Cook's Kitchen, Pool, Redruth, Cornwall: Archaeological Excavation of the Man-Engine House

Cornwall Archaeological Unit

Report No: 2018R023

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Archaeological Excavation of the Man-Engine House

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Acknowledgements

This study was commissioned by Kate Rhodes of Atkins on behalf of Western United Mines and was carried out by Cornwall Archaeological Unit, Cornwall Council.

The Project Manager was Adam Sharpe. Excavation team: Ryan Smith, Fuller Hughes, Martin Andrewes and Adam Sharpe.

The views and recommendations expressed in this report are those of Cornwall Archaeological Unit and are presented in good faith on the basis of professional judgement and on information currently available.

Freedom of Information Act

As Cornwall Council is a public authority it is subject to the terms of the Freedom of Information Act 2000, which came into effect from 1st January 2005.

Cornwall Archaeological Unit is a Registered Organisation with the Chartered Institute for Archaeologists

Cover illustration:

Looking north toward Chapple's shaft across the remains of the Cook's Kitchen man engine.

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Abbreviations

CAU	Cornwall Archaeological Unit
CIfA	Chartered Institute for Archaeologists
LPA	Local Planning Authority (Cornwall Council)
OD	Ordnance Datum – height above mean sea level at Newlyn
OS	Ordnance Survey

1 Summary

Cornwall Archaeological Unit (CAU) was commissioned by Kate Rhodes of Atkins on behalf of Western United Mines Ltd. to carry out an assessment at the site of the former Cook's Kitchen man engine house, South Crofty, Pool, Cornwall. The aim was to determine the condition and extent of the buried remains of the engine house, to excavate and record the remains revealed and prepare them for future conservation work.

In September 2016 a Written Scheme of Investigation had been produced for Western United Mines by Atkins, detailing the requirements for complying with the requirements for archaeological recording set out in conditional planning permission PA10/04564 granted by Cornwall Council in 2011. Four conditions were placed upon the proposed development relating to the protection and recording of areas of archaeological and historical interest within the boundary of the South Crofty mine complex.

The condition relevant to the work to which this report relates included a requirement to carry out the excavation of the Cook's Kitchen man engine house to determine the extent of the buried remains and the degree to which they survived.

Between Monday 12th March and Monday 26th March 2018 the buried remains of the Cook's Kitchen horizontal man engine house and associated boiler houses were revealed and recorded. Although the machinery formerly sited here had been wholly removed and the superstructure of the building had been demolished, and once more than 3m of rubble covering the remains had been removed by machine and by hand, it was found that enough of the structure survived to enable the interpretation of most of what remained.

The excavation revealed the remains of the horizontal engine house which, from 1871 to the end of the 19th century, had powered the Cook's Kitchen man-engine together with its original boiler house and the truncated remains of its attached chimney stack. Abutting this were the reasonably well-preserved remains of a building which had housed an additional pair of Cornish boilers; this appeared to have been constructed during the last decade of the operation of the engine; adjoining this were the poorly-preserved remains of a possible late 19th century compressor house. Associated drains and a cinder disposal area were also revealed and recorded. A number of artefacts were retrieved during the work; these largely consisted of a mixture of small pieces of unidentifiable corroded metalwork and modern rubbish.

This report details the results of the excavation and recording and sets them within a local, national and international context.

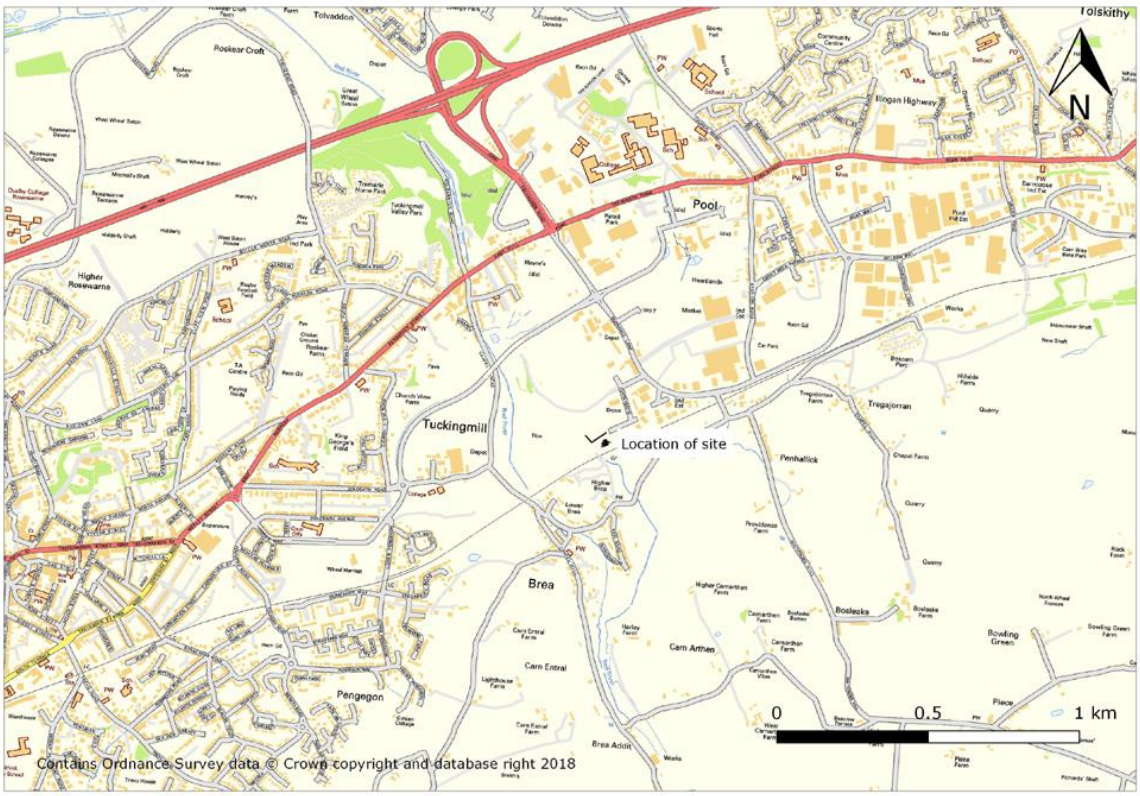


Figure 1: Location of site.

Figure 2: Extent of excavated area (within purple line).

2 Introduction

2.1 Project background

Following nearly two decades of closure, Western United Mines Ltd. has now secured the necessary financial backing to commence with the reopening of South Crofty mine, Pool, Cornwall. In order to achieve this South Crofty will need to construct some significant new surface infrastructure – in particular a mine water treatment facility and a modern minerals processing plant. The latter is to be constructed over the former site of the Cook's Kitchen dressing floors, these having been abandoned and largely demolished at the end of the 19th century when Cook's Kitchen was abandoned as a working entity. The area they occupied was wholly buried under many metres of landscaped waste material during the 20th century, though elements of these floors may well be uncovered and archaeologically recorded during the excavations required for the construction of the new mill.

In tandem with these works, the exposure and recording of the Cook's Kitchen man-engine house and associated buildings was to be undertaken, following which this structure was to be conserved; the adjacent pumping and winding engines adjacent to Chapple's Shaft have already been consolidated.

Planning decision PA10/04564 dated 03 November 2011 contained a number of archaeological recording conditions. Relevant to the archaeological excavation and recording of the man-engine house and adjacent structures, Condition 8 stated:

No demolition/development shall take place/commence until a programme of archaeological work including a Written Scheme of Investigation has been submitted to, and approved in writing by the MPA. The scheme shall include an assessment of significance and research questions and detail:-

(i) the programme and methodology of site investigation and recording;

(ii) the programme for post investigation assessment;

(iii) provision to be made for analysis of the site investigation and recording;

(iv) provision to be made for publication and dissemination of the analysis and records of the site investigation;

(v) provision to be made for archive deposition of the analysis and records of the site investigation;

(vi) nomination of a competent person or persons/organisation to undertake the works set out within the Written Scheme of Investigation.

No demolition/development shall take place other than in accordance with the Written Scheme of Investigation referred to above.

Reason: To protect areas of archaeological/ historical interest.

Condition 15 states:

'The development shall not be brought into use until the site investigation and post investigation assessment has been completed in accordance with the programme set out in the Written Scheme of Investigation and the provision made for analysis, publication and dissemination of results and archive deposition has been secured.

Reason: To protect areas of archaeological/historical interest'.

A Written Scheme of Investigation was produced by Atkins Ltd for the site developer in September 2016 (see Appendix 5). The stated aims of the work described in this document, which has been approved by the LPA, are to:

- *Establish the extent, degree of survival of the former horizontal engine winder house to Dunkin's shaft and to expose and record these remains prior to their consolidation.*
- *Establish the degree to which elements of the Cook's Kitchen mine (specifically the dressing floors and associated structures) survive within the footprint of the proposed processing building.*
- *Establish, where possible, the extent, date, character, condition and significance of archaeological structures, features, deposits and artefacts within the proposed development area.*
- *Define and archaeologically record these remains prior to their loss during construction.*
- *Place any identified archaeological remains within their historical context.*
- *Understand the presence/ absence/ significance of any archaeological features in terms of their relevance and contribution to the Outstanding Universal Value of the World Heritage Site (without prejudice to any remains of earlier or later periods).*
- *Provide a comprehensive and accurate record of the detached mine chimney (also associated with Cook's Kitchen mine) prior to its demolition.*
- *Produce an integrated and indexed archive of the results of the fieldwork for deposition in an appropriate repository.*
- *Produce an assessment report for the results of the archaeological fieldwork outlining the significance of the archaeological remains uncovered and if appropriate advancing proposals for the publication of the results of the archaeological work.*

2.2 Aims

The aims and objectives of these archaeological works were to:

- Establish the extent, degree of survival of the former horizontal man-engine winder associated with Dunkin's shaft and to expose and record these remains prior to their consolidation.
- Produce an integrated and indexed archive of the results of the fieldwork for deposition in an appropriate repository.
- Produce an assessment report summarising the results of the archaeological fieldwork, outlining the significance of the archaeological remains uncovered and if appropriate advancing proposals for the publication of the results of the archaeological work.

2.3 Methods

All recording work was undertaken according to the Chartered Institute for Archaeologists Standards and Guidance for Archaeological watching brief (CIfA 2014) and the CIfA Standard and Guidance for Archaeological excavation (CIfA 2014a). The Chartered Institute for Archaeologists is the professional body for archaeologists working in the UK.

2.3.1 Desk-based research

A desk-based assessment was undertaken in order to investigate the historical and technical background of the man-engine installation at Cook's Kitchen. Historical databases and archives were consulted together with technical sources. The main sources consulted were as follows:

- Cornwall HER and CAU reports including Sharpe 1993;
- Early maps and photographs;
- GIS datasets available to CAU;
- Published histories;
- Web-based resources.

2.3.2 Fieldwork

On Monday 12th March 2018, excavation commenced on the site of the former Cook's Kitchen man engine. An 18 tonne swing shovel fitted with a toothed bucket was used to remove the overburden from the site to a depth of between 2m and 3.5m; a toothless bucket was used to remove spoil in close proximity to the standing remains of the engine house and boiler houses. A one tonne swing shovel was used in the more cramped areas of the site to remove overburden which would have taken a considerable amount of time to remove by hand or where greater delicacy of machine excavation was required. The full machine excavation of the interior of what proved to be the western boiler house on the site had to be halted owing to the marked instability of its eastern and northern walls and this area of the site was not fully cleared and recorded as a result. Whilst bulk excavation of the overburden within the interior of the small building on the eastern side of the site was carried out, there was insufficient time available to undertake any subsequent detailed excavation of its interior.

Hand excavation commenced to determine the extent and condition of the standing remains associated with the engine house and adjoining boiler houses. The presence of some remaining overburden and the structurally poor condition of some features constrained what could be achieved to some extent, as did the presence of large pieces of granite rubble within the interior of the engine house (these being too heavy to be removed by hand), though the majority of the features making up the site were excavated and recorded.

A Leica GPS unit was used to record the locations of walls and other features; further detailed measurements were taken by hand where required.

The resulting plans were backed up by notes. Photographs were taken using Pentax K3 Digital SLR (12mp) camera showing general views and feature detail, and also to allow photogrammetric stitching for elevations. Black and white archive photographs were also taken. A Mavic Pro drone equipped with a 12.4mp camera was used to take vertical images of the site; these were used in the production of the site plan.

All contexts were sequentially numbered (Appendix 1), whilst artefacts were recovered and bagged for further examination off-site. The majority were judged not worth retention.

3 Location and setting

The former Cook's Kitchen copper and tin mine is located to the south of Pool and Tuckingmill (Figs 1 and 2). This was one of a group of very significant, rich and deep mines located to the north of Carn Brea which operated from the early 18th century until the early decades of the 20th century. All were subsequently incorporated into the sett of South Crofty. The core of the Cook's Kitchen site is located at SW 66501 40596 at Chapple's Shaft, close to which are a conserved pumping engine house, its detached chimney and a conserved whim engine house. The man-engine house and associated structures are sited just to the east of these buildings on land adjoining the main line railway centred at SW 66548 40589.

Following the closure of Cook's Kitchen in the early years of the 20th century, almost all of its surface remains (including the man-engine house) were partly or wholly demolished and subsequently became buried under material produced during the excavation of South Crofty's Decline Shaft, together with waste material produced during the operation of South Crofty's mill.

4 Designations

4.1 International

The site falls within Area 5 (Redruth and Camborne) of the Cornwall and West Devon Mining Landscapes World Heritage Site, inscribed by UNESCO in 2006. This part of the

World Heritage Site is recognised as its core area, one which sited the majority of its most important mines, engine houses and engineering works.

4.2 National

None apply to the man-engine house. The nearby and associated Chapple's Shaft pumping engine house and its associated chimney and its winding engine house are all Grade II Listed Buildings (National References 1328162, 1160769 and 1142629 respectively).

4.3 Regional/county/local

None apply to the man-engine house. The southern boundary of the Tuckingmill Conservation Area is 530m to the north of the site.

5 Site history

The sett of Cook's Kitchen, whose principal shaft (Chapple's) is sited at SW 66470 40586, lay immediately to the east of Dolcoath, its workings separated from its world-famous neighbour more or less along the line of the Red River Valley by the Great Cross Course which dislocates the strikes of the lodes running through this section of the landscape. In 1850 Symons' map of the Camborne and Illogan Mining District showed the north-western corner of the sett being located in the Red River Valley where the new Barncoose-Camborne road bridge crosses it, the north-eastern on Dudnance Lane opposite the entrance to Heartlands, the south-western in the valley to the south of Brea village and the south-east just to the east of Harley Farm. At this date it was abutted by Dolcoath to the west, Carnarthen to the south, Tincroft and South Tincroft to the east and East Wheal Crofty to the north. By 1870 it was abutted by Dolcoath to the west, the Illogan Mines to the south, Tincroft to the east and Wheal Crofty to the north. In 1850 the sett measured 970m NNW to SSE and between 340m and 490m WSW to ENE; in 1870 it had changed shape slightly and measured 715m NNW to SSE and between 330m and 450m WSW to ENE. The lodes worked were Middle Engine: developed to 73 fathoms depth, Chapple's: developed to 430 fathoms, Eudy's to an unspecified depth below the 121 fathom level, and Dunkin's: exploited to the 345 fathom level (Dines 1956). Under Brea village the lodes pitch steeply downwards. The lodes worked in Cook's Kitchen are essentially continuations of those exploited by Dolcoath immediately to the west, and were developed in a similar (though a singular and ultimately, uneconomic) fashion (see Appendix 4).

The first recorded working of these lodes date from about 1690, Buckley (1982) suggesting that this was by two early mines: Wheal-an-Gare and John Pawle's Mine, these subsequently being renamed Brea Mine. There may have been some previous shallow working on these lodes, though this cannot be identified in the documentation. Spargo (1865) states that Cook's Kitchen was first named in the 1740s, though Buckley says that Brea Mine was renamed Cook's Kitchen between 1810-30; it was certainly in operation in 1765 when an agreement was reached with Bullen Garden (part of Dolcoath) to connect their shallow adits.

Like Dolcoath, Cook's Kitchen was initially very successful and was evidently quickly being developed in depth, being described by Hatchett in 1796 as *"...one of the most remarkable mines for copper perhaps in the world ... In the last 10 years a clear profit has been produced of £100,000 after the dues to the Lord of 1/6 and the Expences of the Mine have been deducted" (cited in Raistrick 1967).* From the outset very great things were expected of this undertaking and Cook's Kitchen was, during its heyday, the second deepest mine in Cornwall. Water-wheels were initially used for pumping, but in 1794 a 36" double acting Boulton and Watt pumping engine was erected on Steam Engine Shaft to lift water to the 58fm level; a 54 foot diameter water wheel in an underground chamber pumped the water the remaining distance to adit. By 1799 the bottom of the mine was already 176 fathoms from surface and in the following year Richard Trevithick installed his first 'puffer' whim to draw the ore and waste from

Cook's Kitchen's increasingly deep workings. Though the copper ore found here was initially very rich indeed, most of what was subsequently mined was not always of the highest grade, though it was abundant. Records indicate that dues levied by the Bassets on local mines such as Cook's Kitchen would certainly have been sufficient to pay for the lavish rebuilding of Tehidy House between 1861 and 1863 and had probably significantly contributed to the costs of the construction of the previous mansion house in 1734.

The pitch of the lodes and the shape of the sett forced the mine to develop in depth, but by the 1820's the richer grades of copper were already running out, though fortunately sales of tin had begun to supplement those of copper. A new 50" cylinder pumping engine was erected in 1837, together with much other surface plant including two further steam whims and a Sims compound powering additional heads of stamps. The mine had a workforce of 247 in 1838.

Shaft sinking and the driving of levels continued apace but the steadily diminishing production of copper from the mine's lodes brought about a brief closure in 1848. The following year, emboldened by the discoveries of rich tin below the copper in Dolcoath to the west and in Tincroft and Carn Brea to the east, the mine was taken up again. It was found to be in a poor state, even after only eighteen months of disuse, and much of its machinery and equipment required repairs. Although new steam-powered dressing floors were installed, most of the effort was directed at deepening Chapple's Engine Shaft – the principal shaft on the mine. A man-engine powered by flatrods worked from the large underground water-wheel which had formerly been used for pumping was installed in 1859 – this was inked to the man-engine rods by 480 feet of flatrods. Over the following years the surface plant was radically re-structured and enlarged. By 1865 Spargo reported that the mine had a 50" pumping engine, three steam whims (26", 25" and 18" cylinder diameters, including Trevithick's original 'puffer'), a 26" cylinder stamps engine, six large water-wheels -one of 50' diameter driving the man-engine (the dimensions given by Spargo differ from other reports), two of 40' diameter and three of 27' diameter. The mine by this time had been sunk to about 270 fathoms below adit and its tin production was increasing year on year. Spargo reported that 370 persons were employed in 1865.

In 1872 the mine was divided into two, the newly-formed New Cook's Kitchen purchasing the northern part of the sett; the receipts from the sale were spent on improvements to Cook's Kitchen. Slumping tin prices through the later decades of the 19th century brought little profit, however, and the last dividend was paid in 1873. Two rock drills were introduced to improve production, the pumping engine was re-cylindered to a 55" and Chapple's Shaft continued to be deepened. The man-engine was extended to the 190 fathom level in 1882. By 1888, the man-engine, from 1871 powered by a horizontal engine at surface, rather than the old underground water-wheel and relocated to Dunkin's Shaft, had been extended to the 234 fathom level – this was well short of the lowest levels in the mine. It was subsequently deepened to the 270 fathom level, and although it was recognised that it would have to be further extended to reach the lowest workings, this was never achieved.

Inexplicably, by this date the mine was still essentially worked from a single shaft (Chapple's) which was used for both pumping by an engine installed half a century before and for winding, extraordinarily still at that date using a single pair of kibbles on a massively long winding rope, which factor alone should have crippled the mine.

A new skip road to replace (or supplement) the man-engine was installed in 1888, but the work involved in constructing this proved expensive, and in the following years machinery breakages occurred, weak ground requiring heavy timbering was encountered, and the eastern and southern parts of the mine were found not to be worth development in depth. The only option was to continue to follow its lodes downwards at increasing expense. The mine was in a poor state, despite the richness of its lodes: most of the pumping engine was over sixty years old and was working enormous lengths of pitwork in a narrow crooked shaft which was also used for

winding, the dressing floors had not been remodelled since the 1860s, the man-engine reached only two thirds of the way down the mine and the heat in the lower working levels was said to be stupefying. In 1884 the east end of the 335 fathom level had to be left to cool for two months before it was possible to resume work there and men could not enter the 368 fathom east level until a ventilation winze had been sunk to connect to it, given that the temperature in the level was 100 degrees Fahrenheit (37.7 degrees Centigrade).

In 1890 the main pumping rod had broken, resulting in the flooding of the bottom of the mine for a month, whilst in 1891 a major fall of ground in the high-producing 380 fathom stopes significantly affected the mine's output. Exploration of other areas of the mine proved disappointing and work continued to have to be concentrated on the deepening of workings on the Chapple's Lode, despite this becoming poorer in depth, the deepest workings on this lode being those on the 430 fathom (786m) level. An area of very rich ore found near the boundary with Dolcoath had to be left untouched as a result of the agreement between the two mines not to undertake work which might breach the crosscourse which divided their setts. The man-engine was stopped in 1891. In 1893, the market price of tin fell steeply, affecting the profitability of all Cornish mines, and Cook's Kitchen's production costs soared. This proved to be the final straw. It seemed that the only options on the table were to continue to work at a loss or to close the mine. A Burrows' photograph of the mine taken at this time looking upslope across the dressing floors towards Chapple's Shaft shows a ramshackle series of timber sheds, some with large holes in their roofs. The flatrods leading to Dunkin's Shaft can be seen on the skyline.

Given fears that the abandonment of pumping at Cook's Kitchen would threaten the viability of its neighbour, Tincroft, the two mines were amalgamated in 1895 once Cook's Kitchen's debts of £4,000 had been liquidated. Tincroft was found to be in a worse state than Cook's Kitchen, however. The Carn Brea Mines were acquired the following year and in 1899 the combined mines purchased the New Cook's Kitchen sett. All of the workings of the mines in this area were, by this time, interconnected at depth, and relied on their neighbours pumping engines continuing to operate.

A famous image of the mine taken shortly after this date was used on the cover of Trounson and Bullen's 1999 *Mining in Cornwall (Volume 1)*. The scene, looking east from Dolcoath across the Red River Valley, shows the pumping and winding engine houses around Chapple's Shaft, the stamps engine house and the man engine chimney. Its two other whim engine houses can be seen a little further to the east. The man-engine chimney is visible, but the associated buildings are masked by other structures. Another broadly contemporary image of the site showing the view across Brea from the south-east included in the Trounson Collection and reproduced in Morrison (1980) includes the man-engine house, but the quality of the image is too poor to make out any detail of this structure.

Following the 1895 amalgamation, most of the Cook's Kitchen shafts were abandoned. Chapple's Shaft pumping engine was found to be *"...simply a wreck, for the bob was broken, the nozzle patched in at least a dozen places, the cylinder was full of holes, and he (the inspector) could not describe it as worse than it really was. Directly the engine was stopped and cooled down, the principal part of the engine almost dropped off."* (Morrison 1980).

