-eastern side of a smaller wheel-pit enclosed by the engine house. The main wheel-pit is well-constructed with broad drystone walls surfaced with large, dressed paving slabs and remains largely intact; it is 10.8m long by 1.2m wide and is clear to a depth of 3.8m, with only a small amount of tumbled rubble concealing its base. The western end of the internal wall of the pit is battered so as to follow the curve of the wheel more closely. A series of cast iron bolts, of which a few are now missing, were set into the paving on either side of the wheel-pit. These would have secured large timber beams that carried the bearings of the wheel and their positions indicate that the wheel itself may have been 9.8m (32 feet) in diameter and 0.9m (3 feet) in width. The wheel itself was probably wrought iron and was supplied via an overshot arrangement by Leat 3, which was carried from a sluice in Dam 4 along a timber launder. If the arrangement was similar to that in operation at Water Wheel 4, water leaving the wheel may have been drawn off into Leat 7 at a height not much below the level of the axle of the wheel. This may account for the small vertical shaft adjoining the north-eastern end of the wheel-pit. Alternatively, the shaft may have functioned as a 'man-hole' allowing access to a culvert running off from the base of the wheel pit.

The plan thought to have been made before 1861 indicates that Water Wheel 3 was constructed wth an 'Engine House' alongside it on the north, and this survives in a dilapidated condition. Within the building is a smaller wheel-pit, on the same alignment as Water Wheel 3 and sited so that the position of the axles of the two wheels would have matched precisely. This probably housed a drive wheel powered by Water Wheel 3, but there is slight evidence that it may have originated as a wheel-pit for an earlier water wheel (not numbered). It is also of drystone construction and stands to a height of 1.2m above ground level; the engine house was built on top of this walling, apparently in a separate constructional episode. The pit itself is largely filled by rubble tumbled from the walls of the engine house. It is 0.8m wide and its length can be estimated at 5.6m by the position of a series of bolts, and holes where the bolts themselves no longer survive, in the stone slabs on either side of the pit. As with Water Wheel 3, the bolts would have secured large timber beams to which the bearings of the drive wheel would have been attached. The bolts are of a different type from those of Water Wheel 3 and are more corroded. In addition, most of the stone slabs around the wheel-pit appear to be slightly rounded as though obtained from the surface, while most of those around the pit of Water Wheel 3 are dressed blocks with no weathered surfaces. These slight constructional differences, together with the stratigraphic relationship between pit and the walls of the engine house, hint that the structure may have served as a water-wheel pit pre-dating the

introduction of Water Wheel 3. If so, given that the pit lies on the same alignment as Water Wheel 3, it is possible that it was supplied in a similar way via Leat 3. Assuming that the wheel was slightly smaller than the pit, it could have been approximately 5.4m (18 feet) in diameter and 0.6m (2 feet) wide. This putative earlier wheel would presumably have served essentially the same functions as Water Wheel 3, that is, it may have powered winding gear or pumping machinery in Engine Shaft.

The dilapidated walls of the engine house indicate that the building was open on the sides facing Water Wheel 3 and Engine Shaft, so that the machinery was unimpeded and accessible, with a doorway towards the eastern end of the northern side. The building was probably lightly roofed with corrugated iron sheets. The drive wheel, which may have been attached directly to the axle of Water Wheel 3, was presumably of similar diameter to the putative earlier water wheel, but may have been smaller. The profile/section drawing thought to have been made before 1861 suggests that power was transferred from this, presumably by cables or gears, to another wheel much closer to the mouth of Engine Shaft. The depiction of this wheel on the profile drawing suggests that it was a cable drum for winding the bucket, or kibble, in Engine Shaft. The same wheel, or at least the same transfer of power from the drive wheel, may also have been responsible for producing the 'piston' motion which raised and lowered the arm of the pivoted beam attached to the pump rods. As described in Section 5.1, it is most likely that the wheel or the pivot of the beam (or both) was supported on a platform surfaced with large paving slabs directly overlooking the mouth of Engine Shaft.

Although the provision of power to the winding and pumping gear in Engine Shaft was clearly the primary function of Water Wheel 3, it may also have fed power to the south of the wheel-pit. The evidence for this arrangement is not clear-cut, and the purpose of the power is uncertain. A mound of mill tailings on the site of Building 1 (described below) is overlain by two small piles of larger, less weathered stones, which may have served as footings for a timber structure on the same alignment as Water Wheel 3. The larger of the two piles lies precisely on the projected line of the axle of Water Wheel 3.

Water Wheel 4 (Figure 32)

NGR: NY 2902 0218; NMR number: NY 20 SE 37

Water Wheel 4 was the second largest wheel at Greenburn Mine and its site has therefore been identified by previous studies of the remains. During the period of the mine's most intensive use, the wheel powered the main crushing mill housed in Building 9 to the south and the battery of stamps housed in Building 10 to the north (see Section 5.6). The wheel was first depicted on the large-scale schematic plan thought to have been made before 1861, adjoined on either side by the two processing buildings (Cumbria CRO: D/Pen/46/file 90-99/document not numbered; see Figure 5). The section/profile drawing accompanying the plan casts further light on how the arrangement worked. The Second Edition of the 6-inch scale map revised in 1889 made no amendment to the depiction on the First Edition map and so adds no relevant information (Ordnance Survey 1891). The Third Edition map revised in 1912 appears to show the wheel-pit and sheds important light on the date at which the wheel went out of use (Ordnance Survey 1920; see Figure 7). As described above, the map shows that Leat 3, which supplied Water Wheel 3, had been deliberately blocked by 1912. In the light of the documented sequence of tenants, it can be inferred that the leat is

Figure 29. View of the wheel pit of Water Wheel 4 from the east

most likely to have been made inoperable *c*.1906 and was therefore not used after *c*.1885. This is an important inference, for it follows that none of the main water wheels in use during the period of the mine's most intensive use was operable after *c*.1885, and that the crushing mill and other processing equipment must also have been redundant by that date.

The wheel-pit is located at the base of the eastern side of the platform that supports Spalling Floor 2, at an altitude of 250m, and was built as part of the same constructional episode. It is oriented from west-south-west to east-north-east, that is, at an angle to Water Wheel 3. The pit, whose thick drystone walls are largely intact, is 7.8m long by 1.3m wide and remains clear to a depth of 3.1m, with only a small amount of tumbled stone concealing its base (Figure 29). The positions of a series of cast iron bolts, which probably secured large timber beams that carried the bearings of the wheel, indicate that the wheel itself may have been 7.3m (24 feet) in diameter and 1.2m (4 feet) in width. The wheel itself was probably wrought iron and was clearly supplied by Leat 7 in an overshot arrangement. As mentioned above, water must have been drawn off into Leat 8 at a height not much below the level of the axle of the wheel in order to supply Water Wheel 5, which was also an overshot wheel. Alternatively, when Water Wheel 5 was not in use, it may have been possible to direct water along Leat 10, which effectively served as a by-pass channel.

Water Wheel 5 (Figure 32)

NGR: NY 2904 0218; NMR number: NY 20 SE 38

Water Wheel 5 was first depicted on the large-scale schematic plan thought to have been made before 1861, sited next to Building 12 and evidently powering the machinery within it, which is described as 'Jigging etc.' (Cumbria CRO: D/Pen/46/file 90-99/document not numbered; see Figure 5). The section/profile drawing accompanying the plan casts further light on how the arrangement worked. The wheel must have gone out of use at the same time as the larger Water Wheels 3 and 4, probably *c*.1885.

Figure 30. View of the wheel-pit of Water Wheel 5 from the east

The wheel-pit is small and poorly preserved and has therefore not been recognised by previous studies of the complex. It is sited at an altitude of 246m, allowing water drawn off Water Wheel 4 to be supplied almost immediately to Water Wheel 5 via Leat 8 in an overshot arrangement. The wheel-pit was probably not fully enclosed, but comprised an L-shaped wall effectively forming half of the southern side and the western end (Figure 30). The northern side can be identified as an alignment of flat slabs defining the edge of the base. The western end, like the wheel-pits of Water Wheels 3 and 6, is battered to follow the curve of the wheel more closely. On the wall to the south, a pair of large bolts set into the paving pin-point the position of the timber block holding the axle, from which the size of the wheel can be estimated accurately at 2.4m (8 feet) in diameter and 0.9m (3 feet) wide. It may have been constructed entirely or partly in timber, rather than wrought iron.

Water Wheel 6 (Figure 32)

NGR: NY 2908 0221; NMR number: NY 20 SE 39

Water Wheel 6 was first depicted on the large-scale schematic plan thought to have been made before 1861, sited next to Building 15 and evidently powering the machinery within it, which is annotated 'Round Buddle.' (Cumbria CRO: D/Pen/46/file 102-106/ document not numbered; see Figure 5). The section/profile drawing accompanying the plan casts further light on how the arrangement worked. The wheel must have gone out of use at the same time as the larger Water Wheels 3 and 4, probably *c*.1885.

The wheel-pit is small and poorly preserved and has therefore not been recognised by previous studies of the complex. It is sited at an altitude of 241m, allowing water drawn off Water Wheel 5 to be supplied to Water Wheel 6 via Leat 9 in an overshot arrangement. The wheel-pit was not fully enclosed, but comprised a low, roughly built wall effectively forming the southern side and two ends. The western end, like the wheel-pits of Water Wheels 3 and 5, is battered to follow the curve of the wheel more closely. Set into the southern wall are the rotting stumps of a pair of large posts, which seem to have been angled to form an A-frame standing above the height of the

Figure 31. View of the wheel-pit of Water Wheel 6 from the north-east

low wall, whose projected mid-point is marked by the upright ranging rod in Figure 31. At least one of the two other timber posts in the immediate vicinity probably supported the other side of the frame. The axle of the wheel was probably supported just below the apex of this frame, from which the size of the wheel can be estimated with some confidence as being 2.4m (8 feet) in diameter and 0.9m (3 feet) wide. It may have been constructed entirely or partly in timber, rather than wrought iron.

Drainage channels (Figure 10)

At least six narrow channels, each of spade width, were apparently dug to drain the extensive boggy area west of the main processing area. The stretch of the former Leat 2 west of Leat 3 was re-cut to form the main artery of the drainage network and this fed via a newly-dug drainage channel into the channel of Leat 3, directing the water via Leat 4 back to the tributary stream on the southern side of the valley. Remarkably, the construction of these minor channels can be dated fairly precisely. The physical remains show that the work was carried out in a single phase at some point after Leat 3 had fallen into disuse, for one of the drains across the line of its channel, close to where a low earthen bank, presumably constructed at the same time, blocks the course of the earlier watercourse (see Figure 26). The drains must therefore have been dug after 1889, when Leat 3 was mapped for the Second Edition 6-inch scale map (Ordnance Survey 1891). In addition, they must have been dug before the Langdale Silver, Lead and Copper Co took on the lease late in 1912, for the site as a whole is marked as 'disused' on the map surveyed in that year, but the bank blocking Leat 3 was depicted as a gap in the line that depicts the channel and the adjacent drainage channel is also shown (Ordnance Survey 1920). In effect, this almost certainly means that the drains were dug *c*.1906 when the mine re-opened under the management of the Greenburn and Tilberthwaite Syndicate. Two of the channels appear to have been constructed in order to drain the immediate vicinity of Low Gill Vein Shaft, and it seems very plausible that the other drains were intended to improve access between the potential extraction site and the main processing area, some 200m to the east. This probably indicates that the trials were begun at about the same date that the drains were dug.

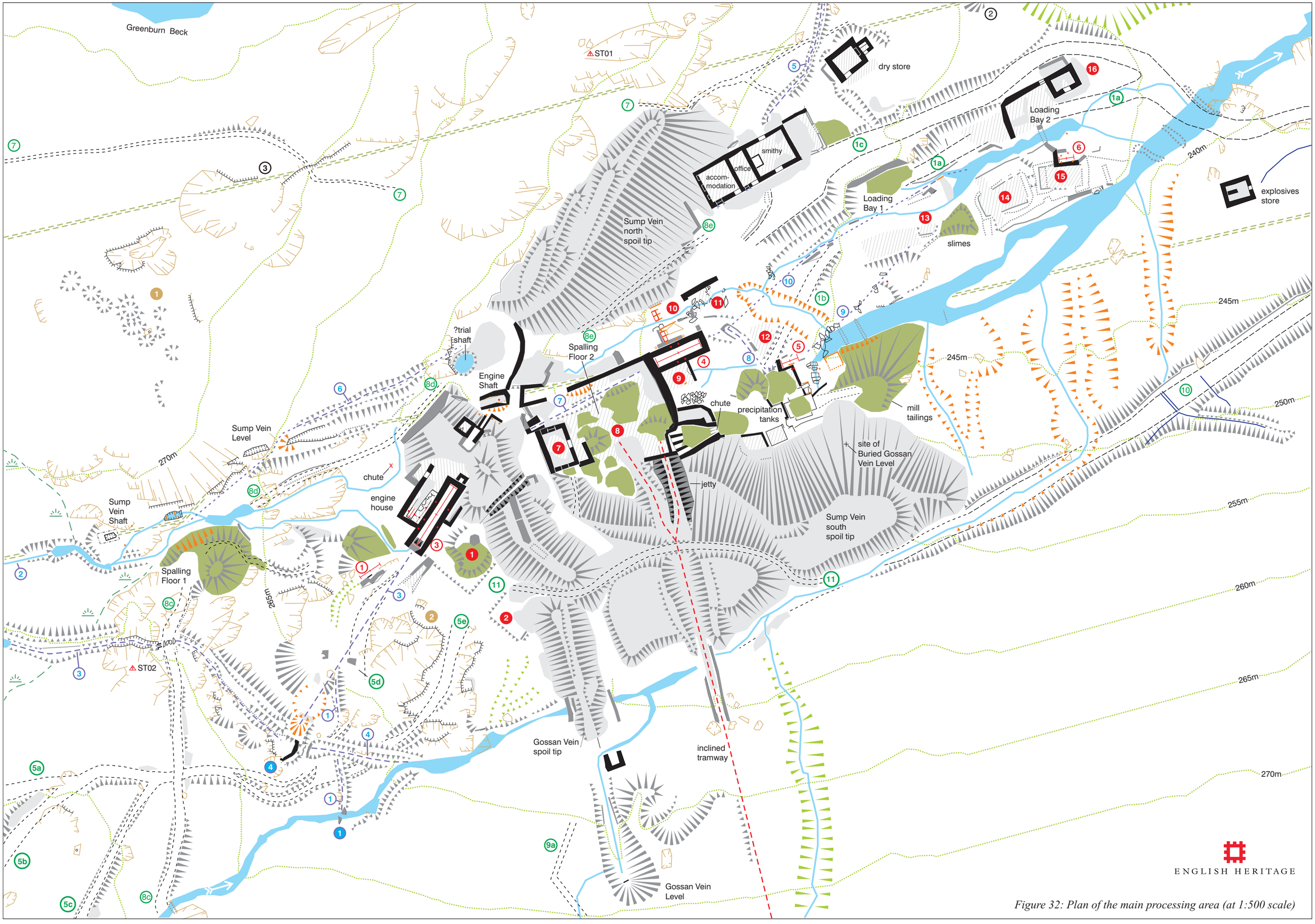


Figure 32: Plan of the main processing area (at 1:500 scale)

5.6 PROCESSING THE ORE

Spalling Floor 1 (Figures 14 a and 32)

NGR: NY 2895 0215; NMR number: NY 20 SE 40

A level area surmounting a mound of small fragments of waste rock is interpreted as a 'spalling floor'. 'Spalling' is the process of initial dressing by hand of lumps of ore-bearing rock, prior to further refining. The mound lies some 50m to the south-west of the main processing area, and some 10m higher than the mouth of Engine Shaft, at an altitude of 268m; its position indicates that it can never have been involved in the processing of ore brought up via Engine Shaft. However, it lies at the same altitude as Sump Vein Shaft, which lies only *c.*15m to the west. The First Edition 6-inch scale map indicates that by 1848 at the latest, Engine Shaft served as the main working shaft by which ore was extracted (Ordnance Survey 1850). Although the existence of the possible hand winch near Sump Vein Shaft hints that the shaft may have been used occasionally in the 19th century, it seems likely that Spalling Floor marked the first stage in the refining process at an earlier date, possibly in the later 17th century.

