FRONGOCH METAL MINE, CEREDIGION ARCHAEOLOGICAL FIELDWORK 2014-2015

DAT Archaeological Services

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FRONGOCH METAL MINE, CEREDIGION
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SUMMARY

One of the largest mines in North Ceredigion, Frongoch (PRN 9151) is an 18th to 20th century lead and zinc mine situated near Pontrhydygroes in central Wales (NGR SN7213 7440). Mine structures, workings and associated features survive as standing buildings and above ground remains across an extensive area of undulating waste tips of ore-processing material. A concentration of ruinous mine buildings at the northern side of the site have been designated as a Scheduled Ancient Monument (SAM CE146). A previous archaeological assessment of the Frongoch lead mines (Murphy 2012) identified a number of zones of varying archaeological potential across the site.

Frongoch mine is a major source of river pollution in the Nant Cell and the Afon Magwr, two tributaries of the River Ystwyth, and is having a severe impact on fish and other river life; causing them to fail to meet the environmental quality standards required by the European Water Framework Directive.

A remediation project was instigated by Natural Resources Wales and their predecessor to reduce the extent of metal discharge from the site. This work involved the excavation of drainage channels, settling ponds and the re-profiling of waste tips that could potentially affect areas identified as having archaeological potential. Between 2012 and 2015 Natural Resources Wales commissioned DAT Archaeological Services to undertake a programme of archaeological works which included the excavation of a series of processing features in April 2014. These features had been identified during an archaeological evaluation of the site in 2012 and their excavation was proposed due to the significant impact the final phase of the remediation scheme would have in this area. This report describes the results of the excavation carried out in 2014 prior to Phase II of the project and the concluding archaeological watching brief carried out during the Phase II works.

Two buddles survived as circular structures c.7.5m in diameter, consisting of a circular convex floor constructed from close-fitting tapered pine planks, radiating out from the centre, surrounded by a low stone wall. These pits processed the crushed mined ore and separated the heavier mineral ore from waste rock by stirring the deposits in water. One buddle was filled with fine material from its last operation; the patterns of which reflected the circular movement of the sweeper that stirred the material mixed with water. The material had not been removed before it was abandoned. The buddles do not correspond to any drawn feature on earlier mapping or historic aerial photographs. Four rectangular slime pits or settling tanks that lay in a line to the north of the buddles were filled with compacted fine material from their final period of use. One slime pit was excavated and found to be 9.0m by 4.0m in size. There was evidence that this slime pit had been connected to at least one of the buddles by a series of sluices and wooden launders. These four slime pits correspond to the position of rectangular features shown on the 1st edition 1:2500 Ordnance Survey map of 1886.

Further to the southeast the ground dropped by just over a metre and at this level a group of concrete and brick structures built against and southeast of a

retaining wall set into the slope, were recorded. Their construction had partly destroyed a former stone floored buddle and beneath this buddle an earlier linear brick wall was recorded. The functions of the concrete and brick structures remain unclear but the structures probably date from the 1920s-50s reworking of waste tips. Close by was what appeared to be evidence of a former wheel pit. The concrete features are not recorded on historic maps but it is possible that the remnant of stone buddle relates to one of a line of 3 buddles shown on the 1st edition 1:2500 Ordnance Survey map surveyed 1886 at this location.

Excavation of a number of areas at deeper depths within the excavation site proved that remains of earlier ore processing structures, including possible slime pits, lay below the recorded circular buddles. This new evidence of additional deeply stratified archaeological deposits in this area led Natural Resources Wales to modify the remediation scheme to avoid further disturbance and preserve in situ these well-preserved mining features.

The final piece of archaeological mitigation was a watching brief during the remaining phase of remediation works. This was carried out in March and April 2015 and due to the changes to the remediation scheme to avoid areas of potential archaeological deposits, few archaeological remains were recorded.

1. INTRODUCTION

1.1 Project Commission

1.1.1 Phase II of the Frongoch Metal Mine Remediation Project is the final phase of a scheme of works instigated by Natural Resources Wales to reduce the discharge of pollutants from the former mine workings into local water courses that flow into the River Ystwyth.

1.1.2 Phase I was completed in 2012/13 and involved the construction of a surface water drain around the west side of the mine that was directed to a new pond. This reduced the amount of water that flowed through contaminated mine waste, controlled the amount of water that left the site and helped to keep the clean water separate from contaminated mine water.

1.1.3 The initial proposals for the Phase II works comprised capping the mine waste and creating a new wetland area to further purify the water flowing from the site. These works included re-profiling of the existing tailings and spoil heaps to create a more uniform hillslope at the northern end of the site (Figure 3). In the southeastern part of the site an area of ground re-profiling was proposed to create a new wetland area approximately 1.5m deeper than existed. Some further ground reduction was to take place to the northeast of this wetland area, reducing the ground by around 1m. Further re-profiling works were proposed in other localised areas.

1.1.4 The design of the Phase II works was based on information gathered from the initial desk-based assessment (Murphy 2012a). It was planned that the majority of the re-profiling works would not cause disturbance to known archaeological remains and that the methodology for moving spoil would keep below ground disturbance to a minimum. In these areas it was anticipated that any surviving remains would be beneficially sealed and protected by increased depths of spoil. However, an archaeological evaluation carried out in 2012 (Poucher) identified significant buried archaeological remains in areas where ground reduction was planned; therefore these remains were very likely to be damaged or even destroyed by the proposed works.

Photo 1: The remains of 2 buddles discovered during the 2012 evaluation

1.1.5 Two trenches opened as part of the evaluation were located where ground reduction was proposed and they revealed 2 buddles at very shallow depth (Photo 1). The eastern of the two buddles had a very well preserved timber floor. The evaluation clearly demonstrated that the area around this part of the trench has very high archaeological potential and that any remains in this area would be destroyed by the initial Phase II proposals.

1.1.6 A number of recommendations were made by the archaeological advisors to Ceredigion County Council (DAT–Heritage Management) that summarised the archaeological mitigation required during the Phase II works.

1.1.7 These recommendations included:

- Open area excavation of the known archaeological remains recorded in and around Trench 3 of the evaluation;
- A rapid photographic survey of the Crushing and Stamp Mill;
- Further survey of any visible remains across the site area, not previously recorded, prior to re-profiling; and
- An archaeological watching brief during ground re-profiling, particularly the 3 drainage channels, with contingency for salvage excavation in the event of significant archaeological remains being revealed.

1.1.8 Paul Edwards, on behalf of Natural Resources Wales, commissioned DAT Archaeological Services to undertake the archaeological mitigation work as described above.

1.1.9 A written scheme of investigation (WSI) was prepared by DAT Archaeological Services prior to the works commencing.

1.2 Scope of the Project

1.2.1 The project objectives as laid out in the WSI were:

- Provision of a written scheme of investigation to outline the methodology by which the watching brief, excavation and photographic survey should be undertaken.
- To identify the presence/absence of any archaeological deposits.
- To establish the character, extent and date range for any archaeological deposits to be affected by the proposed ground works.
- To appropriately investigate and record any archaeological deposits to be affected by the ground works.
- To produce an archive and report of any results.

1.2.2 The archaeological excavation, recording of the Crushing and Stamp Mill and survey of visible remains was undertaken, prior to the start of the Phase II works, between 26th March 2014 and 17th April 2014.

1.2.3 The archaeological watching brief was undertaken during the Phase II works on 4th March, 8th April, 15th and 16th April 2015.

1.3 Report Outline

1.3.1 This report describes the location of the site along with its archaeological background before summarising the results of the archaeological works and the conclusions based on those results.

1.4 Abbreviations

1.4.1 Sites recorded on the Regional Historic Environment Record[1] (HER) are identified by their Primary Record Number (PRN) and located by their National Grid Reference (NGR); Written Scheme of Investigation – WSI.

1.5 Illustrations

1.5.1 Record photographs are included at back of the report. Printed map extracts are not necessarily reproduced to their original scale and are illustrative only.

[1] Held and managed by Dyfed Archaeological Trust, Corner House, 6 Carmarthen Street, Llandeilo, Carmarthenshire, SA19 6AE.

Figure 1: Location map of Frongoch Metal Mine site from the Ordnance Survey

Figure 2: Frongoch Mine Plan of archaeological constraint overlying an extract of the 1st edition Ordnance Survey map published in 1888, taken from Murphy 2012a.