Carn Brea was abandoned in 1913 (some sources say 1914), Tincroft and Cook's Kitchen in 1921. Tincroft was briefly reopened in 1927 for arsenic, but its Cook's Kitchen section was left untouched. The New Cook's Kitchen sett had been taken over by South Crofty in 1899, and it acquired the remainder of the surrounding setts during the 20th century. Cook's Kitchens' shafts were capped off and one of South Crofty's explosives magazines was eventually sited close to Chapple's Shaft.

With the exception of the pumping, winding and man-engine houses serving Chapple's Shaft at the southern end of the site and an isolated dressing floor chimney, almost no

surface evidence for Cooks Kitchen now survives. This reflects the demolition of most of its standing buildings following the closure of the mine, extensive landscaping associated with the redevelopment of parts of the surface of the wider South Crofty site for spoil storage, the recovery of economic minerals from spoil heaps, and, in particular, the cloaking of much of the southern and western parts of the site (including the extensive Cook's Kitchen dressing floors) with material derived from the excavation of the South Crofty Decline Shaft and with rejects from South Crofty's milling process. Excavation around the man-engine house demonstrated the substantial depth of this material, and the mixed nature of it, but also the potential for the survival of the remains of underlying mine structures.

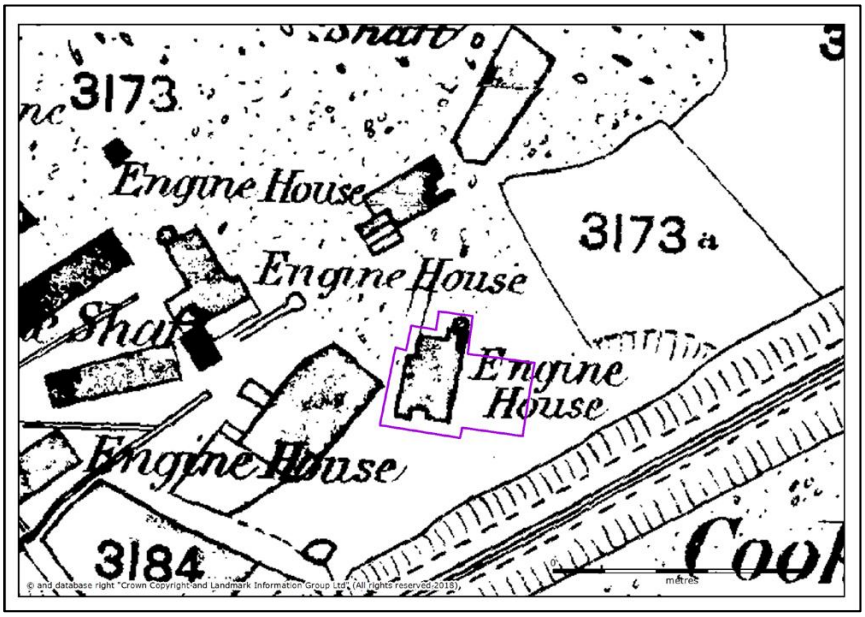


Figure 3: Ordnance Survey 25" mapping c1878 showing the roofed man-engine house and attached boiler house; purple line indicates extent of excavation.

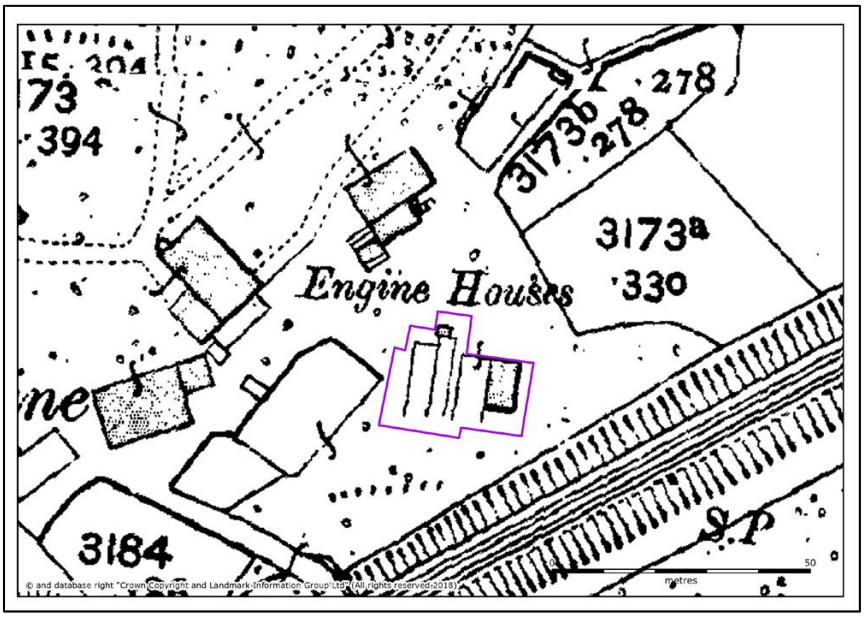


Figure 4: Ordnance Survey c1908 showing the man-engine house and boiler houses disused and un-roofed; the eastern building was still roofed.

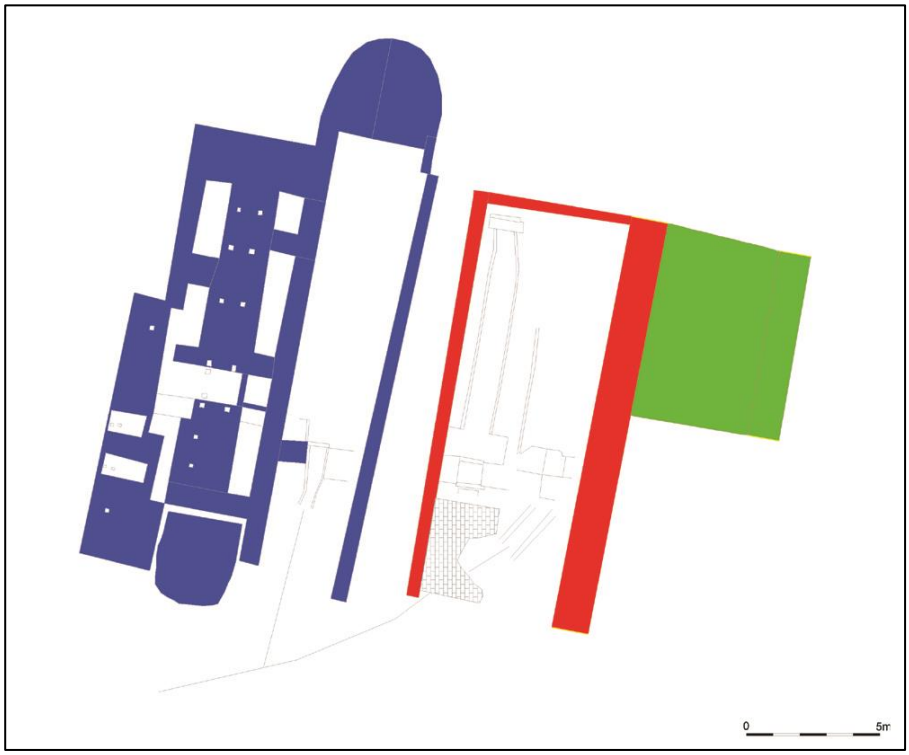


Figure 5: Phases of development derived from map regression. Blue denotes original building from 1871, red – boiler house constructed post 1878, green – possible compressor house surviving until at least 1938.

6 Background information

6.1 The horizontal man-engine house and associated buildings at Cook's Kitchen

The structure of a horizontal engine house differs from a conventional Cornish beam engine house in which the building's structure supported and framed the engine's components. In the case of a horizontal engine house, whilst the foundations of the buildings needed to be strongly-constructed to support the loadings (plinths) on which the equipment was bolted down, none of the masonry above the engine bed needed to be load bearing. It is therefore possible that the walls above the level of the machine loadings and the internal floor of the example at Cook's Kitchen could have been constructed and clad in timber (as is hinted at in the 1904 Geological Survey photograph). The presence of pieces of wall plaster, however, suggests otherwise. The interior of the engine house would have been floored over at the level of the engine beds, and most, if not all, of the substantial pits flanking the machine loadings would have been beneath this floor. Given the removal of the superstructure of the building and the partial demolition of its side and end walls, its original external appearance is unclear. The excavation evidence indicates that the building had a slate roof (possibly gabled), with windows to provide natural light to its interior, as well as a door connecting the engine house driving floor to the adjoining boiler house, which would have been of similar construction to the engine house.

Whilst the general principles underlying the layout of this group of buildings can be understood, there remain some difficulties in interpreting the excavated evidence. The dimensions of the Cook's Kitchen horizontal engine house are small relative to the equipment it contained, and its layout is unusual. It would seem to have been a rather cramped space internally, and it is unclear where the driver would have stood to operate the engine controls, though this may possibly have been on the western side of the engine bed. Given the absence of any photographs of the building, the rarity of this type of engine house constructed to drive a man-engine (Appendix 3) and the absence

of any plans, photographs or descriptions of this or other examples of horizontal man-engine houses, it is unclear whether the drive gearing for the flatrods was located inside or outside the engine house – heavy grease stains on the external stonework on its western side near its south end and on the ground beneath suggest the latter. The location of the flywheel, axle and gearing cannot be identified with full confidence though are likely to have been sited on or close to the loadings at the southern end of the building and the functions of the group of centrally-located hold down bolts remains uncertain.

The relationship between what was the original, attached house for a single boiler and the slightly detached building which contained a pair of additional boilers is also uncertain – the field evidence suggests that the original boiler was replaced (or augmented) by a pair of slightly smaller diameter boilers. Archive OS maps suggest that this took place between 1878 and 1908 (Figs 3 and 4). It is uncertain whether the original boiler remained in use, was mothballed or was removed, though the excavation evidence hints that the latter might have been the case. Some modification to the original tail flue arrangements must have taken place when the additional boiler house was constructed, but the evidence for this has been lost.

The function of the small building adjoining the later boiler house on its eastern side is unknown. This was also built between 1878 and 1908. It is too short to have been a boiler house and is rather poorly sited to have been a coal store. Brown and Acton (2007) suggest that this was the site of the mine's compressor house, which would date its construction to the early 1880s when rock drills were introduced to the mine. This structure was found to be in very poor condition and no diagnostic internal features were revealed during the soil strip (see section 7, below) which might assist in identifying its function. It retained its roof in 1908 when the adjacent engine house and boiler houses are likely to have been unroofed for the best part of a decade and it was still roofed in 1938 when all of the other nearby buildings had been almost completely demolished (OS 6" map evidence). Given that mining had ceased at Cook's Kitchen for nearly two decades by 1938, it has to be assumed that this surviving building was by then being used for some other purpose.

It is unfortunate that with one exception the only late 19th and early 20th century photographs of the Cook's Kitchen's surface arrangements were taken from the opposite side of the Red River Valley. Given this viewpoint the man-engine house and associated boiler houses were obscured by the stamps engine house and by the pumping engine house on Chapple's Shaft. No archive photographs were identified which showed the man-engine house and associated buildings in any useful level of detail, though it is possible that some are privately held in archives whose catalogues (if they exist) are not publicly-accessible. No detailed plans of the engine or of this part of the Cook's Kitchen site have been identified.

6.2 Horizontal engines

Steam was produced in a Cornish boiler (subsequently three boilers of this type at the Cook's Kitchen site) to the desired pressure (this being partially controlled by blow-off valves), by burning fire coal in a grate incorporated into its end. The steam was fed to an insulated steam cylinder via an inlet valve, exerting pressure on a closely-fitting piston which was moved horizontally within the cylinder. This was attached to a piston rod exiting the end of the cylinder via a steam-proof gland. The steam would probably have been used expansively – steam input would have been cut off during the movement of the piston rather than being applied continuously throughout the stroke. At the end of the stroke on a single-acting engine an exhaust port was uncovered or an exhaust valve was automatically opened by a rod connected to an eccentric on the engine's axle, allowing the steam to exhaust the cylinder.

The Cook's Kitchen engine was probably double-acting, steam being alternately applied to each side of the piston at the ends of its strokes; a slide valve in a valve chest attached to the cylinder and operated by a link rod attached to an eccentric on the axle

controlled the reciprocating motion of the valve, opening and closing ports which controlled which side of the piston the steam was applied to. Steam was generally exhausted without being condensed. In the case of compound engines, the high pressure steam used in the cylinder would have been fed to a larger low-pressure steam cylinder before being exhausted.

The piston rod was connected to a cross-head – at its simplest, a slide running on rails fixed to a guide plate. Attached to this via a flexible link was a rod connecting the cross head to a crank on an axle. The horizontal motion of the piston rod and cross-head was thus converted into rotative motion; a flywheel attached to the axle would have helped to maintain the smoothness of rotation of the axle. A governor would also have been fitted – this being a mechanism which automatically controlled the degree to which the steam input valve was opened, limiting the engine's maximum running speed.

There would probably have been no requirement for the engine to have been fitted with reversing gear unless the engine had to be de-clutched to allow it to operate winding or other equipment when miners were not using the man-engine. No documentation relating to the Cook's Kitchen engine has been found suggesting that this was the case.

Most horizontal engines were constructed on a cast iron bed to ensure the correct alignments and distances between the engine components, but this might not have been the case in Cook's Kitchen's relatively early Harvey's engine – the hold-down bolts set into the granite structure and the incorporation of substantial horizontal timbers into the structure may well have provided the required rigid machine bed. If this were the case the engine would have had to have been very carefully set up and frequently checked for any necessary adjustments if unwanted wear resulting from misalignment was to be avoided.

6.3 The operation of the man-engine

In the case of the Cook's Kitchen man-engine the axle would have carried (or driven) a primary gear of around 660mm diameter which was meshed with a second, much larger gear wheel (around 4.6m in diameter) in order to achieve an appropriately slow output rotation rate. The flat rods leading to the shaft would have been given a horizontal reciprocating motion via their attachment to a crankpin on the large gear wheel. The horizontal motion of the flat rods would have been converted into the vertical reciprocating motion required for the operation of the man-engine rod by the use of an angle bob at the head of the shaft.

The man-engine rods in the shaft averaged 200mm square and were joined with strapping plates, whilst the man-riding platforms were around 300mm square. Iron staples were fixed to the rod as handholds. Guides and sheaves were installed to ensure the free-running of the rod, angle or V-bobs were used where the shaft angle changed and balance bobs were installed at surface and underground to balance out most of the weight of the rod. At Cooks' Kitchen in 1862 there was a 7 ton balance bob at surface (whose mountings survived until around two decades ago), a 7 ton balance bob at the 42 fathom level and a 6 ton balance bob at the 111 fathom level.

The man-engine would have operated with around a twelve foot stroke in the shaft, making around five strokes a minute so that men could descend or ascend at a rate of around 10 fathoms per minute. Once the Cook's Kitchen man-engine had been extended to its greatest extent, men could descend on it to the 270 fathom level in just under half an hour. The benefits to miners of using the man-engine rather than climbing ladders for the return journey to surface after an arduous shift in very hot and humid conditions are obvious.

6.4 Components of a Cornish boiler and boiler house

The riveted plate-constructed elongated cylindrical Cornish boiler was invented by Richard Trevithick in which to generate and contain his 'strong steam', replacing what were effectively massive kettles in which steam with pressures of only a few pounds per square inch had been built to assist in producing the vacuum used to work the

earlier Newcomen and Watt engines. So low was the pressure within these early boilers that any leaks could allegedly be sealed by placing a thick piece of turf over them, whilst other examples were built out of pieces of granite and were known as 'moorstone boilers'. Trevithick's development of high pressure steam technology allowed engines to be constructed which were smaller, more efficient and much more powerful than their predecessors, and also led to the development of small-scale, transportable (and even self-propelled) power plants.

The houses for Cornish boilers were universally of single storey design and all conformed to a standard layout. In its developed form, the Cornish boiler house incorporated the Cornish three-pass flue arrangement. Hot gases from the firebox at the firing end of the boiler were drawn through the large iron flue running its length; at its far end they entered an enclosed brick 'hovel' within which the gases were diverted back along the sides of the boiler through flanking side flues; near the firing end of the boiler these connected to a brick-lined under-flue running beneath the boiler for its full length; the flue finally exited the boiler house through a damper frame which was used to regulate the draught and from which the exhaust gases were led into the base of the nearby chimney. By this means maximum benefit was gained from the heat in the flue gases before this was lost to the atmosphere.

Very little of a working boiler would have been visible apart from its firing end – almost the whole of the remainder would have been buried in layers of insulating ash; this material also infilled the space between the boiler and the side walls of the building, covering the side flues. Access to these was provided via doors at the firing end to allow these to be cleared of accumulated ash (usually by children) to ensure that the boiler could continue to work efficiently; the under-flue was accessed for cleaning by the children crawling through the side flues to the hovel and then back under the boiler, or via an access point in the tail flue. The firing end of the boiler was provided with a fire door giving access to the grate for stoking, gauges to allow the water level in the boiler to be monitored, a steam pressure gauge, a fusible plug (a safety device to prevent the boiler exploding if its water levels became dangerously low), an ash door for raking out cinders into the ash pit beneath this end of the boiler and a blow down cock used to empty the boiler of any sludge and dirty water which had built up in its base. Protruding from the boiler's top surface would have been the water feed pipe, the steam feed pipe and shut off valve, a weight-calibrated spring-loaded steam pressure safety valve, and a tightly sealed access hatch (manhole) used during periodic maintenance. Close to the firing end of the boiler would have been the lever used to regulate the degree to which the damper plate at the end of the under-flue was raised or lowered to regulate the draught through the flues.

Other features which would have been present within the boiler house would have included a brick-surfaced firing floor on which coal for the boilers would be stored ready for stoking and a drain to take away the water which was periodically flushed out from the boiler, whilst nearby would have been a coal store or coal yard and an area for the disposal of large amounts of waste cinders, clinker and ash. A doorway would have been provided between the engine house and boiler house to enable the engine driver to stoke the boiler's firebox and keep an eye on the steam pressure and water levels.

It was common practice to demolish one end wall of a boiler house when recovering the equipment it contained for scrap, and in many cases the building's roof would have been removed at the same time. This appears to have been the case at the Cook's Kitchen man-engine site. It is possible that the southern end walls of the boiler houses were of timber construction, as no evidence for wall footings was found in these areas of the buildings.

Figure 6: View of site prior to excavation, looking east.

Figure 7: Post-excavation aerial view of site.

7 Archaeological results

The groundworks commenced with the removal of the overburden believed to cover the engine house remains (Fig 6). The various components of the site are described below. A list of detailed context descriptions can be found in Appendix 1 and finds recovered in Appendix 2 of this report.

7.1 The site

Prior to the excavation taking place, the site known to have been occupied by the man-engine house and its associated structures was a generally level and featureless spread of compacted spoil to the north and west. To the east and south, the site was occupied by a series of humped mounds of scrub-covered rubble traversed by off-road cycle tracks; considerable amounts of fly-tipped rubbish were present in and near this area.

The general location of the engine house was known from historic Ordnance Survey maps (Figs 3 and 4), allowing the excavation area to be marked out on the ground. Some low sections of standing stonework were visible amongst the gorse and brambles, together with a single hold-down bolt protruding about 0.5m from the ground; both were in the middle of the area to be excavated, but it was uncertain prior to work commencing which parts of the engine house these might represent. The depth of material which had been dumped here was also unknown – at the outset it was assumed that this might be between one and two metres in depth. The removal of the overburden using the swing shovels took five days, and was directed by a supervising archaeologist. Spoil was disposed of within an area just to the west of the man-engine house site, this location having been identified as suitable for this purpose by Western United Mines.

The topsoil consisted of a mixture (101) of dark brown clay mixed with an almost black organic peaty soil, whose depth was variable, dependant on the location within the site, which had a pronounced slope to the south. This overlaid (102) a deep deposit of stony rubbish (a mix of fragmented granite and killas mine waste) together with pieces of iron and modern plastic waste mixed with a reddish-brown sandy deposit (103). This material collectively represents the results of dumping activity since the abandonment of Cook's Kitchen, and largely derived from the operations of South Crofty mine during the 20th century. The ground surface upon which the engine house had been constructed largely consisted of redeposited mine waste – no topsoil or other indications of a natural ground surface were found. Adjacent to the railway line to the east, the basal material which was exposed through excavation consisted of a mixture of coal dust and cinders.

On the completion of the bulk excavation about 3.5m depth of overburden had been removed from the immediate environs of the engine house and at least 2m from over the area of the adjacent boiler houses to the east, revealing an engine house 23m long and 6.5m wide; the cleared area of the site measured 25m by 20m in plan (Fig 7).

7.2 The horizontal engine house

This was known to have been the site of a horizontal engine house, so it was expected that what would be revealed would consist of relatively low but strongly-constructed foundations incorporating the loadings (mountings) for a steam engine and associated equipment such as gearing, a flywheel, etc. In the event, the masonry remains which were uncovered were considerably more massive than had been expected, surviving up to 3.8m in height. The building was broadly rectangular in plan and consisted of a mortared mass of granite mixed with some killas and mine waste. It incorporated two separate areas which incorporated machine loadings – those to the north east would have sited the steam cylinder and cross head (the engine bed), those to the south west would have sited the power train driving the man-engine.

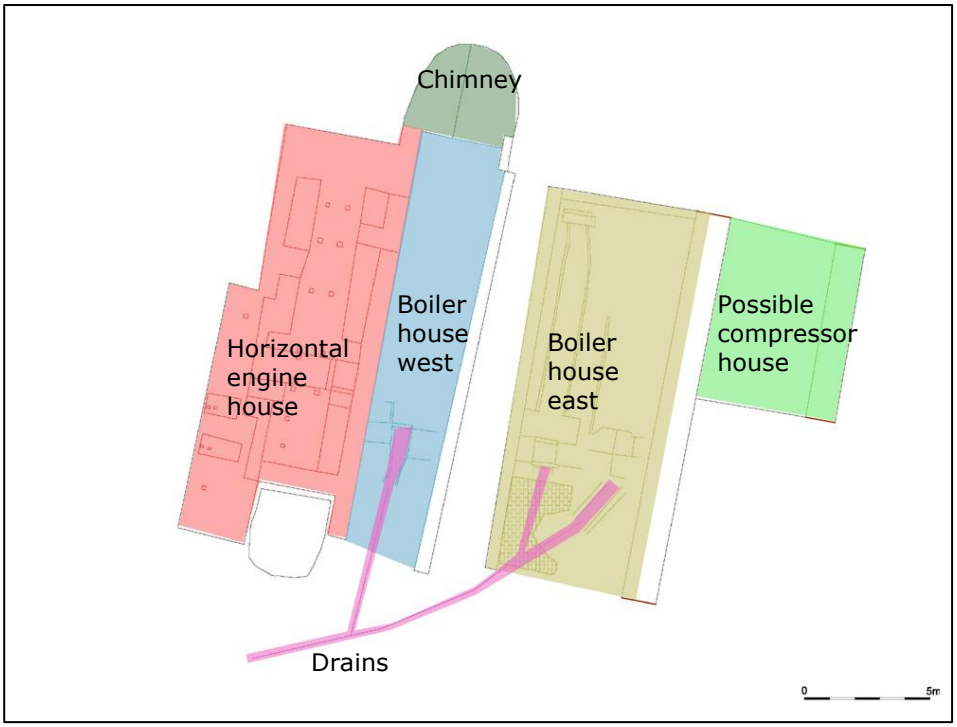


Figure 8: Cook's Kitchen man-engine house and associated buildings. Colours have been used to assist in the delineation of the extents of each structure.