The floor itself is a level area roughly 4m square, defined by a rock outcrop upslope to the west, and the spoil heap resulting from the hand-dressing downslope to the east. In total, the spoil covers an irregular area of around 100m^2 of which part is grassed over, but the mound of exposed fragments is the most prominent part, standing up to 1.4m high. From the floor, a narrow, sinuous path suggestive of a wheelbarrow run descends the eastern side of the spoil heap and continues down a deliberately built ramp for a few metres more. At that point, it reaches a low terraced 'step' overlooking a larger platform. This larger platform may have been the site of a set of 'grates', a fixed mesh which allowed the dressed ore to be graded by size. Immediately downslope from the platform, a second, smaller mound of relatively small fragments of rock may represent waste created by dressing lumps of ore which would not pass through the grates. This lends support to the interpretation of the fragmentary remains of Water Wheel 1, which lies immediately to the south of this second mound of waste.

Figure 33. View of Spalling Floor 1 from the south

Building 1 (Figure 32)

NGR NY 2899 0215

Buildings 1 and 2 are not depicted on the First Edition 6-inch scale map surveyed in 1847-8, nor on the large-scale schematic plan thought to have been made before 1861 (Ordnance Survey 1850; see Figure 3; Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figure 5). The sites of both buildings are partially buried beneath the Gossan Vein Spoil tip, so they clearly cannot have been built after 1865, and the relationship of Building 1 to Water Wheel 3, while not absolutely clear-cut, suggests that the site of building was truncated by the construction of the wheel-pit. Certainly, a mound of mill tailings within the building is overlain by two small piles of larger, less weathered stones, which appear to have served as footings for a structure linked to Water Wheel 3 (discussed in Section 5.5). This stratigraphic evidence, together with the condition of the physical remains, suggests that the buildings may have been constructed at a relatively early date, perhaps in the late 17th century.

The plan of Building 1 can be inferred from two shallow gullies, probably representing wall lines, which correspond to the south-western side and south-eastern end of a rectangular structure approximately 10m long by at least 7m wide, with its long axis oriented roughly from north-west to south-east. It was probably constructed primarily in timber, since there is no evidence for stone walling. The area within the building is almost entirely taken up by a mound up to 0.4m high of small fragments of stone, interpreted as tailings from a crushing mill (behind the rear ranging rod in Figure 34). The weathered condition of the fragments, together with the fact that the mound is in part grassed over, contrasts with the fresh appearance of the Gossan Vein spoil heap, which accumulated in 1865-6. At the north-west corner of the building, a stone-built 'pier' may have supported heavy machinery or allowed material to be delivered into the building at a height 0.8m above floor level. Its rough quality of construction, as well as its poorly-preserved and weathered condition, contrast with the adjacent wheel-pit of Water Wheel 3.

Figure 34. View of the sites of Buildings 1 and 2 from the south-east

The presence of mill tailings within the building strongly suggests that it housed a crushing mill, or lay close to one. The stratigraphic relationship with the wheel-pit of Water Wheel 3 is not clear-cut, but the wheel-pit appears to be later and the two structures lie on slightly different alignments from each other. The alignment of Buildings 1 and 2 seems to correspond fairly closely to that of the fragmentary remains of Water Wheel 1, which could equally well have powered a crushing mill sited immediately adjacent to Building 1.

Building 2 (Figure 32)

NGR NY 2900 0214

The documentary and stratigraphic evidence that Buildings 1 and 2 were constructed at a relatively early date, perhaps in the late 17th century, has been presented above. The plan of Building 2 can be inferred from two shallow gullies, probably representing wall lines, which correspond to the south-western side and north-western end of a rectangular structure some 7m square, oriented roughly from north-west to south-east on the same alignment as Building 1. The south-eastern side is marked by a narrow bank of minimal height (marked by the front ranging rod in Figure 34), which may indicate the existence of a low wall surviving below the ground surface. However, where the earthwork has been cut into by an erosion channel, the bank appears to lack formal structure, suggesting that is more likely to represent the accumulation of waste material against the line of the walling. It was probably constructed in timber, since there is no strong evidence for stone walling.

The function of the building is uncertain, but it may have housed equipment for washing or refining the ore crushed in Building 1. Water may have been supplied from the small tributary stream to the south, which in the subsequent phase of activity was diverted into a culvert running beneath the Sump Vein south spoil tip. The former channel, which can be traced as an earthwork, passes close to the building.

Buildings 3, 4, 5 and 6 (see Figures 3 and 8)

The First Edition 6-inch scale map surveyed in 1847-8 depicts five buildings that can be presumed to relate to the processing of the ore at that date (Ordnance Survey 1850). Where verifiable, features depicted on the First Edition are generally accurate to within about 7m of their actual plan position on the ground, while the nearby dry store and explosives store are in almost precisely the correct positions, though their orientations are slightly inaccurate. This allows the positions of the other mapped buildings to be plotted with a considerable degree of confidence. One corresponds closely to a stone-built structure which apparently continued in use into the later 19th century and still survives in dilapidated condition (described below as Building 11). Two of the other four buildings would have necessarily been demolished to make way for the various structures which are depicted on the large-scale scematic plan thought to have been made before 1861 (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figure 5). Not surprisingly, nothing of these can now be identified with confidence on the surface, nor is there any trace of the other two buildings which would not necessarily have been demolished, though it is possible that remains survive in some form below ground. Despite the strong evidence that the buildings did not survive the wholescale modification of the complex at some point before 1861, the Second Edition revised in 1889 exactly replicates the depiction on the First Edition map (Ordnance Survey 1891).

Building 3 lay at the terminus of Leat 2, oriented at right angles to the line of the final stretch of the watercourse as depicted on the map. Therefore, the building may well have been an engine house associated with Water Wheel 2, whose existence is implied by the existence of the leat. The building appears to have been sited in the area immediately west of the extant Building 7 and it is not impossible that the earliest surviving element of Building 7 - its western wall - was part of the earlier building.

Building 4 was located immediately east of Engine Shaft, in approximately the same position as the extant conduit which carried water from the pump rising main. The function of the building is uncertain, but it appears to have lain on a different alignment from Building 3, which suggests that power would not have been transferred into it from Water Wheel 2.

Assuming that the central one of the other three structures depicted on the First Edition map corresponds to the extant Building 11, Buildings 5 and 6 evidently stood respectively immediately to its north and south. The orientation of the three buildings as shown on the map is slightly different from that of Building 11, but the discrepancy is not much greater than that in the orientations of the extant dry store and explosive store. The function of Buildings 5 and 6 is unclear, but the fact that they are depicted on the same alignment as Building 11 hints that whatever processing machinery they held may have powered from the same source.

Building 7 (see Figure 32)

NGR NY 2900 0217

Building 7 is not depicted on the First Edition 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850), but its position apparently corresponds to the building called the 'Grates Shade' on the large-scale schematic plan thought to have been made before 1861 (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figures 5 and 35). 'Grates' were a form of crude sieve which served to sort lumps of ore into different sizes, so that those that were too large to be fed into the crusher could be separated out and taken to the spalling floor to be broken up by hand (Shaw 1970, 124). The word 'shade' indicates that the building was probably a lightweight timber shed with a roof designed to give some shelter to the workers. Analysis of the physical remains suggests that the building went through three or four phases of modification, but it is difficult to infer the dates at which these changes took place.

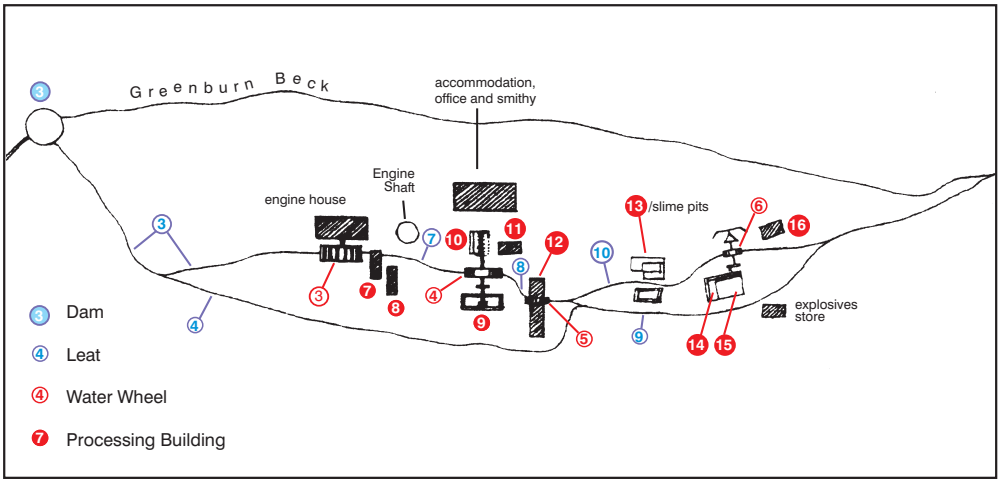


Figure 35. Extract from the large-scale schematic plan of New Coniston Mine, possibly made before 1861 (Cumbria CRO), annotated with references to buildings recorded by the English Heritage survey

In the first phase, a carefully constructed drystone wall 1.8m high was built, retaining the waste rock dumped onto the Sump Vein south spoil tip in the second episode of its use. This relationship indicates that the wall was in existence soon after the start of the period of the mine's most intensive use; it may have been part of Building 3 (see above). Ore-bearing rock (as well as spoil) would have been transported from Engine Shaft in hand-pushed trolleys along the tramway immediately to the west of Building 7. The wall was probably the point at which the ore was tipped onto the grates for initial sorting. The wall may also have supported one side of a structure presumably built primarily in timber, which was open on the other three sides. If so, the building may have been precisely the sort of lightly-built shelter that might have been termed a 'shade'. In other words, it was perhaps this initial phase of the building that was depicted on the large-scale schematic plan thought to have been made before 1861 (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figures 5 and 35).

In the second phase, the open sides of the structure were walled in to form a rectangular building 5.5m long by 3.4m wide internally, oriented roughly north to south at right angles to Water Wheel 4. The function of the building probably changed at this point. Broad openings were located mid-way along each of the newly-built walls, but it seems likely that only the opening in the eastern side was actually a doorway, while the other two may have been connected with machinery, or with the movement of ore. This modification may have been carried out after 1868, the year in which the large-scale schematic plan thought to have been made before 1861 was eventually circulated (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figure 5).

In the third phase, the southern doorway was blocked completely and the northern one was blocked partially to form a window. If the theory is correct that these broad openings had formerly related to machinery rather than access, the blocking of the openings must indicate either a change in the type of machinery or a complete change of use. Given that water power seems not to have been used after *c.*1885, the re-opening of the mine in 1906 is perhaps the most plausible context for this, or the previous episode, of remodelling. It may have been in the same phase, or later, that a small drystone-built structure was added to the southern end of the eastern side. This was 1.5m wide and 2.7m long internally, with its open northern end adjacent to the doorway into the main building; its form is suggestive of a lean-to storeroom.

Figure 36. View of Building 7 from the north-east

Spalling Floor 2 and Building 8 (Figure 32)

NGR: NY 2901 0217; NMR number NY 20 SE 41

'Spalling' was the process of breaking by hand all the larger lumps of ore-bearing rock into fragments small enough to be fed into a crushing mill. Spalling Floor 2 occupies the top of a platform some 15m square, built using waste rock, whose top lies at an altitude of 255m, projecting eastwards from the natural slope so that the eastern edge stands 6.5m above the valley floor. The platform was designed so that its top lay just below the mouth of Engine Shaft and the base of the wheel-pit of Water Wheel 3 to the west and just above the top of Water Wheel 4 and the the crushing mill housed in Building 9 to the east. This arrangement allowed ore to be transported from Engine Shaft along a level tramway immediately above the western edge of the spalling floor, to be tipped onto the grates housed in Building 7 for initial sorting, and then to be moved onwards from there for further processing, all with the aid of gravity. The platform seems to have been built before the second episode of tipping on the Sump Vein south spoil tip took place. This must indicate that the platform, along with most of the other components of the main processing area, were in place very early in the period of the mine's most intensive use, or even immediately before the extraction began in earnest. In 1865-6, Gossan Vein Level was evidently sited so that had extraction proved successful, ore could have been moved to the spalling floor by a similar system, although by that time the tramway ran at a slightly higher level.

Building 8 is not depicted on the First Edition 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850), but is depicted on the large-scale schematic plan thought to have been made before 1861, where it is termed a 'spalling shade' (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figures 5 and 35). The word 'shade' indicates that the building was probably a lightweight timber shed with a roof, probably of corrugated iron, designed to give some shelter to the workers. The exact location of the building cannot be identified through analysis of the surface of the platform, which has undoubtedly been overlain by later episodes of small-scale tipping. If the schematic depiction on the plan is taken at face value, the shed would appear to

Figure 37. View of Spalling Floor 2 from the south-east

have been of similar proportions to Building 7, that is, much smaller than the total surface area of the platform. However, small mounds of ore-bearing rock, mostly broken into fist-sized and smaller pieces, indicate that processing took place over almost the whole floor, at least during the later use of the complex. Leat 7, which effectively formed both the tail-race of Water Wheel 3 and the head-race of Water Wheel 4, runs parallel to the northern edge of the platform and marks the northern limit of the spreads of ore-bearing rock.

At some stage, the eastern edge of the platform, which is subject to great pressure from upslope and still leans outwards at an angle of *c*.5 degrees, appears to have been reinforced by the addition of a facing wall built using large, flat blocks of slate. These were apparently specially quarried for the purpose, for the blocks have a much less weathered appearance than certain structures that were demonstrably built at a later date, using waste rock readily available from the spoil tips. The facing wall was clearly deliberately constructed in such a way that it did not interfere with any of the pre-existing arrangements. Ore, probably broken into fist-sized lumps on Spalling Floor 2, would have been tipped into a hopper that fed directly into the jaws of the crushing mill housed in Building 9.

The construction of the inclined tramway from Pave York Vein Middle Level seems to have been associated with a major change to the earlier sequence of processing. As described in Section 5.4, at its lower end, the tramway was carried along a stone-built 'jetty', probably terminating on a timber trestle 2.7m above the level of Spalling Floor 2, from where the ore-bearing rock may have been tipped from the trolleys automatically. The existence of the trestle is inferred from a concentration of spoil *c*.3m beyond the end of the jetty. In the same constructional episode, a steeply-angled chute was built at the southern end of the eastern edge of the platform, allowing material to be tipped down to the site of the precipitation tanks (described below; see Figure 41)). The chute is roughly V shaped with sides are formed by low walls, narrowing from 4.5m at the top to 0.9m at the bottom, and ends 0.9m above ground level. A series of stacks of waste rock against its northern side appear to represent successive attempts to buttress the structure. Access to the top of the chute was apparently gained by passing under the trestle that formed the terminus of the inclined tramway, which may have been part of the reason for the use of timber for the final section of the jetty. Although it seems likely that the tramway was dismantled *c*.1908, the chute may well have been used again *c*.1912 for its surface is covered with fine material containing frequent flecks and small lumps of cuprite ore. This is similar in appearance to that scattered on the surface outside Pave York Vein Middle Level and hints that this may have been the site of the final episode of extraction at the mine. The appearance of the ore also suggests that it had already been subject to some degree of processing before it was tipped from Spalling Floor 2. This concurs with the hypothesis that following the removal of the crushing mill powered by Water Wheel 4 *c*.1885, new crushing machinery may have been brought in and set up on Spalling Floor 2. Since no water-wheel survived to power this machinery, it is possible that a steam engine was used, although there is no evidence to support this possibility.

Building 9 (Figure 32)

NGR NY 2902 0218

Building 9 is not depicted on the First Edition 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850), but is depicted on the large-scale schematic plan thought to have been made before 1861, one of two separate buildings jointly annotated as

'Crusher & Stamper' (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figures 5 and 35). It is clear both from the plan and from the physical remains that Building 9, abutting the southern side of Water Wheel 4, housed the crushing mill. The mill would probably have comprised two massive cast-iron rollers, fed from Spalling Floor 2 above via a hopper. The building was rectangular, its western side formed by the eastern wall of the platform supporting Spalling Floor 2 and its northern side by the wall of the wheel pit of Water Wheel 4; the surviving flooring suggests that it measured 4.5m long from west to east by at least 3.5m wide. The floor is constructed of large, thick, dressed slabs, which would have been necessary to support the weight of the crushing mill. Some of these appear to have been prised up and dumped to the south of the building, perhaps when the machinery was removed. The roof would probably have been a lightweight structure of timber and corrugated iron, pitched against the wall of Spalling Floor 2.