Area 1: Scheduled Ancient Monument -- CED 146

Area 2: Area of high archaeological potential

Areas 3 & 4: Areas of medium archaeological potential

Areas 5 & 6: Areas of low archaeological potential

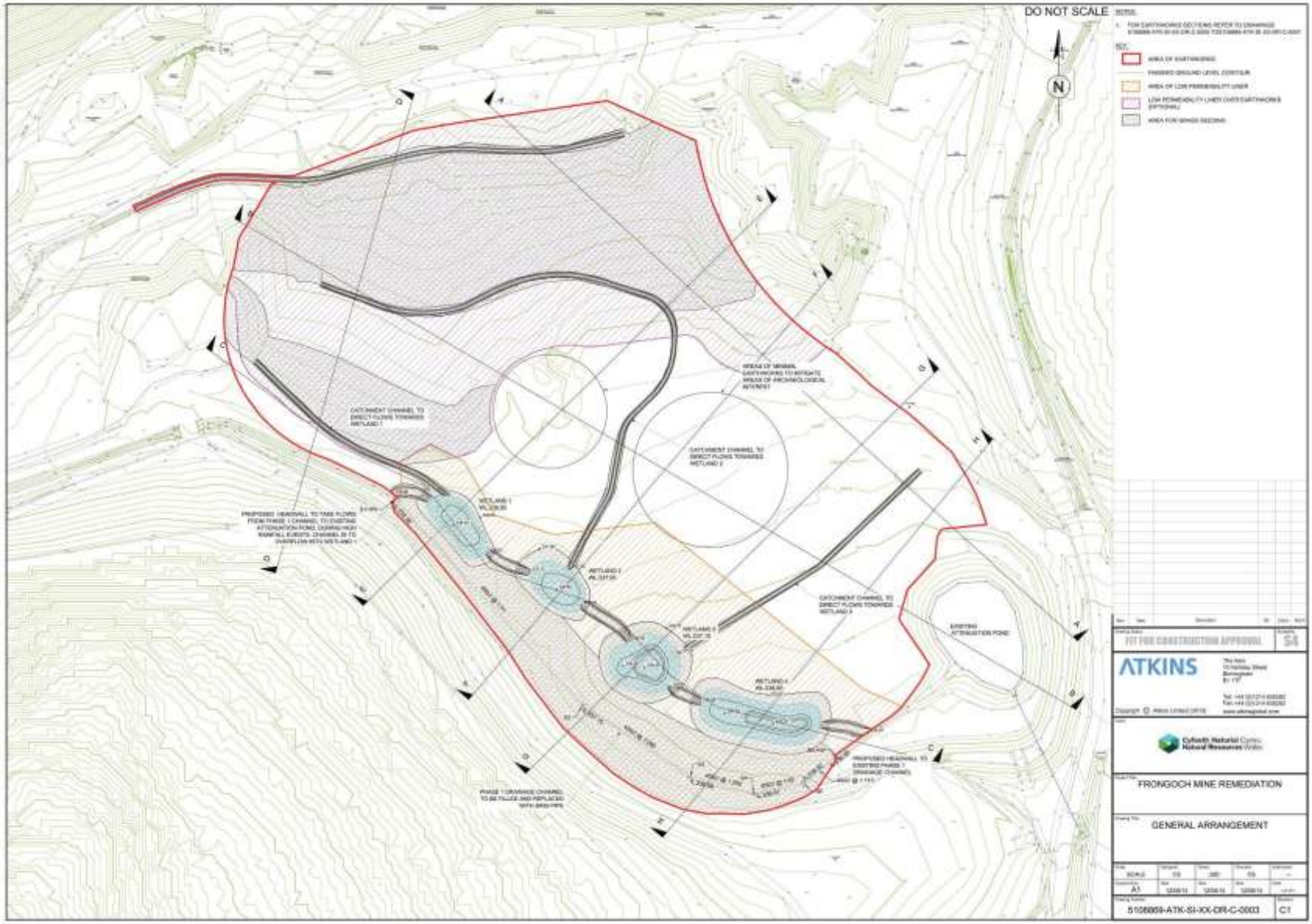


Figure 3: Plan of Phase II remediation works (plan supplied by client).

2 THE SITE

2.1 Location and Topography

2.1.1 Frongoch lead and zinc mine is situated in a remote upland area northwest of the village of Pontrhydygroes, Ceredigion (Figure 1) at NGR SN7213 7440.

2.1.2 The Mine lies within an extensive upland area lying between 240 and 260m above sea level. Apart from conifer plantations and small stands of broadleaf woodland, it is virtually a treeless landscape. The field pattern is one of large, irregular enclosures. The earth banks that once divided the enclosures are now redundant or augmented with wire fences.

2.1.3 The physical remains of mining are much in evidence and form an important element of the historic landscape (Photo 2). Frongoch Mine buildings are of national importance, though in a poor state of preservation. The northern part of the site had been, until a few years ago, used as a sawmill; evidenced by the existing large heaps of timber shavings and offcuts in the area. Associated with the mine are further landscape components such as spoil heaps, reservoirs and leats.

Photo 2: Overall view of Frongoch mine looking south in April 2014. Some of the mine buildings can be seen in the foreground.

2.2 Historical Development (from Murphy 2012a)

2.2.1 Frongoch Metal Mine was first leased in 1759, however, it wasn't until 1834 that the full potential of the mine was realised. In this year John Taylor & Sons formed a company - the Lisburne Mines – to take over the unexpired lease of the Lisburne Estate that comprised several mines within a mile or two of Pontrhydygroes, including Frongoch. For the next 40 years Frongoch Mine became the biggest producer of lead ore (galena) in Cardiganshire (Ceredigion).

2.2.2 Due to the altitude of the mine the supply of water to drive the waterwheels that pumped the lower levels of the mine was always problematic. Messrs. Taylor tried to solve this problem by installing steam engines in 1841 and 1863, but the cost of transporting coal to the mine proved prohibitive and they fell out of use. Additional reservoirs were constructed on higher ground to the north to supply, via leats, more water to the wheels used for pumping, as well as those for winding and crushing the ore.

2.2.3 The Wemyss Mine to the west was acquired, as the lode passed through both properties and the Wemyss deep adit was extended eastwards to serve both workings.

2.2.4 In 1860 an inspection of Frongoch reported that it was active down to the 78 fathom level (143m) and employing a waterwheel of 55ft diameter for pumping. The workings covered a length of three quarters of a mile. The lode varied from 10 to 30 ft wide and had yielded 14,000 tons of lead ore concentrates over the past decade alone.

2.2.5 By 1879 it was clear the mine was past its best and Messrs. Taylor (since 1868 operating as the Lisburne Mining Co Ltd in this locality) disposed of the mine and the lease was taken up by The Frongoch Mine Ltd. The salvation of the mine at this time lay in the enormous reserves of zinc blende that lay untouched within the workings. Over the next 20 years 50,000 tons were raised, together with several thousand tons of galena.

2.2.6 An attempt by a Belgian company 'the Societe Anonyme Miniere' in 1898 to use electrically driven equipment was short lived, and with decreasing productivity and rising costs the mine was put up for sale in 1903.

2.2.7 The demand for metals rose during the First World War and led people to consider the vast waste-dumps of material that surrounded the mine workings accumulated over the previous century.

2.2.8 From 1924 to 1930 the dumps were reworked on a substantial scale; over 50,000 tons being transported by aerial ropeway to a processing plant in the Ystwyth Valley. Up to the mid-1950's a small processing plant was used to reclaim lead and zinc ore from what was left of the dumps.

2.2.9 Since the 1980s there has been a sawmill on the northeast part of the site. Waste from the sawmill covered large areas of the surrounding dumps and ruined mine buildings and in 2003, as a result of this encroachment, a few hundred tons of this waste material was moved 200m further south on the mine site.