Incorporated into the loadings were a series of vertical bolt tunnels, some with surviving hold down bolts, whilst at the base of the western wall were 'crow holes' – horizontal tunnels giving access to the lower ends of the bolts. A series of rectangular pits were set within the structure's upper surface; further crow holes were found in some of these. It was clear that the side walls of the building had formerly been taller – the pits were universally infilled with substantial pieces of granite masonry mixed with smaller stones, decayed lime mortar and pieces of lime-rendered wall plaster. There were also abundant scantle roofing slates in this mix, together with some corroded ferrous artefacts. A similar mix of material covered most of the structure and was found around it, in places to considerable depths.

The remains of a boiler house with the low foundations of an attached northern chimney lay immediately to its south-east. Abutting this to the south-east again was the detached house for a further pair of boilers, and to the south-east of this were the truncated remains of a smaller rectangular structure, interpreted as a possible compressor house (see Fig 8).

The engine house outer wall elevations on all sides [105] (Figs 9–14) were primarily constructed from large granite blocks, many of which appeared to have been dressed (faced up and squared), mixed with smaller pieces of granite, killas and mine waste, all of which had been bonded with lime mortar. The majority of the larger stones had been used as lintels above the crow holes found on the west side of the building and those within the lower parts of the structure within the interiors of Pits 5 and 6. Large pieces of dressed granite had also been used on the upper parts of the loadings which had supported the engine bed and the power train. The stonework at the northern end of the north-west facing wall retained remnants of scribed pointing – thin, regularly arranged horizontal and vertical lines of lime mortar intended to give the impression that the building had been constructed throughout of squared blocks of stonework, rather than largely of randomly-coursed rubble masonry.

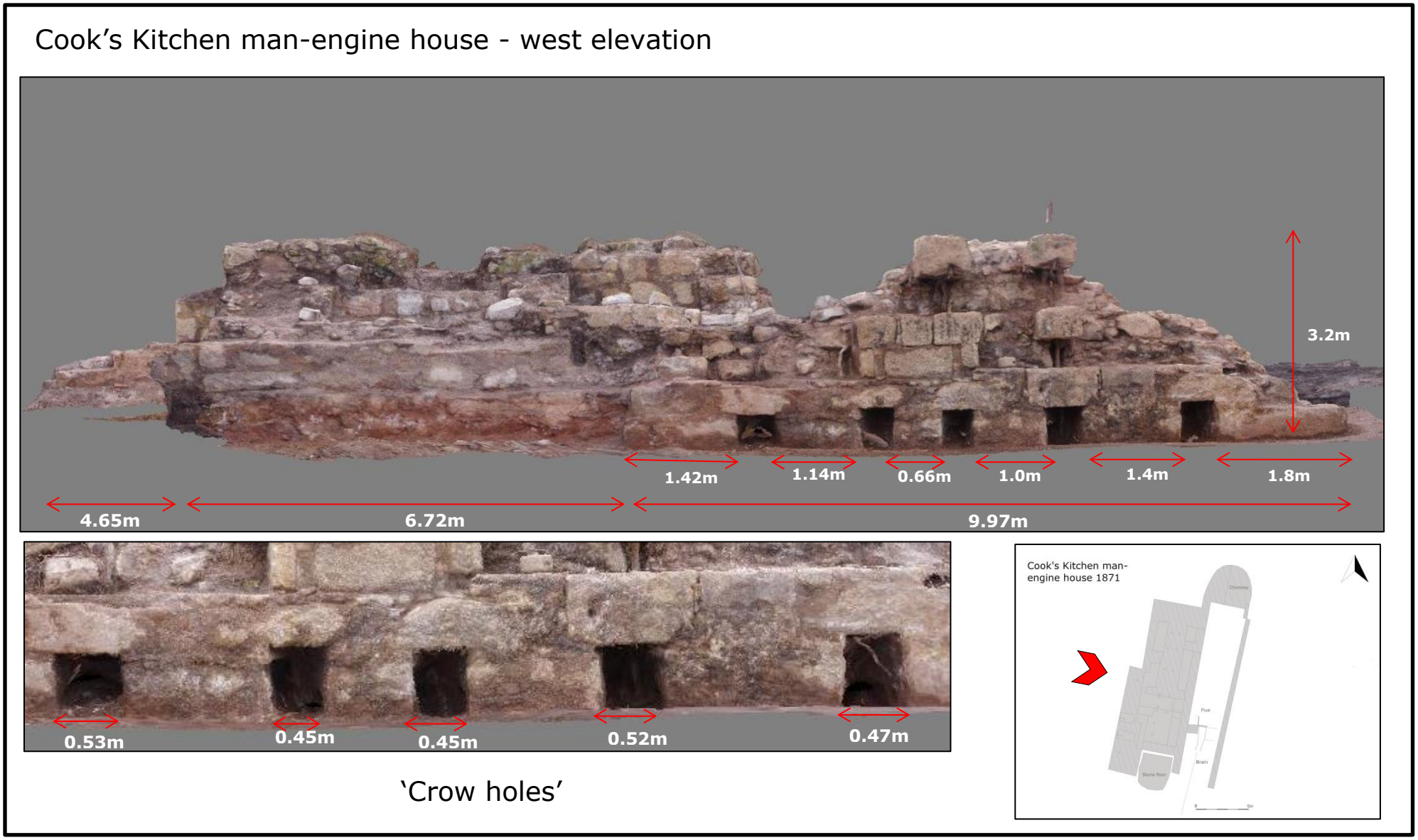


Figure 9: West elevation of man-engine building showing measurements.

Cook’s Kitchen man-engine house - west elevation

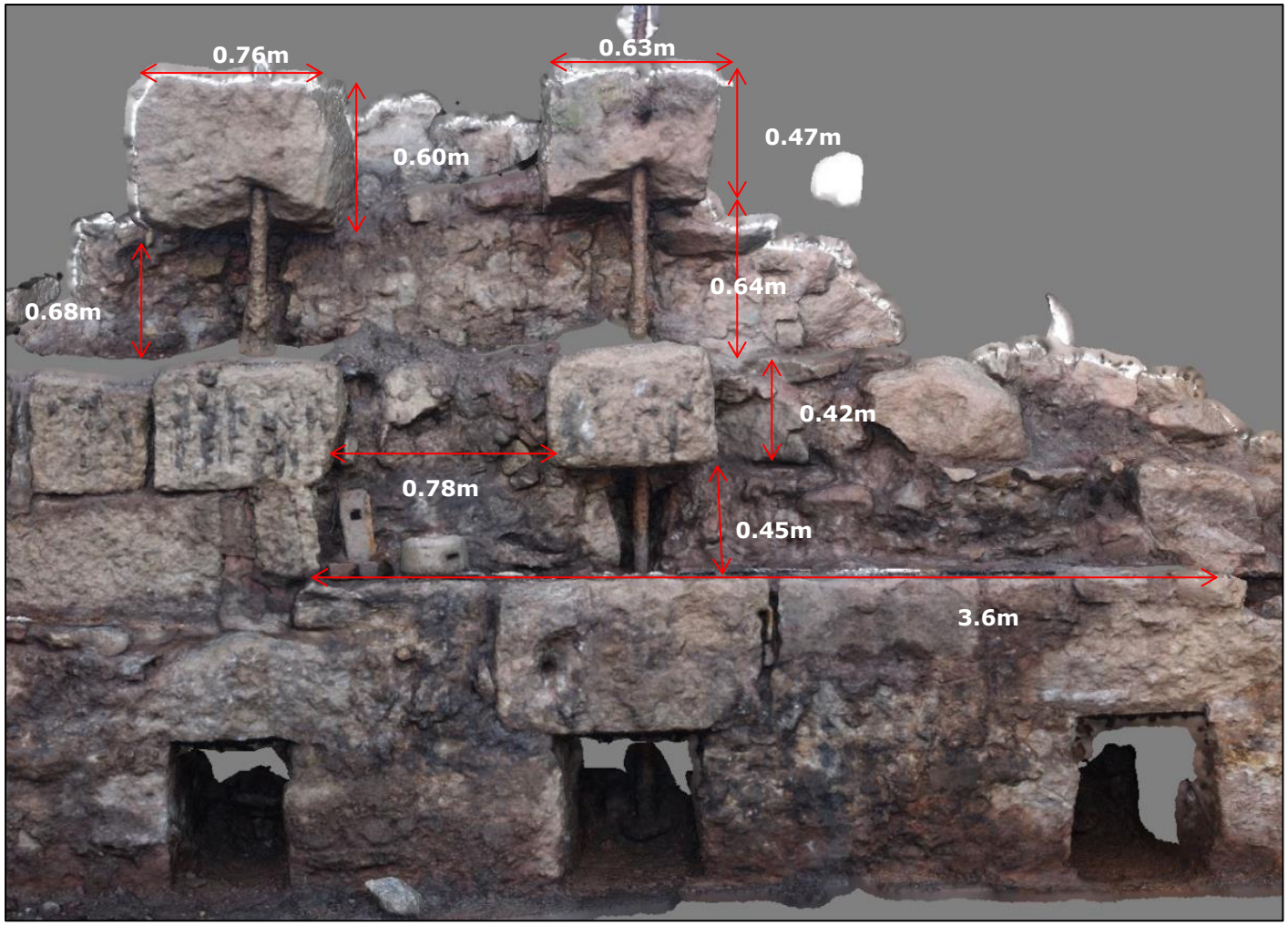


Figure 10: West elevation of man-engine building: close up of 'crow holes' and power train loadings.

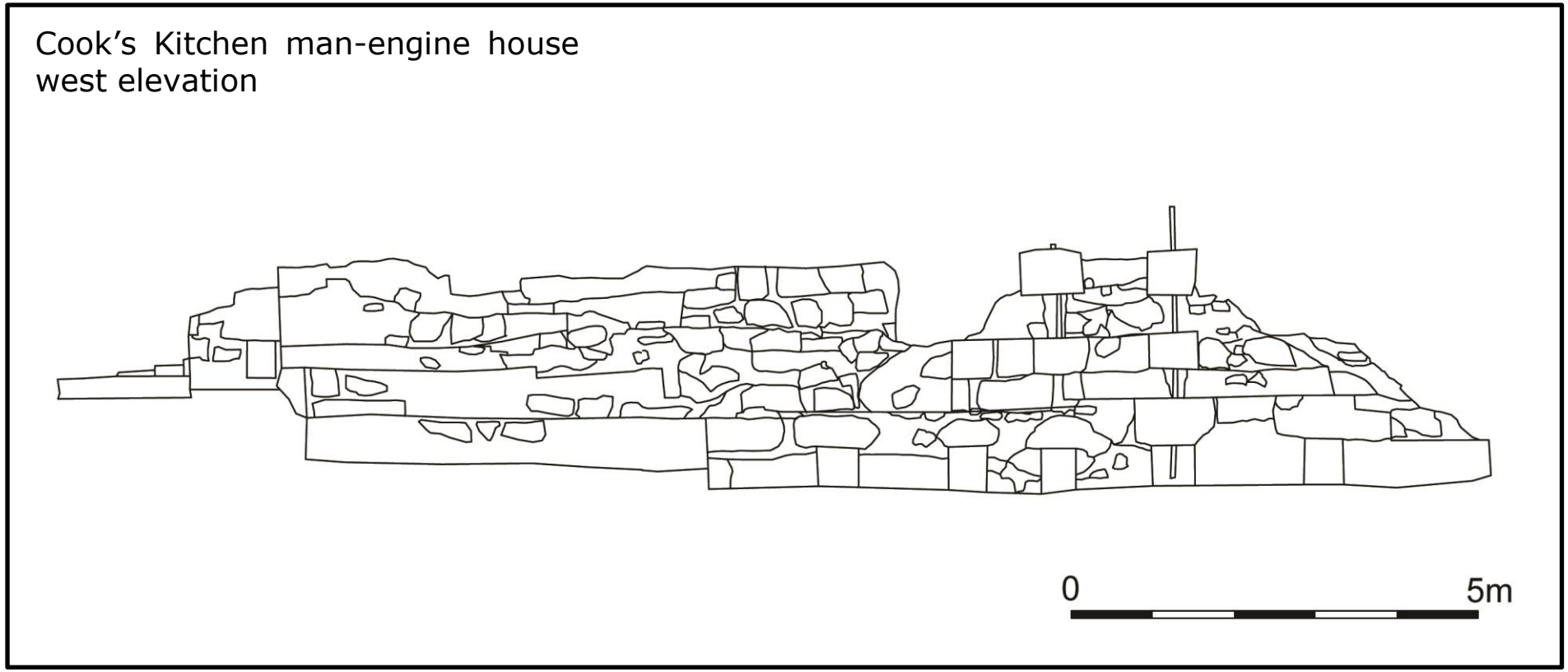
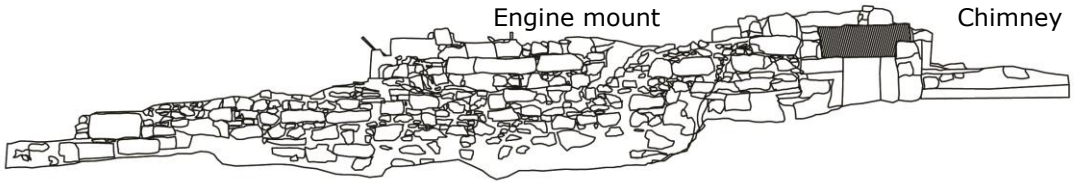


Figure 11: Section drawing using photogrammetry of west elevation of man-engine house.

Cook’s Kitchen man-engine house east elevation



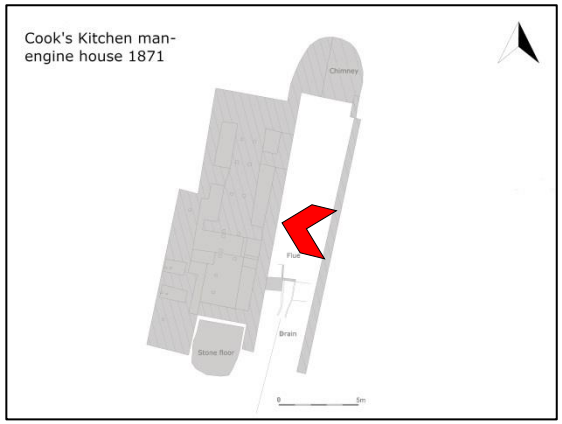


Figure 12: East elevation of man-engine house, photogrammetric image and section image.

Cook’s Kitchen man-engine house north elevation and chimney foundation

Figure 13: North elevation of man-engine house showing measurements.

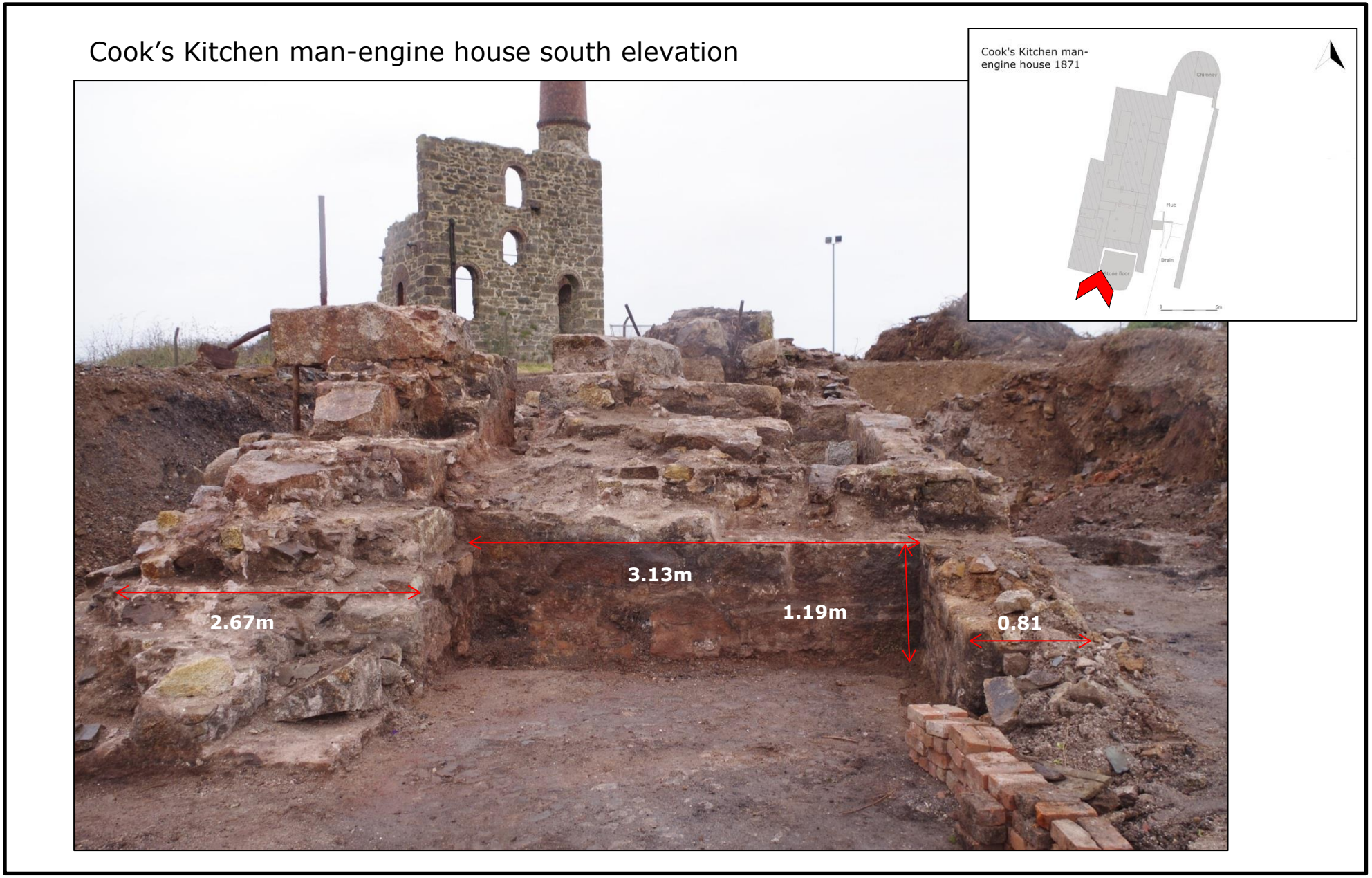


Figure 14: South elevation of man-engine house showing measurements.

The engine house can be divided into three areas – the northern elevated section which had sited the steam cylinder and cross head (engine bed loadings), a lower central area, and the southern end of the building which had sited the power train. A dogleg in the west elevation and a rise in the building's foundation level at the same point more or less matches the junction between the northern and central areas of the building (though is offset slightly to the north of this).

The western wall of the building was excavated down to the original ground level, which consisted of relatively fine mine waste, partially covered by red clay (135). Pools of grease on this material indicated that it represented the ground surface at the time that the engine was in operation. This wall incorporated five crow holes at its base, these having been constructed to give access to the lower ends of the hold down bolts running through the masonry, to which the machinery on the loadings was bolted down. Some of the blacksmith-made wrought iron bolts [139] survived *in situ*, and were up to 3.5m long. At their lower ends flat pieces of iron hammered through slits cut in the bolts would have been drawn up against massive washers which in turn bore on the roofs of the crow holes, allowing the nuts above to be tightened down. The northernmost crow hole extended most of the way through the building (5.84m), but the remainder averaged between 1.3m and 1.4m deep.

In some cases on the western elevation of the building the western sides of the square-section bolt tunnels had clearly been left open until the bolts were installed; small stones had been mortared in place to close them off. A small number of the bolts passed through holes drilled in substantial blocks of granite and these must have been dropped into place.

At least three different diameters of hold down bolts were identified within the structure: 4.5cm, 5.5cm and 6cm (see Figs 19 and 20). The majority of these were arranged in east-west pairs along a common central axis running most of the length of the building; a second set ran along the western edge of the building at its southern end. Those within the loadings at the northern end of the building would have held down the cylinder and crosshead, these quite possibly being mounted on a common bedplate. Those to the south are clearly associated with the gear train transferring the motion of the engine to the man-engine flat rod drive. The function of a group of hold down bolts set at a lower level near the centre of the building between the two loadings is uncertain.

Abutting the north-west corner of the building was a low stone wall [134] retaining material to its west. This was exposed on its eastern side, but its full length was not fully revealed as it extended into the unexcavated area to the north. It is unclear whether this feature had been vertically truncated. It was not mapped by the OS in either 1878 or 1908 and its function is uncertain.

The northern end of the engine house is orientated south-west to north-east (Fig 13), and was abutted by the foundations of the now-demolished chimney. This wall did not incorporate any features. The eastern elevation of the engine house also formed the western wall of the abutting original boiler house. It averaged 1.5m high, though had clearly lost much of its upper masonry.

The east elevation of the man-engine house projected a short distance further than the north elevation, butting the chimney. This wall fabric incorporated a rectangular full depth opening measuring 0.9m high by 0.6m wide which was spanned by a substantial granite lintel, though this opening had been blocked in with a thin panel of stonework on its western side. The function of this substantial feature is somewhat unclear. Its proximity to the chimney might suggest that it was part of the flue structure for the original boiler house, but if this was the case, this would have been an unusual arrangement. It was clearly a significant original feature, but one which subsequently became redundant, and it is possible that it was blocked in when the additional boiler house was constructed between 1878 and 1908.

The southern end of the engine house had an inverted U-shaped plan (Fig 14) formed by extensions of the eastern and western elevations beyond the main part of the engine house. The western wall extension was notably more massive than that to the east, probably reflecting its former function as the part of the location of the power train loadings. The space between these walls was floored in smooth stone cobbles (see below (126).

There was abundant evidence in the form of displaced construction material covering and infilling the remains of the engine house and adjacent to it to demonstrate that the building had been significantly truncated; whilst some of this was probably a result of deliberate demolition to recover the machinery for scrap in the early 20th century, further damage almost certainly occurred when rubble was bulldozed over this part of the site, burying the remains of the building. Some of the hold down bolts had been significantly bent over during the site's burial. It is uncertain to what height the walls originally stood, or how their upper sections had been constructed. It is possible that the building might have been built of mortared stone only up to the height of the engine loadings; above this it could have been of timber construction. However, the presence of substantial amounts of lime-rendered plaster in the rubble backfill may suggest that the engine house side and rear walls were originally constructed to full height in masonry. Some stones had clearly been lost from both sets of loadings, the side walls had certainly lost at least 1.5m of their original height, and a fairly substantial mass of masonry had been removed from the south-western corner of the structure, probably removing some evidence for the way in which the man-engine gear train had been arranged.

7.2.1 The engine bed loadings

Figure 15: Engine bed loadings.