The waste tailings from the mill were apparently removed in hand-pushed tram trolleys and tipped to form a spoil heap *c*.3m high some 25m east of the building. The quantity of material is relatively small, although it is possible that a considerable quantity of material may have been taken away to surface Track 1. The date at which the crushing mill went out of use is unclear, but the stone precipitation tanks, thought to have been introduced *c*.1873, block the route from the building to the spoil tip. It is therefore possible that the mill was redundant by that date. Water Wheels 3 and 4 were not operational after *c*.1885, so there would certainly have been no power supply to the crushing mill, or to any of the associated processing machinery, after that date. It is quite possible that the crushing mill and water wheels were removed for scrap or re-use elsewhere at that time.

Building 10 (Figure 32)

NGR NY 2902 0219

Figure 38. View of Building 10 and the battery of stamps from the north

Building 10 is not shown on the First Edition 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850), but is depicted on the large-scale schematic plan thought to have been made before 1861, one of two separate buildings jointly annotated as 'Crusher & Stamper' (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figures 5 and 35). It is clear from the details of the plan and from the physical remains that Building 10, abutting the northern side of Water Wheel 4, housed two batteries of 'stamps'. Stamps were essentially vertical hammers which pulverised the lumps of ore; those at Greenburn Mine were almost certainly simple 'Cornish' stamps, as opposed to the more complex 'Californian' stamps which twisted through 90 degrees after each impact to prevent uneven wear (Jones 1996, 355-6).

The building was about 5.5m square internally and was set at right angles to the wheel-pit. The northern and western walls are marked by timber sleeper beams, with low revetment walls immediately outside them. This suggests that the structure may have been open on all sides, probably with a lightweight roof of corrugated iron sheets. The southern wall of the building is more substantial and stands 0.9m high, its main function apparently being to reinforce the footings of four large posts (of which two survive as rotting stumps and the others only as voids where posts would have stood). The four posts, which were set at an angle into the thickness of the wall, evidently served to support an A-frame, which presumably carried the overhead cam shaft that would have raised and dropped the stamps. The projected apex of the frame (marked by the upright ranging rod in Figure 38) is not on precisely the same line as the axle of Water Wheel 4, indicating that the rotation of the water wheel would have been geared down to turn the cam shaft. The two batteries of stamps are the best preserved items of processing equipment still *in situ* at Greenburn and retain corroded residue from the stamping process. Each battery comprises a shallow cast iron tray divided into two halves, each half 0.7m long by 0.5m wide, supported on massive timber sleeper beams. Given that the stamps lie just above ground level, they may have been of the 'wet' type; that is, water may have flowed over them to wash the surfaces and assist with the crushing. The water may have been supplied by the outflow from the pumps in Engine Shaft.

Building 11 (Figure 32)

NGR NY 2903 0219

As described above, the position of Building 11 seems to correspond closely to the central one of three structures shown on the First Edition 6-inch scale map surveyed in 1847-8, although the small scale of the map makes it difficult to be absolutely certain (Ordnance Survey 1850). Therefore, the building may well have been constructed *c.*1845; its form supports this theory and throws some light on its possible function at that date (see below). However, the orientation of the structure portrayed on the map differs somewhat from that of the extant building. On the other

Figure 39. View of Building 11 from the south

hand, the discrepancy is not much greater than those in the depictions of the dry store and explosives store, which can be more confidently equated with the mapped buildings. Building 11 was certainly depicted on the large-scale schematic plan thought to have been made before 1861, where it is described as a 'Copper House' (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figures 5 and 35). However, there is some evidence that before it had that function, the building may have served a more important role in the processing of the ore. The building almost certainly correponds to the easternmost of the three buildings shown on the Third Edition map revised in 1912, which suggests that it may have survived more or less intact until the final abandonment of the complex (Ordnance Survey 1920).

The dilapidated building, of drystone construction, seems to have been approximately 5.5m square internally, although it is depicted as being rectangular on the plan thought to have been made before 1861. The northern wall survives to a height of 1.3m and parts of the lowermost courses of the western wall can also be identified, but there is little evidence for the precise line of the southern side. The eastern end of the northern wall is an original terminal, so is possible that the eastern end of the building was entirely open. Where the floor is exposed beneath the spread of tumbled rubble and boulders washed down by the stream, it can be seen to be remarkably carefully constructed: large, thick slabs with flat surfaces (which are smooth but not heavily dressed) are laid edge to edge, leaving only narrow cracks in between; some of these are visible beneath the submerged horizontal ranging rod in Figure 39. The appearance of the floor is similar to that of the floor of Building 9, which supported a heavy crushing mill. This, together with the open end of the building hints that at some stage, perhaps *c.*1845, the building may have served some other function, perhaps housing a crushing mill or some other heavy processing equipment. If so, when the site was remodeled at some point before 1861, the building was evidently retained, but thereafter served only as a storeroom. The normal meaning of the term 'copper house' – that is, a store for ore ready to be smelted - is difficult to reconcile with the location of the building, close to the early stages of the processing sequence and with no obvious vehicular access. It is perhaps more likely that the building served as a temporary store for semi-processed ore, or as a general store.

Building 12 (Figure 32)

NGR NY 2904 0218

Building 12 is not shown on the First Edition 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850), but is depicted on the large-scale schematic plan thought to have been made before 1861, where it is annotated as 'Jigging etc.' (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figures 5 and 35). 'Jigs', which were also known as 'hotching tubs', separated relatively fine waste rock from heavier ore-bearing material by a process of flotation, using sieves that were mechanically shaken, or jigged (Jones 1996, 187). Water Wheel 5, which was located mid-way along the rectangular range and is also depicted on the large-scale schematic plan, would have provided the fairly small amount of power required to move the sieves. It seems quite likely from the physical evidence that the building was redundant by the time the precipitation tanks were installed nearby *c.*1873. Water Wheel 5, like Water Wheels 3 and 4, would almost certainly have been inoperable after *c.*1885 and it seems very unlikely that the building would have remained in use after that date. It was not shown on the Third Edition map revised in 1912, which suggests that it may have been dismantled by that date (Ordnance Survey 1920).

The precise limits of the building cannot be identified with certainty, but it was probably rectangular, at least 12m long by 4m wide, with its long axis oriented from south-by-south-east to north-by-north-west. There is no evidence for drystone walling, so it seems likely that the building was constructed primarily in timber and corrugated iron sheeting. Part of the compacted floor surface can be identified extending for *c*.5m to the north of the wheel-pit of Water Wheel 5. If the large-scale schematic plan thought to have been made before 1861 can be taken at face value, the building may have extended for a greater distance to the south of the wheel pit. It follows that the introduction of the precipitation tanks *c*.1873 would have required the demolition or shortening of the building.

Building 13 and the slime pits (Figure 32)

NGR NY 2906 0220

Building 13 is not shown on the First Edition 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850), nor is it depicted explicitly on the large-scale schematic plan thought to have been made before 1861 (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figures 5 and 35). However, it appears to have been associated with the 'slime-pits', which are depicted on the plan and whose position can still be identified approximately on the ground. 'Slime pits' were shallow timber-built tanks in which the residue from the ore-washing process was allowed to settle gradually in order to retrieve tiny particles of ore. This process eventually formed a dense mud known as 'slimes', at the base of which the ore particles accumulated. Like most of the other processing buildings, it seems very unlikely that the structure would have been used after *c*.1885 and it was not shown on the Third Edition map revised in 1912, which suggests that it may have been dismantled by that date (Ordnance Survey 1920).

Building 13 stood at the eastern end of a level strip of ground whose surface was roughly metalled. All that can identified of the building itself is a fragment of compacted floor surface defined by a discontinuous alignment of stones and vestigial earthworks. It is possible that these mark the wall lines of part of a small structure, perhaps a shed only 3m square, presumably built primarily in timber and corrugated iron sheeting. Alternatively, what can be traced may represent an outshot from the fairly large structure shown on the large-scale schematic plan thought to have been made before 1861. Little more of the rest of the structure can be identified with confidence. The depiction indicates that the main structure stood immediately north of the slime tanks, suggesting that the timber tanks may have rested on the metalled surface to the west. Immediately to the east of the site of the building is a low mound of dense dark grey silt, which can be interpreted with some confidence as slimes. The finger-like form of the mound suggests that it does not represent the site of the tanks themselves, but rather a tip of waste material brought in from a westerly direction. Eric Holland has pointed out that the quantity of slimes is small by comparison with many other mining complexes and has suggested that some waste material may have been disposed of into the stream (Holland 1981, 103). Alternatively, it is possible that the process was simply of minor importance at Greenburn.

Building 14 (Figure 32)

NGR NY 2907 0220

Building 14 is not shown on the First Edition 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850). On the large-scale schematic plan thought to have been made before 1861, it may have been treated as part of the adjoining Building 15, which is annotated 'Round Buddle' and is described further below. Building 14 may therefore have been involved in the washing of ore before it was fed into the buddle. It seems unlikely that the building would have been used after *c.*1885; it was not shown on the Third Edition map revised in 1912, which suggests that it may have been dismantled by that date (Ordnance Survey 1920).

The building was rectangular, approximately 7m long by 3.5m wide, with its long axis aligned from west-south-west to east-north-east, and its eastern end abutting the western end of Building 15. The dimensions of the structure can be gauged approximately from the extent of the compacted floor surface, which is defined by an almost continuous alignment of stones and vestigial earthworks. These traces, which probably mark the wall lines of a structure built primarily in timber and corrugated iron sheeting, also suggest that there may have been two opposing doorways towards the western end of the building. A footpath leading from the doorway on the north may have been carried across the stream on a wooden footbridge of which no trace survives. The well-preserved wooden duct located along the course of Leat 10 some 5m to the north-west of the building may have supplied water to whatever process took place in the building. A slight depression extending between Buildings 14 and 15 suggests that there may have been some form of opening in the eastern wall of Building 14, perhaps allowing ore to be transferred through to the buddle.

Building 15 (Figure 32)

NGR NY 2908 0221

Building 15 is not shown on the First Edition 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850), but is depicted on the large-scale schematic plan thought to have been made before 1861, where it is annotated 'Round Buddle' (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figures 5 and 35). A 'round buddle' was a circular container in which water continuously washed over the finely ground material, separating out the heavier ore-bearing particles through a centrifugal or centripetal process, depending on the design of the machinery. Designs from the mid-19th century onwards tended to use a revolving paddle to stimulate the movement of the particles (Jones 1996, 47-8). This seems to have been the arrangement at Greenburn Mine: Water Wheel 6, which was located against the northern wall of the building, would have provided the fairly small amount of power required to turn the paddle. Like Water Wheels 3, 4 and 5, Water Wheel 6 was almost certainly inoperable after *c.*1885 and it seems very unlikely that the structure would have remained in use after that date. Certainly, it was not shown on the Third Edition map revised in 1912, which suggests that it may have been dismantled by that date (Ordnance Survey 1920).

The building was rectangular, approximately 7m long by 3.5m wide, with its long axis aligned from west to east, and its western end abutting the eastern end of Building 10. The dimensions of the structure can be gauged approximately from the extent of the compacted floor surface, which is defined by an almost continuous

alignment of stones and vestigial earthworks. These traces, which probably mark the wall lines of a structure built primarily in timber and corrugated iron sheeting, also suggest that there may have been a doorway mid-way along the southern side of the building. A slight depression extending between Buildings 14 and 15 suggests that there may have been some form of opening in the western wall of Building 15, perhaps allowing ore to be transferred through from the other building. A slightly raised step at the western end of the interior may have supported some kind of equipment for preparing the material to be fed into the buddle; this may correspond to one of the lines shown on the large-scale schematic plan. The buddle itself was probably located immediately south of Water Wheel 6; it is uncertain what is signified by the lines shown to the north of the water wheel on the large-scale schematic plan.

Building 16 (Figure 32)

NGR: NY 2908 0222

Building 16 is not shown on the First Edition 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850). It is depicted on the large-scale schematic plan thought to have been made before 1861, where it is annotated 'Copper House', that is, a temporary storeroom for processed ore ready for smelting (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figures 5 and 35). The portrayal of the building on the Second Edition map revised in 1889 is the sole amendment made to the First Edition in the vicinity of the processing area (Ordnance Survey 1891). The building is also shown on the Third Edition map revised in 1912, which suggests that it may have remained in use until the final abandonment of the complex (Ordnance Survey 1920).

The small building of drystone construction, which lies at the eastern end of Loading Bay 2, was rectangular with internal dimensions of 3.4m by 2.2m (to the right in Figure 40). There are traces of internal render, identical in appearance to that applied to the interior of the accomodation block. In that instance, the render was certainly

Figure 40. View of Building 16 and Loading Bay 2 from the south

added after 1871 and probably in the early 20th century. The doorway was located centrally in the southern side, facing onto Track 1a. The walls only stand to a maximum height of 0.6m, but it seems unlikely that there would have been any windows. A low ramp-like embankment on the exterior of the northern wall slopes onto Track 1b. This hints that there may have been an aperture through which containers of ore (possibly barrels) could be passed, facilitating their movement to the upper side of Loading Bay 2. The roof was probably pitched and covered with slates. However, only a few fragments of roofing slates were identified in the rubble, which may indicate that they were taken away for re-use elsewhere. Unlike Building 11, which is also referred to as a 'copper house' on the plan thought to have been made before 1861, the form and location of Building 16 are entirely compatible with that function, nor is there any indication that it ever served any other purpose.

Loading Bay 1 (Figure 32)

NGR: NY 2905 0221

Prior to the construction of Loading Bay 2, Track 1a seems to have continued for *c*.30m further to the west, joining Track 1b and terminating adjacent to a drystone wall 0.9m high which serves to revet the platform in front of the accommodation and office block. The surface of the track next to the wall is largely concealed by a dump of fist-sized and smaller lumps of stone with a high quartz content, evidently tipped from the higher level. It is likely that the tip may represent a load of ore-bearing stone prepared for crushing. The wall would have allowed material to be moved from the higher level onto the back of a cart standing on Track 1a with relative ease; it may therefore represent the loading bay of the complex as it was laid out *c*.1845. It is unclear whether the tip of ore-bearing stone is broadly contemporary with the use of the loading bay, or whether the disused area was simply a convenient place for dumping material that was not required.

Loading Bay 2 (Figure 32)

NGR: NY 2908 0222

A platform with a metalled surface, which can be securely interpreted as a loading bay, adjoins the western end of Building 16 and is accessible from the east by Track 1a. Holland's (1981, fig 48) interpretation of the walling as part of a wheel-pit is certainly erroneous. Although not depicted on the the large-scale schematic plan thought to have been made before 1861, it can be assumed to be contemporary in origin with the adjacent copper store Building 16, which is depicted (Cumbria CRO D/Pen/46/file 102-106/document not numbered; see Figures 5 and 35). The loading bay was not depicted on the Second Edition 6-inch scale map revised in 1889, but was shown accurately on the Third Edition map revised in 1912 (Ordnance Survey 1891; 1920; see Figures 3, 7 and 8). The platform cuts into the line of the earlier Track 1a, making the western end of the track and Loading Bay 1 redundant. It is terraced into the slope on its north and west sides to a maximum depth of 1.2m; these sides are revetted by drystone walls (to the left in Figure 40). The difference in levels would have ensured that when a wagon was backed up to the western end of the loading bay, its floor would have been level with the adjacent ground surface, allowing containers of ore to be moved onto it without lifting. Immediately adjacent to Building 16, a flight of steps would have facilitated access from Track 1c. A band of stones defining a small rectangular area in the north-west corner of the loading bay seems to mark the site of a tent.