2.3 Cartographic Information

Ordnance Survey 1st edition 25" map surveyed in 1886 and published in 1888 (Figures 2 & 5)

2.3.1 The map shows the considerable development that occurred at Frongoch mine over the 40 years of ownership by Messrs. Taylor. A full range of mine buildings is depicted. On higher ground to the northwest are the pumping engine house built in 1863 by John Taylor as well as the older engine house of 1841. A crusher house lies to the east and to the west is an office. To the far west lies the smithy building. To the southeast on flatter ground is an extensive area of ore dressing floors, including stores, a winding house, stamp mill, tramways, circular buddles, and slime pits. Further southwest a reservoir has been constructed. This map would appear to show the furthermost extent to which the mine buildings reached on the southeast.

Ordnance Survey 2nd edition 25" surveyed in 1904 and published in 1905 (Figure 6)

2.3.2 Sometime before 1905 major changes had taken place. Frongoch Mine is now labelled as disused. Gone is the extensive area of dressing mills, buddles and slime pits. All the dressing of the ore was now undertaken at the new mill at Wemyss to the west and a tramway runs east to west from Vaughan's New Shaft to the dressing mill at Wemyss, passing beneath the road.

2.4 Visible Archaeological Remains (from Murphy 2012a)

2.4.1 The continuous development that has occurred over the years at Frongoch, followed by the large scale removal of the waste dumps in the 1920s has left a varied collection of ruins dating from the mid-19th century through to the mid-20th century. These include the remains of three engine houses, a crusher house, a stamp mill, a winding house, the 'old' dressing mill, the structures and earthworks associated with at least 10 working shafts, a larger open-working, two powder magazines, the earthworks for a series of watercourses and a substantial reservoir, structures and earthworks associated with various ore preparation processes, sundry offices and stores, and the earthworks of a tramway linking the mine with a later dressing mill at Wemyss. There are no structures that can be attributed to the period before the Taylors acquired the mine in 1834.

Photo 3: The ruined pumping engine house.

2.4.2 Most of the buildings are situated on higher ground along the northwest edge of the study area, but from beneath the tips and dumps across the rest of the area can be seen the walls of other structures that are not always as easy to identify.

2.4.3 The northwest section of the mine site, adjoining the road and containing standing remains is designated as a Scheduled Ancient Monument (Ceredigion 146). These standing remains consist of an office (the last phase of which was built *c.*1900), a pumping engine house *c.*1863 with adjacent shaft and double balance bob pit (Photo 3), an older engine house and a crusher house, originally constructed around 1860, and later used as a winding house, perhaps after it was extended in about 1900.

2.4.4 Other fragmentary structures are to be seen across much of the northern part of the study area, which undoubtedly still offers considerable potential for the survival of sub-surface archaeological remains, despite the loss of much surface evidence. These standing remains include a former smithy and office to the west, and remains of an old dressing mill, engine house and winding house to the east, with adjacent buddle pits. This eastern area is now largely occupied by a variety of old trailers and scrap.

2.4.5 The southern half of the complex was occupied in the main by extensive spoil tips and a large reservoir that supplied water to the ore-processing plant at the Wemyss Mine, to which it was connected by a leat that is visible for much of its course. The area of spoil tips has been greatly disturbed during the 20th century and the reservoir has long been drained and its site is now barely identifiable. Structural remains still visible in this area include a crushing and stamping mill, and adjacent buddle pits.

2.4.6 Remains of several former mine shafts can be identified, following a mineral vein running roughly ENE – WSW across the northern half of the site. These shafts within the Frongoch mine area are largely collapsed or infilled.

2.4.7 Other associated mine buildings dot the surrounding landscape, such as the remains of miners barracks to the north, and buildings for storing the explosives on the slopes of Banc Lletty-synod to the south.

2.5 Previous archaeological work

2.5.1 In 1984, the Royal Commission on the Ancient and Historic Monuments of Wales (RCAHMW) carried out a detailed survey of the standing buildings and above ground remains, the results of which were featured in a book 'Frongoch Lead and Zinc Mine' written by David Bick and published by the Northern Mine Research Society (Bick 1986; rev. ed. 1996). The RCAHMW recorded the standing buildings in plan and section and these plans indicate how much the buildings have deteriorated since the date of the survey, notably the collapse of the bob wall of the pumping engine house and its chimney.

2.5.2 The site area has also been subject to a number of previous archaeological studies, by DAT Archaeological Services. These include an initial desk-based archaeological appraisal undertaken in January 2012 (Murphy 2012a), a watching brief during geotechnical investigations in February 2012 (Murphy 2012b), an archaeological trial trench evaluation in September 2012 (Poucher 2012) and a watching brief during the Phase I remediation works (Shobbrook 2013). A summary of this programme of works is given below but please refer to the respective reports for a full account of the results.

2.5.3 The archaeological appraisal of the mine established 6 separate zones of archaeological potential (Murphy 2012a; Figure 2). These ranged from the northwest section of the mine that is designated as a Scheduled Ancient Monument (Ceredigion 146) to areas of fairly low archaeological potential.

2.5.4 The 2012 watching brief undertaken during the excavation of a number of geotechnical test pits (Murphy 2012b) confirmed the high probability for disturbing archaeological deposits in Area 2; identified during the 2012 archaeological appraisal as having high archaeological potential, and underlined the difficulty in avoiding archaeological deposits if undertaking ground works in areas near the scheduled mine buildings or the former dressing floors of the mine.

2.5.5 The trial trench evaluation undertaken in August 2012 (Poucher 2012) was targeted within the central part of the former lead mine, where the bulk of the Phase II remediation works were proposed.

2.5.6 The evaluation comprised the excavation of six trenches across the site area, in locations determined by the Environment Agency. The trenches varied between 27m and 65m long, and 1.6m to 2m wide (Photo 4).

2.5.7 Structural features and deposits of archaeological interest were recorded in five of the six evaluation trenches. These included the well-preserved remains of two buddle-pits, several wall-lines, in situ tram rails and tramway banks, a reservoir bank, ephemeral timber structures and other ditches and banks. The depth of these features varied significantly across the site from 0.2m to 1m below current ground levels. Numerous nearby features visible as either surface remains or standing structures were also partially recorded during the course of the works.

2.5.8 As well as identifying these specific features the evaluation demonstrated a remarkable survival of structural remains as depicted on historic map sources, but also indicated that many structures and features were not recorded on these map sources, and therefore an accurate plan of where these remains may be cannot be ascertained from these maps alone. As archaeological features were discovered at varying depths the removal of any deposits was determined to have the potential to expose or damage archaeological features, but clearly some of the proposed works were likely to have a direct impact on several archaeological features identified during the course of this evaluation.

2.5.9 A further watching brief (Shobbrook 2013) was undertaken in early 2013 during Phase I of the remediation works that included ground works associated with the installation of a new surface water drain and settling pond.

2.5.10 The majority of the Phase I works was located along the west side of Area 5 (Figure 2); and the watching brief confirmed the 2012 appraisal's assessment that the area was one of low archaeological potential, with few archaeological remains recorded within this area.

Photo 4: One of a number of trenches excavated during the archaeological evaluation in 2012, showing the deep deposits of mine waste that cover the former dressing floors.

3 METHODOLOGY

3.1 Open Area Excavation of Archaeological Remains in vicinity of buddles discovered during 2012 evaluation

3.1.1 The proposed open area excavation was of approximately 40m², covering the buddles seen in Trench 3 during the 2012 archaeological evaluation, the adjacent structures to the east and the wall within the northern part of Trench 2 (Figure 4). The final size of the area was determined by the character and extent of the exposed remains.

3.1.2 Overburden was removed by machine under full archaeological supervision. The area was then cleaned using hand tools and brushes to expose the remains.

3.1.3 Recording of all archaeological structures, features or deposits conformed to best current professional practice and was carried out in accordance with the Recording Manual[2] used by DAT Archaeological Services. Where hand drawing was undertaken, they were drawn at a suitable scale (no less than 1:20) and photographed in an appropriate format.

3.1.4 Some excavation and removal of remains was carried out to determine if any earlier remains survived beneath.

3.1.5 All archaeologically significant finds were retained and, where possible, related to the contexts from which they derived. Finds have been temporarily stored by DAT Archaeological Services in stable conditions. All finds, except those deemed to be Treasure Trove, will be donated by the landowner to Dyfed Archaeological Trust, who will ensure that they are stored in appropriate conditions as part of the site archive at a suitable repository (to be confirmed).