The loadings [122] for the bed which sited the steam cylinder and crosshead are 7m long and 1.8m wide, constructed of generally substantial pieces of granite bonded by lime mortar to produce a strong base for the machinery they supported (Fig 15). They were located down the centreline of the building at its northern end, and were flanked by a series of rectangular pits. Four sets of paired bolts at (north set) 1.39m x 0.84mm centres (south set) 2.27m x 0.84m protruded from its upper surface. These would have been used to position and secure the engine's bedplate. Small amounts of stone appear to have been lost from the upper surface of the loadings, but they have otherwise survived generally intact. A slightly lower section within part of these loadings may

have been an original feature, or may simply reflect stone loss. It sites four of the hold down bolts; from their locations these would have secured part of the engine bed.

7.2.2 The power train loadings

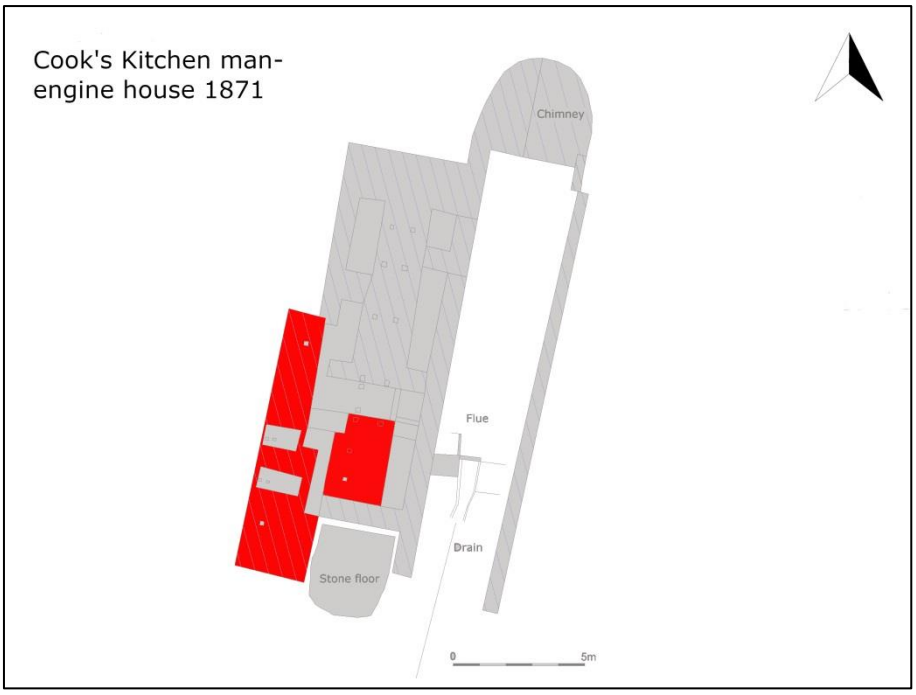


Figure 16: Power train loadings.

These were sited towards the southwestern end of the building, and consisted of two substantial masses of mortared masonry (Fig 16).

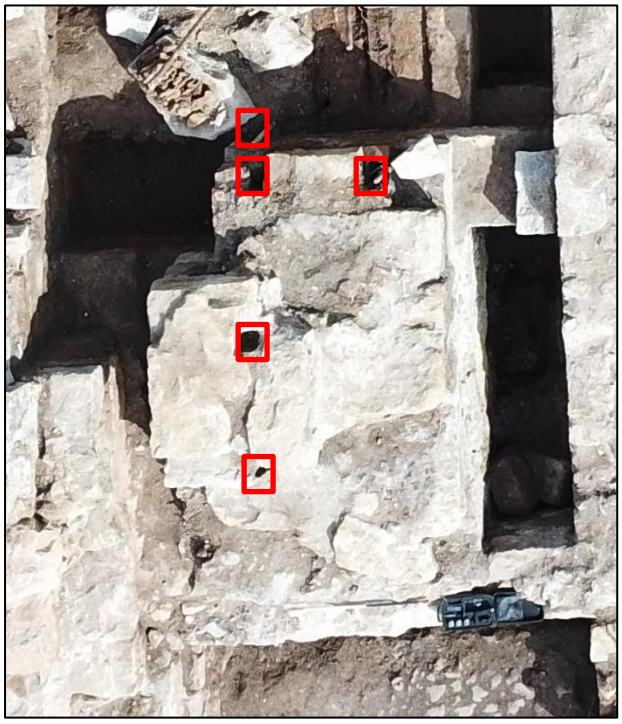


Figure 17: Eastern section of the power train loadings (red boxes indicate locations of holding down bolts).

Again they incorporated vertical hold down bolt tunnels, some of these retaining surviving bolts; crow holes at the base of the western elevation gave access to most of these, whilst others were sited in a flanking pit to the east. The southern sections of the loading were separated by an elongated slot [124], this possibly having been a gear pit (Fig 21).

The eastern section (Fig 17) of the power train loadings [123] took the form of a massive mortared granite plinth, the southern part of which showed evidence for some masonry loss, this probably having occurred during the burial of the structure. This section of the loadings incorporated two pairs of holes for hold down bolts, (Fig 18), the northern pair being on the same alignment as those on the engine bed loading to the north, though set at a lower level – these were boxed in with brickwork; the southern pair

shared an alignment with the four hold down bolts on the western section of the loading [125] and are likely to have secured an axle or crankshaft.

What is interpreted as the western section [125] of the loadings was narrower but more elongated than that to the east, measuring 7m x 2m, but its upper surface was at the same height as the eastern section. Its central section incorporated four closely-set hold down bolts, these running through a pair of substantial granite blocks (the southern block measures 1.04mm x 0.63m and the northern block measures 1.22m x 0.72m). The outer faces of these blocks and the wall beneath exhibit grease staining, whilst a pool of grease was found on the ground surface beneath these features, suggesting that a gear wheel or other machinery had overhung this wall.

The western wall beneath this part of the loading incorporated two elongated rectangular section slots which would have held a pair of substantial horizontally-set timbers (Fig 9). These would have served to strengthen the masonry structure at a point where particularly heavy loads were imposed on it by the action of the machinery sited here. It is probable that similarly-sized timbers would have been set on the tops of the loadings at this point to support the bearing trunnions.

The evidence suggests that this area sited the power train where the engine speed was geared down and where the drive for the flat-rods leading to the man-engine was attached.

Figure 18: Locations of visible hold down bolt locations within the man-engine house.

Figure 19: Bottom end of hold down bolt within crow hole.

Figure 20: Threaded top of hold down bolt.

7.2.3 Slot between eastern and western power train loadings

Figure 21: Looking south showing a large horizontal low-level slab of granite adjacent to the slot between the power train loadings (scale 0.5m).

The power train loadings were divided by an elongated gap at their southern end [124] (Fig 21); this was 0.45m wide and was at least 2.7m long. Extensive masonry loss from the southern end of the engine house has removed at least some of this feature and thus makes its interpretation somewhat difficult. The surviving sections of the walls of the feature were vertical and its base, 1m below the tops of the adjacent loadings, was flat. Prior to excavation it had been wholly infilled with a mixture of displaced wall construction material.

Given its location between the adjacent sections of loading, it is probable that this feature accommodated a gear or flywheel on the axle which spanned it.

7.2.4 Area 3

Figure 22: Location of Area 3.

Figure 23: Decayed timbers within Area 3, looking west (scale 0.5m).

Area 3 [111] extended across the width of the engine house (Fig 22), dividing the northern engine bed loadings from the southern power train loadings and containing several features (see Figs 15 and 16). Most of its floor consisted of the granite lintels covering a wide crow hole extending across the building from the base of its western wall.

Owing to the presence of some very large blocks of granite within the rubble fills, the western part of this area could not be fully excavated. The removal of the demolition rubble from the central part of this area exposed a pair of decayed 1.25m x 0.43m east-west aligned square timbers (Fig 23). These were set on the east-west aligned granite lintels forming the roof of the crow hole. The lintels did not extend all of the way to the inner face of the eastern wall of the engine house, but stopped 0.78m from it. There was insufficient time available to excavate the full depth of the demolition rubble infilling this deeper pit-like feature against the eastern wall or to remove the material which had spilled into the crow hole under the lintels. The infill was excavated to a half a metre deep and it seemed likely that the fills would extend down to the level of the base of the crow

hole. Removal of the upper fills revealed recessed ledges on the north and south sides of the pit, as well as a step in the external wall (see Fig 24). These appear to be construction features rather than those designed to support machinery.

Figure 24: Recessed ledges on the northern and southern sides of the pit at the eastern end of Area 3 (scale 0.5m), looking east.

The central part of this area between the two loadings contained a pair of hold down bolts. These were on the same north-south alignment as the western bolts on the cylinder bed loadings, but their tops were a metre lower than them, of a similar height to the northern pair of hold down bolts on the power train loadings. Matching bolts to the east were anticipated but were not found; these might have been lost. It is uncertain what equipment was bolted down in this area, which would have lain over a metre beneath the floor of the engine house.

Excavation of this area produced substantial amounts of corroded ferrous material, some strips of lead sheet which appeared to have been used as pipe connectors, together with some copper-alloy objects, glass bottles and domestic china (Figs 57 and 60).

Excavation of the south-western part of this area adjacent to the western section of the power train loadings revealed a large horizontally-set square slab of granite [138] (Fig 25) forming a small plinth measuring 0.66m square adjacent to a possible gear slot [124] and immediately to the south of a probable water tank [136]. The walling to the south of the slab was constructed of six courses of red brick bonded with lime mortar topped with a level-topped slab of granite.

Figure 25: Large horizontally-set square slab of granite (scale 0.5m), looking south-west.

The removal of demolition rubble from the south-western part of this central area revealed a probable low level water tank [136], this measuring 1.8m long, 0.8m wide and 0.3m deep. Its northern edge abutted an area which could not be excavated as the demolition rubble within this area contained some large displaced pieces of granite which proved impossible to move by hand (Fig 26). The floor level adjacent to the northern side of the tank was not revealed as a result. The fill of the tank consisted of a sticky dark red clay (137) incorporating numerous corroded ferrous objects. Its base was partly lined with the remains of wooden boards – others might

have existed and completely rotted away. There were indications that the stone and brick walls of the tank might have been lime rendered.
It is unclear which parts of the engine were located within this area, and whether this section of the building was originally open or was floored over.

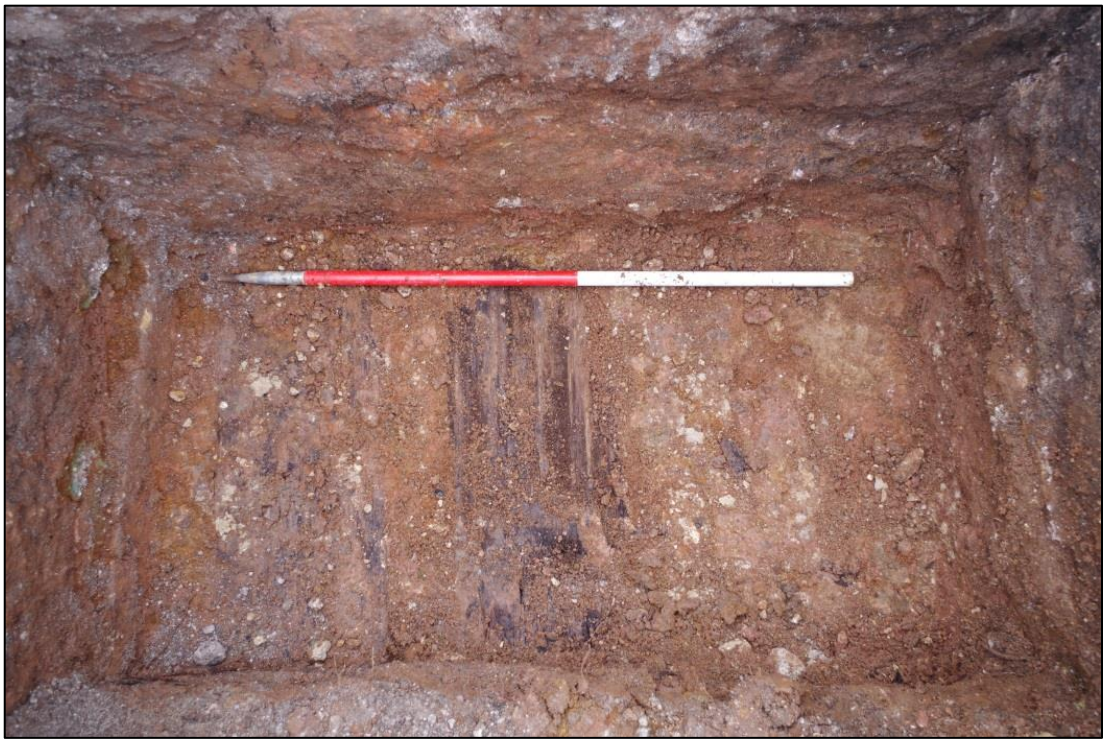


Figure 26: Possible water tank [136] looking south-west (scale 1m).

7.2.5 Pit 1

A rectangular shaped pit [107], this measured 2.63m long by 1.07m wide and reached a depth of 1.67m from the top of the central engine loadings (Figs 27 and 28). The north end of the pit was 1.67m from the northern end of the building. To the west was the external wall of the engine house, this being 0.72m wide; a dividing wall between Pit 1 and Pit 2 was 0.97m wide. All of the internal wall faces were vertical, and were integral with the fabric of the engine house.

This feature was filled with demolition rubble (108) comprising large blocks of displaced granite, fragmented lime mortar and pieces of lime-rendered wall plaster. This material was soft and partly voided in some areas and compacted in others. Some corroded

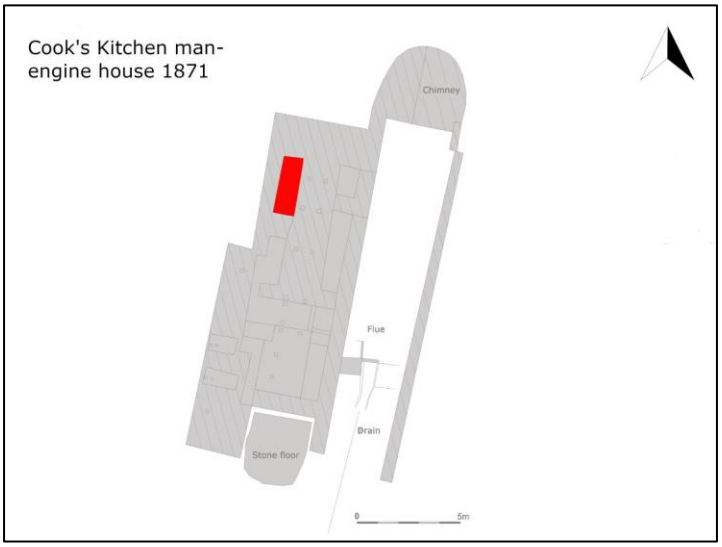


Figure 27: Location of Pit 1.

pieces of iron were recovered from within this fill, particularly towards its base. The floor of the pit consisted of a generally level compact reddish-brown sandy/gritty deposit (135). This was not excavated, so it cannot be confirmed whether it represented the original base of the feature.

Figure 28: Pit 1 as excavated looking west.

The function of this pit is uncertain. It abuts the cylinder loadings on their western side, but did not incorporate the entrance to a crow hole.

It is assumed, therefore, given its relatively substantial size and position adjacent to the former location of the steam cylinder that it would have contained equipment associated with the operation of the engine.

7.2.6 Pit 2

Figure 29: Location of Pit 2.

A rectangular shaped pit [109], with a dog leg on its outer wall and a narrowed extension to the south where it joins Area 3 (Figs 29 and 30). The northern end of the pit was 1m wide. 1.08m from the pit's northern end it widened by 0.33m on its western side; at 2.05m from its northern end, a 0.76 long by 0.84m long stub wall attached to the engine bed loadings formed a partial southern end to the pit; the pit continued 0.45m beyond this wall, where it joined Area 3 [111].

Figure 30: View of Pit 2 showing collapsed stones in situ.

The feature was filled with demolition rubble (110) comprising large displaced blocks of granite, fragmented lime mortar and lime-rendered wall plaster. This material was soft and partly voided in some areas and compacted in others. Some corroded pieces of iron, decayed leather pipe seals and other objects were recovered from within the fills, particularly towards their base. The floor consisted of a compact yellowish gritty sand (159), the southern end of which sloped upwards towards Pit 3.

The function of this feature is uncertain. It abuts the loadings on which the cross head is likely to have been sited; it did not give access to any crow holes. It would originally have been floored over, and it is possible that it represents the location of the under-floor parts of the driving controls.

7.2.7 Pit 4

Figure 31: Location of Pit 4.

This relatively small rectangular feature was the one of the only components of the engine house which was still visible prior to excavation. Pit 4 [113] was located at the northern end of the engine house on its eastern side, adjacent to the cylinder loadings and mirroring Pit 1, though shorter in length; it measured 1.35m long, 0.9m wide and 1.3m deep (depth measured from the top of the wall to the top of the fill within the pit) (Figs 31 and 32); this feature was not wholly emptied of its fills. The north wall of this

Figure 32: Pit 4 un-excavated (scale 0.5m), looking east.

pit was 1.77m from the northern wall of the engine house. The eastern face of the pit was formed by the eastern wall of the man-engine house – this was 0.7m-0.8m wide and consisted of a mixture of roughly coursed mixture of granite, killas and mine waste bonded with lime mortar. The upper fill of the pit was (114) a vegetation-topped dark brown compacted clay/soil mix containing some modern rubbish. The lower fills were not excavated due to time constraints.

The function of this pit is unclear, and its full depth is uncertain. It may well have given access to a crow hole accessing one or more of the engine bed hold down bolts.

7.2.8 Pit 5

Figure 33: Location of Pit 5.

Figure 34: Pit 5 looking north, (scale 2m).

A long rectangular pit [115] located on the east side of the engine house, partly mirroring Pit 2 to the west (Figs 33 and 34). It abutted the loadings for the cylinder and cross head and measured 3.8m long and 1.5m wide. It did not prove possible to excavate the full extent of Pit 5 given time constraints, but its northern end was excavated down to 1.5m below the surviving head of the eastern wall. It was estimated that a maximum of 0.5m of material remained unexcavated in the base of the pit. The top of a crow hole accessing a pair of cylinder hold down bolts was revealed at the northern end of the pit; it is likely that a second crow hole exists towards the southern end of the pit, given the presence of further hold down bolts above this part of the feature.

The area was filled with several layers. The top layer (116) was a dark brown compacted clay soil with some vegetation covering. This deposit was less than 0.2m deep, well compacted, but easy to trowel once the ground had been broken.

This covered deposit (117) which incorporated glass bottles, jam jars (Fig 56), pottery (Fig 58), corrugated iron and other metal rubbish, mixed with decayed wood and what appeared to be broken window glass (see Fig 56). The material was notably voided. This mostly represents mid- to late-20th century rubbish, dumped on the site before the engine house was buried, though also incorporates some 19th century ceramics.

This in turn overlaid the demolition material found elsewhere within pits and voids across the building (118). Again, this consisted of large pieces of granite, smaller displaced building stones and lime-rendered plaster fragments mixed with a gritty sand deriving from decayed lime mortar. The fills were notably voided in places and proved difficult to excavate given the pit's depth and the confined working space.

A line of granite coursing (Fig 33) protruded from the western wall face 1m below the height of the upper edge of the eastern wall and immediately above the top of the exposed crow hole.

This pit gave access to at least one, probably two, crow holes.

7.2.9 Pit 6

A rectangular pit [119] measuring 2.54m long, 0.84m wide, and about 1.7m deep (Figs 35 and 36). Its eastern and southern walls were formed by the outer walls of the engine house, its western wall was formed by the eastern edge of the power train loading and the northern end of the pit was divided by walling from the access into the crow hole tunnel at the eastern end of Pit 3. The eastern and northern walls exhibited steps in their construction.

Figure 36: Pit 6 post excavation looking south.

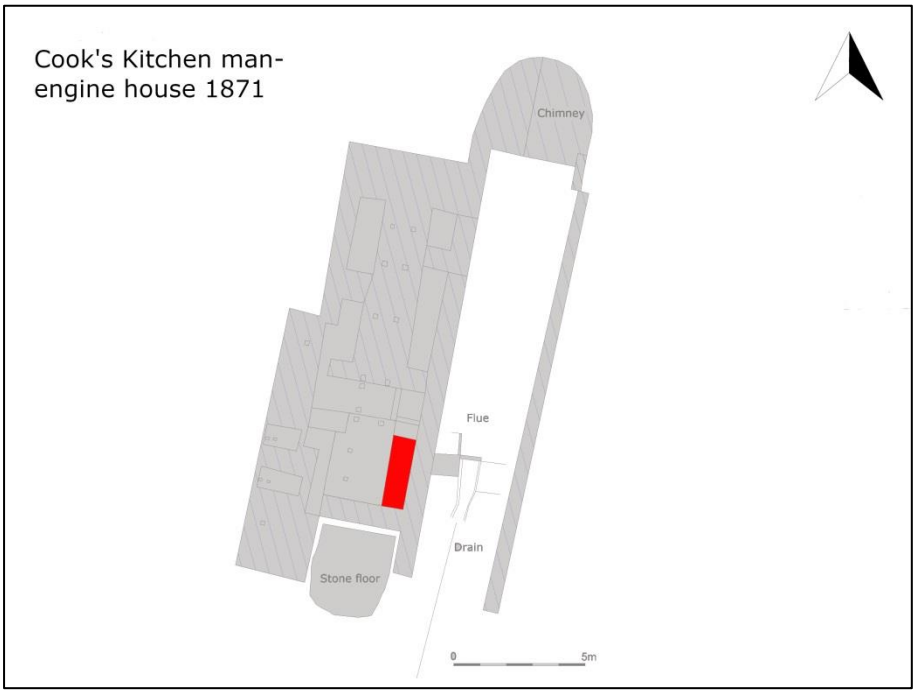


Figure 35: Location of Pit 6.

The majority of the fills were excavated from this rectangular pit, revealing a crow hole at its northern end accessing the power train hold down bolts. No artefacts were recovered from this feature. The fill of the pit comprised (120), the partly voided demolition rubble found elsewhere on and within the engine house. It seems likely that the function of this pit was to give access to one or more crow holes.

7.3 Chimney foundation

The chimney foundation [130] was located at the northern end of the original (western) boiler house (see Figs 5, 8, 13 and 37). Whilst this feature was cleared of demolition rubble the surrounding area was not completely excavated down to the original ground

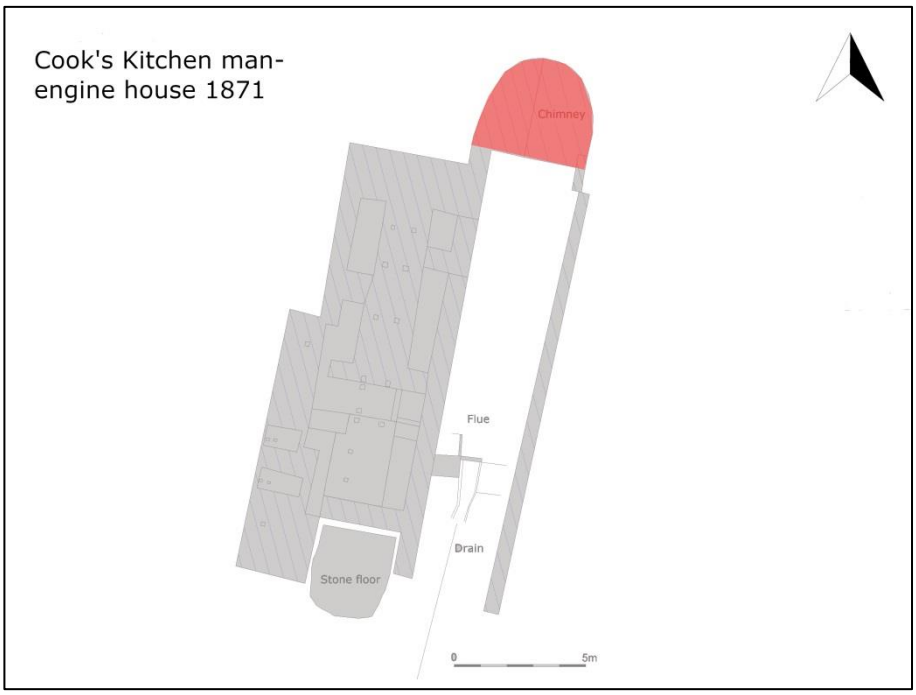


Figure 37: Location of chimney foundation.

levels given limitations on the amount of time for which the mechanical excavators were available. No connection between the boiler house flues and the chimney was found; it is uncertain whether these had originally been above ground and had been demolished or whether they connected at a deeper level and so were not exposed during the excavation. The former seems most likely, given the level at which the under-flues were exposed in the north wall of the eastern boiler house.