Precipitation tanks (Figure 32)

NGR: NY 2904 0217; NMR number: NY 20 SE 42

The remains of two square tanks constructed from large finely-dressed slabs of sandstone are interpreted as the 'stone tanks' referred to in Thomas Lawn's report of 15 August 1874 quoted in Section 4, which had probably been installed by the Great Coniston Copper Mining Co in the previous year (Cumbria CRO D/Pen/46/file 90-99/document not numbered). The tanks would have held sulphuric (or less probably hydrochloric) acid, which was used to precipitate the copper from the crushed copper oxide ore onto scrap metal, the reaction producing copper salt and water. According to Eric Holland (1981, 106), the tanks would originally have been lined with lead sheeting. No trace of the lead sheeting now survives, suggesting that if it existed, it was probably removed at some point for re-use elsewhere. Each tank is 2.4m square and 1.2m deep, each side formed by a single stone slab set on edge, resting in a shallow groove in the basal slab. The joints between the slabs were apparently sealed by some form of caulking, traces of which survive. The more westerly of the two tanks is better preserved, with all but one of the slabs that form the sides still *in situ*. All four sides of the eastern tank have collapsed outwards, breaking one of the slabs. The base and sides are overlain by a small mound of finely-crushed ore-bearing material. If, as appears to be the case, this represents the contents of the precipitation tank at the point it collapsed, it is impossible that the tanks were lined with lead sheeting: instead, the caulking around the joints must have been sufficient to prevent acid leaking out. Alternatively, it is possible that lead sheeting was used originally but was removed at some later date (*c*.1885, for example) and that the caulking was put in later still when processing was resumed (*c*.1906, for example).

Both tanks are overlooked on their west sides by platforms raised to the same height as the tops of the tanks, which would have allowed crushed ore to be fed into them with relative ease. The placement of the two tanks suggests that they were initially positioned so as to receive ore that had been pulverised by the crushing mill housed in Building 9. The addition of the ore chute from Spalling Floor 2 (visible in the background in Figure 41), which is certainly contemporary with the inclined

Figure 41. View of the precipitation tanks from the north-east

tramway probably built *c.*1906, would have allowed ore to be transferred more directly to the tanks by by-passing Building 9 altogether.

Thomas Lawn's report also mentions the existence of '…two reservoirs into which the water is conveyed', adding that the water was '…then allowed to run gradually into the river.' The water referred to is apparently that formed in the tanks as a by-product of the precipitation reaction ($CuO + H_2SO_4 = CuSo_4 + H_2O$), which would have been highly toxic. Set into the ground adjacent to the stream some 10m to the north-east of the precipitation tanks is a container of similar proportions to the stone tanks, but with its sides built with wooden planks, placed horizontally edge to edge. Immediately to the east of this, two roughly built stone weirs extend across the stream, spaced far enough apart to have supported a second timber container of the same size. The southern edge of the stream is steep-sided at this point, suggesting that the bank may have been held in place by the side of the putative container. If this is indeed the site of the second reservoir mentioned by Lawn, their placement in relation to each other would have echoed that of the two stone precipitation tanks. This arrangement presumably allowed one tank and one reservoir to remain in use while the others were emptied, cleaned and refilled.

Thoams Lawn's report also mentions the use of 'barrels' to transport the acid used in the precipitation process. It is worth stating that these cannot be equated with the numerous rusting steel drums scattered around the complex, including two in close proximity to the stone tanks (visible in Figure 41). The English Heritage investigation shed no light on the function or original contents of the drums, but it is possible that they post-date the abandonment of the mine.

5.7 ANCILLARY BUILDINGS

Accommodation, office and smithy (Figures 42 a - c)

NGR: NY 2903 0221; NMR number NY 20 SE 9

At the terminus of Track 1c stands a rectangular stone-built range which comprises three units evidently constructed in a single episode, all facing southwards onto the track, without intercommunicating doors. Part of an earlier structure, comprising three courses of the corner of a wall built on the same alignment from east-north-east to west-south-west, was incorporated into the south-west corner of the extant building. Unlike the later drystone walling, which makes use primarily of angular fragments of waste rock presumably produced by blasting in the mines, the earlier walling is built using weathered blocks evidently exposed on the surface and rounded boulders probably gathered from the valley floor nearby. It seems likely that the earlier building was roofed with thick round-headed slates, for numerous small fragments of these were used to pack the joints of the later walls. The fact that these slates were not re-used simply as roofing material may indicate that they were already broken when the later building was constructed, hinting that the earlier building may have fallen into disrepair. The round headed slates are similar to those used on the smithy below Long Crag Level, which was depicted on the First Edition 6-inch scale map surveyed in 1847-8 and was therefore probably built *c.*1845 (Ordnance Survey 1850; see Figure 3). The use of weathered stone and boulders is comparable to the drying room and the explosives store, which were also depicted on the First Edition map and were therefore also probably built *c.*1845. In the light of these similar constructional characteristics, it seems very probable that the earlier building was constructed in broadly the same phase. However, the First Edition map does not depict the building; instead, the annotation 'GREENBURN VALLEY' impinges on its site. Since such wording was generally deliberately placed to avoid any conflict and the First Edition seems to be reliable in every verifiable aspect, the best interpretation of the evidence is perhaps that the building was built very soon after 1847. Little can be inferred regarding the function of the earlier building, but given that its position is somewhat removed from the likely site of the processing area in use at that time, it is reasonable to speculate that it may have performed ancillary functions similar to the later building.

The later building is shown on the large-scale schematic plan thought to have been made before 1861, where it is annotated 'Office, Smithy, etc.', suggesting that its third function - accommodation - was considered too unimportant to mention (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5). The Sump Vein north spoil tip, which also dates to before 1861, is piled up to a maximum depth of 2.5m against the rear of the range, indicating that the building was in place before the most intensive phase of extraction began. Despite the size and importance of the building and the incontrovertible evidence that it was in existence by 1868 at the very latest, the Second Edition map revised in 1889 does not show the building; instead, it exactly replicates the depiction on the First Edition (Ordnance Survey 1891; see Figure 6). This is one of several key omissions in the vicinity of the main processing area, which cast doubt on the reliability of the Second Edition map. However, the revision undertaken for the Third Edition in 1912 was more thorough, not only depicting the range but indicating that it was roofed, and therefore presumably in good repair at that point (Ordnance Survey 1920; see Figure 7). Aerial photographs taken in August 1945, only three years after the last company to occupy the complex was dissolved, indicate that all the buildings had lost their rooves by that date (RAF 1945a & b). A number of pieces of burned roof timbers, probably from this building, are scattered around the

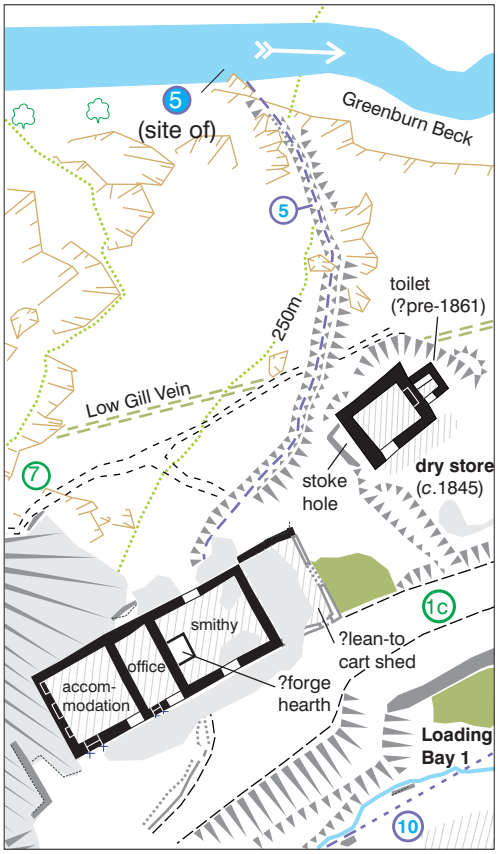


Figure 42 a. Plan of the accommodation, office and smithy

area. It seems unlikely that the building burned down; it is more probable that the timbers were used to fuel relatively recent camp fires. Along the whole length of the range, larger, roughly dressed blocks set on edge were used to define quoins and door jambs, a technique common amongst a range of vernacular building types in the region throughout the 19th century (and beyond). However, this slightly elaborate constructional style was ill-suited to the stability of a drystone structure: in consequence, the range as a whole is now dilapidated and shows signs in places of being near collapse. Despite this, sufficient physical characteristics are still identifiable to indicate that the western unit provided accommodation for the miners, while the central unit was designed as an office and the eastern unit as a smithy and probably a general workshop. A platform which may have been the site of a lean-to store or cart shed built primarily in timber lies at the eastern end of the range.

Contrary to the impression given by Eric Holland's (1981, fig35) reconstruction drawing, the accommodation unit was the only part of the range with two storeys. It survives to the level of the top of the upstairs window, approximately 3.5m high. The ground floor room, which measures 4.9m by 4.5m, evidently served as common room. It was rendered internally, with a single broad window in the southern wall (the only one in the range which can be seen for certain to have been glazed) and there was a fireplace located centrally in the western wall. The initials 'R.S' have been chiseled faintly into the lintel above the fireplace; the same initials appear with the date 1871 on the exterior wall of the office. Robert Stott was one of the original directors of the New Coniston Copper Mining Co, which held the lease from 1868 to *c*.1871. However, he is described in the prospectus produced by the company as a 'gentleman' from Lower Broughton in Manchester, so it seems more likely that it would have been the mine foreman who carried out the carving. The render on the wall of the common room would have covered the initials, indicating that it was a relatively modern addition, certainly dating to after 1871 and more probably to *c*.1906 or *c*.1912. On either side of the fireplace are two rendered recesses; the render retains the imprints of timber fixtures. The northern recess was evidently divided into six 'pigeon holes', while the southern one had two shelves and hinged doors. Above the fireplace, a small recess probably served to hold a lamp or candle. The absence of joist sockets along the eastern half of the rear north wall indicates the position of the stair-well and a faint scar in the render near floor level shows that the staircase ascended from the middle of the wall. The upstairs room, of similar dimensions to that downstairs, presumably served as a dormitory, with sufficient space for about ten men. There was a single window located centrally in the southern wall.

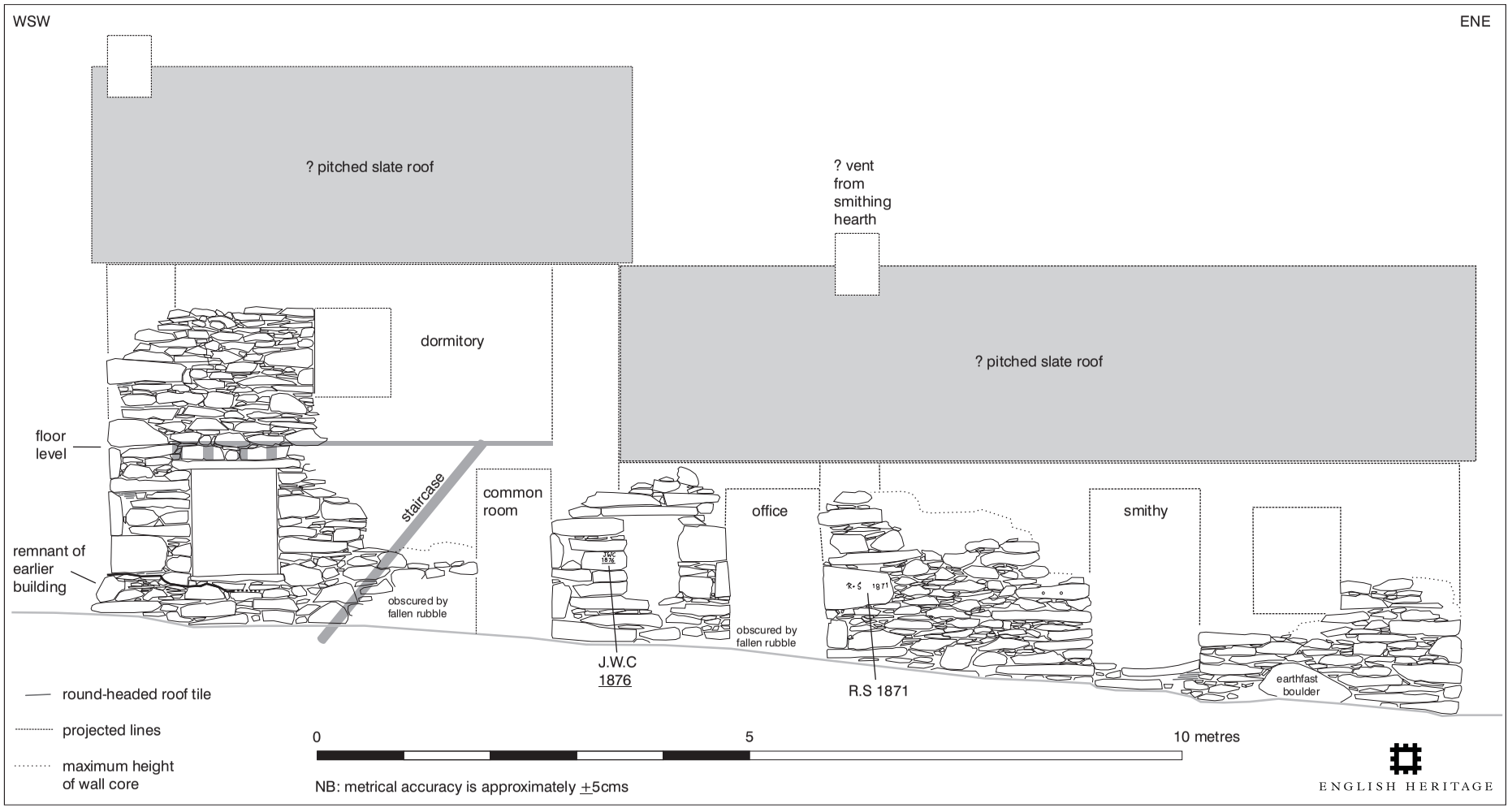
Figure 42 b. View of the accommodation, office and smithy from the south

The office measures 2.4m by 4.5m internally. It has a single narrow window adjacent to the door; the walls are not rendered internally and there is no evidence for fixtures within the room. As mentioned above, the initials 'R.S' have been carved rather faintly, apparently using a chisel, into the largest upright stone adjacent to the doorway of the office, accompanied by the date 1871. The style is identical to that of the same initials over the fireplace in the accommodation block. On a stone adjacent to the window, the initials 'J.W.C' have been carved more carefully, apparently using a small pointed tool, accompanied by the date 1876. Messrs. McGowan and Cooper held the lease between 1875 and *c*.1885, but it was clearly not Cooper, whose first name was Reuben, who carried out the carving. Again, the initials are likely to belong to the mine engineers or foremen in charge of the operation. The existence of these graffiti, together with the small size of the room, is good evidence that it housed the office indicated on the plan thought to have been made before 1861.

The smithy measures 6.2m by 4.5m internally. It has two opposing doors, but that in the northern wall does not appear to have been regularly used for access, and may have served primarily to improve ventilation. The opening may also have allowed Leat 5, which turns towards the building at this point, to supply water to the interior. A large window in the south wall would have lit the eastern end of the room. In the middle of the south-western wall was a rectangular table-like structure, built in stone, 1.8m long by 1.2m wide and standing at least 0.9m high, which is interpreted as a raised hearth. A few small fragments of smithing waste were noted towards the eastern end of the building. The threshold of the southern door is pock-marked by triangular chisel holes, as is that of the smithy below Long Crag Level. Taken together, the evidence confirms that the room housed the smithy mentioned on the plan thought to have been made before 1861.

Abutting the eastern wall of the range is a stone-floored platform, apparently built in the same episode, which may represent the site of a lean-to shed built primarily in timber. The paved floor measures 5.5m by 4.0m; there is no conclusive evidence that it was roofed, but its position in relation to Track 1c suggests that it may have functioned as a covered store, perhaps for a cart. The paving overlies a deposit of small chips of stone including numerous chips of quartzite and ore-bearing rock,

Figure 42 c. Elevation drawing of the accommodation, office and smithy



which seems to represent the residue from a crushing mill or some other form of processing. The deposit may simply have been brought in deliberately to create a flat bed for the paving, but more of the same material is spread in the surrounding area. It therefore seems more likely that it represents residue more or less *in situ* from processing which predates the construction of the range; whether dating to *c*.1845 or earlier is uncertain.