3.2 Photographic Survey of the Crushing and Stamp Mill

3.2.1 It was recommended that a photographic survey of the Stamp and Crushing Mill was undertaken. The area had been fenced off to prevent any disturbance occurring to the building from works traffic. A simple photographic survey of the structure in its present state was undertaken.

3.2.2 The photo survey included general view or views of the building, its external appearance and views inside the building. Details of internal features were also photographed.

3.3 Survey and Recording of unrecorded above ground structures prior to re-profiling

3.3.1 There were two areas of visible remains exposed at ground surface to the north and south of the 2012 evaluation Trenches 4 and 5. These included at least 6 buddles and numerous walls. Since the initial rapid survey undertaken during the trial trench evaluation in 2012, further remains had become exposed.

3.3.2 The visible remains were surveyed using an Electronic Distance Measurer, supplemented with photographs and written records.

[2] Dyfed Archaeological Trust Field Services have adopted the new Recording Manual developed by English Heritage Centre for Archaeology. A copy will be available on-site for inspection if required

3.3.3 Recording of all archaeological structures, features or deposits conformed to best current professional practice and was carried out in accordance with the Recording Manual used by DAT Archaeological Services. Where hand drawing was undertaken, they were drawn at a suitable scale (no less than 1:20) and photographed in an appropriate format.

3.4 Watching Brief

3.4.1 The definition of an archaeological watching brief, taken from the Institute for Archaeologists Standards and Guidance: for Archaeological Watching Briefs (IfA S&G: AWB) is a formal programme of observation and investigation conducted during any operation carried out for non-archaeological reasons. This will be within a specified area or site on land, inter-tidal zone or underwater, where there is a possibility that archaeological deposits may be disturbed or destroyed. The programme will result in the preparation of a report and ordered archive.

- The purpose of a watching brief, as laid down in the IFA S&G AWB is: to allow, within the resources available, the preservation by record of archaeological deposits, the presence and nature of which could not be established (or established with sufficient accuracy) in advance of development or other potentially disruptive works;
- to provide an opportunity, if needed, for the watching archaeologist to signal to all interested parties, before the destruction of the material in question, that an archaeological find has been made for which the resources allocated to the watching brief itself are not sufficient to support treatment.

3.4.2 A 'watching brief' was undertaken at the commencement of groundworks at the site which had the potential to expose, damage or destroy underlying archaeological remains. This required the presence of at least one archaeologist during ground re-profiling works.

3.4.3 Any archaeological features or deposits revealed during the groundworks were examined and recorded to an appropriate level. Recording of all archaeological features or deposits conformed to best current professional practice and be carried out in accordance with the Recording Manual used by DAT Archaeological Services. Significant archaeological features or deposits were drawn at a suitable scale (no less than 1:20) and photographed in an appropriate format.

3.4.4 All archaeologically significant finds were retained and, where possible, related to the contexts from which they derived. All finds were donated by the landowner to Dyfed Archaeological Trust, who ensured that they were stored in appropriate conditions as part of the site archive.

3.4.5 It had been stipulated in the method statement that in the event that unforeseen archaeological discoveries were made during the development, or that archaeological remains of high significance procedures could be put in place to ensure that such remains could be recorded in an appropriate manner prior to the groundworks commencing (in the event this was not needed).

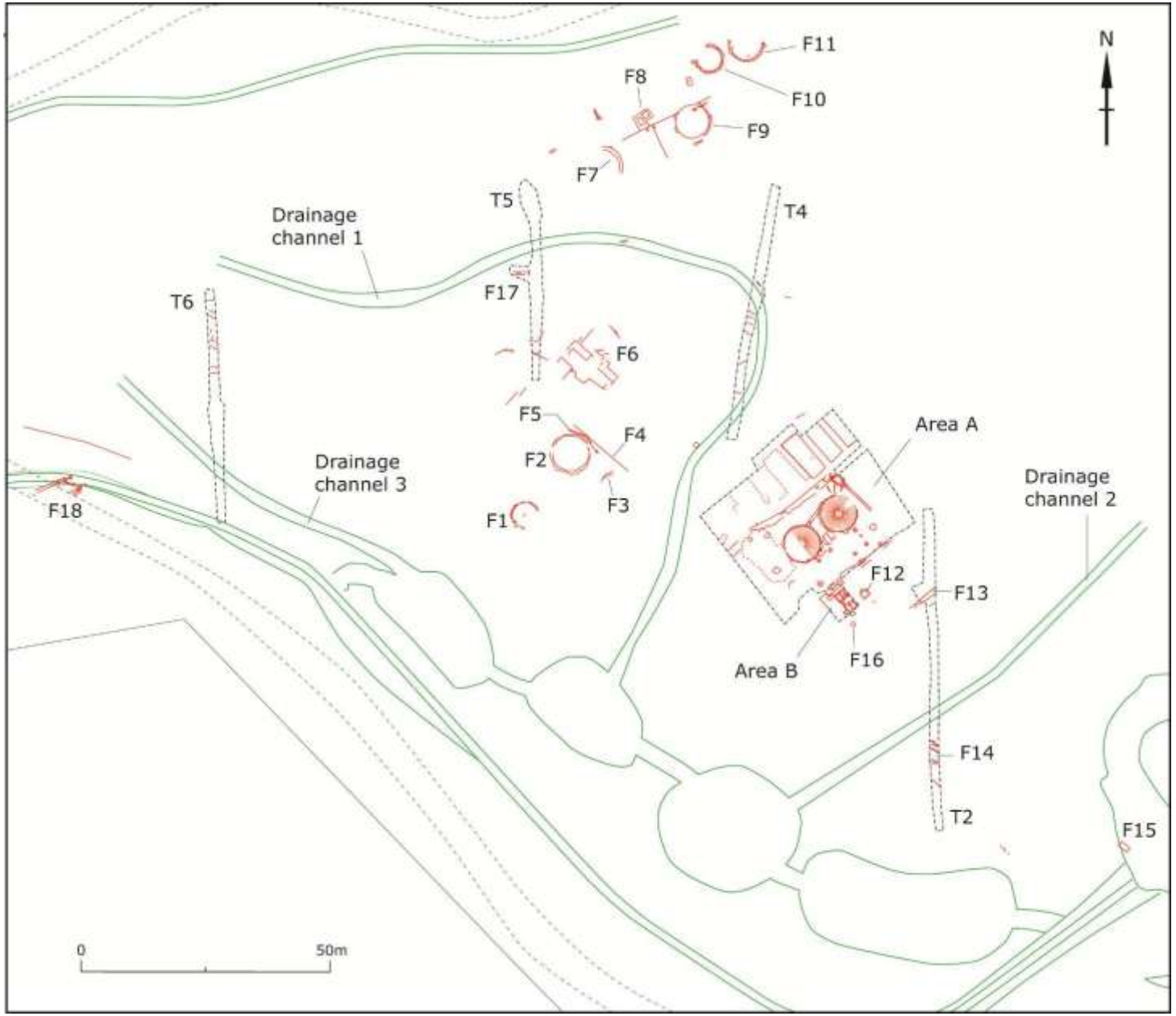


Figure 4:

Plan showing the lagoons and drainage channels of the Phase II remediation works overlaid with recorded archaeological features