The curved chimney foundation was 4.1m wide and its upper surface stood an average of 0.4m above the excavated ground surface. It was constructed of substantial blocks of granite bonded with a lime based mortar. Although the basal courses of the chimney on its eastern side were keyed into the fabric of the boiler house, this was not the case where the chimney abutted the north-eastern corner of the engine house.

The western section of the chimney foundations was 0.2m higher than that on its eastern side, this area being defined on its eastern side by a north to south aligned face; this probably represents the remains of a cleaning access opening into the base of the chimney. No evidence for any flue opening into the chimney was found, and it was concluded that this must have been within its now-demolished section.

7.4 Cobbled surface at the south-western end of the engine house

At the southern end of the engine house, its western and eastern walls extended to enclose a small rectangular area. The western wall extension was 2.67m wide and 2.61m long, whilst the eastern wall extension measured 1.47m long and 0.81m wide (Figs 38 and 39). The space between the walls measured 3.13m and was occupied by a small area of cobbling (126). These did not abut the engine house to the north and east, but were separated from it by a linear gap 0.35m wide between the cobbles and the southern end of the engine house and a 0.24m wide gap between them and the eastern wall. These had the appearance of two timber beam slots, possibly the foundation timbers for a small structure of unknown function. At the northern edge of the cobbled area, the surfacing became a layer of generally level compacted coal dust and fine cinders (160) which extended at least as far north as drain [140]. The full extent of this coal dust and cinder surface was not revealed. Removal of (160) revealed a smooth compacted surface (159).

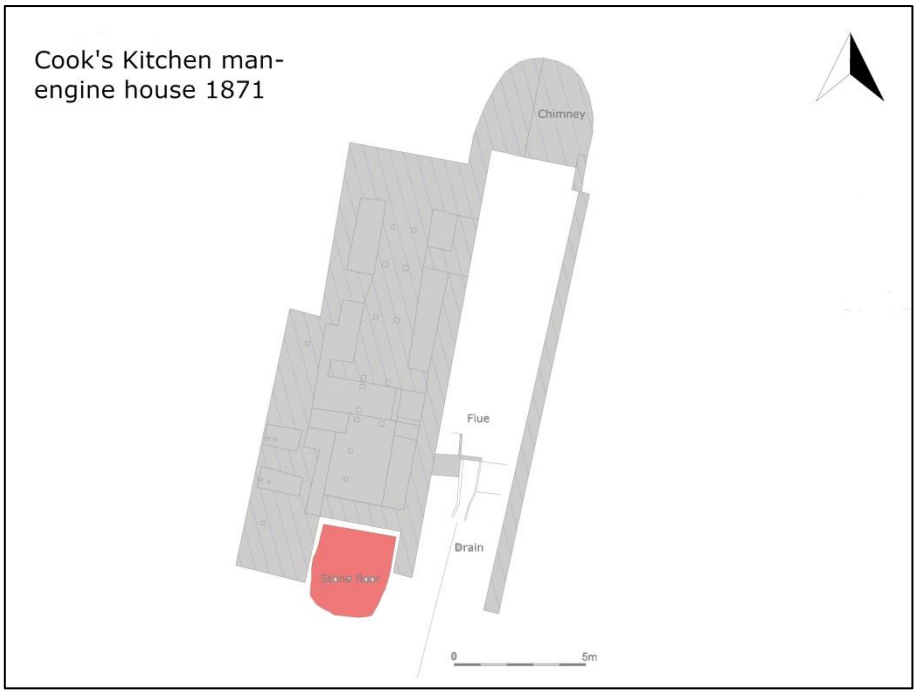


Figure 38: Location of cobbled surface.

Figure 39: View of southern end of the man-engine house, cobbled surface located in the foreground.

7.5 Western boiler house

The original western boiler house [134] measured 16.5m long and 3m wide. It had been constructed up against the eastern wall of the engine house, was abutted by the chimney to the north; a poorly-constructed wall divided off the northern section of the building (Fig 40); it had incorporated an originally free-standing western wall. Its southern wall had been completely demolished, presumably when its boiler was being scrapped and had left no archaeological trace; it might well have been entirely of timber construction.

The doorway into this building from the adjacent engine house would have been around 2.5m above ground level; given the loss of masonry from the eastern wall of the engine house the location of this feature could not be identified.

Figure 40: Location of western boiler house.

7.5.1 The western boiler house – eastern and northern walls

The western wall of the original western boiler house was shared with that of the engine house and was well-constructed (see Section 7.2 for the description of the engine house); in contrast the eastern wall of this boiler house comprised loosely-stacked killas and mine waste; this wall was not bonded by any mortar except at its southern end (where it would have been exposed next to the firing area). As a result it was unstable to the extent that it progressively collapsed as the excavation progressed.(Fig 41).

Figure 41: The eastern and northern walls of the western boiler house, looking north.

Whilst the northern section of the walling would have been internally supported by fills around the boiler, it is unclear how such a poorly built wall could have carried the loads imposed on the upper sections of the walls and a roof structure. Its eastern face was

not exposed as the narrow gap between this and the later boiler houses to the east proved too difficult to hand excavate in the time available, but it must have been fairly strongly constructed in order to support the upper sections of the walling of the building and its roof superstructure, even if the upper parts of the boiler house walls were of timber construction.

So poor was the construction of this feature that it was initially not recognised as a structural element. It measured 16m long, was 0.5m thick and where measurable, was nearly 2m in height. It was abutted by a loose earthy fill which had accumulated between this wall and the eastern boiler house. Its internal face was uneven and most of it appeared not to have been mortared. Its core appeared to be made up of an un-mortared mixture of relatively small stones bedded in earth. The southern end of the eastern wall had been severely vertically truncated, though some granite foundation stones had survived, allowing its extent to be recorded. The equivalent northern wall had collapsed to the point where it resembled a linear mound of rubble rather than a structural feature.

7.5.2 Floor area

Prior to excavation, the whole of the boiler house had been buried under dumped material. This was machine excavated in several stages, partly revealing details of its internal arrangements and floor surfacing, following which some trial trenches and sondages were excavated.

Following machine excavation, most of the floor of the boiler house remained covered with some demolition material (142) (see Figs 43 and 44); to the east this comprised greyish sandy grit and pieces of lime mortar mixed with small pieces of granite, killas and mine waste. This appeared to overlie a natural ground surface (143) made up of a yellowish brown gritty soil. A central strip along the length of the building had been the site of a boiler under-flue. This was very poorly preserved, however, and appeared to have been significantly vertically truncated. A trial trench was cut across this feature in the northern part of the middle section of the building, revealing a section of a linear cut containing a single line of parallel bricks set on top of a lime mortar bed. The evidence at this location appeared to be typical of the very poor level of preservation of this feature elsewhere in the building. Unfortunately the full extent of the flue could not be examined given the limited excavation time and the presence of the very unstable collapsing remains of the internal wall crossing the northern end of the boiler house and the equally unstable eastern wall (Fig 41).

Abutting the western wall of the boiler house was a narrow linear red clayey deposit (145); this material was extremely soft and sticky and appeared to be fairly deep, though was not excavated to its full depth. Given its location it probably represents the remnant ash infill of a wholly demolished side flue.

7.5.3 Firing area features

At the south-western end of the western boiler house, trial excavation revealed a small section of a sloping brick surface (Fig 42) [144]. The bricks, bonded with lime mortar, sloped down to the east to part of a basal feature consisting of two courses of bricks laid on their flats on a north-east to south-west axis. These horizontally laid bricks were set on (158), a compacted reddish brown gritty clay which probably represents the levelled mine waste onto which the boiler house was constructed.

The horizontally laid bricks formed a low wall which was 1.3m long; there were no indications that it extended further to the north. This area was covered with demolition rubble (142) consisting of brick fragments, pieces of granite and a grey gritty clay mixed with soil and other waste material.

The brick feature is likely to represent the truncated remains of the feature where the side flues connected with the under-flue (Fig 42).

Figure 42: Section of the under-flue in the western boiler house (scale 0.5m), looking south-east.

7.5.4 Boiler firing end mounts

The boiler firing end mounts [157], located at the south-west end of the western boiler house, survived as two truncated brick plinths (Figs 43 and 44); the easternmost of these measured 1.06m long and 0.93m wide, whilst the westernmost measured 1.02m long and 0.95m wide. They were 0.46m high and each had been constructed of five courses of brick. They were linked at their northern end by a single brick width lime-rendered brick wall 0.74m long. This appeared to divide the southern end of the under-flue from an ash pit and drain. These features had been covered with demolition rubble (143) and had been truncated.

7.5.5 Drain

A brick walled drain [146] was found leading away to the south from the area of the boiler firing end mounts [157] (see Figs 43 and 44). This was 0.74m wide at its northern end, though rapidly narrowed to 0.36m wide for the remainder of the length examined. The narrower section of the drain was topped with reused sections of boilerplate. Its base was flat and it appeared to slope gently to the south, where it joined a similar drain from the eastern boiler house. These features would have been used to drain away dirty water from the boiler during periodic maintenance operations.

A sample area of the drain was excavated, and it was found to be infilled with (147), a red sandy slurry mixed with pieces of broken brick and small stones.

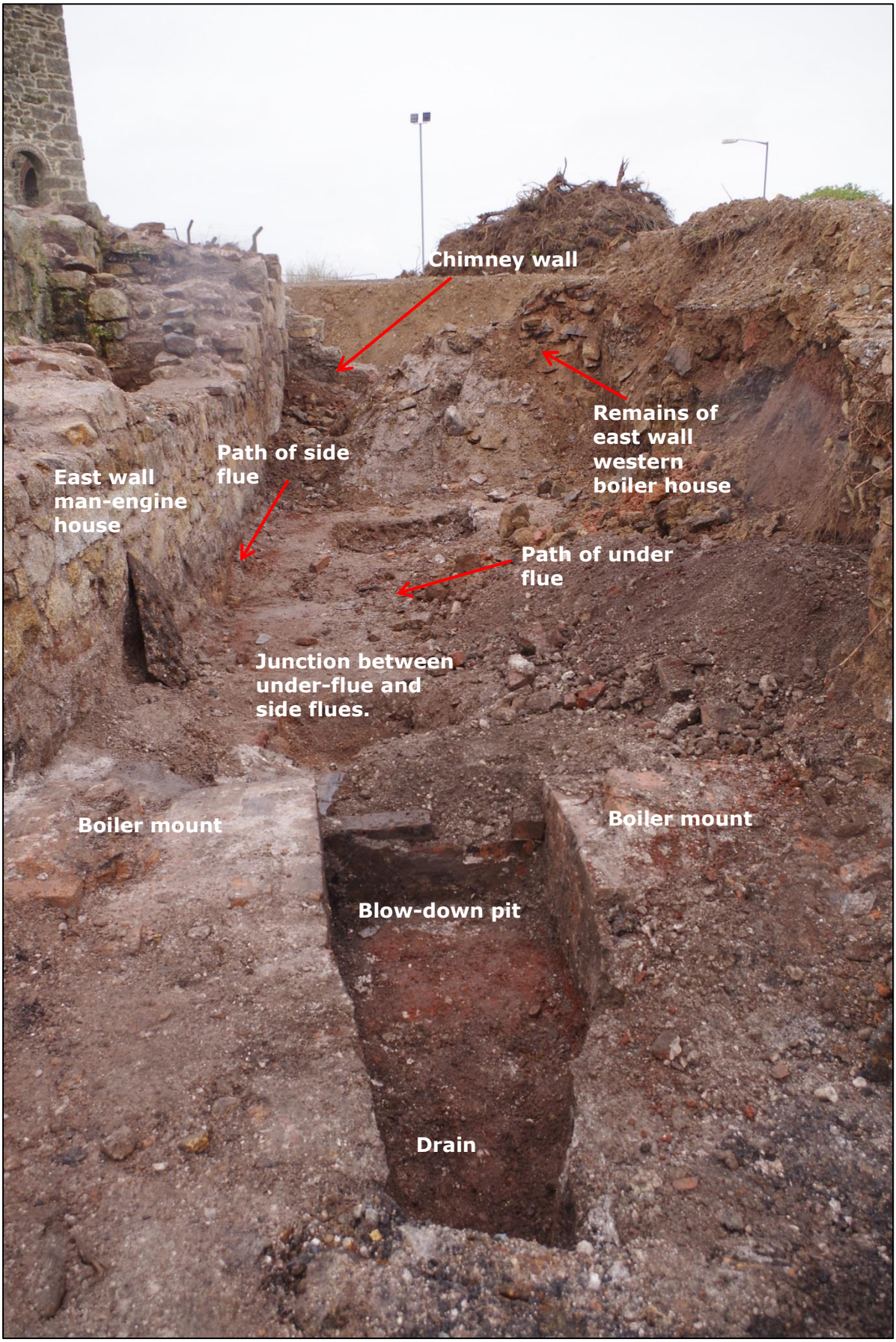


Figure 43: Interior of western boiler house looking north.

Figure 44: Interior of western boiler house looking south.

7.6 Eastern boiler house

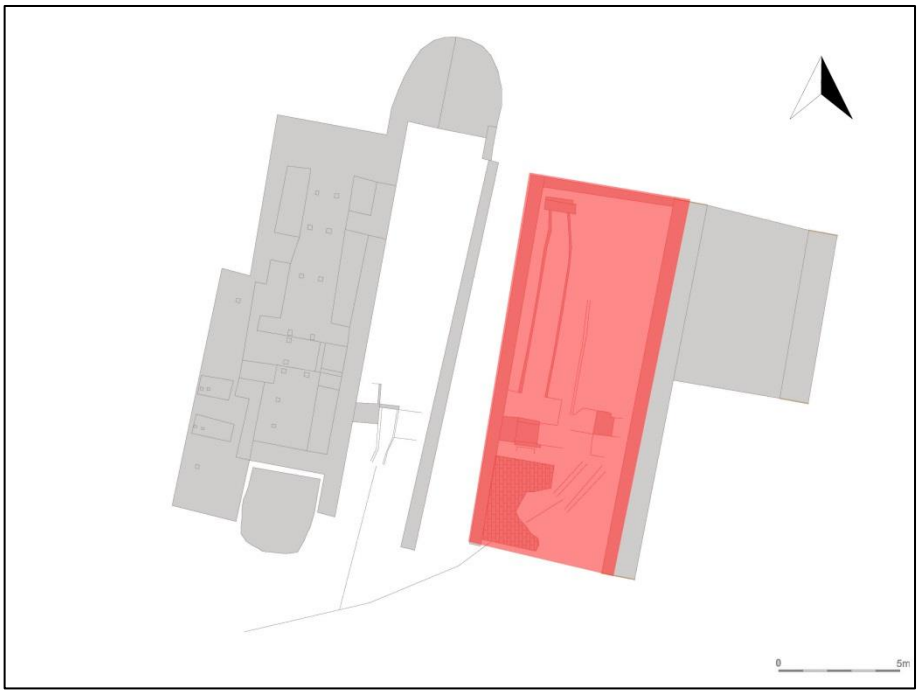


Figure 45: Location of eastern boiler house (circa 1878-1906).

The eastern boiler house was located to the east of the original western example; it measured 15.3m long, and 6m wide (Figs 3, 8, 45, 46, 47 and 48). Ordnance Survey map evidence indicates that it was constructed between 1878 and 1908 (Figs 4 and 5).

The building had been built as a standalone structure, and was originally from the pre-existing western boiler house, though the gap between the two buildings had become infilled when this area of the site was over-dumped during the later decades of the 20th century. The construction of most of the features of this building was to a higher standard than those found in the original western boiler house. Its southern wall had been completely demolished and had left no archaeological trace. It is uncertain where its access door would have been sited, but the southern elevation would be the most likely candidate.

Its interior appeared to have been built on two slightly different levels; the features associated with the eastern boiler in this building were at a slightly lower level than those associated with the western boiler. The two areas were separated by a north-south aligned brick walled plinth which would originally have been topped with a pair of now-demolished side flues.

The features associated with the eastern boiler appeared to be less intact than those associated with the western boiler, in part because the eastern wall of the boiler house appeared to have partially collapsed into the building.

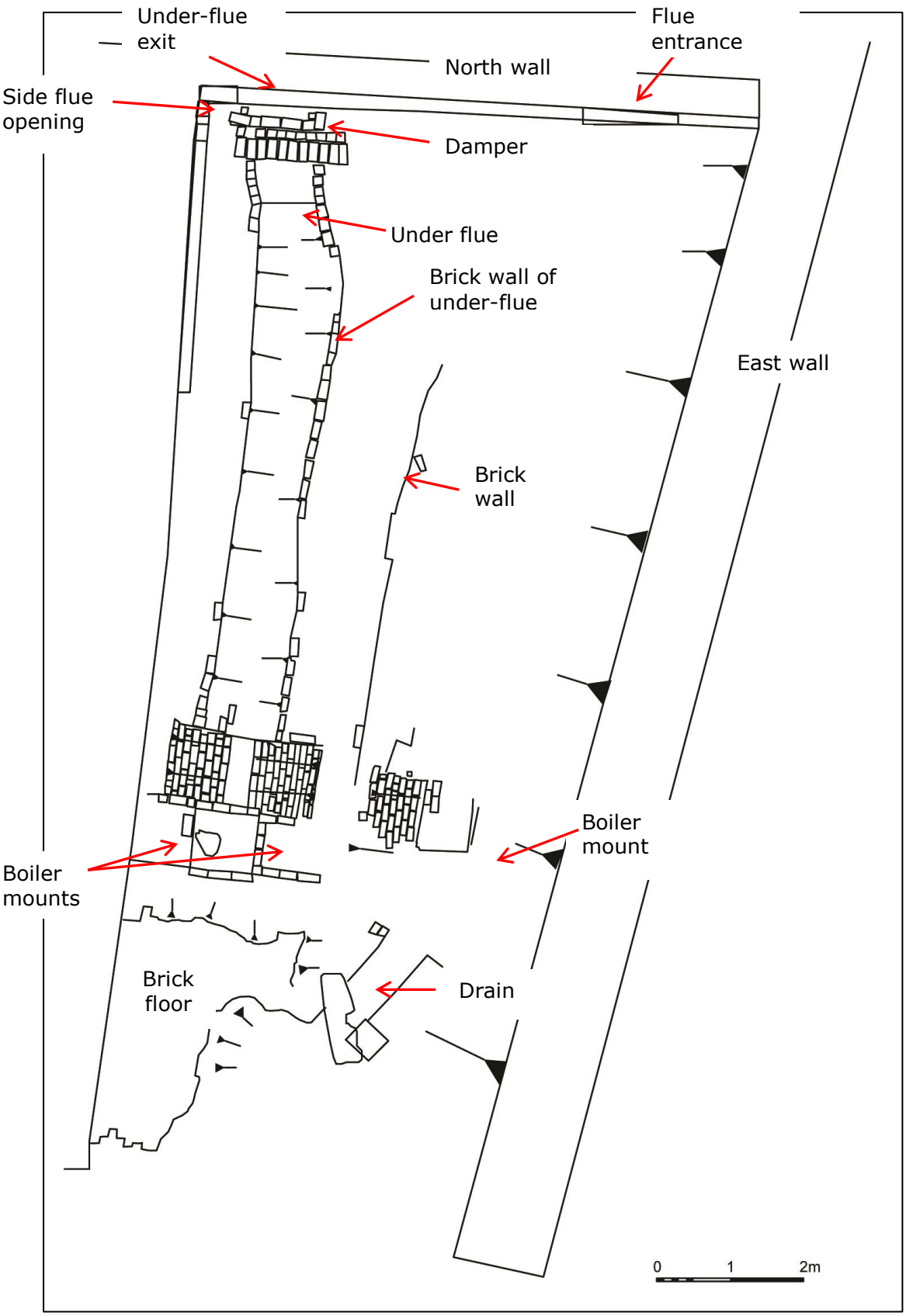


Figure 46: Layout of eastern boiler house.

Figure 47: Pre-excavation view of eastern boiler house, looking north.

Figure 48: Post-excavation view of eastern boiler house, looking north.

7.6.1 Western wall

The western wall of the boiler house [148] to the north of the boiler firing end location was 15m long, 0.5m thick and a maximum of 1.7m high (see Figs 46, 47 and 48). It appeared to be constructed predominantly of randomly coursed killas and mine waste; its lower 0.5m was bonded with lime mortar, but above this height this bonding was absent. This lower section of the wall would originally have been abutted by the side flue, whilst ash would have infilled the space between the boiler and the wall above the side flue. The upper section of the western wall has been demolished, and its construction and original appearance are uncertain.

The southern 4m of the wall which would have abutted the firing area had been mortar bonded and pointed; this walling contained some larger pieces of stone than found elsewhere in the structure. The wall terminated in squared granite, of which one foundation block survived. A low wall bordering the boiler end supports was tied into the wall. Within the firing area, the wall was abutted by a surviving section of a brick floor [132].

7.6.2 Eastern wall

The eastern wall [149] of this boiler house was predominantly constructed from killas and mine waste (see Figs 46, 47 and 48). What survived measured 13m long, 0.5m thick and averaged 1.2m high. Its western face was a loose tumble of densely packed un-mortared stone, whist its eastern face retained some lime mortar bonding in places and had a vertical face.

The southern end of this wall had been revealed during the clearance of scrub during the installation of the site perimeter fence. Here it had more the appearance of a field boundary; the roots of a small thorn tree growing out of the wall fills are destabilising the structure of the wall. The upper surface of the wall was not cleared of covering material owing to the risk that this would result in further structural destabilisation. As a result it is unclear whether the apparently non-structural build of its western (inner) face is a result of collapse over time; it is unlikely to reflect its original form.

7.6.3 Brick firing floor at the south-western end of the boiler house

Figure 49: Brick floor in eastern boiler house looking north (scale 1m x 0.5m).

Brick floor [132] was located at the southern end of the eastern boiler house on its western side (Figs 46 and 49). The surviving section of what was likely to have been a much larger area of flooring measured 3.4m by 2.46m; the western edge of the floor abutted the western wall of the boiler house and was still in reasonably good condition (see Fig 49). In contrast much of the flooring to the east had been lost, partly through the effects of over-dumping and partly through the collapse of the underlying drain covering sheets.