The dry store (Figure 42 a)

NGR: NY 2905 0226; NMR number: NY 20 SE 43

A short distance to the north-east of the range comprising the accommodation, office and smithy is a dilapidated building, constructed in two or more phases, which can be interpreted with confidence as a dry store and/or dry changing room, with an adjoining toilet block. The main part of the building, that is, the dry store, was depicted on the First Edition 6-inch scale map surveyed in 1847-8, indicating that it was probably built *c*.1845, although it is difficult to be certain that it had the same function at that date (Ordnance Survey 1850). The building is not depicted on the large-scale schematic plan thought to have been made before 1861 (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5). However, this omission probably stems from the ancillary function of the building, for the physical remains suggest that it was still in use and that the toilet block may have been added in that period. The building is shown on the Second Edition map revised in 1889, and on the Third Edition map revised in 1912, although the depiction suggests that it may have lost its roof by this time (Ordnance Survey 1891; 1920).

The dry store is a rectangular room with internal dimensions of 3.9m by 3.0m; it has a single door facing south and no windows (Figure 43). The walls are built using weathered blocks evidently exposed on the surface and rounded boulders probably gathered from the course of the stream nearby, like those of the other buildings thought to have been constructed *c*.1845; they survive to a height of 1.6m. Round-headed slates similar to those noted elsewhere may have been used for the

Figure 43. View of the dry store from the south

roof, but the only examples found in the vicinity were incorporated into the walls of the toilet block, suggesting that the main building may have been re-roofed when the toilet block was added. The building was heated by a system comparable to a Roman 'hypocaust'. Abutting the external wall at the western end of the building was a pit dug to below floor level, which gave access to a stoke-hole for a small furnace. The stoke-hole is the only feature on the complex constructed in brick, presumably in order to withstand the heat from the fire, and shows signs of having been rebuilt. The rebuilding of this section means that it is impossible to be certain that it was not inserted at some point after the building was first constructed. In other words, the building may not always have been used as a dry store, although the absence of windows would have restricted the possible functions. The hot air produced by the fire passed beneath the floor of the building, which is mostly constructed with large roughly-dressed slate slabs, probably raised on low stone walls. Eric Holland, who first examined the building in the 1970s when it was considerably better preserved, mentions the existence of an iron plate in the floor, but this no longer lies *in situ* and its site cannot be precisely ascertained (Holland 1981, 106). From beneath the floor, the heat passed into a chimney or wall flue in the wall at the eastern end of the building.

In a later phase, a small annexe 1.2m square internally, with a door facing south, was built adjoining the eastern end of the dry store; this has been correctly interpreted by previous studies as a 'dry closet', that is, a toilet (Holland 1981, 106; 1987, fig. 87). There were a few concessions to comfort: a narrow strip between the doors of the dry store and the toilet was roughly cobbled; the room is rendered internally and was evidently sited so as to benefit from the warmth of the chimney in the adjacent wall. A large stone slab set on edge extends parallel to the rear wall of the room, forming a narrow trough in which buckets would have been placed, presumably covered by a wooden seat. The walls still survive to a height of 1.8m, but a photograph of the building taken in 1980 indicates that the door lintel was still in place at that date and that the building as a whole was in better condition (Holland 1987, fig. 87). A small opening at ground level in the eastern wall probably functioned as a drain.

The date at which the toilet was added is uncertain, but the constructional technique has much in common with buildings known to have been built during the period of the mine's most intensive use, at some point between 1848 and 1861. On the other hand, the fact that the interior is rendered, like the interior of the accommodation block, hints that it may have remained in use until the early 20th century, or may have been built then.

To the south of the building, adjoining Track 1c, the ground has been built up slightly to form a fairly level platform; a slight hollowing mid-way along the downslope edge suggests that a footpath may have ascended from the track at this point. The platform cannot be interpreted with confidence as the site of a building but may have been the site of some ancillary structure. The platform seems to be built up with small chips of stone which appear to represent tailings from a crushing mill. Similar material is concentrated around the site of the lean-to structure at the end of the range comprising the accommodation, office and smithy. This may point to processing activities having taken place in the vicinity either *c.*1845 or even earlier.

The explosives store (Figure 32)

NGR: NY 2911 0220; NMR number NY 20 SE 44

A dilapidated stone-built structure which, on the evidence of its size, location and orientation can be securely interpreted as an explosives store, occupies the summit of a rise some 30m to the east of the processing area. A building of the same proportions is shown in the same position, though on a slightly different orientation, on the First Edition 6-inch scale map surveyed in 1847-8, the Second Edition revised in 1889 and the Third Edition revised in 1912 (Ordnance Survey 1850; 1891; 1920; see Figures 3, 6 and 7). It is also shown on the large-scale schematic plan thought to have been made before 1861, where it is labelled 'powder house' (Cumbria CRO: D/Pen/46/file 102-106/document not numbered; see Figure 5).

The single room is rectangular with internal dimensions of 3.3m by 2.4m. The doorway is located in the east end, facing away from the main areas of activity, and there is no evidence for any windows. The drystone walls, which are 0.6m thick, are constructed predominantly using weathered boulders but with some quarried stone; they now survive to a maximum height of 1.6m. The building may have been roofed with slates, although only one was noted in the rubble that has tumbled from the walls. This may indicate that the majority were removed for re-use at some point, or that the building was roofed with some other material. Wooden shingles were commonly used to ensure that the blast from any explosion was directed vertically upwards. Although explosives stores were frequently destroyed and rebuilt, these constructional characteristics are similar to other buildings identified as having been built *c.*1845, so it probable that the building represents the original explosives store for the mine. Other known examples had timber floors to prevent sparks being struck by hob-nailed boots, but any evidence in this instance is concealed by collapsed material. A narrow internal partition wall, which divides the western end of the room into two compartments of equal size, is apparently a later addition, probably built to allow the storage of different materials. Gunpowder would have been the only explosive available until the 1870s, after which dynamite would have been used; this development may account for the modification of the storage arrangements.

Figure 44. View of the explosives store from the east

6. DISCUSSION AND CONCLUSIONS

At Greenburn Mine, the physical remains of the period prior to 1861, under the tenancy of Crossfield & Co, are numerous, well-preserved and therefore visually overwhelming. A key documentary record - the sheet comprising the large-scale schematic plan and the detailed profile/section drawing which was reproduced with the prospectus of 1868 - offers a revealing insight into the working of many of the features (especially machinery) in use before 1861 which no longer survive (Cumbria CRO D/Pen/46/file 102-106/document not numbered). As a result of these two major sources of evidence, previous studies have tended to overlook or misinterpret evidence that is less immediately apparent, which sheds light on the use of the site before and after the tenancy of Crossfield & Co. The complex has generally been presented as essentially the product of a single major phase of work, but mining activity at Greenburn can actually be divided into five broad phases. Each is characterised by its own distinct physical remains and, more fundamentally, by a significant change in the underlying approach of the companies involved:

- the late 17th century
- the period immediately after *c*.1845
- the period before 1861 under Crossfield & Co
- the period from 1864 to 1885, under various companies
- the period from 1906 to 1940, primarily under the Greenburn and Tilberthwaite Syndicate

The late 17th century (Figure 45)

The work perhaps carried out by William Monson and William Thompson in the late 17th century, of which relatively little is known, seems to have been typical of mining in the period prior to the industrial revolution: the attempts at extraction were clearly fairly intensive and not unsuccessful by the standards of the day, but from a modern point of view there seems to have been little concern for the infrastructure required for efficient processing. The overall impression is that to a large extent the infrastructure necessary for processing the ore was on the scale of what might be termed a ‘cottage industry’.

Prior to the English Heritage investigation, historical research had brought to light documentary evidence for mining in the Greenburn Valley in the late 17th century, but no corresponding physical remains had been recognised. Analysis of the form and location of the workings suggests that several - Greenburn Beck Level, Greenburn Beck Shaft and Sump Vein Level - can be distinguished as very probably pre-dating the 19th-century complex and therefore as most plausibly corresponding to the 17th-century activity. None of these shows any signs of the large-bore triangular chisels used in the 19th century. Greenburn Beck Level and Shaft are not easily accessible and are inconveniently located in relation to the later processing area. The entrances to all three workings are situated directly on the line of the veins and the two levels follow its alignment, a strategy which contrasts with the willingness in the 19th century to drive fairly long cross-cut levels to reach the veins. This characteristic is reminiscent of the minor trials which follow the mineral veins where they are exposed on the surface (Trials 1, 2, 3 and 8), as well as the possible trial shaft

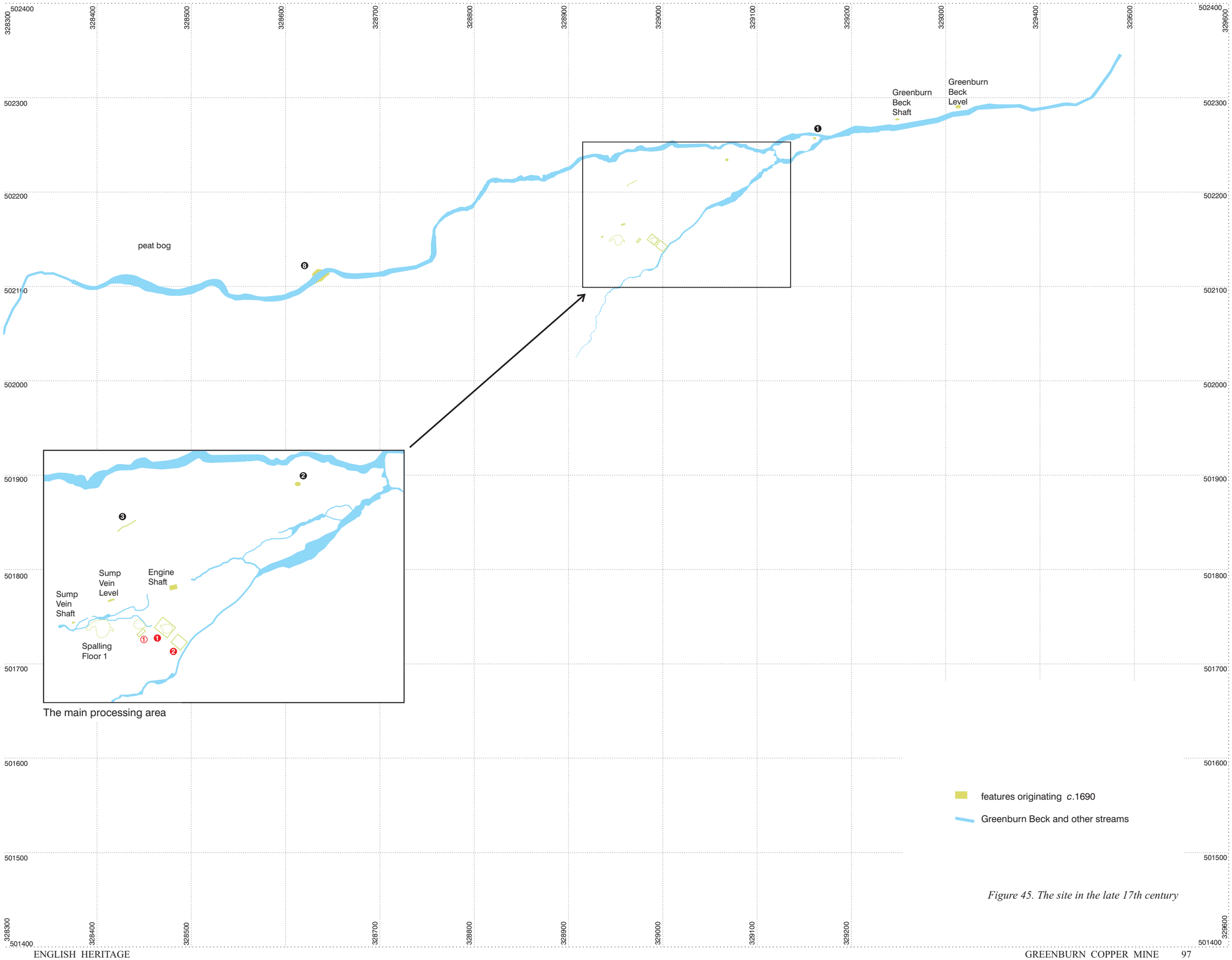


Figure 45. The site in the late 17th century

immediately north of Engine Shaft, and it seems quite likely that these may also date to the 17th century. It is doubtful whether these workings, of which only Greenburn Beck Level is of any significant size, are sufficient to account for the minimum of 80 tonnes of ore documented as having been extracted in the late 17th century. Therefore, the origins of Engine Shaft and Sump Vein Shaft may well also lie in this period. The depth at which Sump Vein Shaft connects with Engine Shaft, at *c*.51m below the ground surface, may mark the maximum depth of the 17th-century work. The construction of twin shafts, creating good ventilation and allowing emergency access, became a legal requirement in 1862, but was common thoughout the post-medieval period (Jones 1996, 112). The discovery of copper workings of the late 17th century is important in itself, but not without parallel; mines of the late 16th and early 17th century are known, for example at the main Coniston Copper Mines. Arguably, the major significance of the identification of the early workings at Greenburn lies in their contribution to the understanding of the development of the complex as a whole.

Although there is good documentary evidence for the existence of a number of 'hutts or houses' on the site in the late 1680s and early 1690s, physical remains relating to ore-processing in the late 17th century are not easy to distinguish with confidence. The earliest identifiable processing area seems to have related to Sump Vein Shaft, suggesting that this, rather than Engine Shaft, may have been the main working shaft for the 17th-century mine. It seems likely that ore brought to the surface at that point would have been taken to Spalling Floor 1 for initial dressing by hand. From there, it seems to have been moved by wheelbarrow to a small platform downslope, where it may have been tipped onto grates, below which the oversized pieces may have been broken up further. It may then have been fed into a small crushing mill powered by Water Wheel 1, although the poorly preserved remains of the wheel pit itself are not entirely convincing. The documented huts may have been lightly built timber structures that would have left remains very similar to those of Buildings 1 and 2, and the fact that these two buildings are not depicted on any known historic maps supports the theory that they predate the 19th-century mine. A mound of what appear to be mill tailings within Building 1 suggests that a crushing mill was housed in or adjacent to the building, but it is uncertain whether this is contemporary with Water Wheel 1 and Spalling Floor 1. The stone-built 'pier' at the north-west corner of the building suggests that ore may have been introduced from that direction, which would be consistent with material extracted from Sump Vein Shaft. Water may well have been channelled into Building 2 from the nearby tributary stream, suggesting that some form of washing may have been carried out there, but this is purely speculative, given that water was involved in most stages of the processing sequence. Other structures associated with the processing of ore may have been situated further downslope, but these would have been destroyed or buried beneath later remains. For example, there may have been some activity on the platform cut into the hillside immediately north of Engine Shaft, although there are no recognisable processing remains of this date on the platform itself. Leat 6, whose relationship to Sump Vein Level suggests a relatively early date, may have supplied some kind of ore-washing process on the platform. The concentration of finely crushed material in the area between the later dry store and the range comprising the accommodation, office and smithy may also relate to the earliest mining activity at Greenburn.

The period immediately after *c.*1845 (Figure 46)

In the period after *c.*1845, apparently under the tenancy of Crossfield & Co, the operation took the first steps towards a truly industrial scale and efficiency of extraction and processing. This initial period of redevelopment laid the foundations for the subsequent phase of massive investment in the infrastructure of the mine. The duration of the period is uncertain: the evidence for the date of 1845 is circumstantial and there is no firm documentary or physical evidence for the date at which the subsequent remodelling may have taken place, save that it occurred at some point between 1848 and 1861. Detailed history of the ownership and effectiveness of the operation is also lacking. Yet through the depiction of the complex on the First Edition of the 6-inch scale map surveyed in 1847-8 (Ordnance Survey 1850) and the few surviving physical remains, it is possible to gain a partial picture of this stage in the development of the mine.