Archaeological features are prefixed with the letter F

2012 archaeological evaluation trenches are prefixed with the letter T

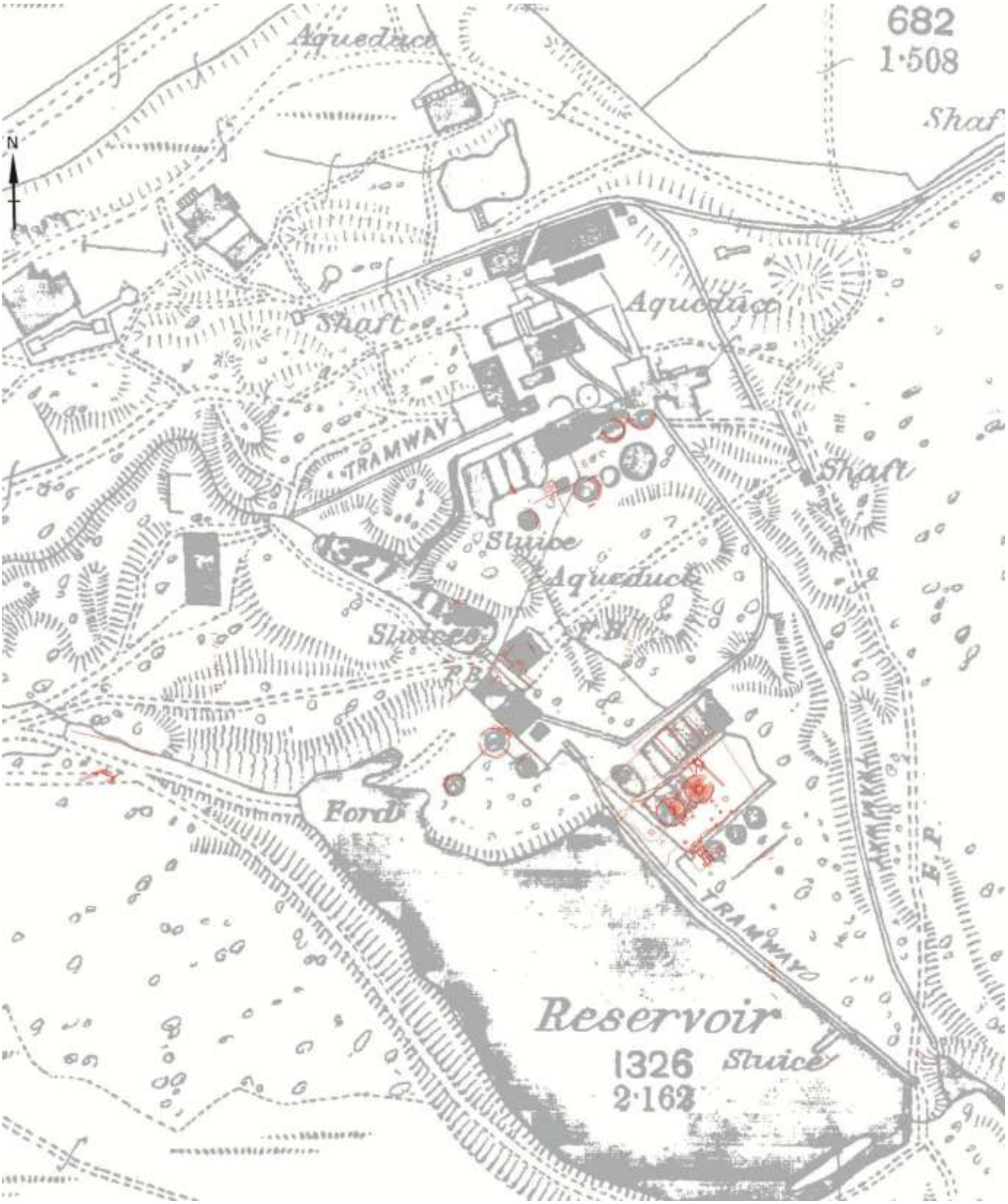


Figure 5: Extract from the 1st edition 1:2500 Ordnance Survey map surveyed in 1886, overlaid with all recorded archaeological features in red**.**

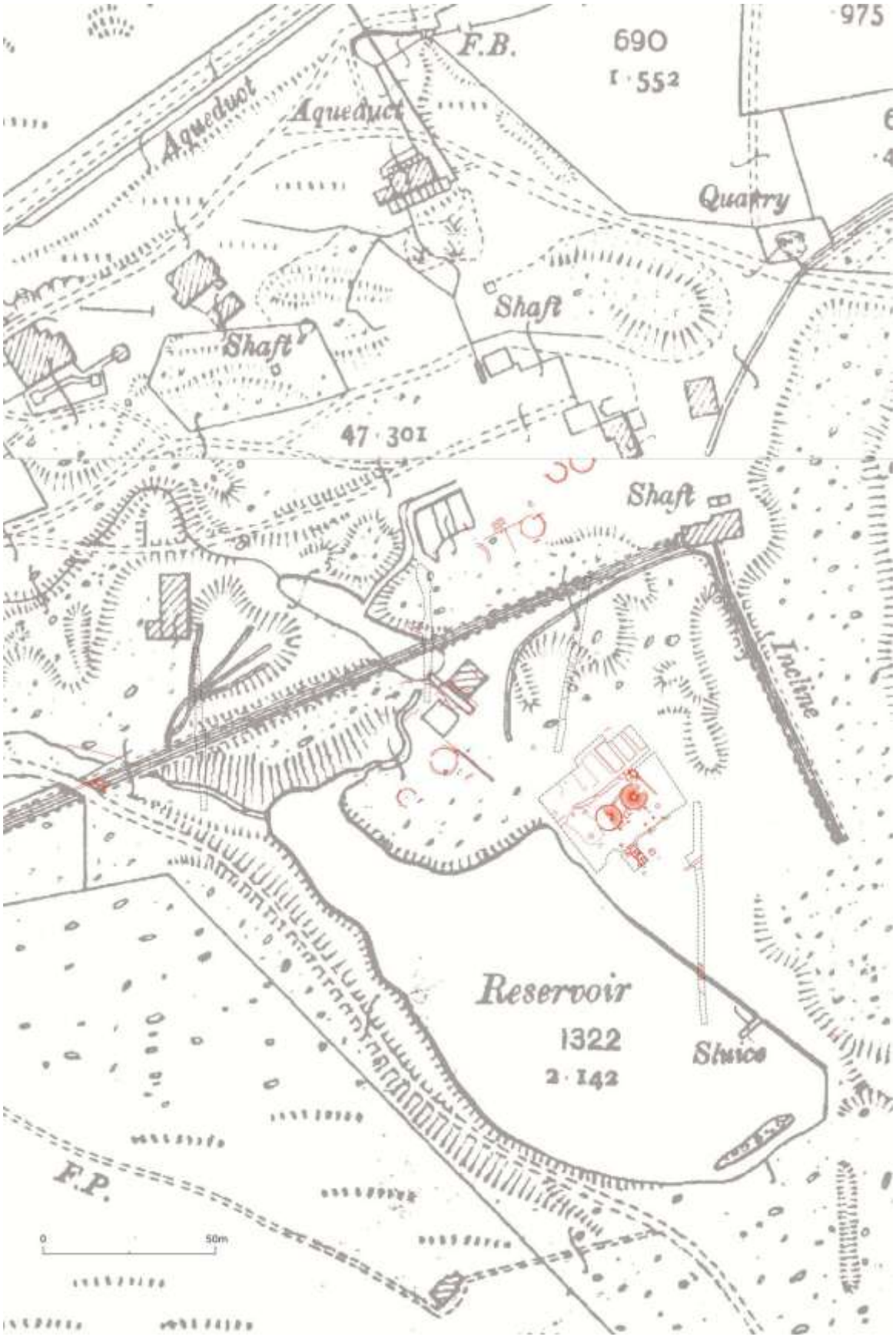


Figure 6: Extract from the 2nd edition 1:2500 Ordnance Survey map surveyed in 1904, overlaid with all recorded archaeology in red.

4 Results

4.1 Open Area Excavation

Area A – Buddles and Rectangular Pits (Figures 7-9)

4.1.1 Each archaeological structure or feature identified was given a number prefixed by the letter A. Figure 7 shows Area A in plan with each feature individually labelled.

4.1.2 Prior to machining, an area approximately 35m² encompassing the buddles discovered during the 2012 archaeological evaluation was surveyed and marked out on the ground.

4.1.3 Using a mechanical 360° excavator the marked out area was stripped of overlying deposits until archaeological layers or features were exposed (Photo 5).

4.1.4 The overlying deposits comprised fine ore processing waste that covered the former dressing floors, tracks and reservoir of the mine to varying depths. Within the excavation area approximately 0.25-0.40m of various light/mid-brown and orange silts and sands were removed by machine to reveal a distinct and contrasting coloured deposit of very fine compacted silt and grit varying in colour from dark grey to yellow/orange, interspersed with loose deposits of sand (Photo 5)

4.1.5 Initially the 2012 evaluation Trench 3 was located and the backfill in the area of Buddle B partially removed to reveal the timber floor (Photo 6).

4.1.6 It had been envisaged that the area to be excavated would extend from both buddles to the wall (F13) seen in Trench 2 during the 2012 evaluation (Figure 4). However, when machining just to the north of the buddles a series of rectangular features (A14-17) were exposed and it was decided to move the excavation area slightly to the north in order to be able to record this group of features (Figure 4).