7.6.4 Western boiler under-flue

The under-flue [151], serving the western boiler was well-preserved and measured 9.5m long, 0.9m wide and was 0.6m deep (see Figs 46, 48 and 50). It ran parallel to the western wall of the boiler house for most of its length, though exhibited a noticeable curve toward the north-western corner of the building at its northern end.

The under flue walls were made up of at least nine courses of white brick bonded together using lime mortar. At their southern end

Figure 50: Western boiler under-flue and side flue (scale 1m) looking north.

adjacent to the boiler firing end plinths, the connection between the under-flue and the side flues was marked by a curved brick-lined depression 2.2m wide, 1m long and 0.6m deep at its centre. From this point northwards, the brick-constructed flue had a U-shaped profile and was 0.97m wide and 0.6m high.

Towards the northern end of the building, the walls were found to be missing several of their upper brick courses, though excavation revealed that the lower courses were still intact. At its northern end the flue curved slightly to the west, the side walling became vertical and the floor flat and the space between the walls narrowed to 0.69m. This area would have been occupied by the 'hovel' in which the flue gases travelling down the centre of the boiler were diverted into the side flues, and below which the under-flue ran. No evidence for this feature was found, and it is probable that it was completely dismantled during the removal of the boiler when it was scrapped or taken out for re-use elsewhere.

Adjacent to the north wall of the building, the flue, constructed of nine courses of brick, was covered by substantial iron lintels, topped with several surviving courses of brick laid on their flats and bonded with lime mortar. The flue at this point was 0.9m high. Just before the flue passed through the north wall of the building a 0.06m gap had been left between two of the iron lintels. This was occupied by four upright strips of metal 0.64m high, 0.06m wide, 0.025m apart, with a 0.72m gap between the two pairs. These represent the guides for a damper plate (the means by which the draught was regulated).

7.6.1 Side flue

The cleaning door opening to the side flue at the western end of the north wall [133] measured 0.63m high and 0.27m wide (Figs 46 and 50); an iron plate 0.49m long and 0.025m thick served as the lintel off which the overlying walling would have been constructed (though the majority of this had been lost). The walls of the flue consisted of seven courses of brick bonded with lime mortar; the base of the flue consisted of a solid flat layer of lime mortar.

The side flue within the western side of the engine house had been almost wholly removed, but this would have been constructed of brick with a half-arched head. Its location within the interior of the boiler house showed up as a single line of bricks set 0.3m away from the west wall and running back to the junction with the under-flue.

This feature would originally have been paralleled on the eastern side of the boiler, but no surviving traces of the other side flue could be identified other than the wall off which it would have been constructed [152]. The poor state of the northern wall of the boiler house meant that it could not be fully excavated, and given its significant truncation it is uncertain whether or not it incorporated further side flue openings. No indications of these were seen in its external face, however.

7.6.2 Eastern boiler house central wall

Dividing the eastern boiler house into two sections and aligned north-east to south-west was wall [152] (Figs 46 and 51). This was not fully excavated, though approximately 5m of its length was exposed on its eastern side; its western edge was not revealed. It was found to have been constructed of at least four courses of red brick bonded with grey lime mortar; the northern section was in poor condition with several upper courses of brick missing; some areas of almost complete collapse were also found.

Figure 51: Central wall dividing the eastern boiler house, (scale 1m) looking west.

It is probable that this wall had supported a pair of side flues – one for each of the boilers which flanked it – though all traces of these would have been destroyed when the boilers were removed.

7.6.3 Eastern boiler foundation features

The only substantial evidence for the eastern boiler in this boiler house which was exposed by excavation was a brick-built curving depression [156] which would have been sited at the junction point of the under-flue and side flues (Figs 46 and 52); it was similar in appearance to that found associated with the western boiler in this building. This curved brick feature was shallower than that to the west and appeared to be more poorly constructed. Overall the feature was 0.98m wide, 0.72m long and survived to a depth of 0.14m.

Figure 52: Brick curved depression belonging to the easternmost boiler, looking south.

The western side of the curved structure comprised seven courses of horizontally-laid brick bonded with lime mortar and sloping at about a 30 degree angle. At the lower edge of this curved section was a brick floor made up of two courses of horizontally laid bricks bonded with lime mortar; the sloping bricks were set directly on top of this 0.98m long feature. The area adjoining this feature was not fully excavated to reveal whether an under-flue extended northwards from this point, though one would have been sited in this part of the building. Trial machine excavation in the north-eastern part of the building suggested that no obvious intact features survived where the under-flue would have been located.

The eastern side of the boiler foundations were partially covered by significant amounts of tumble from the partly-collapsed masonry forming the eastern wall of this boiler

house (see Fig 52) and the full extent of this feature could therefore not be excavated and recorded.

7.6.4 Eastern boiler house drains

The northern end [153] of one of the drains from the eastern boiler house was initially revealed through excavation near the location of the firing end of the eastern boiler (Figs 46, 52 and 53). Here, it consisted of two vertical sections of parallel brickwork 0.63m apart and 0.4m high sloping gently away to the south-west. The base of the drain was rendered in lime mortar.

Figure 53: Eastern boiler house drain on the east side (scale 1m x 0.5m) looking south.

The two walls enclosed an area containing two deposits. The surface deposit (154) consisted of dark organic loose peaty silt containing fragmented stone and organic material; this was nowhere more than 0.3m deep and had been disturbed by animal burrowing and plant growth. The basal deposit (155) was a very plastic red clay at a maximum of 0.1m deep; this was easy to trowel and is assumed to be iron-rich sludge derived from draining down the boiler mixed with fine ash.

The drain continued under brick floor [132] to the south-west where it would have been joined by its equivalent from the western boiler blow down pit; it then continued on under the location of the lost south wall out of the building; beyond this point it turned to the west, where it narrowed to less than 0.3m. Where this section was sample excavated its walls were made up of lime-mortared stonework and the drain was covered with sections of recycled iron boilerplate. The drain from the western boiler house linked into this system a little further to the south-west.

The areas of the drain external to the boiler houses were filled with (141), the black fine cinder and coal dust mixture which cloaked this part of the site.

7.7 Possible compressor house

Ordnance Survey mapping dating to 1908 and 1938 (Figures 4, 5 and 8) show that this building, set parallel to the eastern boiler house and sharing a wall with it, remained roofed until at least the late 1930s. It has been suggested that it had been constructed *circa* 1880 for a compressor house for the mine's newly-introduced rock drills; it is known that the compressed air pipes were led down Dunkin's Shaft not far away, and steam from the man-engine boilers could have been used to power the compressor (Brown and Acton 2007). However, why it was still roofed in the 1930s, long after the boilers had been scrapped and the mine had closed is unclear. It is assumed that it must have been converted to another use.

The standing remains of the building's eastern wall [150] are now only 7m long, 0.6m thick and survive to 1.5m high (Fig 54). It is constructed of killas and mine waste with some brick and granite in random courses, all bonded with lime mortar. It appears to have been truncated at its southern end and its northern wall has been demolished.

Time constraints precluded investigative excavation of this building, but the preliminary lowering of ground levels within its interior revealed no evidence for machine bases, or for a floor.

Figure 54: View looking north of the possible compressor house east wall.

8 Chronology/dating evidence

A time line for Cook's Kitchen is provided in this report as Appendix 4. Relevant detail has been incorporated into the site history (Section 5). Whilst the date of installation of the horizontal engine-powered man-engine is well-documented, changes to the site including the addition of a further pair of boilers in a detached boiler house and the construction of a further building to the east can only be loosely dated to between *circa* 1878 and *circa* 1908. However, the Ordnance Survey maps (1st and 2nd Editions of the 25" to a mile) illustrate that these additional buildings had been constructed during this timeframe. No other documentation indicating when and why the steam production capacity at this site was increased have been identified, though this may in part be related to the installation of an air compressor *circa* 1880.

It is also unclear exactly when the man engine became disused and when it was scrapped, though the OS mapping indicates that this had taken place by 1908.

9 Significance

Only a small number of man-engines were erected in Cornwall and very little now survives of the buildings which housed the engines which powered most of these. The best-preserved is that at South Tincroft, not far from Cook's Kitchen; what remains consists principally of the house for the rotative beam engine, though Brown and Acton (2007) suggest that the loadings to the south of the house are diagnostic of having driven a man-engine. There are some low remains of the horizontal man-engine house and boiler house at Levant, together with its now slightly truncated, conserved chimney; at Jope's Shaft, South Caradon, the site of the horizontal engine house which drove the man-engine is marked by an overgrown rectangular hollow.

Nothing now survives of the installations at the remaining sites: Dolcoath, the United Mines, Fowey Consols, Tresavean, Great Wheal Vor, Par Consols, Carn Brea, Wheal Reeth, Devon Great Consols, Wheal Mary Ann and the Providence Mines at Carbis Bay.

The man-engine house at Cook's Kitchen is therefore of considerable significance, both as a very rare surviving example of an engine house associated with a Cornish man-engine, but also as the only substantial remaining evidence anywhere in Britain and possibly in the world for a horizontal steam engine driving a man-engine.

10 Discussion

The work undertaken by CAU at the Cooks Kitchen site in March 2018 has revealed and recorded the remains of a very rare site type – the power source for a man-engine. It is understood that it is intended to conserve, display and interpret the surviving remains of this group of structures in due course.

The man-engine at Cook's Kitchen is poorly documented and only appears in archive photographs as a distant structure; no plan or technical drawings of the complex have been located, though they must have existed. Furthermore, the buildings were substantially demolished when the engine and boilers were removed for scrap, and the buildings suffered further damage during their burial in the late 20th century. As a result, the original appearance and construction of this group of structures is uncertain. It is also unclear how the components of the engine house were laid out, though some broad guesses can be made given the layout of the hold down bolts on the engine house's loadings.

There is also some uncertainty at what date the man-engine went out of use, though its engine house and boiler house were unroofed by 1908.

Other unanswered questions relate to the boiler houses. It is clear that additional steam producing capacity was installed between 1878 and 1908, probably in response to the deepening of the man engine, but possibly also because the original boiler had become worn out and also possibly to provide steam to an engine driving the mine's air compressor. What is not clear is whether all three boilers were operated together, or whether the later pair replaced the original single boiler. The marked contrast in the degree of preservation between the earlier and later boiler houses may suggest the latter, but suggests that the earlier building would have been internally derelict for the last two decades of operation of the man-engine. The absence of internal features such as the side flues and hovels in the boiler houses can be explained by deliberate demolition when the boilers were scrapped, but the removal of internal features within the earlier boiler house was taken to an extent where almost nothing now survives – this appear to have been deliberate. Within the later boiler house, there are differences both in construction detailing and survival between the beds and features associated with the eastern and western boilers. It may be that this is an indication that they were not installed at the same time.

A further unanswered question relating to the boiler houses is why they appear to have been so poorly constructed – to the degree that their side walls appear structurally incapable of having supported any form of upper sections or roof structures. Given the absence for any evidence for stone wall footings, the southern walls of both boiler houses are likely to have been of timber construction; this may also have been the case with the upper sections of their side walls.

The function of the small eastern building remains unclear. It was built between 1878 and 1908 and shares a wall with the later boiler house, so is contemporary with it or post-dates it. It has been suggested that it might have sited the air compressor used to power the rock drills which were introduced to the mine around 1880, and this could have been powered by steam from one of the boilers in the adjacent building. Rubble clearance within the building did not expose any evidence for the loadings which would have sited the compressor, however.

It is also unclear why this building remained roofed in 1908 when the man-engine house and boiler houses had clearly become disused and the mine was close to closure. If this were a compressor house, it would have lacked a source of steam to drive its machinery by this date. The building remained roofed until at least the mid-1930s when all mining activity at Cook's Kitchen had long ceased.

11 Recommendations

Further documentary research may have the potential to answer some of the questions posed in the previous section of this report. A search of the online National Archive and Cornwall Record Office catalogues for Cook's Kitchen revealed some entries relating to Cook's Kitchen but none appear to relate to its man-engine. Some Cook's Kitchen records might have been acquired by South Crofty when this mine took over the former's sett, but an online search of archives relating to South Crofty reveals that this contains only a small number of records which might be relevant. The same is true for searches relating to Tincroft and to the Carn Brea Mines, or from a general search for documents in local and national archives which in any way relate to man-engines. It is quite possible, therefore, that on the closure of the mine all relevant archive material suffered the same fate as those disposed of in 1844, when the Cook's Kitchen agents destroyed 'nearly half a ton of documents'.

There remains the potential for some limited targeted excavation on the site to provide answers to some of the questions highlighted above, in particular in relation to the two boiler houses and the small building to their east. Given that the removal of bulk rubble from the site took up half of the fieldwork time during the 2018 project, the remaining time available to the team had to be targeted at key areas of the site, and its complete excavation and recording was not possible. Some further physical works will probably need to be undertaken prior to the consolidation of the standing fabric of the remains of the boiler houses, in particular the likely partial demolition of their currently unstable sections of walling. The removal of collapsed material and the last of the infilling rubble, together with the landscaping of the dump material surrounding the buildings may well reveal further detail requiring recording; this work should be accompanied by an archaeological watching brief.

The consolidation of the engine house and the stabilised sections of the boiler house should be undertaken in lime mortar. Some limited rebuilding using site won materials may be required to ensure the stability of these rare and unusual structures. The information presented in this report should help in guiding that work, and also in the interpretation of the site to the public.

Figure 55: Lubricator from demolition rubble within the eastern boiler house.

Figure 56: Hartley's jam jars (late 19th century) from Pit 5.

Figure 57: Pottery sherds from Area 3. This included one of Benjamin Franklin's popular 'Poor Richard' maxims: 'When the well runs dry they shall know the value of water'.

Figure 58: Pottery sherd from Pit 5. This was made at the Ford and Riley Pottery in Burslem, Staffordshire, between 1882 and 1893.

Figure 59: Chimney or side flue arch brick with 'GWR' stamp from the demolition rubble on the west side of the engine house.

Figure 60: Selection of small bottles from the central part of Area 3.

12 References

Maps and plans

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13 Project archive

The CAU project number is **146755**

The project's documentary, digital, photographic and drawn archive is maintained by Cornwall Archaeological Unit

Electronic data is stored in the following locations:

Drawings reference: GRE 905/1-4

The finds have been temporarily stored by CAU in Truro pending advice from the client as to whether they wish to retain them.

Historic England/ADS OASIS online reference: cornwall2-315940

Appendix 1: List of contexts

Context Number	Location	Description
(101)	Site	Topsoil. A mixture of a dark brown clay silt with an almost black organic peaty soil. Its depth was variable, dependant on its location within the site.
(102)	Mine waste and rubbish	The site levels were found to have been built up with mine waste, substantial boulders of granite and killas, brick, plastic, metal and other discarded waste. These deposits varied in depth across the site. In places they were mixed with (101). To the south-west of the site a hollowed trackway had been cut into the steep edge of the dumped material by off-road motorcycle users; this exposed (101) together with a reddish-brown layer of a gritty sandy material (103).
(103)	Mine waste	A reddish-brown gritty sand deposit, probably redeposited mine waste. This appeared to be the material off which the man-engine house had been constructed.
(104)	Surface rubbish	Surface rubbish found around the site, including plastics and metal; mostly fly-tipped material.
[105]	Man-engine house	The man-engine house. This was constructed largely of pieces of granite in a range of sizes, some quite large (over 0.5m to a side) and deliberately squared up, in a matrix of lime mortar which had degraded to some degree in some areas. Some pieces of killas and a small number of bricks incorporated into the fabric in some areas. Remnant scribed pointing found in some areas of the western and northern wall faces. What survives represents the foundation of the building, which has been vertically truncated, now reaching a maximum height of 3.8m, though lower to the south. It is broadly rectangular in plan
(106)	Man-engine Core filling of walls	Wall core material, made up of smaller fragments of granite, some slate spacers and degraded lime mortar - very sandy/gritty.
[107]	Man-engine Pit 1	Pit 1 was located in the north-west corner of the engine house. It was a rectangular-shaped stone-lined hollow within the fabric of the building, bordered on all four sides by solid stone walls. It measured 2.63m long and 1.07m wide, and was at least 1.67m deep against the adjacent engine bed loadings. The external wall of the pit was 0.72m in width.
(108)	Man-engine Pit 1	Fill of Pit 1. A mixture of granite, lime mortar and pieces of decayed wall render at least 1m in depth. The fill was both loose and compacted, voids being present below the larger stones; some areas were sandier than others. It overlaid (135).

Context Number	Location	Description
[109]	Man-engine Pit 2	Pit 2 was located on the central western edge of the engine building. It was an irregular rectangular shaped pit, stone-faced on three sides, sloping shallowly at its southern end where it joined the Central Area. The walls of the pit were constructed of granite blocks bonded with lime mortar. The northern section of the pit measured 1.08m long x 1m wide. Beyond this point the pit widened to the west and this section measured 2.3m long by 1.33m wide. On its eastern side a stub wall 0.72m long by 0.38m wide projected westwards into the pit from the adjacent central loadings, partly dividing it from Area 3. This was up to 1m high, but had clearly lost stone from its upper surface. The eastern wall of the pit extended 0.35m beyond this wall. The base of the pit was formed by the same compacted yellowish-red coarse sand (108) found in [107]. The base of the pit was 1.7m below the adjacent engine bed loadings.
(110)	Man-engine Pit 2	Fill of Pit 2: A mixture of granite blocks, pieces of lime mortar and pieces of corroded iron, the material varied in compaction within the pit; there were larger granite blocks within this feature which were too large to move to allow its complete excavation.
[111]	Man-engine Area 3	Area 3 formed a broadly rectangular east-west aligned low area between the engine bed loadings [122] and the power train loadings [123 - 125]. It ran between the two outer walls of the building. At its western end it adjoined Pit 2, from which it was partially divided by a stub wall. This area contained two low-level hold down bolts on the same alignment as those on the western side of the engine bed. The part of the engine house could not be fully excavated owing to the presence of a very large slab of granite which proved impossible to move. This area incorporated a low level water tank [136] was; this was partly framed in timber and had the remnants of a planked base; this feature measured 1.42m long, 0.82m wide and was 0.3m deep. To the south of this pit was a gap between the two sections of the power train loadings. This area was wholly underlain by an elongated granite-lintelled crow hole extending from the western side of the building. Lintels were absent at the eastern end of the crow hole, possibly representing an original access into the tunnel from above. Set on top of the crow hole lintels and aligned north-east to south-west were a pair of rather decayed baulks of timber – these had probably originally been 0.18m square in section, supporting a feature.
(112)	Man-engine Area 3	Fill of Area 3. This contained two separate deposits. (112) and (137). In the south-west of this area near the water tank the upper fill (112) was a grey sandy gritty soft mixture, which contained some corroded ferrous objects and some broken ceramics.

Context Number	Location	Description
[113]	Man-engine Pit 4	A rectangular pit, this was not fully excavated, but was topped with an earthy layer. The pit measured 1.35m long, 0.9m wide and its upper surface was 1.3m below the top of the engine loadings. The north end of the pit was 1.77m from the northern wall of the engine house, 0.7m from the eastern wall of the building and 0.76m from Pit 5. It abutted the northern end of the engine bed loadings. Its walls were made up of granite blocks and smaller pieces of killas, bonded with a greyish sandy lime mortar. It probably extended to a similar depth as Pit 5 to the south and is likely to have given access to a crow hole.
(114)	Man-engine Pit 4	Fill of Pit 4. A dark brown loose soil mixed with mine waste. Its surface was partly covered by modern rubbish and large pieces of concrete.
[115]	Man-engine Pit 5	Pit 5. A large rectangular pit on the eastern side of the man-engine house; it measured 3.8m long and 0.93m wide. It abutted the engine bed loadings and its outer edge was 0.73m from the eastern wall of the building. The top of the upper fill (116) was 1.58m below the adjacent loadings, the surface of the third fill (118) was 1.94m below the surface of the loadings. Owing to time constrains and the difficulty in working in this confined space the pit was not bottomed, but excavation revealed a crow hole in its north-western corner. An approximately 1.5m length of the pit was excavated. Given the presence of multiple hold down bolts on the adjacent engine bed loadings it would seem likely that the pit gave access to further crow holes to the south, though these were not exposed during the excavation.
(116)	Man-engine Pit 5	Upper fill of Pit 5. A loose dark brown organic fill containing mine waste and modern rubbish about 0.2m deep, topped with ivy and brambles.
(117)	Man-engine Pit 5	Second deposit in Pit 5. Rubble and rubbish comprising glass bottles (some labelled 'SAUCE') and jars, date unknown but probably mid-20th century. These were mixed with pieces of corrugated iron and other corroded ferrous objects. The depth of this fill averaged 0.4m.
(118)	Man-engine Pit 5	Basal fill of it 5. Demolition rubble comprising granite and killas mixed with decayed lime mortar and pieces of render; the material was clean and did not incorporate any organic material.
[119]	Man-engine Pit 6	Pit 6. Located in the south-eastern corner of the man-engine house; 2.54m long and 0.84m wide. Most of the pit was excavated, revealing a crow hole. Several large displaced blocks of granite proved impossible to remove from this pit. The northern end of the pit terminated at a granite wall separating the pit from Area 3. This incorporated three large pieces of squared granite running the full width of the pit.
(120)	Man-engine Pit 6	Fill of Pit 6. Demolition rubble from the engine house comprising blocks of granite (some very large), pieces of killas, lime mortar and plaster. The fills were at least 1.7m deep.

Context Number	Location	Description
(121)	Man-engine Fill of main engine house interior.	Fill of the pit at the eastern end of Area 3. This was a mixture of mine waste and various coloured layers of clay and greyish clayey material mixed with decayed lime mortar, pieces of brick and granite. This fill was not bottomed but was at least two metres deep.
[122]	Man-engine Engine bed loadings	The engine bed loadings, forming the centre of the engine house structure at its northern end were 8.88m long and 1.7m wide; this formed the highest surviving point of the building. It incorporated eight upright hold down bolts; these stood between 0.3m and 0.5m above the loadings. Two of the hold down bolts were at the southern end of this feature, and had been significantly bent, probably during the bulldozing of material across the structure in the 1990s. The loading was constructed of an originally level-topped raised bed of granite and killas bonded with grey lime mortar. At its northern end it terminated at the northern wall of the building, whilst its southern end was abutted by Area 3.
[123]	Man-engine Power train loadings (eastern side)	A rectangular area at the southern end of the engine house building. This feature was raised above Area 3 by 1.13m to the north and 0.55m above the southern end of the engine house; it was at the same level as the western section of the loadings [125]. This feature contained several surviving holding down bolts and the vertical bolt tunnels where others would have been sited; these were aligned with those on the engine bed loadings. It was divided from the western section of the power train loadings by possible gear slot [124].
[124]	Man-engine Possible gear pit	Possible gear pit between the eastern and western sections of the power train loadings. This was 0.47m in width and probably and probably originally extended to the southern end of the building. It was infilled with demolition rubble.
[125]	Man-engine Power train loadings (western side)	The western section of the power train loadings consisted of a raised plinth whose upper surface was at the same level as the eastern section of the loadings. This incorporated two substantial rectangular blocks of granite through which two pairs of hold down bolts passed. Grease marks found down the side of the building below these stones and a pool of grease on the ground surface at the foot of the wall imply the presence of machinery (probably gearing) overhanging the western wall of the building.
[126]	South-west end of man-engine building. Cobbled floor	A cobbled floor located at the southern end of the building, made up of stones around 0.3m in size, with flat surfaces, possibly bedded in lime mortar; the floor appeared to slope slightly down to the south where it blended into a surface of coal dust and fine cinders. Linear gaps between the cobbling and the engine house on the eastern and northern sides of this cobbled surface may mark the locations of timber beam slots.