The mining effort appears to have been concentrated in two places: the Sump Vein and Long Crag Vein. The Buried Gossan Vein Level may also have been worked, although it was perhaps not in active use when the Ordnance Survey mapped the complex, along with Trials 9, 12 and 14, which are more crudely executed than those thought to have been undertaken in the subsequent phase. The interconnecting shafts on the Sump Vein, Engine Shaft and Sump Vein Shaft, may have originated in the 17th century and both were probably again used to extract ore after *c.*1845. The fact that Engine Shaft was annotated 'Shaft' on the First Edition map suggests that it may have been the more important of the two, but due to the later development in its immediate vicinity it is impossible to distinguish earlier remains. There is also evidence that Sump Vein Shaft may have continued in occasional use: the two timber 'axles' to the east of the shaft, which are interpreted as elements of a hand-powered winch, seem too well-preserved to have been made before the 19th century. However, such a winch would not have been adequate for extracting ore on a regular basis. The First Edition map proves that Long Crag Level was in existence by 1848 at the latest and it is probable that the Upper Workings on the vein were in contemporary use, although perhaps started shortly after 1847. The brief description in Captain Vivian's report gives the impression that the work on Long Crag Vein was a relatively minor trial and this has led more recent historians to underestimate its importance in this early phase. Despite the remote and relatively inaccessible location of the workings, the physical remains on the surface, as well as the extent of the workings below ground, indicate that the levels entailed a considerable commitment of time and effort, with fairly successful results. Ore from the workings must have been transported to the main processing area along Track 3 and in this way, all the ore would have been combined into a single processing sequence.

Relatively little can be inferred about the processing of the ore during this period, for most of the relevant structures would have been destroyed or buried during the subsequent phase of remodelling. Leat 1, though not shown on any historic map, is stratigraphically earlier than Leat 4, which was in turn constructed before 1861; it may have supplied water to a washing process. The First Edition map indicates that by 1848 at the latest Leat 2 had been constructed and this implies the existence of Water Wheel 2. The map depiction suggests that the wheel was probably housed in or next to Building 3, but it is unclear whether the building was an engine house connected with the winding gear in Engine Shaft, or the site of a crushing mill, or both (Ordnance Survey 1850; see Figure 3). The precise functions of Buildings 4, 5 and 6 are uncertain, but all were probably involved in the processing of ore. Building 11 may have originated at about this time; the substantial and well-constructed

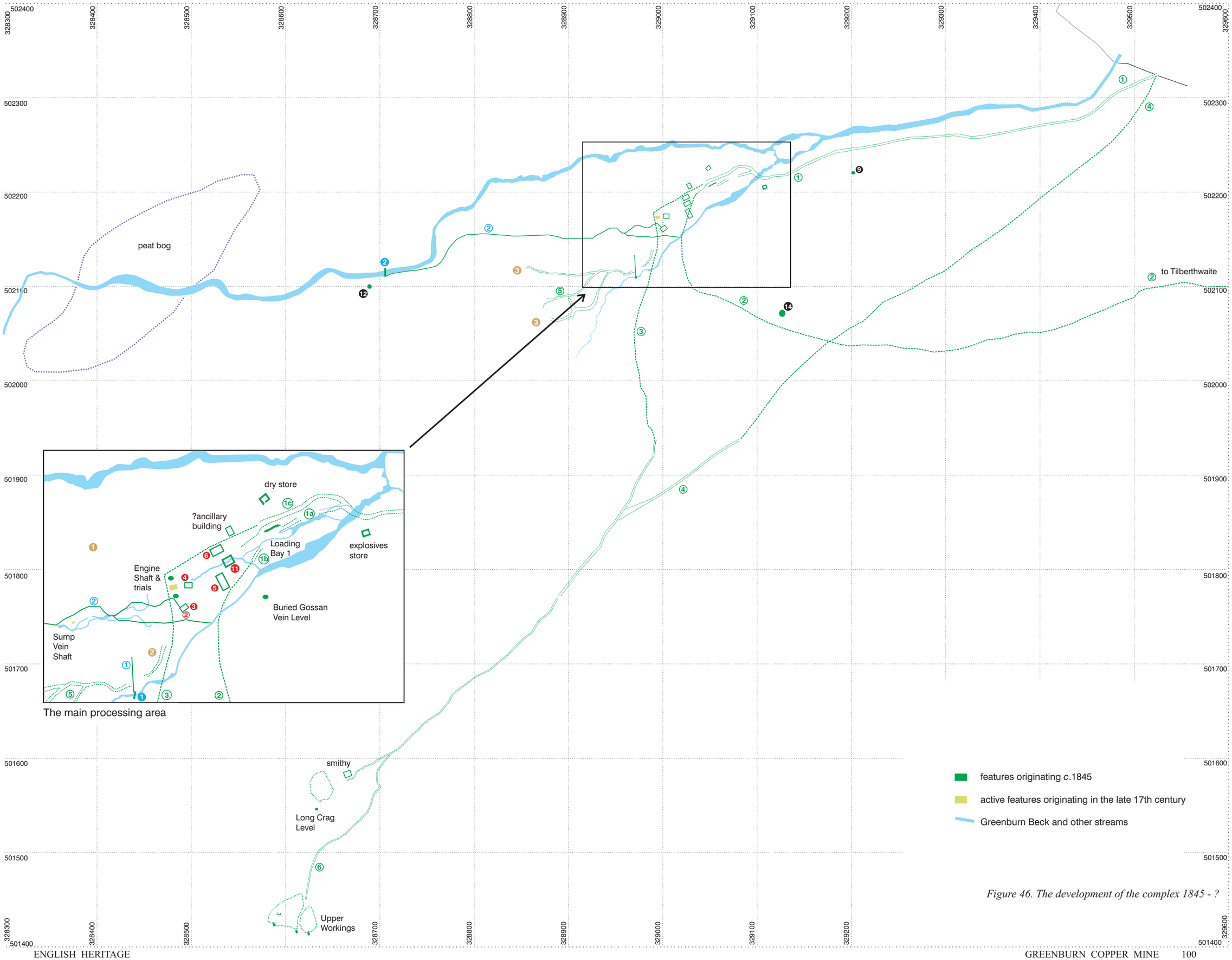


Figure 46. The development of the complex 1845 - ?

flooring of the building suggests that it may have held heavy machinery, but the precise nature of the equipment is uncertain. The concentration of small fragments of copper ore in the area to the east of the later range comprising the accommodation, office and smithy is also difficult to interpret. However, the identification of the physical remains of Loading Bay 1, which appears to predate the redevelopment of the site in the subsequent phase, allows the extent of the processing sequence to be inferred. This structure, like Loading Bay 2 which succeeded it, would almost certainly have lain at the easternmost end of the sequence of structures. This arrangement signalled a shift in the importance of Engine Shaft and a move towards a more efficient sequence of processing, which were greatly to influence the development of the complex in the subsequent phase.

The period immediately after *c.*1845 also saw the construction of Trackway 1 and various ancillary buildings, including the smithy outside Long Crag Level, the dry store and the explosives store, some of which remain relatively well-preserved due to their later re-use. The building on the site of the later range comprising the accommodation, office and smithy, which may well have performed similar functions to the later range, was probably built shortly after 1848. In short, from small-scale beginnings when the mine was first opened *c.*1845, Greenburn Mine appears to have grown rapidly in size and efficiency. Within a few years, a number of the key foundations for the subsequent phase of massive remodelling were put in place.

The period before 1861 (Figure 47)

The tenancy of Crossfield & Co in the period before 1861 can certainly be characterised as the most intensive phase of the exploitation of Greenburn Mine. There was massive investment in the infrastructure, which was matched by extraction on an unprecedented scale. The impressive statistic of £14,000 worth of ore extracted during the tenancy of Crossfield & Co was held up by Captain Vivian and others as clear evidence of the mine's potential for profit-making, but more cautious consideration of the physical remains hints that the operation may not have been as successful as it first seems.

In the absence of detailed documentary evidence for the tenancy of Crossfield & Co, all that can be said concerning the date at which the remodelling of the complex took place is that it occurred after 1848, since it evidently post-dated the mapping of the area in 1847-8, and before 1861, when the company is known to have surrendered the lease. The physical remains offer some clues: the roofs of the buildings erected *c.*1845 may have fallen into disrepair, for in several places roof slates were used in the fabric of the later walls, hinting that the slates had broken and were therefore not fit for re-use as roofing material. Similarly, although the walls of the dry store and explosive store built *c.*1845 still stood, only the lowermost courses of the building on the site of the range comprising the accommodation, office and smithy were re-used, suggesting that this may have been in a ruinous condition by the time the remodelling took place. There are, then, signs that the mine may have lain deserted for some years before the wholescale remodelling took place: a date in the mid-1850s therefore seems plausible.

Following exploratory work in Pave York Top Level, work was probably started on the Pave York Middle Level. Eric Holland's (1981, fig 50) mapping below ground indicates that a fairly long drive through barren rock was needed to reach the vein, but that the workings on the actual line of the vein were not extensive. There is little

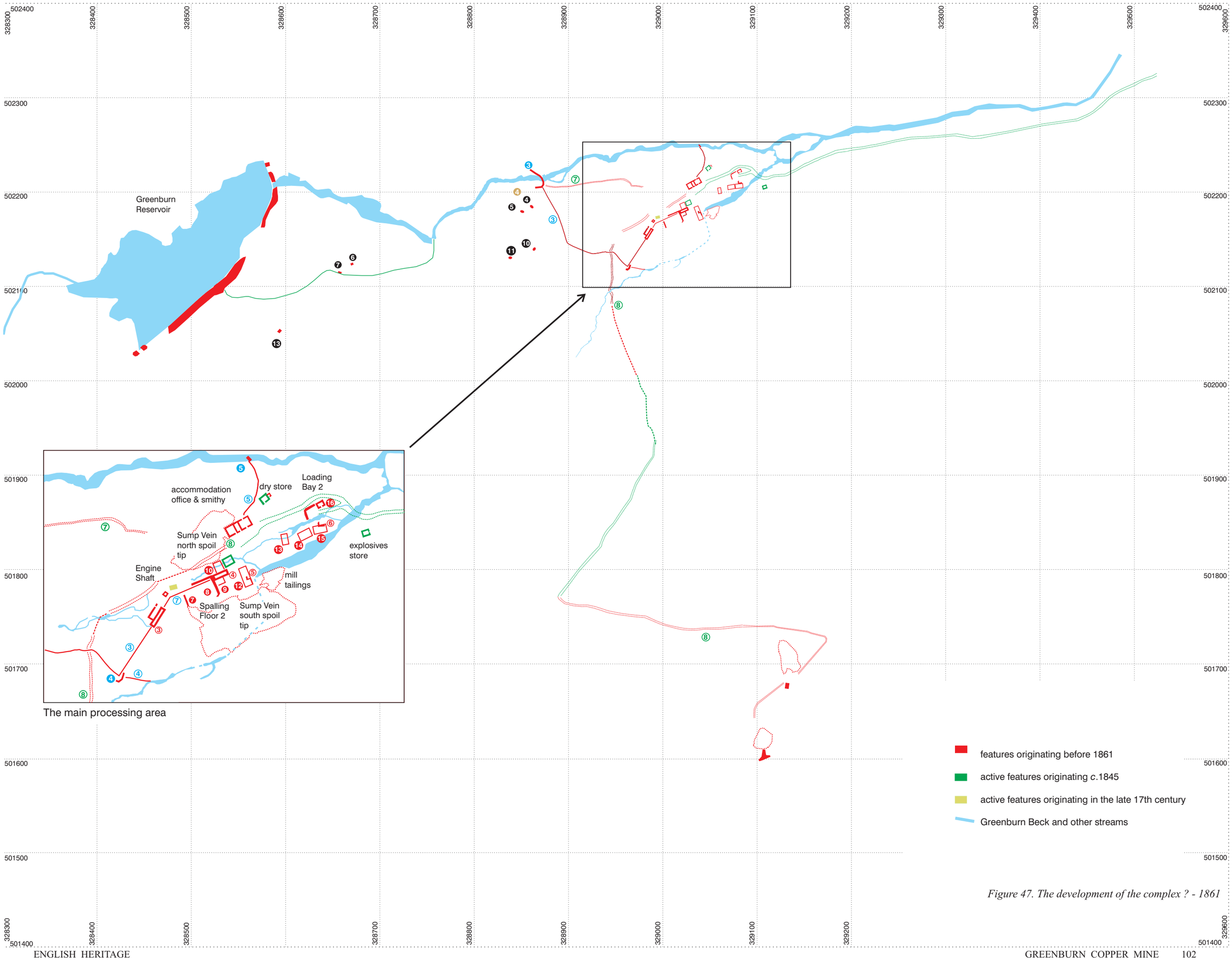


Figure 47. The development of the complex ? - 1861

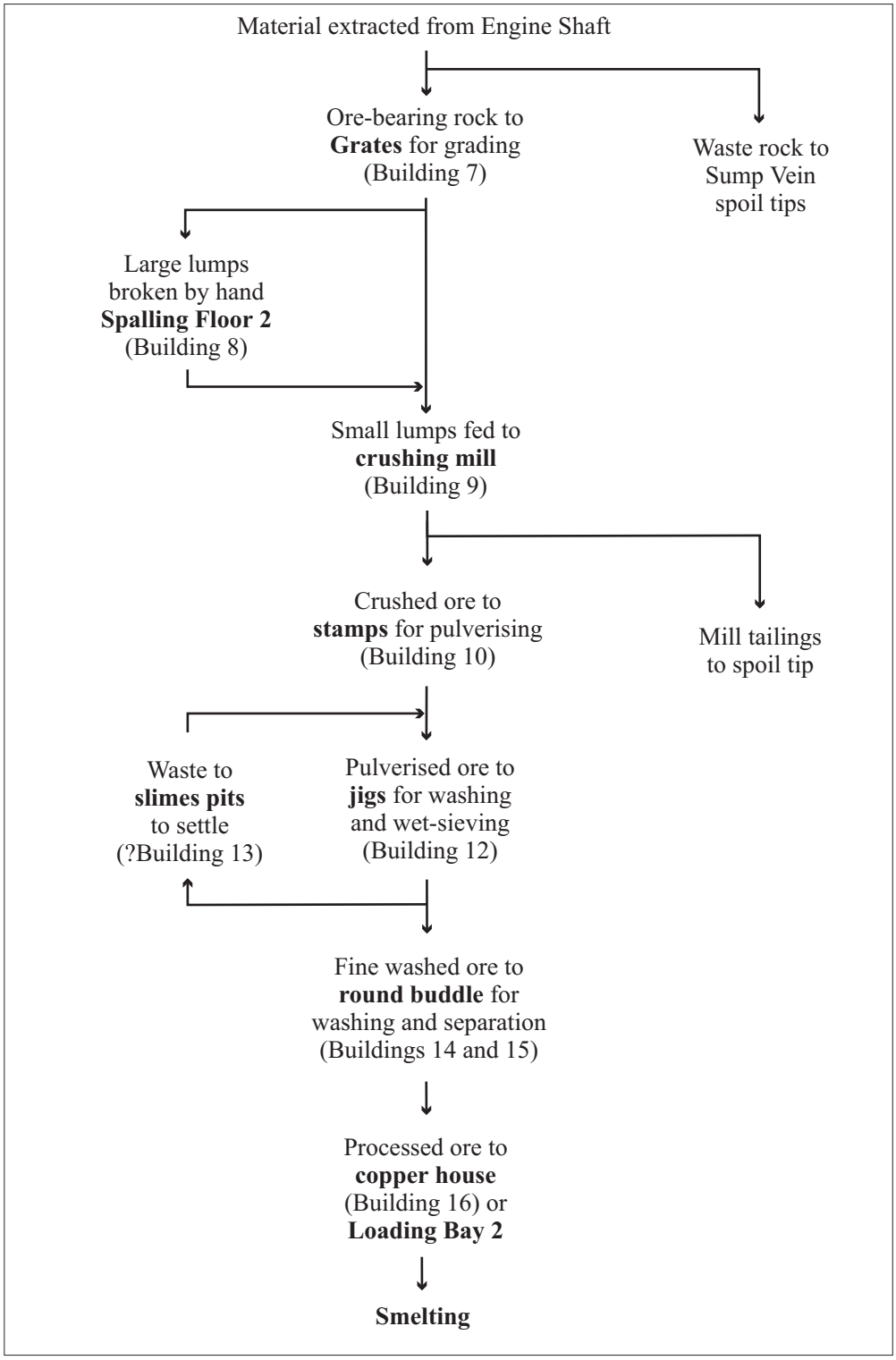
evidence of regular traffic between the working and Spalling Floor 2 and Captain Vivian's report refers to a '…small amount of work', so it is possible that the venture was largely exploratory in nature. Extraction of ore was concentrated on the Sump Vein and, more precisely, on Engine Shaft. Trials 10 and 11 were almost certainly undertaken near the outset of the work to test the alignment and quality of the vein, for they are shown on the large-scale profile/section thought to have been made before 1861 (Cumbria CRO D/Pen/46/file 102-106/document not numbered). Trial 13, which is a cross-cut of similar placement and form, and some of the exploratory quarrying in the immediate vicinty of Sump Vein Trial Shaft may have been carried out at about the same time for similar reasons. Several small cross-cuts on the Low Gill Vein (Trials 4, 5, 6 and 7) are closely comparable in their physical characteristics and may have been completed in the same episode of work. There is no indication that further work at these points on the surface was seriously considered, but the plan of the workings thought to have been added in 1868 to the earlier sheet of drawings indicates that below ground, two cross-cuts were driven towards the vein from the workings on Sump Vein, one east and one west of Engine Shaft.