4.1.7 It is worth noting here that it became apparent as the excavation progressed that it was extremely difficult to differentiate the boundaries between the different deposits of ore processing waste and establish a deposition sequence. Initially we began to record the individual different coloured deposits as first revealed by machining but further excavation proved that structures could be covered with material that had exactly the same appearance as the material it was constructed upon or cut through. What appeared to be a clearly identifiable layer in one area overlying a distinctly different coloured material would, when investigated further, appear to flow under what it had just been above. These deposits comprise accumulated ore processing waste that had amassed before these visible structures were in use, during their use and after they had gone out of use; a constant accumulation of fine waste that was probably permanently wet through the constant use of water in the dressing floor processes. Therefore these deposits of silts and sands would have had a fluid dimension filling every available space. With time these deposits were compressed into hard layers that merged and blended into each other.

4.1.8 Therefore the relative level of the archaeological structures and their physical relationships to each other was more informative than the small differences in the deposits that the structures cut through or were filled by.

Western Buddle (A1) (Figures 7 & 8)

4.1.9 The western buddle (A1) was 7.20m in diameter measured from inner to inner edge. It was filled with compacted dark grey silt and orange/brown sand or fine grit. The fill had been deposited in a circular pattern around a central circular deposit of loose orange sand surrounded by a hard concreted edge (Photo 7).

4.1.10 The purpose of a buddle was to concentrate the lead ore. Finely crushed ore and water was fed into the centre of the buddle and this flowed down the slightly convex floor towards its rim. The process graded by gravity the finely crushed ore, concentrating denser particles (mainly ore) near the inlet point, followed by increasingly less dense particles (mainly waste rock) in concentric rings; hence the concentric patterns seen in the fill of the buddle (Photo 7). A set of brushes, often powered by a water wheel, rotated in the water in order to agitate the mixture and these were supported by a frame that spanned the circular buddle. When a suitable level had been reached in the buddle the supply of finely crushed ore and water was cut off and the water allowed to drain away through a sluice. The contents of the buddle were then carefully dug out in concentric circles to keep the various grades separate.

4.1.11 The fill of the western buddle (A1) was half sectioned. The perimeter wall of the buddle was found to be constructed from local stone, several courses high to a height of *c.* 0.40m (Photo 14).

4.1.12 The internal edge of the stones had been roughly faced on their inner edge to form a gradual curve around the inner perimeter of the buddle. The floor of the buddle was constructed from closely laid thin pine planks that radiated out from the centre and cut with a taper so that they widened towards the edge of the buddle. The average length of a plank was 2.75m. The width of a plank ranged from 0.06m at its narrowest to 0.30m at the outer edge of the buddle. The planks were nailed to thin wooden batons that lay underneath the planks using machine made nails. The planks ran up to and butted the stone perimeter wall (Photo 12).

4.1.13 At the centre of the buddle the planks ran underneath a concreted ring of iron rich deposit, which had an inner diameter of approximately 1.50m. The planks were individually nailed to underlying short wooden planks that formed a hexagon shape around a central depression (Photo 9).

4.1.14 The circular concretion, which had an elevated outer edge still bore some residual shape of raised 'teeth' along its internal edge as can be seen in Photo 9.

4.1.15 The central hole was 0.55m deep and cut through an earlier feature (A2) constructed from large stones as can be seen in Photo 10 and Figure 8. The stones continued under the buddle and therefore were not packing for the post but an earlier feature. Within the area of the stones was compacted dark grey/blue silt.

4.1.16 Buddle (A1) was filled with a uniform fine mid blue/grey silt towards its centre; the heavier galena. With increased distance from the centre, the silt became more and more interspersed with thin layers of coarse orange sand until merely sand was recorded at the outer edge of the buddle (Photo 11, Figure 8). These deposits represent the increasingly galena-poor material deposited during the concentrating process with increased distance from the central inlet.

4.1.17 On the southeast side of the buddle was a short box shaped wooden outlet or inlet (A3) built on a level with the stones that formed the buddle edge (Photo 12). It measured 0.67m long and 0.27m wide. There was no

indication of a cut for a continuing channel leading from the outlet southwards away from the buddle.

4.1.18 On the north side of the buddle was a wooden sluice gate (A4). It was constructed from 2 short pine stakes and thin pine planks (Photo 13). It measured 0.35 deep and 0.30 m wide internally. Variations in colour in the surrounding compacted silts suggested that a channel (A5) once ran from the sluice in a northeast-southwest direction (Photo 15). A one metre section of this channel was excavated from the northeast side of the sluice. The channel cut through compacted blue and orange sandy silts and was filled by similar, though slightly more orange, material. The edges of the cut were not obvious and not straight but undulated.

4.1.19 Channel (A5) that ran northeast from the wooden sluice in the western buddle was cut by the construction of the eastern buddle (A6) as can be seen in Photo 15. There was no indication of an equivalent sluice in the eastern buddle where the channel meets it. The channel measured approximately 5.80m long.

4.1.20 Positioned roughly to the east of buddle (A1), and approximately 1.0m from its inner edge, were the remains of a wooden post within a sub-rectangular cut (A19). A further post was situated approximately 3.0m to the northeast that leaned markedly towards the north (A20) (Photo 16). These are all that remains of the structure that supported the sweep arms and drive mechanism.

Eastern Buddle (A6) (Figure 7)

4.1.21 The eastern buddle (A6) was 7.26m in diameter measured from inner to inner edge (Photo 17). This buddle had already had most of its fill removed during the 2012 evaluation and by later excavation by the Welsh Mines Preservation Trust in 2012. As with the western buddle, the floor was constructed from closely laid thin pine planks that radiated out from the centre and the surrounding wall was again constructed from local stone, several courses high to a height of 0.30m (Photo 18).

4.1.22 Unlike buddle (A1) at the bottom of the circular wall was a thin band of short sections of thin pine planking (possibly offcuts from the plank flooring?). This band lay on top of the pine floor of the buddle (Photo 18).

4.1.23 At the centre of the buddle the planks came together to form a circle 1.55m in diameter. The planks were individually nailed to underlying short wooden planks that formed a hexagon shape around a central wooden post that still remained *in situ* and measured 0.40m high and 0.30m square at its base (Photo 19).

4.1.24 The northeast section of the wall of the eastern buddle had not survived, but in this area was the remains of a base of what is presumed to be a wooden sluice (A7), 0.30m wide, located in the side of the buddle outer wall (Photo 20). To the north of this were the remains of a small wooden launder (A8) that appears to have run for 1.80m from the sluice gate (A7) to an irregular shaped stone built chamber (A9). There was a 0.06m drop in level from the sluice to the northern end of the launder suggesting that it was an outlet flowing from the buddle into the chamber (A9).

4.1.25 Slightly further round to the west from the possible sluice gate was a broken line of narrow single pine planks (A10) that appeared to run from buddle (A6) to the rectangular shallow pit (A15) (Figure 7). This length of planking was broken by a remnant of linear wall (A11). The levels showed that the planks were not sloping but laid on a level surface.

4.1.26 Positioned to the southeast of buddle (A6), approximately 1.0m from the edge of the buddle, were the remains of a wooden post within a sub-rectangular cut; with a further cut 1.5m away (A18) (Photo 21). These are all that remains of the structure that supported the sweep arms and drive mechanism.

4.1.27 Between the 2 buddles a sondage measuring approximately 2.2m² was excavated. At approximately 0.45m below the level of the buddle floors a right angled corner of a possible stone lined pit, filled with very dark blue/grey silt, was recorded (A25). To the southwest, also within the sondage, was a suggestion of another line of stone running nearly parallel with the west side of A25 (Photo 22). The orientation and the position of the corner wall would appear to align with a line of slime pits shown on the 1st edition 1:2500 Ordnance Survey map of 1888 (Figure 14).

4.1.28 The pit was excavated to a depth of approximately 0.40m but the bottom was not reached because of water ingress (Photo 23).