Context Number	Location	Description
[127]	Western boiler house Eastern and northern walls.	The eastern and northern walls of the eastern boiler house. These were constructed from killas; there was no evidence for mortar bonding in in the central and northern part of the building. The walling was of poor quality and very unstable, and as demolition material and rubble material was machine excavated from the centre of the building the majority of the walling collapsed. The wall was at least 1.7m in height and 0.5m thick; the masonry at the southern end of the building (adjacent to the boiler firing area, where the wall would have been exposed) was bonded with lime mortar and remained standing. The wall to the north appears to abut the granite masonry used in the construction of the engine house, and was of similarly poor quality to the eastern wall. Only parts of this remained standing.
[128]	Western boiler house Under-flue	The under-flue in the central and northern end of the interior of the western boiler house. The only remains of this feature were some indistinct walls constructed from bricks bonded with lime mortar; these appeared at surface to indicate one possible edge of the under-flue. Trial excavation of the feature revealed its base to be less than 0.3m below the possible floor level. The flue could not be followed further north towards the chimney due to the amount of rubble and infill still present within this area, but its southern end was exposed and excavated. This was half-sectioned due to time constraints revealing the western half of the U-shaped feature where the side flues and under-flue joined. This had a curving side and a flat base, both constructed of brick.
(129)	Western boiler house Fill of under-flue	Fill of under-flue. A mixture of the imported infill material found elsewhere on site together with demolition rubble.
[130]	Chimney foundation	Chimney foundation. The chimney had been almost completely demolished, leaving only a half oval shaped platform of lime mortared granite and killas blocks. The chimney was attached to the northern end of the western boiler house and abutted the northern wall of the engine house, though was not bonded into it. It was approximately 4m across at its widest point. The remains of a probably cleaning access into the chimney from its northern side took the form of a raised section of masonry on its western side with a face to the east. Its upper surface was 0.4m above the eastern section of the chimney.

Context Number	Location	Description
[131]	Eastern boiler house Western wall	The western wall of the eastern boiler house. Dry stone walling with uneven facing over most of its length; in its lower 0.5m the stones were bonded with lime mortar representing the location of a now-removed side flue. The wall was about 12m in length, and 0.4m thick. The southern part of the wall adjacent to the former coal storage and firing area had been pointed using lime mortar; this section abutted the brick floor. The northern part of the wall retained traces of it having been lined with bricks – this representing the remains of the side flue, of which only a few bricks remained.
[132]	Eastern boiler house Brick floor at south-west end	The remains of a brick floor at the south end of the eastern boiler house; 2.3m by 3.4m in extent. The feature had been disturbed by demolition and by the collapse of an underlying drain on its eastern side. The bricks were tightly bonded together with lime mortar. A second drain probably runs beneath the surviving western section of the floor. The floor abutted wall [131] of the boiler house.
[133]	Eastern boiler house Side flue	The remains of a side flue on the western side of the eastern boiler house consisting of some of the basal courses of its brickwork. The flue passed through the northern wall of the building through a rectangular shaped hole, topped with a small sheet of iron plate; the opening measured 0.63m high and 0.27m wide; its side walls were made up of seven courses of brick. This feature was sited to the west of and above the under-flue opening.
[134]	Western boiler house	Located on the east side of the man-engine house, this measured 23.5m long and 3m wide, its northern end abutted the chimney foundations; to the east it was bounded by a loosely constructed killas wall. To the south no trace of a wall was found, and it may well have been of timber construction. The eastern wall was shared with the man-engine house.
(135)	Man-engine Sub-fill of Pit 1	Possible floor level of Pit 1, a very compacted yellowish-red coarse sand overlain by (108). Depth not known.
[136]	Man-engine Area 3 low level water tank	This was partly framed in timber and had the remnants of a planked base; this feature measured 1.42m long, 0.82m wide and was 0.3m deep.
(137)	Man-engine Upper fill of Area 3	The central and eastern part of Area 3 was infilled with (137) the demolition material found elsewhere within the engine house, for example (108). This incorporated pieces of corroded metal and a number of small glass bottles (Fig 60). It was mixed with (112).

Context Number	Location	Description
[138]	Man-engine Feature in south-western corner of Area 3	Excavation of the south-western area adjacent to power train loadings revealed a large horizontally-set square slab of granite, forming a plinth measuring 0.66m square, located adjacent to a possible gear slot [124].
[139]	Man-engine Hold down bolts	Hold down bolts running through the masonry, onto which the machinery on the loadings had been bolted down. Some of the surviving clearly blacksmith-made wrought iron bolts survived *in situ*, and were up to 3.5m long. At their lower ends flat pieces of iron hammered through slits cut in the bolts would have been drawn up against massive washers which in turn bore on the roofs of the crow holes, allowing the nuts above to be tightened down. The northernmost crow hole extended most of the way through the building, but the remainder were between 1.3 and 2m deep.
[140]	Western boiler house drain external	This connected with the culvert leaving [146] and [153], and had the form of a brick-lined drain, located at the southern end of the western boiler house. This measured 0.36m wide, 0.3m deep.
(141)	Eastern boiler house drains	The sections of the drains to the south of the boiler houses were filled with a fine black cinder and coal dust mixture which cloaked the area and which also seem to have formed a working surface
(142)	Western boiler house rubble fill	Demolition rubble found within the area of the western boiler house.
[143]	Western boiler house surface	Possible natural ground surface, made up of yellowish-brown gritty soil.
[144]	Western boiler house, sloping brick surface	At the south-western end of the western boiler house, trial excavation revealed a small section of a sloping brick surface. The bricks, bonded with lime mortar, sloped down to the east to part of a basal feature consisting of two courses of bricks laid on their flats on a east - west axis. This represents the junction of the side flues and the under-flue. The horizontally laid bricks were set on (144), a compacted reddish brown gritty clay; this probably represented the levelled mine waste onto which the boiler house had been constructed.
(145)	Western boiler house narrow clay linear	Abutting the western wall of the boiler house was a narrow linear red clayey deposit; this material was extremely soft and sticky and appeared to be fairly deep, though was not excavated to its full depth. Given its location it may represent the ash infill of a wholly demolished side flue.

Context Number	Location	Description
[146]	Western boiler room drain	A brick-walled drain found leading away to the south from the area of the boiler firing end mounts [157]. This was 0.74m wide at its northern end, though rapidly narrowed to 0.36m wide for the remainder of the length examined. The narrower section of the drain was topped with re-used sections of boilerplate. Its base was flat and it appeared to slope gently to the south, where it joined a similar drain from the eastern boiler house.
(147)	Western boiler room drain	A sample area of the drain was excavated and was found to infilled with a red sandy slurry mixed with pieces of broken brick and small stones.
[148]	Western wall of eastern boiler house	The western wall of the boiler house to the north of the boiler firing end location was 15m long, 0.5m thick and a maximum of 1.7m high. It appeared to be predominantly constructed of randomly coursed killas and mine waste; its lower 0.5m was bonded with lime mortar, but above this height this bonding was absent. This section of the wall would have been abutted by the side flue at its base, and by ash infill between the boiler and the wall above this point. The upper section of the wall has been demolished, and its construction and original appearance are uncertain. The southern 4m of the wall which would have abutted the firing area had been mortar bonded and pointed; this walling contained some larger pieces of stone than found elsewhere. The western wall was terminated with squared granite, of which one foundation block survived. A low wall bordering the boiler end supports was tied into the west wall. Within the firing area, the wall was abutted by a surviving section of brick floor.
[149]	Eastern boiler house East wall	The eastern wall of eastern boiler house was predominantly constructed from killas and mine waste. What survived measured 13m long, 0.5m thick and averaged 1.2m high. Its western face was a loose tumble of densely packed un-mortared stone, whist its eastern face retained some lime mortar bonding in places and had a vertical face. The southern end of this wall had been revealed during the clearance of scrub during the installation of the site perimeter fence. Here it had more the appearance of a field boundary; a small thorn tree grows out of the wall fills and its roots were destabilising the wall structure. The upper surface of the wall was not cleared of covering material owing to the risk that this would result in further structural destabilisation. As a result it is unclear whether the apparently non-structural build of its western (inner) face is a result of collapse over time, or reflects its original form.
[150]	Eastern compressor house	The remains of the eastern compressor house consisted of a single upstanding wall, 7m long and 0.6m wide, the upstanding remains stood no more than 1.5m above the excavated ground level; the interior of the building was not fully excavated. The wall was made up of killas and some granite bonded together with lime mortar.

Context Number	Location	Description
[151]	Eastern boiler house – western boiler under-flue	The under-flue serving the western boiler was well-preserved and measured 9.5m long, 0.9m wide and was 0.6m deep. It ran parallel to the western wall of the boiler house for most of its length, though exhibited a noticeable curve toward the north-western corner of the building at its northern end. The under flue walls were made up of at least nine courses of white brick bonded together using lime mortar. At its southern end adjacent to the boiler firing end plinths, the connection between the under-flue and the side flues were marked by a curved brick-lined depression 2.2m wide, 1m long and 0.6m deep at its centre. From this point northwards, the brick-constructed flue had a U-shaped profile and was 0.97m wide and 0.6m high. Towards the northern end of the building, the walls were found to be missing several of their upper brick courses, though excavation revealed that the lower courses were still intact. At its northern end the flue curved slightly to the west, the side walling became vertical and the floor flat and the space between the walls narrowed to 0.69m. Adjacent to the north wall of the building, the flue, constructed of nine courses of brick, was covered by substantial iron lintels, topped with several surviving courses of brick laid on their flats and bonded with lime mortar. The flue at this point was 0.9m high. Just before the flue passed through the north wall of the building a gap had been left between two of the iron lintels. This was occupied by four upright strips of metal in two paired groups 0.01m apart. These represented the guides for a damper plate (the means by which the draught was regulated).
[152]	Eastern boiler house central wall	Dividing the eastern boiler house into two sections and aligned north-east to south-west was a brick wall made up of red bricks consisted of at least four courses, only 5m of wall was revealed during the excavation. The brick was bonded with lime mortar and in several locations the bricks had collapsed. It was probable that this wall supported a pair of side flues – one for each of the boilers which flanked it.
[153]	Eastern boiler house drains	The northern end of one of the drains from the eastern boiler house was initially revealed through excavation near the location of the firing end of the eastern boiler. Here, it consisted of two vertical sections of parallel brickwork 0.63m apart and 0.4m high running gently away to the south-west. The base of the drain was rendered in lime mortar.
(154)	Eastern boiler house Fill of eastern boiler drain	The surface deposit consisted of dark organic loose peaty silt containing fragmented stone and organic material; this was nowhere more than 0.3m deep; the deposit had been disturbed by animal burrowing and plant growth.

Context Number	Location	Description
(155)	Eastern boiler house Fill of eastern boiler drain	The basal deposit was a very plastic red clay a maximum of 0.1m deep; this was easy to trowel and is assumed to be a mixture of iron-rich sludge derived from draining down the boiler, possibly mixed with fine ash.
[156]	Eastern boiler house foundation features	The only substantial evidence for the eastern boiler in the eastern boiler house was an exposed brick-built curving depression, which would have been sited at the junction point of the under-flue and side flues and was similar in appearance to that found associated with the western boiler in this building. This curved brick feature was shallower than that to the west and appeared to be more poorly constructed. Overall the feature was 0.98m wide, 0.72m long and survived to 0.14m depth.
[157]	Western boiler house boiler firing end mounts	The boiler firing end mounts, located at the south end of the western boiler house, survived as two truncated brick plinths; the easternmost of these measured 1.06m long and 0.93m wide, whilst the westernmost measured 1.02m long, 0.95m wide. They were 0.46m high and each had been constructed of five courses of brick. They were linked at their northern end by a single brick width lime-rendered brick wall 0.74m long. This appeared to divide the under-flue to the north from an ash pit and drain to the south. These features had been infilled and covered with demolition rubble (142).
(158)	Western boiler room, floor surface	A compacted reddish brown gritty clay; this probably represents the levelled mine waste onto which the boiler house was constructed.
(159)	Man-engine Pit 2 Fill	A yellowish red compacted sandy deposit.
(160)	Man-engine Flat surface to the south	A smooth surface to the south-west of the man-engine house, the extent of this cinder and ash deposit (160) is not known, but it appeared to continue toward drain [140].
(161)	Man-engine Cinder and ash deposit	A dark almost black/dark grey extensive deposit of cinder and ash material strewn around the south-western end of the man-engine house and the western boiler house. At least 0.2m deep, it extended over the drain [140] toward the main railway track. Dumps of this material were found at the southern end of the eastern boiler house.

Appendix 2: Finds report

See Figures 50 to 60.

Context/Area	Description
Pit 1	Piece of leather, possibly originally part of a pipe gasket. Iron fragments, probably broken engine parts and fittings.
Pit 2	Various small pieces of corroded iron, probably broken engine parts and fittings.
Area 3	Small pieces of corroded iron. Fragments of copper alloy objects. Nails. Drill core fragment. Small, narrow blue glass bottles (Fig 60). Pieces of ceramic, including parts of at least two decorated tea cups (Figs 57).
Pit 5	Glass jars. Glass bottles marked 'SAUCE'. Ceramic jam jars marked 'Hartleys' (Fig 56). Pottery sherd (Fig 58). Fragments of corroded iron. Piece of a clay pipe stem. Enamelled metal dish (corroded).
Pit 6	Piece of leather. Fragments of corroded iron, these being likely to be engine parts of fittings.
Pit 7	Pieces of corroded ironwork. Bolts. Nuts.
Unstratified	Ceramic fragments. Glass pieces. Piece of probable copper ore. Arch brick (Fig 59). Remains of a lubricator (Fig 55).

Appendix 3: Man-engines

There is a certain amount of disagreement about when and where the first man-engine was installed. A version of this type of machine had been created by Christopher Polhammer at the Falun mines in Sweden in 1694 to raise minerals, and another was installed not long after to perform the same function at a coal mine near Liege.

The first reciprocating device documented as used for man-riding was created by a Herr Dörell, who added platforms to a pair of existing waterwheel-powered pump rods at a mine near Clausthal-Zellerfeld in Lower Saxony in 1833. A second was installed in 1835 at the Georges Wilhelm mine nearby and others were subsequently installed elsewhere in the Harz and in the Erzgebirge mining region (between Saxony and Bohemia). These machines were known as *Fahrkünst*e and, in these mining regions, were universally operated by waterwheels until 1876, their rods sometimes also working pumps (Krassmann 2014).

Miners would step onto a platform on one rod, descend around two fathoms, at which point the rod was at the lowest point of its downward stroke; they would then step across onto a platform on the other rod, which was just beginning its downward stroke. By moving alternately from one rod to another the miners could descend the shaft, or, at the end of their shift, by reversing the process, return to surface. From as early as 1841 some German examples utilised systems in which the platforms were fixed to paired steel cables rather than wooden rods – at least one of these *Fahrkünst* at the former Grube Samson silver mine at Sankt Andreasberg in the Rammelsberg, originally installed in 1837, is still used to the 130m level for maintenance access to the Grüner Hirsch hydroelectric plant turbines and the 190m depth Sieberstollen turbines located there (this *Fahrkünst* has been powered by an electric motor since 1922). Other surviving (non-working) *Fahrkünst*e are located in the Upper Harz Mining Museum and the Norwegian Mining Museum at the former Kongsberg silver mines.

The first Cornish man-engine was separately invented by Matthew Loam in 1829; he attempted to sell his invention to Dolcoath Mine, but it was rejected without a trial being made. In 1834 he won a competition organised by Charles Fox for the Royal Cornwall Polytechnic Society (RCPS) for '*the best improvement on the present method of ascending and descending mines'* whose principal aim was to devise a means to address the operational impacts of miners having to climb increasingly long lengths of ladders to get to their places of work; the main driver behind the installation of man-engines was to improve the efficiency of mines rather than any humanitarian considerations. Ladder climbing – unproductive work - could take up 20% or 30% of the time available on a shift (Tew 1956; 1981; Maynard 1873; Burt 1982).

Loam's attempt to sell the idea to the Consolidated Mines in 1839 was rejected given the (at the time) uncertain financial situation of this concern, though its owner John Taylor discussed the possibility of installing a man-engine there with his friend Count Buest, Government Inspector of Mines in the Harz.

After an account of the German *Fahrkünst*e was discussed by the RCPS in 1838 and 1839 and published by them in 1840 the first Cornish man-engine was installed on a trial basis at Tresavean Mine, Lanner in 1841 (January 1842 according to Moissenet 1859); Godolphin, Wheal Vor and Fowey Consols also expressed interest in the idea. The Tresavean double rod man-engine was powered by a waterwheel, but an account given by Captain W. Francis of United Mines in the following year indicated that it had been replaced by a much deeper example powered by a 36" cylinder beam engine once the efficacy of the trial mechanism had been demonstrated.

In contrast to the German *Fahrkünst*e, the example installed by Captain Puckey and William West at Fowey Consols in 1851, together with almost all subsequent man-engines installed in Cornwall, utilised single rods, miners stepping onto small platforms fixed at two fathom intervals to the side of the shaft at the end of the stroke of the rod, where they waited for the start of its next downward stroke, stepping onto the next

lower platform when it arrived to take the next stage in their descent. This was repeated until they had got to the level on which they were working, or to the deepest point reached by the man-engine (following which they might have had to continue on downwards on ladders). The single rod example installed at Dolcoath in 1854 had two sets of sollars in the shaft: one for men ascending, the others for descending miners, whilst that at the Providence Mines, Carbis Bay, was equipped with larger sollars which could accommodate five or six men at a time.

Man-engines generally worked at between around three to five strokes per minute, and each stroke was usually two fathoms in length (12 feet or around four metres). A number of balance bobs would have been required at surface and at intervals down the shaft to counteract the weight of the man-engine rods and its load of men, significantly reducing the working load on the engine. Man-engine rods always worked in tension.

Within Cornwall it was considered that the single rod system was both simpler to construct and safer in use than the German double-rod design. Accidents certainly occurred from time to time (with the exception of the catastrophic 1919 Levant man-engine disaster these were generally crush injuries caused by the inattention or inexperience of the men riding the rods), but these events were relatively rare and miners certainly recognised the health benefits of not having to climb many hundreds of feet of ladders on each shift. A series of catch wings attached to the rod were intended to prevent it falling more than two fathoms should it break (though given the way the rod twisted during the breakage of the Levant man-engine, in that instance these failed to prevent significant fatalities owing to the fact that the rod twisted as it fell).

The use of a horizontal steam engine to operate the man-engine at Cook's Kitchen was relatively unusual in Cornwall – only four used this type of power source. Almost all other Cornish examples were operated by rotative beam engines (the exception being that at Wheal Reeth where the rod was attached to the nose of the bob of a pumping engine); three were operated by waterwheels - only one of these was powered in this way throughout the whole of its period of operation. One potential problem with horizontal and rotary beam engines as power sources for man-engines was that they operated continuously, there being no pause between strokes during which miners would have plenty of time to move from the rod to the shaft platforms. Through gearing down the rate of motion to around five strokes per minute, however, it proved possible to safely operate man-engines operated by rotative and horizontal engines.

In 1880, following a series of accidents and in recognition of the need to introduce minimum standards, Special Rules were introduced under the Metalliferous Mines Regulation Act 1872 to improve safety on man-engines. By 1895 only the installation at Dolcoath and Levant were still at work in Cornwall; the last man-engine to operate in the British Isles was that at Laxey on the Isle of Man, this stopping work in 1930.

The crookedness of most lode-dip following Cornish shafts and the resultant difficulty of installing the machinery resulted in only a small number of local mines adopting man-engines – only eight had been installed by 1860. Nineteen were eventually installed (including two at Devon Great Consols on the eastern bank of the Tamar); six other installations were planned but either not completed or their construction was not started (see table below). Following the development of strong and reliable wire ropes during the mid-19th century in Germany, wheeled man-riding gigs were adopted at the larger and deeper Cornish mines, particularly those which possessed larger, vertical (or at least less crooked) shafts. Gig riding systems (and later, cages) were considerably easier to install, operate and extend than man-engines and ore-hauling skips could be substituted for gigs once a 'core' was underground, allowing a shaft to be used for two functions. However one significant advantage of man-engines over gigs or cages was that men could get on and off the rods at any working level; in contrast cages or gigs had to be stopped at precise distances from surface, and 'knocker lines' and bell code systems were essential for the two-way communication between miners underground and the winding engine driver which ensured the safety of the men using the gigs.

Men continued to climb ladders to and from their places of work underground in those smaller, shallower mines which were still in operation at the end of the 19th century.

In Britain, in addition to the nineteen Cornish and Devon examples there was one at the lead mine at Laxey on the Isle of Man. In Germany at least 64 *Fahrkünst*e were installed; other countries in which this man-riding machine was installed included Belgium (19), France (5), Norway (at least 3), Austria (number unknown), the Czech Republic (number unknown), the Michigan mines in the USA (6), Ireland (1 at the Mountain Mine, Allihies) and Australia (1, at Wallaroo).

The Cornish and west Devon man-engine installations (including proposed installations) were as follows:

Mine	Dates	Power source	Comments
Tresavean	1841-57	Waterwheel, then 36" double acting beam engine	Two separate installations, both double rod designs.
United Mines	1845-70	32" double acting beam engine	Hocking and Loam double rod design, 3 strokes per minute, engine also worked pumps and crushers.
Fowey Consols	1851-67	30' waterwheel	The first single rod installation in Cornwall.
Dolcoath	1854-97	19" beam engine	Photographs of this example were taken by J.C. Burrows.
Levant	1855/7-1919	20" beam engine then 24" beam engine, from 1893 an 18"/30" horizontal compound steam engine	The last Cornish example to operate; stopped 1919 after catastrophic failure.
Great Wheal Vor	1857-60 1868-74	32" beam engine; 30" Bull engine (this possibly sited in the Wheal Metal section of the mine)	Two examples constructed; the first engine also operated a whim and a capstan.
Cook's Kitchen	1859-71 1871-91	52' waterwheel, then 26" horizontal steam engine	Two different shafts utilised.
Par Consols	1861-65	24" beam engine	
Carn Brea Mines	1861-97	26" beam engine	Described as 'the worst in Cornwall'.
Wheal Reeth	1861-69	30" beam engine	Rod attached directly to the engine beam.
Tincroft	1863-91/4	Beam engine	Engine house survives. Proposed in 1854 but not constructed then.