Except that it would have continued to provide ventilation and emergency access, Sump Vein Shaft was effectively abandoned, so that Engine Shaft became the sole working shaft, housing the pumping and winding gear and allowing access for the miners. This concentration of effort allowed the creation of a much more efficient single production line – almost the embodiment of the Industrial Revolution. Although the extent of the earlier work in the shaft is uncertain, it is clear from the size of the Sump Vein north and south spoil tips that a considerable amount of extraction was undertaken. It seems likely that the concentration on Engine Shaft would have corresponded to the decision to push deeper than the level at which the workings connect with the Sump Vein Shaft, sinking the shaft for a further 168m. The eventual outcome of this work is reflected on the large-scale profile/section thought to have been made before 1861.

The period also saw the construction of Greenburn Reservoir and most of the water wheels and processing buildings whose sites can still be identified, some of which have been overlooked or misinterpreted by previous studies. The large scale plan and profile/section are invaluable in understanding the functions of these structures, allowing a 'flow diagram' for the sequence of processing during the period prior to 1861 to be inferred.

The redesign of the machinery for processing the ore was thorough and well-planned, making good use of the topographic situation of the mine and other natural resources, as well as the pre-existing structures. The ingenuity of the design is particularly evident in the way in which the power of water was harnessed and recycled to supply four water wheels, as well, no doubt, as various washing processes that are less easy to identify. Captain Vivian later commented that the use of water '…saves a vast expense over steam'. However, in so saying, he was referring to the prospects for subsequent tenants, rather than the huge investment of labour, time and money that would would have been necessary to build structures such as the dam of Greenburn Reservoir.

In this period, for the first time, there is also good evidence for the provision of facilities for the men who worked the mine. Although the dry store or dry changing room had probably been constructed *c.*1845, it is possible that the building had originally served some other function and was converted during the tenancy of Crossfield & Co. The toilet block was little more than utilitarian, but was very



probably an improvement on whatever had preceeded it. The newly-constructed range comprising the accommodation block, office and smithy would have offered some degree of comfort. Even the office, with unimproved drystone walls and only a small and apparently unglazed window, would at least have been warm, being sandwiched between the hearth of the smithy and the common room of the accomodation block. Likewise, the accommodation block would have provided light, warmth and a fair degree of space and comfort by the standards of the day.

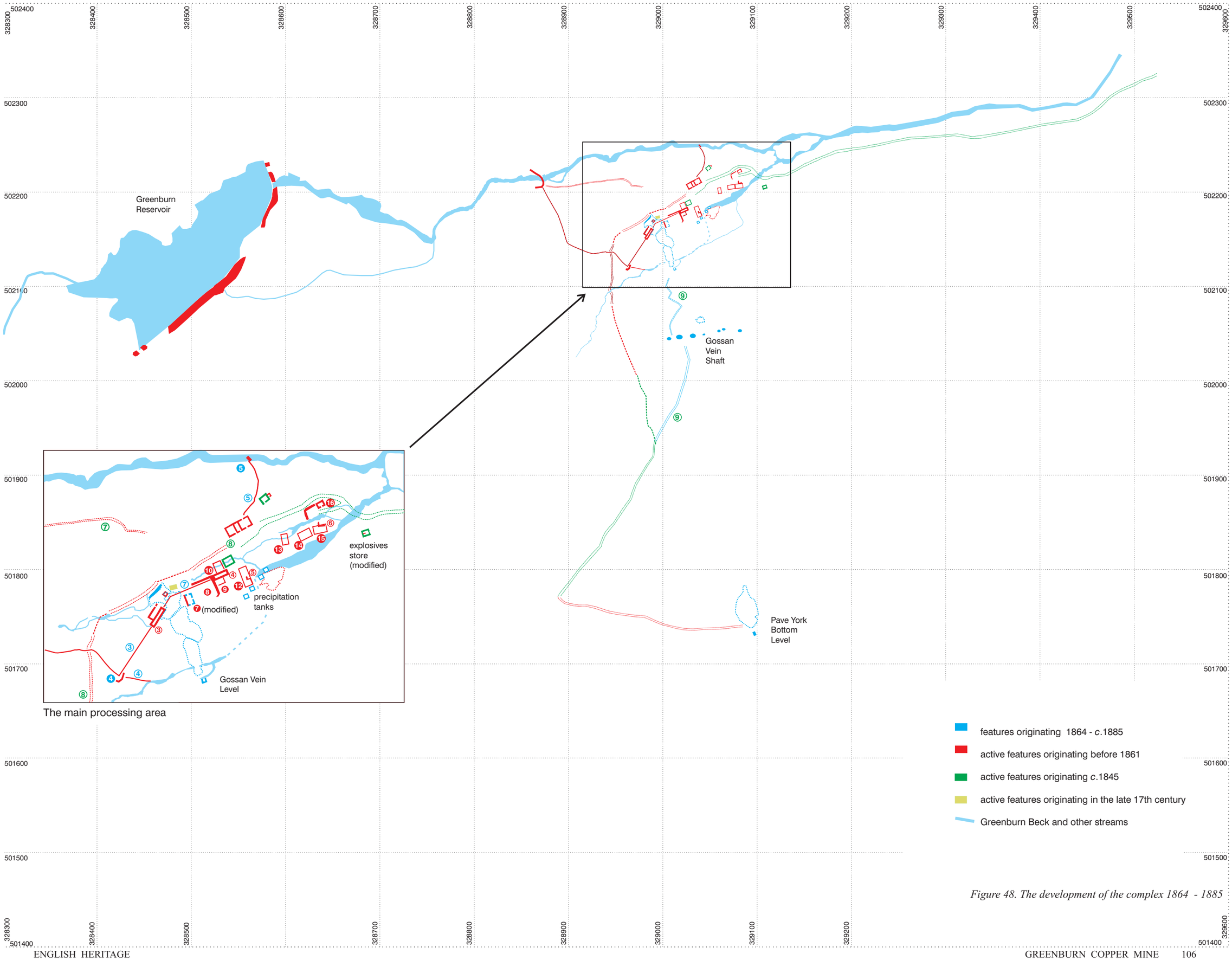
The thoroughness of the remodelling of the complex, together with the sheer size of some of the individual components, suggests that the operation must have been extremely successful, an impression which is reinforced by the glowing comments of Captain Vivian and later mine engineers. Yet there are indications that despite the massive and costly investment in the infrastructure of the mine and the large volume of material that was undoubtedly extracted from Engine Shaft, the actual product in terms of the quantity of processed ore obtained may have represented a relatively poor return. The mound of mill tailings produced by the crushing mill housed in Building 9 is fairly small by comparison with other sites. Although it is possible that some of this material was removed and used to resurface Track 1, the small quantity remaining provides a stark contrast with the massive volume of barren rock dumped on the Sump Vein north and south spoil tips. It is also worth noting that there is no evidence that these spoil heaps were reworked at any stage, as was common at other sites. Eric Holland has also pointed out that the quantity of slimes is small by comparison with many other mining complexes (Holland 1981, 103). His suggestion that some waste material may have been disposed of into the Greenburn Beck is plausible, but does not satisfactorily explain the negligible quantity that does survive. Although this appears to directly contradict what little documentary evidence is available, it is difficult to see why Crossfield & Co would have surrendered their lease within years of such a major capital investment, unless the deposits had been entirely exhausted or the returns were not as high as they had hoped.

The period from 1864 to 1885 (Figure 48)

In 1864, when the entrepreneurial merchant David Dunlop acquired the lease, Greenburn Mine must have seemed on paper to be an attractive opportunity: not only did it possess proven mineral reserves, but also major capital assets in the form of the infrastructure and equipment necessary for efficient production to continue. The years between 1865 and 1885, under the tenancy of various companies including the New Coniston Copper Mining Co and the Greenburn Mining Co, can be characterised as the period when a series of attempts were made to seize the opportunity created by the work done in the preceeding period. Some of these attempts appear to have failed for lack of investment before work even began on the site.

There are hints that the final episode of spoil dumping on the Sump Vein south spoil tip may have resulted from a trial carried out *c.*1864 and this hypothesis is supported by Captain Vivian's comment in 1865 that Engine Shaft was '…in good working order'. The trial must have proved unsuccessful, for there is no documentary or physical evidence to indicate that the shaft was worked at all after 1866. In 1868, Captain Jeffrey recorded that the bottom of Engine Shaft was flooded to a considerable depth and that the reserves of copper ore above that were exhausted. In the light of the trial and the fact that Crossfield & Co had abandoned the working, it must have seemed more sensible to concentrate efforts on the other mineral veins, while making use of the existing processing facilities.

The shaft and level driven to reach the Gossan Vein in 1865-6 were probably amongst the first new ventures. Although Captain Vivian was optimistic in his description of the work, the small quantity of spoil and the lack of clear evidence for a tramway connecting the level with Spalling Floor 2 suggests that it proved unproductive. The fact that the company involved in the work, whose name is not recorded, was no longer in existence three years later seems to confirm that this too proved less profitable than had been hoped.



The main processing area

Figure 48. The development of the complex 1864 - 1885

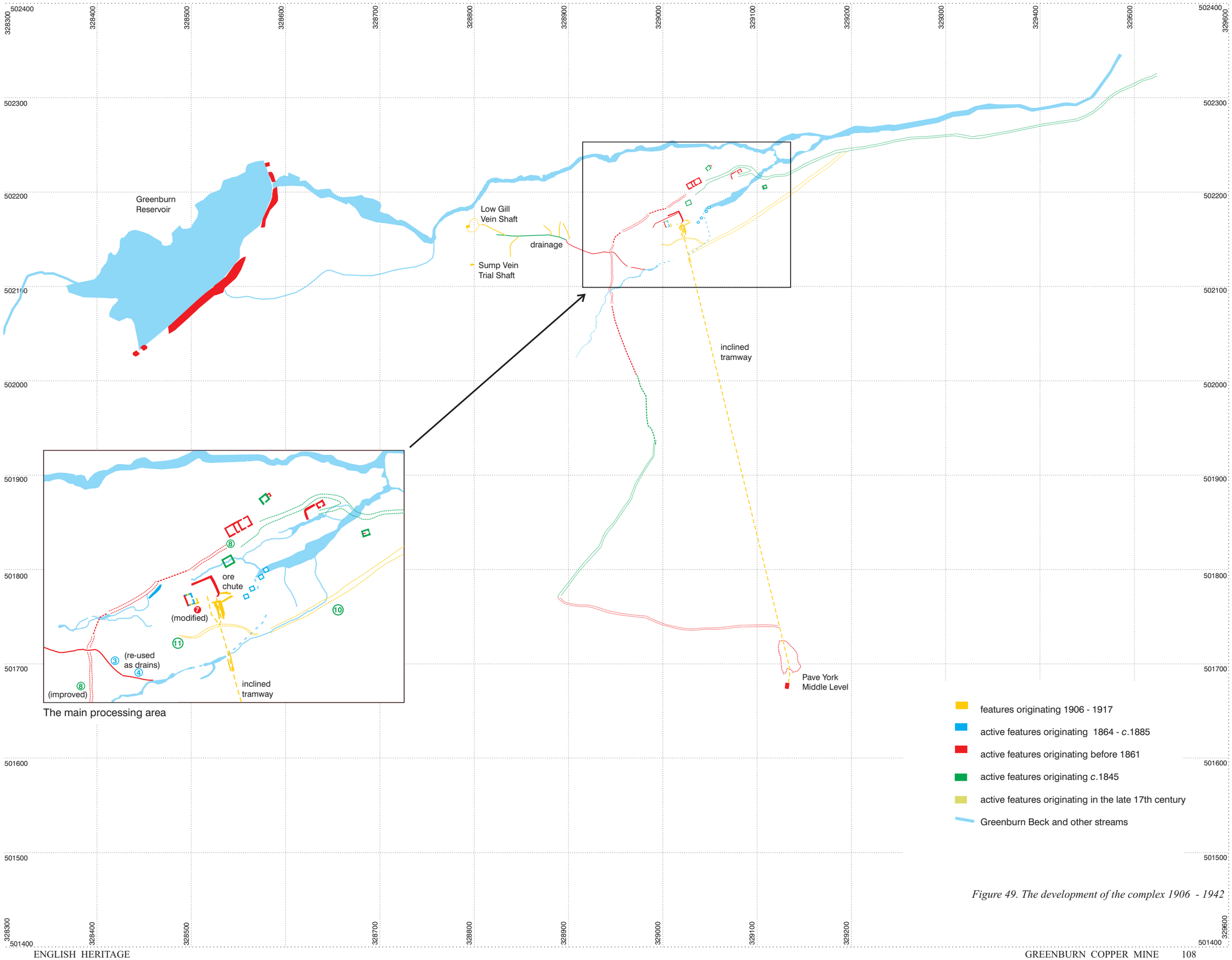
Captain Vivian described the Pave York Vein as '…the main lode…deserving of vigorous prosecution' and his high opinion was echoed by Captain Jeffrey in February 1868, who declared 'I cannot speak too highly of it'. Whether any actual work was done by the New Coniston Copper Mining Co which had commissioned Captain Jeffrey's report is uncertain, but Thomas Lawn's report proves that work on the Pave York Bottom Level took place during the tenancy of the Great Coniston Copper Mining Co, after *c.*1873. This company probably installed the precipitation tanks, perhaps necessitating the demolition of part of Building 12, which had formerly housed the jigging equipment. The switch to a new processing technique may have made some of the other buildings redundant. Water Wheel 4, which powered the crushing mill housed in Building 9 and the battery of stamps in Building 10, probably remained in use, for the tanks were apparently deliberately sited in proximity to this equipment. After 1866, Water Wheel 3 would no longer been used to power the pumping and winding gear in Engine Shaft, but it may have been converted to serve other functions, perhaps powering equipment on Spalling Floor 2. It is difficult to detect whether any further changes were made on the site between *c.*1875 and *c.*1885, but it seems unlikely that any intensive mining or processing would have been completed.

The period from 1906 to 1940 (Figure 49)

During the first three years of the tenancy of the Greenburn and Tilberthwaite Syndicate, between 1906 and 1908, it is clear that a serious attempt was made to resurrect work at Greenburn Mine almost from scratch. The water wheels and processing equipment had probably been removed for scrap or re-use elsewhere soon after 1885, robbing the site of one of the most important assets it had possessed in the preceeding period. The ambitious nature of the projects undertaken *c.*1906 and the presence of a workforce of up to seven men implies considerable capital investment and a determination to succeed, but in the event the high expectations of the company proved ill-founded.

The main effort at copper extraction was on the Pave York Middle Level, where work had been started and discontinued prior to 1861. The inclined tramway was constructed to facilitate the transport of ore to the main processing area and it is probable the easternmost of the three workings on the vein was chosen as being the most conveniently sited. The total of 46 tonnes extracted in 1906 and 1907 was not great by the standards of the day, so the investment of time and money in the construction of the tramway would have been poorly rewarded. Similarly, careful and extensive work was undertaken in preparation for the Low Gill Vein Shaft, exemplified by the well-constructed mouth of the shaft and the attempt to drain the boggy area between the working and the main processing area. The small quatity of spoil, both at the Low Gill Vein Shaft and at the more opportunistic Sump Vein Trial Shaft, indicates that it would have been wiser to establish the quality of the ore before committing so much effort to the preparatory work.