Chamber (A9) and wooden launder (A12) (Figure 9)

4.1.29 The irregular shaped chamber (A9) was constructed from roughly shaped local stone surviving to at least 4 courses high, set into and built against layers of compacted mine waste (Photo 24). There was no evidence of bonding material between the stones (Figure 9). The internal height of the chamber walls varied from 0.60m at the northwest end to 0.12m at the southeast. The uneven floor of the chamber comprised compacted stone and mine waste. A small wooden launder (A8) entered the chamber to the southwest and connected the chamber to the eastern buddle (A6).

4.1.30 At the northeast end of the chamber was a gap in wall (A11) either side of which were the remains of 2 wooden posts (A26) that probably mark the position of a former sluice (Photo 25). Variation in the colour of deposits to the northeast of this sluice suggested that the chamber had in some way been connected to the shallow rectangular pit (A15) in the past.

4.1.31 Excavation of material to the southeast of the wooden posts (A27) revealed a northeast-southwest line of tightly packed stones (A29) at much lower depth (0.60m below the top of northeast chamber wall) sitting within a linear cut (Photo 25). The stones were surrounded by distinctive dark blue/grey silt.

4.1.32 The narrower southeast end of the chamber was built around the northwest end of a long wooden launder (A12). The launder was 0.42m wide and an 8.40m length was exposed during the excavation. It was constructed from lengths of pine planking (Photo 26). Short sections of planks nailed along the top of the launder, in line with the planks, may indicate repairs made to the structure. Towards the northwest end of the launder was a rectangular (0.67m x 0.55m) piece of corroded iron (A28) centrally placed across the northern end of the launder (A12) (Photo 27). It appeared to be positioned on several short pieces of flat pine plank, between it and the top of the launder, making it sit approximately 0.10m above the top of the launder. The iron plate was approximately 6-8 mm thick and had a raised linear flange on its northwest side.

4.1.33 The top of the northwest end of the launder was slightly lower in height than the level of the buddle floor and as the launder sloped gradually southwestwards, dropping 0.16m over the exposed 8.40m length, it is probable that water could flow from the buddle into the chamber and out through the launder to the southwest.

Linear wall (A11) (Figure 7)

4.1.34 The linear wall (A11) aligned northeast-southwest separated the area of buddles from the rectangular pits (Photo 29). The northwest side of the wall was defined by a fragmented line of large stones protruding through the compacted mine waste; the southeast side by a broken line of smaller stones. The wall was roughly 1.10m wide. To the northwest of buddle (A1) was a gap in the wall, 1.27m wide. Lying within this gap and laid directly on the ground surface was a thin pine plank; perhaps a doorsill. The wall survived less well to the northeast.

4.1.35 This wall is shown on the 1st edition 1:2500 Ordnance Survey map surveyed in 1886 (Figure 14).

4.1.36 To the southwest of buddle (A1) was a very distinctive area of loose yellow sand (A23) (Photo 28). This was not investigated further during the excavation. The northeast and southwest long edges of the yellow sand, as surveyed, appear to align with the edge of a rectangular slime pit and the edge of the tramway as shown on the 1st edition 1:2500 Ordnance Survey map surveyed in 1886 (Figure 14).

4.1.37 Situated on the north western edge of the excavation were 2 raised areas of concrete and stone (A24). These were not investigated during the excavation but could be related to the tramway as shown on the 1st edition 1:2500 Ordnance Survey map surveyed in 1886 (Figure 14).

Rectangular Pits (A14-17) (Figure 7)

4.1.38 A line of four rectangular areas of dark blue/grey silt were revealed after the machining away of the looser light brown/orange tailings. Within the silt could be seen a myriad of swirling bands of yellow, orange and blue/grey silt and sand (Photo 30).

4.1.39 One rectangular area of silt was excavated by machine (A15) (Photo 31). The dark blue/grey silt filled a shallow rectangular pit, orientated northwest-southeast, that after cleaning by hand was revealed to be approximately 9.40m long, 3.85m wide and 0.40m deep (Photo 32). The rectangular pits, or slime pits, are for the settling and concentration of fine material after material has passed through the processes of crushing and jigging (the preliminary gravity separation of ore from waste rock using water). The settled fine material, or 'slimes', are then further processed using buddles.

4.1.40 The sides of the pit were constructed from large stones of 2 courses high (Photo 32). The dark silt that filled the pit had penetrated and occupied every small void between the stones.

4.1.41 Tightly packed in and around the stones that formed the sides of the pits was a mixture of dark humic material, sand and stones; as if the sides had been constructed by pressing the stones into this dense material. This material filled the area (1.0-1.3m width) between the parallel sides of the pits.

4.1.42 The floor surface of the pit was an uneven but compacted mixture of silt and small stones. A sondage was cut through this surface at the southeast end of the trench, and below this surface (*c*.0.06m depth) was a levelling layer of pale pink clay above natural shale bedrock (Photo 33).

4.1.43 The remaining 3 rectangular pits were filled with similar blue/grey silt but were not excavated.

4.1.44 At the southeastern corner of rectangular pit (A15) was a break in the stone wall that corresponded to the position of an opening through wall

(A11) into chamber (A9) to the southeast. There was a suggestion of a shallow U-shaped depression in the ground surface above this break in the wall but excavation did not demonstrate that it continued as far as the opening in the wall.

4.1.45 Feature A13 was an area of darker silt that was separated from rectangular pit A14 by an area of stone rubble. The edges of A13, as surveyed, appear to align with an oval feature shown on the 1st edition 1:2500 Ordnance Survey map surveyed in 1886 (Figure 14).

4.1.46 A number of wooden posts set within concrete (A21 & A22) were located at the southern edge of Area A; 2 of which were set right on the edge before the 1.2m drop to Area B.

4.1.47 Photo 35 shows Area A at the end of the excavation.

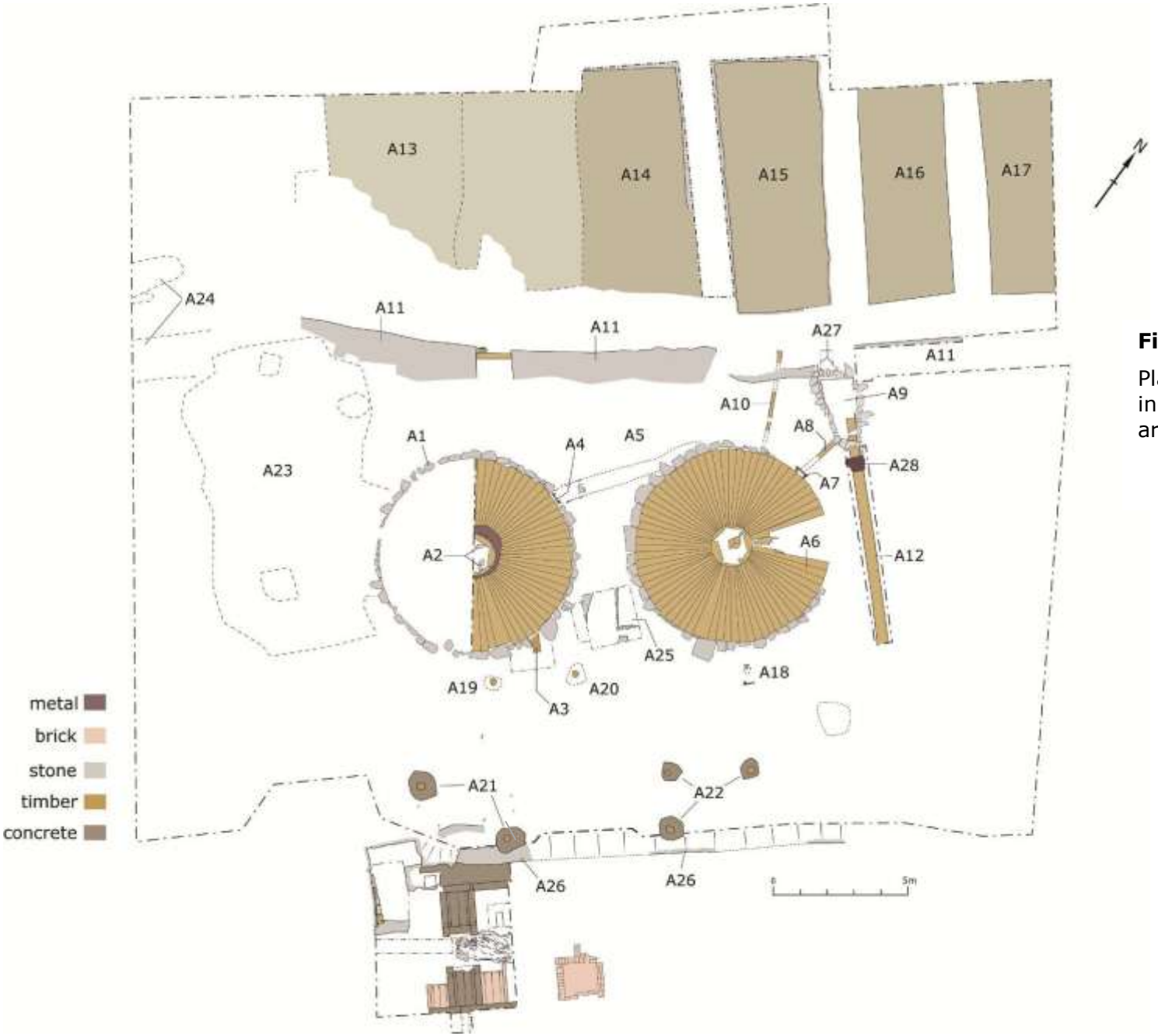


Figure 7:

Plan of Area A showing the individually numbered archaeological features.