Mine	Dates	Power source	Comments
Wheal Josiah, Devon Great Consols	1865-91	Beam engine	
Wheal Emma, Devon Great Consols	1865-91	Beam engine	
Poldice, St. Day United	1865-67	Beam engine	Installation incomplete beyond the 143 fathom level when the mine closed in 1867.
Wheal Mary Ann Menheniot	1869-74	22" horizontal steam engine	Trialled in 1868 but not in full use until 1869.
Providence Mines, Carbis Bay	1869-77	20" double acting beam engine	Large sollars installed to accommodate five or six men at a time.
Condurrow (Pendarves Utd)	1869	Unknown	Designed but not constructed.
West Chiverton	1871	Unknown	Not constructed.
Herodsfoot	1872	Unknown	Not completed.
Crenver and Abraham	1872-76	Beam engine	
South Caradon	1872-85	Beam engine, then horizontal steam engine	Kittow's Shaft then Jope's Shaft.
East Pool	1881	Unknown	Not completed.
West Seton	1887	Unknown	Not completed.

Appendix 4: Cook's Kitchen timeline

1590s Mining mentioned at Penhellick.

1680s Mining mentioned at Penhellick Vean and Tyn Croft.

Late C17th Wheal-an-Gare and John Pawle's Mine at work, these occupying an area which was later the sites of Cook's Kitchen and New Cook's Kitchen. Both were sited in Brea tenement; they were known as Brea Mine in the early C18th.

1690s Cook's Kitchen started (according to Hamilton Jenkin).

1710-30 Brea Mine and Wheal-an-Gare restarted as Cook's Kitchen (Hamilton Jenkin).

1730s Newcomen engines erected in the local area.

1740s Cook's Kitchen started (Spargo 1865).

1763 to 1777 Cook's Kitchen recorded as selling copper.

1765 Cook's Kitchen mentioned as being at work (mentioned in agreement with Bullen Garden adventurers to connect Dolcoath adit with Cook's Kitchen adit).

1766 Cook's Kitchen was working at this date (Trounson and Bullen 1999).

1778 Pryce in *Mineralogia Cornubiensis* reported that Cook's Kitchen had a 48 foot diameter water wheel working four lifts of pumps drawing water from 80 fathoms under the adit. He stated that if enough water were available to fill the wheel's buckets completely it could draw from 40 fathoms deeper.

1787 Great Copper Slump until 1799 closes many Cornish mines including Dolcoath and probably also Cook's Kitchen.

1794 Boulton and Watt engine erected on Engine (Chapple's) Shaft.

1796 Cook's Kitchen mentioned by Hatchett as one of the most remarkable copper mines in the world.

1800/01 Richard Trevithick constructs pioneering 'puffer' whim for Cook's Kitchen. This was still working in 1870.

1808-9 Two steam whims at work at Cook's Kitchen (Hamilton Jenkin 1927)

1809 Stroke of pumping engine shortened to 7'; this was a double acting Boulton and Watt engine working as a single acting engine.

1819 Hoisting by double-cone horse whims. Underground 54' water wheel plus 48' and 42' wheels for power at surface. Another 54' pumping water wheel erected in the Red River Valley.

1830s New 50" pumping engine erected on Chapple's Shaft as well as additional equipment elsewhere on the mine.

1837 36" pumping engine replaced by a 50". Two winders of 15" and 16", and a 45"/24" Sims compound stamps engine. 54' x 2'3", 52' x 3'0" and 46' x 2'5" waterwheels, the first two working pumps, the last the stamps. 247 people working at the mine.

1841 Cook's Kitchen combines with Carn Brea Mine and Tincroft to sell copper ore privately to the Miners' Company.

1844 Mine agents burn nearly half a ton of 'old documents' (mine records).

1846 Stamps boiler explodes, killing a boy.

1848 Mine shuts for 18 months.

1849 Mine reopens and found to be in a poor state.

1850 New tin dressing plant installed.

1859 Waterwheel-powered man-engine installed. Barton (1965, 211) says this measured 52' x 3'6", the rods extending 190f from surface, re-using underground pumping waterwheel. Carn Brea had one worked by a 26" engine.

1861 Northern part of the Cook's Kitchen sett sold to South Wheal Crofty.

1865 Spargo mentions an 18" engine working the Dolcoath man engine. Spargo says a 50 feet by 3 feet water wheel used at Cook's Kitchen at the time.

1869 Barton (1965, 213) says decision taken to overhaul the Cook's Kitchen man engine and to move it to a more central shaft (Dunkin's) where it could extend deeper to the 140f level. New 26" horizontal engine built by Harvey for a cost of £596 was installed. The man-engine was put into service in autumn 1871, the installation having cost £1,100 in total.

1871 26" Harvey-built horizontal engine installed to work the man engine. Buckley says this was installed in 1873.

1872 Cooks Kitchen subdivided into Cooks Kitchen and New Cooks Kitchen. The revenues from the sale were spent on upgrading the Cook's Kitchen infrastructure.

1873 Accident on Cook's Kitchen man engine.

1873 Last dividend paid.

1879 Rock drills introduced, worked by a 12" compressor.

1882 Man engine rods extended to the 190f level.

1883 Main shareholders were Daubuz and Bolitho smelters; deficit was £20,068.

1886 Cook's Kitchen had two boring machines (compressed air rock drills).

1888 New skip road installed with man-riding gig (shaft not named).

1888 Man engine extended down to the 234f, and finally to the 270f.

1893 Severe fall in tin prices. Cook's Kitchen at risk of closure. New Cook's Kitchen closes.

1894 Losses had been very heavy throughout 1894, and decision was taken to sell Cook's Kitchen to Tincroft.

1895 Cooks Kitchen amalgamated with Tincroft after debts of £4,000 liquidated. The mine reported to be in a dreadful state. Man engine probably abandoned not long around this date.

1896 Cooks Kitchen and Tincroft amalgamated with Carn Brea. Bullen says this took place in 1895.

1895 Burrows (Burrows and Thomas 1893) say that the man-engine had reached 180f below adit or 215f from surface. Man-engine shaft sunk to the 270f and the man-engine carried to the 234f. Man-engine had 12 foot stroke. The compressed air pipe for the rock drills was taken down Dunkin's Shaft.

1899 Cooks Kitchen, Tincroft and Carn Brea purchase New Cooks Kitchen.

1900 Carn Brea and Tincroft becomes a Limited Company.

1906 South Wheal Crofty re-structured as South Crofty Ltd.

1913 Carn Brea abandoned. Bullen (1999) says Cook's Kitchen abandoned in 1913.

1919 Tincroft failing.

1920 Receiver appointed.

1921 Tincroft and Cook's Kitchen abandoned.

1927 Tincroft briefly reopened for arsenic, 100 at work.

Appendix 5: Summary of approved Written Scheme of Investigation

Client Name: Atkins

Site name: South Crofty Mine, Pool, Redruth, Cornwall

Site location: SW

Planning reference: PA10/04564

A WSI was produced by Atkins on behalf of Western United Mines in September 2016 as part of the planning submission for the overall South Crofty redevelopment. This included aims, objectives and methodological statements for the following:

- The recording of a chimney on the former Cook's Kitchen dressing floors.
- The excavation and recording of the Cook's Kitchen man-engine house and allied structures.
- A watching brief to be undertaken on the site of the new South Crofty mill and its associated structures where these fall within the boundary of the Cornish Mining World Heritage Site.

The following text reproduces sections of the WSI relevant to the archaeological recording undertaken on the South Crofty MWTP site.

Introduction

Planning permission for the relocation and modernisation of mineral processing of South Crofty Mine was proposed in 2010, including the erection of buildings for ore processing and ancillary activities. Conditional Planning Permission was granted by Cornwall Council in 2011 (permission number: PA10/04564). Four conditions were placed upon the proposed development which relate to the protection of areas of archaeological and historical interest:

• **Condition 8:** No demolition/development shall take place/commence until a programme of archaeological work including a Written Scheme of Investigation has been submitted to, and approved in writing by the MPA. The scheme shall include an assessment of significance

and research questions and detail:-

(i) the programme and methodology of site investigation and recording;

(ii) the programme for post investigation assessment;

(iii) provision to be made for analysis of the site investigation and recording;

(iv) provision to be made for publication and dissemination of the analysis and records of the site investigation;

(v) provision to be made for archive deposition of the analysis and records of the site investigation;

(vi) nomination of a competent person or persons/organisation to undertake the works set out within the Written Scheme of Investigation.

(vii) No demolition/development shall take place other than in accordance with the Written Scheme of Investigation referred to above.

Condition 15: The development shall not be brought into use until the site investigation and post investigation assessment has been completed in accordance with the programme set out in the Written Scheme of Investigation and the provision made for analysis, publication and dissemination of results and archive deposition has been secured.

• **Condition 16:** Unless otherwise agreed in writing by the MPA, the developer shall not bring any building or buildings constructed pursuant to the development into use until the repairs and consolidation works to the winder engine house, pumping engine house and detached chimney have been completed. The works to be set out in a specification and timetabled programme to be submitted, and agreed in writing, by the MPA.

• **Condition 17:** Unless otherwise agreed in writing by the MPA, the developer shall not bring any building or buildings constructed pursuant to the development into use, until the archaeological remains of the horizontal winder are exposed and where necessary consolidated, in accordance with a specification and timetabled programme to be submitted, and agreed in writing by the MPA.

The implementation of the proposed development has been divided into three phased areas. This Written Scheme of Investigation (WSI) relates to the first two and the last of these conditions (Condition 8, Condition 15 and Condition 17). Condition 16 has already been addressed.

Scope of document

This WSI sets out the methodologies and standards that will be employed in order to address these planning conditions. In format and content, it conforms with current best practice and to the guidance outlined in Management of Research Projects in the Historic Environment (MoRPHE, Historic England 2015).

This document will be submitted to the Development Officer (Historic Environment) for Cornwall Council (the Curator) for approval prior to the commencement of any ground works. The Cultural Heritage Chapter within the Environmental Statement prepared for the planning application for the project identified a number of potential impacts and opportunities for improvement works and mitigation both outside and within the World Heritage Site.

In the area outside the World Heritage Site these include:

• The retention and stabilisation of the listed buildings at Chappel's Shaft to ensure their long term conservation. There may also be an opportunity to excavate the horizontal whim beddings adjacent to them.

• The retention of all significant historic surface remains, with design of buildings stockpiles, lagoons, bunds and lay down areas ensuring that any impact on surface remains is minimised.

• Design works intended to enable and enhance views of the Chappel's Shaft Engine House and associated features.

• The retention of Eastern Valley Shaft, Middle Engine Shaft, Valley Shaft, Chappel's Shaft, and Hard and Old East shafts, with renovation works proposed on Middle Engine and Valley shafts, whilst Blights and Miahs shafts would be made safe.

The proposed new ore processing building and associated infrastructure lie partially within the boundary of the World Heritage Site. Limited impacts were anticipated, including:

• The loss of a single dressing floor chimney

• The proposed mill building lies on the site of the dressing floors of the former Cook's Kitchen mine, and has a potential to impact on these remains.

Proposed mitigation measures for these impacts in the Environmental Statement comprised:

• An archaeological watching brief on all ground works to confirm and record deposits of waste rock and processing rejects

• Sensitive design of new ancillary buildings to reflect the historic character of the area

• The retention, conservation and display of currently extant but derelict industrial features and the provision of public access.

In response to this Environmental Statement, the Historic Environment Planning Team for

Cornwall proposed a programme of more detailed archaeological mitigation which was reflected in the planning conditions placed upon the planning permission.

The purpose of this WSI is to specifically address the planning conditions relating to the recording of the chimney stack proposed for demolition and the archaeological mitigation of the impacts of the construction works through a programme of archaeological work.

Aims and Objectives

The Archaeological potential of mining has been highlighted in the regional research agenda for the south-west, with mining remains having the potential to provide stratified and well dated deposits contributing to our understanding of technological change within the industry (Webster 2007, 288). In view of the long history of mining at South Crofty, identifying phases of technological change would potentially provide an important contribution to the understanding of development of the Site and non-ferrous metal mining within the World Heritage Site.

The period 1700-1914 is considered the period of the most significant industrial development with the technology and infrastructure developed at the Cornwall and West Devon Mines influencing both the industrial revolution of Britain and internationally - and contributes to the Outstanding Universal Value of the World Heritage Site (Cornish Mining World Heritage 2013, 19). Any archaeological remains, deposits and features from this period would, therefore, have the potential to contribute to the understanding of the development of the Site and its context within the Cornwall and West Devon mining landscape and more broadly within national and international industrial development.

The engine houses and beam engines characterising the mining landscape 'reflect the substantial contribution the area made to the industrial revolution' (ibid. 21). The importance of such mining structures therefore emphasises the need for records to be made where planning proposals for their removal are accepted.

In particular, consultation has emphasised the importance of obtaining an accurate archaeological record of the site of the dressing floors and associated structures of Cook's Kitchen mine, extensive areas of which may survive beneath the site proposed for the processing building.

The aims and objectives of these archaeological works are to:

- Establish the extent, degree of survival of the former horizontal engine winder house to Dunkins Shaft and to expose and record these remains prior to their consolidation.
- Establish the degree to which elements of the Cook's Kitchen mine (specifically the dressing floors and associated structures) survive within the footprint of the proposed processing building.
- Establish, where possible, the extent, date, character, condition and significance of archaeological structures, features, deposits and artefacts within the proposed development area.
- Define and archaeologically record these remains prior to their loss during construction.
- Place any identified archaeological remains within their historical context.
- Understand the presence/ absence/ significance of any archaeological features in terms of their relevance and contribution to the Outstanding Universal Value of the World Heritage Site (without prejudice to any remains of earlier or later periods).

- Provide a comprehensive and accurate record of the detached mine chimney (also associated with Cook's Kitchen mine) prior to its demolition.
- Produce an integrated and indexed archive of the results of the fieldwork for deposition in an appropriate repository.
- Produce an assessment report for the results of the archaeological fieldwork outlining the significance of the archaeological remains uncovered and if appropriate advancing proposals for the publication of the results of the archaeological work.

Scope of archaeological works

The following phases of archaeological work are proposed within the Site:

• The targeted archaeological excavation of the former horizontal winding engine house tox expose the remains of the building and any associated machinery or fittings, record the remains and present them in a suitable condition for consolidation works.

• A targeted archaeological recording exercise to investigate the extent of the survival of the dressing floors and associated structures within the footprint of the proposed processing building.

• Recording of the extant non-designated mine chimney at the south west part of the Site.

• Intermittent watching brief during construction groundworks (Phases 1, 2 and 3), within the World Heritage Site focussed on recording any structural elements encountered during the work.

• Assessment and analysis (as appropriate) of any remains encountered and publication in a regional journal, or relevant national journal where significant archaeological remains are encountered.

Archaeological Recording Exercise

A targeted archaeological recording exercise is proposed to record any elements of the dressing floors and associated structures which lie within the footprint of the proposed processing building. The extent of these dressing floors and associated structures are known from historic mapping, but it is unclear to what degree they have survived later truncation and landscaping. It is proposed that the known extent of these structures will be explored where they lie within the footprint of the proposed building.

The overburden (primarily mining debris and 'rejects' deposited as part of the Tuckingmill Decline works) will be removed by tracked excavators equipped with bladed ditching buckets under the supervision of a suitably experienced archaeologist. Machining will continue in spits until either archaeological remains or the upper surface of the underlying geology are encountered, or the required formation levels for the development are reached, whichever is the soonest.

Once machining is complete, hand cleaning will be undertaken - sufficient to ensure that any archaeological features or remains are clearly defined and to allow for production of a base plan. Plans will be produced at an appropriate scale and tied into the Ordnance Survey National Grid. Any additional recording of discrete archaeological features will be drawn to scale using drafting film, at an appropriate scale (e.g. 1:10 for sections and 1:20 or 1:50 for plans). Any archaeological structures encountered should be recorded both in plan and elevation where possible. Should extensive structural remains be encountered, these will also be recorded photogrammetrically. Discrete archaeological features will be half-sectioned, and a section through linear features of not less than 1m will be excavated, where safe to do so. Finds will be collected from topsoil and archaeological contexts, and recorded by context.

Archaeological recording will be undertaken in accordance with current best practice, using proforma context sheets. Relationships between structures, features and deposits will be recorded using a Harris matrix system. All photographs, drawings, finds and

samples will be recorded upon pro-forma sheets using a numeric identification sequence. A photographic register will include details of individual photographs and the orientation taken. The photographic record will include black and white print and digital photography, and will include both detailed photographs of archaeological structures, features and deposits and wider shots of the Site as a whole.

All excavation and recording undertaken as part of this exercise will conform to the Standard and Guidance for Archaeological Excavation (CIfA 2014a)

Artefacts

All finds should be treated in accordance with current best practice (UKIC 2001, MGc 1991, HE 2005, 2006) and the requirements of the receiving museum. All artefacts from excavated contexts should be retained except for unstratified modern material. Any artefacts requiring conservation will be treated in line with First Aid for Finds (Watkinson and Neal1998). In the event of the discovery of artefacts covered or potentially covered by the Treasure Act 1996, the contractor will contact the Client and the Curator. Excavation and removal of the artefacts will only take pace once this has been undertaken. Any such discoveries will be reported to the Curator within 14 days. On completion of the archaeological post-excavation programme, and with the permission of the landowner, it is anticipated that any artefacts will be deposited with the relevant museum.

Environmental sampling

Potentially significant archaeological deposits and fills will be bulk sampled for palaeoenvironmental material or other finds. Bulk environmental soil samples will be taken from sealed contexts where there is an expectation that there is a potential for the survival of charred plant materials, charcoal, waterlogged material, dating evidence or the presence of small artefacts. Bulk samples would normally be taken as 40L bulk samples, or, if less, the whole of the deposit concerned. Samples should only be taken from dated deposits or if there is a potential for the sample itself to provide a scientific date. Other samples (dendrochronology, soil micromorphology, monolith samples, C14 dating etc.) should only be taken following discussion with the Curator and, if appropriate, with the relevant Historic England Regional Science Advisor or other specialist.

Human remains

In the event of discovery of human remains, work will stop and they will be left in situ, covered and protected. The Curator will be informed and a burial licence will be obtained from the Ministry of Justice. If necessary, the trench will be widened to expose the full extent of the feature containing human bone, and then the human remains will be fully excavated, recorded and removed from the Site. All excavation and reporting of human remains will be in line with current best practice, and will follow the standards set out in CIfA Technical Paper 13 Excavation and post-excavation treatment of cremated and inhumed remains (McKinley and Roberts 1993).

Treasure

Finds of treasure, as defined by the Treasure Act 1996, will be reported in accordance with that Act and the guidelines contained in the Treasure Act 1996 Code of Practice (DCMS 2000). Finds will be removed and reported to the District Coroner within 14 days of discovery. Suitable security measures will be put in place to protect finds from theft if they are left in situ. Finds will be reported to the regional Portable Antiquities Scheme Finds Liaison Officer.

Archaeological Watching Brief

An intermittent archaeological Watching Brief will be undertaken in the remaining areas of the World Heritage Site to be subject to construction groundworks. This will comprise a periodic visit to the Site by a suitably experienced archaeologist (initially on a weekly basis) to monitor the progress of the works, and to record any structural remains

encountered. The purpose of this Watching Brief will be to allow, within the resources available, the preservation by record of archaeological structures, features and deposits exposed during the course of the construction groundworks. Should archaeological remains be encountered, the developer will allow sufficient time for basic archaeological investigation and recording. Where significant or extensive archaeological deposits are encountered which cannot be satisfactorily recorded as part of the Watching Brief, Cornwall Council's Planning Archaeologist will be notified and an appropriate mitigation strategy will be agreed between all parties. Any archaeological mitigation strategy will be subject to a revised WSI - to be approved in advance by Cornwall Council's Planning Archaeologist. The Watching Brief will be undertaken in accordance with CIFA guidelines (CIFA 2014b) and the Management of Research Projects in the Historic Environment: The MoRPHE Project Managers Guide (Historic England 2015), by a Registered Archaeological Organisation (RAO) of the CIFA.

Post-excavation

At the end of each phase of fieldwork a site archive will be produced in line with the MoRPHE specification, including all specialist assessments of excavated material. The archive will be assessed for its potential for further analysis. If appropriate, an updated Project Design will be prepared, outlining a programme of post-excavation assessment and analysis leading to publication of the results. The updated Project Design will be completed within 6 months of the end of fieldwork (unless the updated Project Design sets out a revised timetable).

Should the results of the fieldwork be of insufficient scale to merit post-excavation assessment and an updated Project Design, a standard technical (grey literature) report will be produced within 6 months of fieldwork completion. This will be submitted to the Cornwall Council Planning Archaeologist for approval. A summary of the results will be submitted to a relevant regional journal. If appropriate, proposals will be advanced for detailed analysis of the results of the fieldwork and for publication of the results of this analysis.

Reporting

It is anticipated that individual assessment reports will be required for each of the four separate phases of investigation. These will be written in accordance with the current best practice as outlined in the relevant standards and guidance of the Chartered Institute for Archaeologists.

They will include as a minimum:

• An executive summary of the work undertaken and the results obtained;

• A background to the project and circumstances of work;

• The aims and methods adopted in the course of the programme of archaeological works;

• The nature, location, extent, date, significance and quality of any archaeological deposits and material uncovered;

• The nature and location of the features and deposits encountered;

• An interpretive discussion of the results, placing them in a local and regional context

• The results of assessments and/or analyses of artefacts, ecofacts and industrial remains carried out by suitable specialists;

• Appropriate illustrative material such as maps, plans, sections, drawings and photographs;

• An assessment of the potential for further analysis of the results of the archaeological works and recommendations as to the requirement for a full publication report in an appropriate format. If this is deemed appropriate, it will also include an updated project design and detailed costings for the analysis and publication works;

A summary of results; and

• A description of the archive contents and details of its location for long-term storage.

A draft copy of the report will be issued for approval by the Curator, prior to its final acceptance.

The final report should be submitted as a .pdf document.

A summary of information from the project should be entered into the OASIS online database of archaeological projects in Britain.

Should a programme of analysis and publication be considered appropriate, this will be subject to a separate programme of works to be agreed in advance with Western Union Mines Limited, and in accordance with an updated project design approved by the archaeological advisor to Cornwall Council.

Archiving

The complete project archive, which will include paper records, artefacts, ecofacts and digital data including photographs, will be prepared in accordance with guidelines for the preparation of excavation archives for long-term storage following nationally recommended guidelines (UKIC 2001, CIfA 2014c SMA 1995; Brown 2011; ADS 2013).

The archive will be deposited with a suitable repository, and will be prepared in accordance with its requirements and guidelines. It will be marked with the corresponding accession number (as required). If necessary, the paper records of the site archive will be security microfilmed prior to deposition. Archive deposition will be arranged in consultation with an appropriate repository following the completion of fieldwork.

Archaeological Contractor

The archaeological works will be undertaken by an appropriately qualified archaeological contractor. Prior to undertaking the work, the archaeological contractor will submit cvs for key staff to the Curator for approval. This will include, as a minimum, the Project Manager, lead member of the fieldwork team and key post-excavation specialists. The contractor will also be expected to demonstrate that it has access to expert advice on Industrial Archaeology, and specifically to mines and mining.

The archaeological contractor will also be expected to submit a generic company Health and Safety Plan as well as job-specific Risk Assessments and Method Statements for the work, and to provide evidence of both public liability insurance cover (£10,000,000) and professional indemnity insurance cover (£5,000,000).

Monitoring

The work will be monitored on behalf of Cornwall Council by the Cornwall Council Planning Archaeologist. Provision will be made for monitoring progress and standards throughout the fieldwork. Any changes to the approved WSI or methodology will be agreed in writing with the Curator.

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