There is strong evidence that the water wheels which had powered the crushing mill and other processing machinery until *c.*1885 were made inoperable by the blocking of Leat 3 in about 1906; it is possible that the wheels themselves were removed for scrap or re-use soon after 1885. The provision of power to the complex in the early 20th century remains an important, and unanswered, question. It is possible that a steam engine, many of which were in use at this time, may have been installed on Spalling Floor 2. Alternatively, a 'pelton wheel' may have been used; this was a type of enclosed water wheel driven by a pressurised jet supplied via a cast iron pipe. Once



The main processing area

Figure 49. The development of the complex 1906 - 1942

removed for scrap or re-use, such equipment might have left little or no trace on the surface. However, there is no physical or documentary evidence to support either conjecture. Building 7 may have experienced its final episode of use at this time, perhaps even functioning as a housing for the putative steam engine. It seems likely that what little ore was crushed would have been processed solely in the precipitation tanks that had been installed *c.*1873.

The tenancy of the Langdale, Silver Lead and Copper Co was probably the final period of serious work at Greenburn Mine. Although the company extracted a similar quantity of ore to the Greenburn and Tilberthwaite Syndicate, there is no obvious sign of their presence at the site. In part, this may be because the earlier equipment remained in use, but the inclined tramway had apparently already been dismantled and the source of the ore remains uncertain. It is particularly telling that while other mineral mines were experiencing a boom, due in particular to the high demand from the armaments industry, the operation at Greenburn did not outlast the First World War. The period between 1917 and the dissolution of the Greenburn and Tilberthwaite Mining Co in 1942 witnessed very little apart from the slow deterioration of the buildings and the donation of the land to the National Trust by Beatrix Heelis.

Conclusions

The surviving remains of Greenburn Mine are not as extensive as those of the main group of the Coniston Copper Mines and in some respects are less spectacular. The relevant documentary evidence is also relatively scarce, especially for the period of the mine's most intensive phase of use. However, in spite of the lack of historical detail, the development of Greenburn Mine is relatively well understood as a result of the detailed field investigation. Furthermore, unlike many other mines, the complex experienced a very gradual decline over the period from *c.*1861 to 1942, during which most of the earlier structures were evidently kept in good repair and few major modifications were made. As a result, the site presents an unusually complete picture of a mine of the mid-19th century. As previous investigations have concluded, this quality of preservation makes the complex relatively easy to appreciate visually and lends itself to the display and interpretation of the remains.

structure possibly built *c*.1690
structure built *c*.1845
structure built before 1861
structure built 1864 - *c*.1885
structure built 1906 - 1917
leat

Figure 50.
Profiles across the main processing area at different phases

WSW

ENE

c.1690

possible buried structures
Engine Shaft
Buildings 1 & 2
Water Wheel 1 (?crushing mill)
?grates platform
barrow run
Spalling Floor 1
Sump Vein Shaft

c.1845 - ?

Loading Bay 1
?Buried Gossan Vein Level
Building 11 (heavy machinery?)
Approximate position of Buildings 5 and 6
Approximate position of Building 4
Engine Shaft
Approximate position of Building 3 and Water Wheel 2
Leat 2
Sump Vein Shaft

? - 1861

Building 16 (copper store)
Loading Bay 2
Building 15 (round buddle)
Building 14
Building 13 (?slime pits)
slimes
Leat 9
tailings from crushing mill
Building 12 Water Wheel 5 (jigs)
Building 11 (? store)
Leat 8
Building 10 to front (stamps)
Spalling Floor 2 Building 8 (site uncertain)
Water Wheel 4 Building 9 to rear (crushing mill)
Leat 7
Building 7 (grates)
tramway
winding and pumping gear
Water Wheel 3 and engine house
Leat 3
Dam 4
?virtually disused
Engine Shaft

1864 - *c*.1885

Building 16 (copper store)
Loading Bay 2
processing buildings disused after 1873?
reservoirs
Building 12 disused or partially demolished?
precipitation tanks (1873)
Gossan Vein Level (1865 - 1866)
Building 7 (modified)
tramway (?1864-5)
disused by 1866

1906 - 1917

Building 16 refurbished (copper store?)
Loading Bay 2
?reservoirs
precipitation tanks
chute
inclined tramway from Pave York Middle Level
steam engine powering crushing mill?
Building 7 (modified - function unknown)
disused

242.0m above mean sea level
0 10 50 100 metres
0 10 20

7. METHODOLOGY

The field investigation was carried out by Alastair Oswald, David McOmish and Stewart Ainsworth, with assistance from Kim Naylor-Vane. The ground photographs included in this report were taken by Alastair Oswald, but it is intended to complete medium-format photographic recording, replicating all the images included in this report, in the summer of 2001. The RCHME aerial photographs were taken in April 1997 by Peter Horne.

The majority of the survey was carried out using a Trimble dual frequency Global Positioning Satellite (GPS) system. The base receiver was set up overlooking the processing area on permanent survey station ST01 and two receivers (Trimble 4700 and 4800 models) were used to record the remains, working independently in real-time kinematic mode. The co-ordinates of the base receiver were initially calibrated to the National Grid (OSGB36) using Trimble Geomatics software, based on the position of the receiver relative to Ordnance Survey active GPS stations at Carlisle, Glasgow and Newcastle. In addition to permanent survey station ST01, a second marker (ST02) was established, intervisible with the first, to allow future work with conventional survey equipment. The positions of both stations are marked by brass rivets set into rock outcrops. Their positions are indicated on the 1:500 plans and further details are recorded in Appendix 2. The resulting plan was plotted at 1:500 scale and 1:2500 scale via Key Terrafirma, AutoCAD and Coreldraw 8 software. Minor details of the plan were supplied with tape measures using standard graphical techniques. The profile/section across the processing area was surveyed using a Leica TC1610 Electronic Theodolite with integral Electromagnetic Distance Measurement (Total Station).

All the plans, profiles, and interpretative drawings were prepared by Alastair Oswald, with assistance in the later stages from Trevor Pearson, using AutoCAD and CorelDraw 8 software. The three historic editions of the Ordnance Survey 6-inch scale map were compared with the English Heritage plan in a digital environment, offering the best possible accuracy in the context of the small scale of the original depiction. The elevation of the front of the range comprising the accommodation, office and smithy was prepared using a sequence of digital photographs: photogrammetric rectification of these images was not carried out, so parts of the resulting drawing are slightly distorted. This report was researched and written by Alastair Oswald, and edited by Stewart Ainsworth.

The site archive has been deposited in English Heritage's National Monuments Record, Great Western Village, Kemble Drive, Swindon SN2 2GZ, to where applications for copyright should be made (reference number: NY 20 SE 9).

8. ACKNOWLEDGEMENTS

English Heritage would like to thank Robert Maxwell of the National Trust for commissioning the field investigation and facilitating its completion, as well as for contributing to some very productive discussions on site. Thanks are also due to Mrs S Barker, Honorary Secretary of the Cumbria Amenity Trust Mining History Society, to Eric Holland, to John Adams and to the staff of the Cumbria County Records Offices for their help in tracking down documentary material. Warren Allison of the Mines of Lakeland Exploration Society kindly commented on the interpretation of certain aspects of the processing.

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9.2 Primary sources held in Cumbria County Record Office

A box of documents labelled D/Pen/46, held in the Whitehaven branch of Cumbria Record Office contains a series of files, each containing a series of individually numbered documents. However, the numbered documents are not all held in the files that bear their numbers, nor are they in numerical order, and several documents that are not numbered at all have been added; these appear to have been catalogued previously under the reference D/Pen/Bundle 60, and are currently listed as 'missing' from that collection. In the list below, the titles of the relevant individual documents are reproduced as catalogued, but the descriptions have been corrected or completed where necessary; such amendments are distinguished by square brackets.

D/Pen/Bundle 60 Counterpart lease (draft) signed by David Dunlop

D/Pen/46/file 83-89 contains (in the order that they are filed):

(85) Document re sale of mining equipment at Gillhead copper mine [and Greenburn] in Manor of Tilberthwaite to Sir William Pennington by William Monson and William Thompson, 28 February 1698

(84) Account of copper ore weighed up at Gillhead Mine, Tilberthwaite [and Greenburn] [1694-7]

(88) Proposals for lease of copper mines in Langdale and Tilberthwaite [02 October] 1730

(87) Lease, Sir William Pennington to Nehemiah Champion and James Gorton of copper mines in Tilberthwaite, 10 October 1717

(86) Draft lease of copper mines in Tilberthwaite (copy of above lease) 20 September 1717

(not numbered) Share application form for New Coniston Copper Mining Co [*c.*1868]

D/Pen/46/file 90-99 contains (in the order that they are filed):

(not numbered) Report on Great Coniston Copper Mine by Thomas Lawn, 15 August 1874

(106) Lease, Sir John Pennington to Michael Knott of Waterhead House in the parish of Hawkshead and John Taylor of Bedford Row, minerals at Tilberthwaite and Little Langdale, 14 February [1826]

(104) Draft lease of minerals at Tilberthwaite [and Little Langdale] to William Roe, July 1799

(not numbered) Map of [New] Coniston Copper Mine [pre-1861]

(not numbered) Prospectus of The New Coniston Copper Mining Co, including reports on the mine by Captain S Vivian, principal agent of the West Caradon Mine, Cornwall, 7 December 1865, and Captain William Jeffrey of Driggeth Mines,

Caldbeck, Cumberland, 11 February 1868 [and Captain Benjamin Gribble of Coniston, Lancashire, 11 March and 21 March 1868] [*c*.1868]

(103) Draft license to search for copper at Tilberthwaite [and Little Langdale] Rt. Hon. Sir John Pennington to George Wilson and Rowland Wilson, 1799

D/Pen/46/file 102-106 contains (in the order that they are filed):

(not numbered) [Draft] lease, the Rt. Hon Gamel Augustus Pennington Baronet Lord Muncaster to John Barratt, Church Coniston in the County of Lancaster, miner, James Hambleton of Alsten Field, Ashbourne, in the County of Derby, Gent., and Joseph Mason of Grassington in the County of York, Gent., of the copper mines in Tilberthwaite known as [Greenburn] Copper Mine 10 August 1853

(not numbered) Small surface plan of New Coniston Lodes [pre-1861]

(not numbered) Articles of Association, Great Coniston Copper Mining Company [in the names of James Andrew, Samuel Clift, Elijah Robinson, William Stanyer, Reuben Cooper, Robert Wilson and William Penny] registered on 10 April 1873

(102) Draft lease, Rt. Hon. Sir John Pennington to George Wilson & Co to search for copper and iron ores in Little langdale and Tilberthwaite, 1799

APPENDIX 1. NMR NUMBERS LINKED TO THE SURVEY

Feature	Grid reference	NMR number
Accommodation block, office and smithy (**parent record**)	NY 2903 0221	NY 20 SE 9
Greenburn Beck Level	NY 2931 0229	NY 20 SE 10
Greenburn Beck Shaft	NY 2925 0228	NY 20 SE 11
Sump Vein Level	NY 2896 0217	NY 20 SE 12
Engine Shaft	NY 2899 0217	NY 20 SE 13
Sump Vein Shaft	NY 2894 0215	NY 20 SE 14
Buried Gossan Vein Level	NY 2904 0216	NY 20 SE 45
Long Crag Level	NY 2864 0155	NY 20 SE 15
Upper Workings on Long Crag Vein	NY 2861 0142	NY 20 SE 16
Pave York Vein Upper Level	NY 2911 0160	NY 20 SE 19
Pave York Vein Middle Level	NY 2913 0168	NY 20 SE 18
Pave York Vein Bottom Level	NY 2910 0174	NY 20 SE 17
Gossan Vein Shaft	NY 2904 0205	NY 20 SE 20
Gossan Vein Level	NY 2901 0210	NY 20 SE 21
Low Gill Vein Shaft	NY 2879 0216	NY 20 SE 22
Sump Vein Trial Shaft	NY 2880 0212	NY 20 SE 23
Minor Trials	VARIOUS	NY 20 SE 24
Slate quarries	VARIOUS	NY 20 SE 25
Track 1	NY 2904 0221 - NY 2952 0232	NY 20 SE 26
Inclined Tramway	NY 2913 0168 - NY 2902 0217	NY 20 SE 2
Dam 1	NY 2897 0211	NY 20 SE 28
Dam 2	NY 2871 0212	NY 20 SE 29
Dam 3	NY 2896 0212	NY 20 SE 30
Greenburn Reservoir	NY 2848 0205 - NY 2858 0222	NY 20 SE 31
Dam 4	NY 2887 0221	NY 20 SE 32
Dam 5	NY 2904 0225	NY 20 SE 33
Water Wheel 1	NY 2898 0215	NY 20 SE 34

Water Wheel 2	NY 2900 0216	NY 20 SE 35
Water Wheel 3	NY 2899 0216	NY 20 SE 36
Water Wheel 4	NY 2902 0218	NY 20 SE 37
Water Wheel 5	NY 2904 0218	NY 20 SE 38
Water Wheel 6	NY 2908 0221	NY 20 SE 39
Spalling Floor 1	NY 2895 0215	NY 20 SE 40
Spalling Floor 2	NY 2901 0217	NY 20 SE 41
Precipitation tanks	NY 2904 0217	NY 20 SE 42
Dry store	NY 2905 0226	NY 20 SE 43
Explosives store	NY 2911 0220	NY 20 SE 44

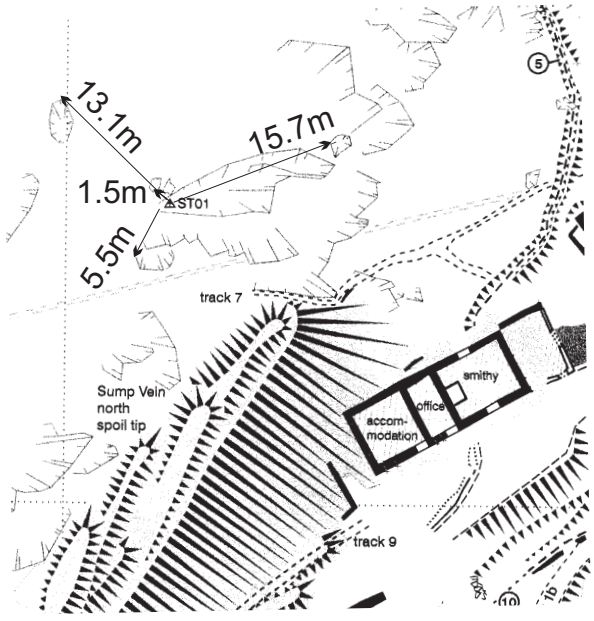
APPENDIX 2. DETAILS OF PERMANENT MARKERS

SURVEY STATION INFORMATION

ENGLISH HERITAGE

SITE NAME	Grenburn Mine, Cumbria		
Station number	ST 01	**Status**	Permanent
Type of Mark	Brass rivet in rock	**NMR number**	NY 20 SE 9
Date of Survey	27-NOV-2000	**Sam number**	
Office of origin	York	**RSM number**	
Surveyor(s)	AO; DM; SA	**Neg number**	

Co-ordinate Scheme	**Eastings**	**Northings**	**Height**
OS National Grid	329 009.085	502 226.389	261.678
Divorced Site Grid			



SURVEY STATION INFORMATION

ENGLISH HERITAGE

SITE NAME	Greenburn Mine, Cumbria		
Station number	ST 02	**Status**	Permanent
Type of Mark	Brass rivet in rock	**NMR number**	NY 20 SE 9
Date of Survey	27-NOV-2000	**Sam number**	
Office of origin	York	**RSM number**	
Surveyor(s)	AO; DM; SA	**Neg number**	

Co-ordinate Scheme	**Eastings**	**Northings**	**Height**
OS National Grid	328 939.143	502 132.520	270.950
Divorced Site Grid