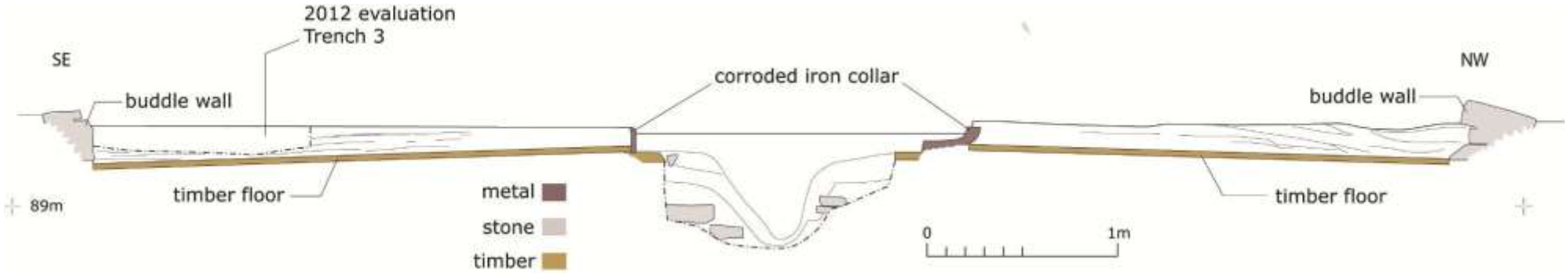


Figure 8: The northeast facing section through the western buddle (A1).

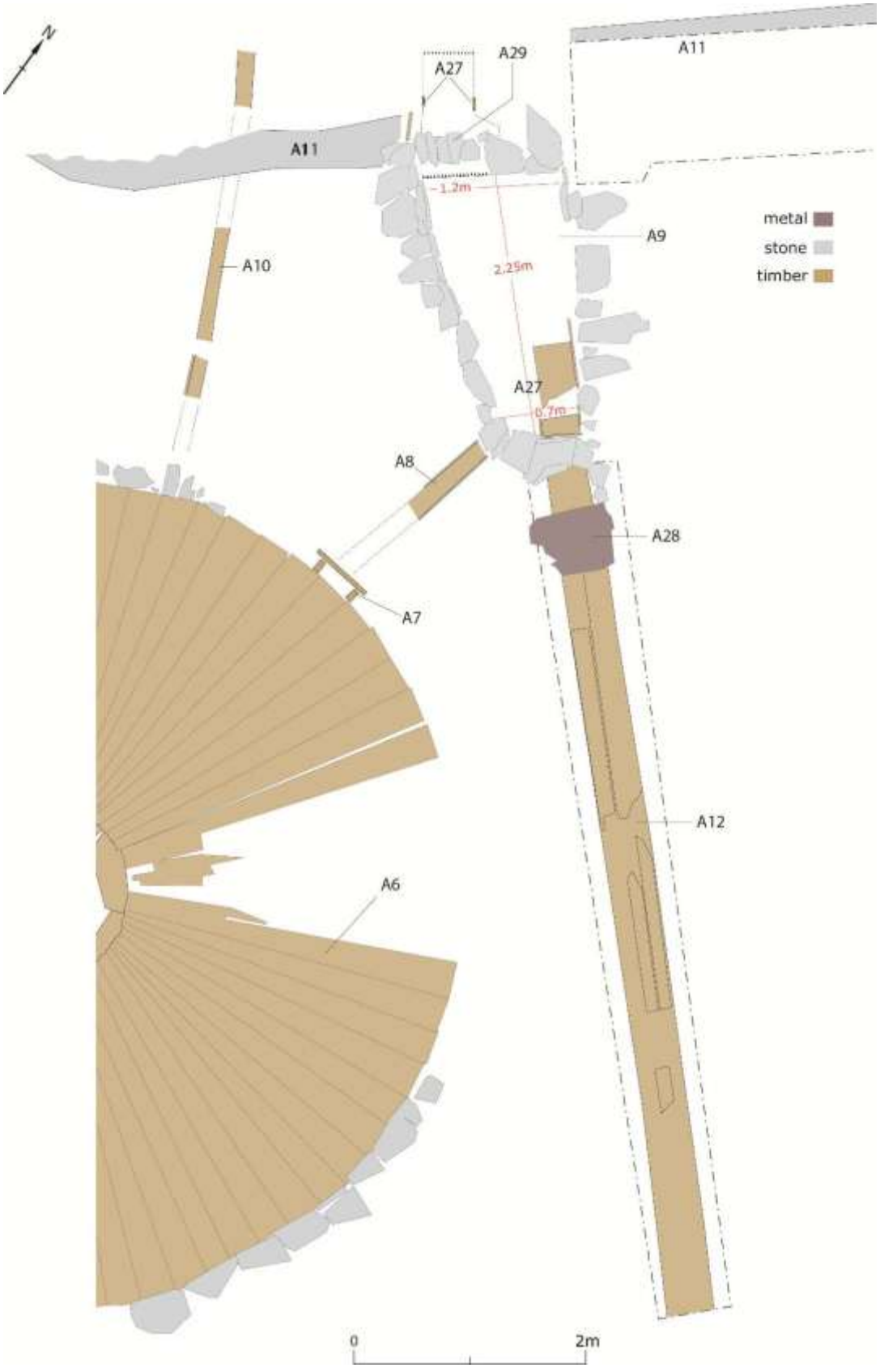


Figure 9: Detailed plan of eastern buddle (A6), chamber (A9) and wooden launder (A12).

Area A – Photographs

Photo 5: Removing ore processing waste deposits to reveal the top of the western buddle (A1). Looking west.

Photo 6: The partially excavated eastern buddle (A6). Looking roughly south. 1m scale.

Photo 7: The western buddle (A1) before excavation of the fills within it.The fills have been deposited in a concentric pattern around a central circular deposit. Looking northeast. 2m scale

Photo 8: The western buddle (A1) are removal of half of its fill. Looking northwest. 2m scale.

Photo 9: The half sectioned central pit of western buddle (A1). Looking southwest. 1m scale.

Photo 10: The half sectioned central pit of western buddle (A1) showing the cut for the central post that damaged an earlier feature (A2) constructed from large stones Looking southwest. 0.5m scale.

Photo 11: The northwest portion of the half-sectioned fill of buddle (A1) showing the variation in fill. Looking southwest. 2m scale.

Photo 12: The short box shaped wooden outlet or inlet (A3) built on a level with the stones that formed the edge of buddle (A1). Looking southeast.

Photo 13: The wooden sluice (A4) located in the northeast side of buddle (A1). Looking southwest. 0.25m scale.

Photo 14: A section of the outer stone wall of buddle (A1) showing its construction. On the right of the picture is the wooden sluice (A4). Looking north.

Left: Photo 15 shows the dark linear deposit that fills channel (A5) running northeast from sluice (A4). Note how it is cut by the outer stone wall of buddle (A6). Looking southwest. 2m scale.

Right: Photo 16 shows the 2 wooden posts (A19 & A20) that lay to the east of buddle (A1). Looking roughly northeast. 1m scale.

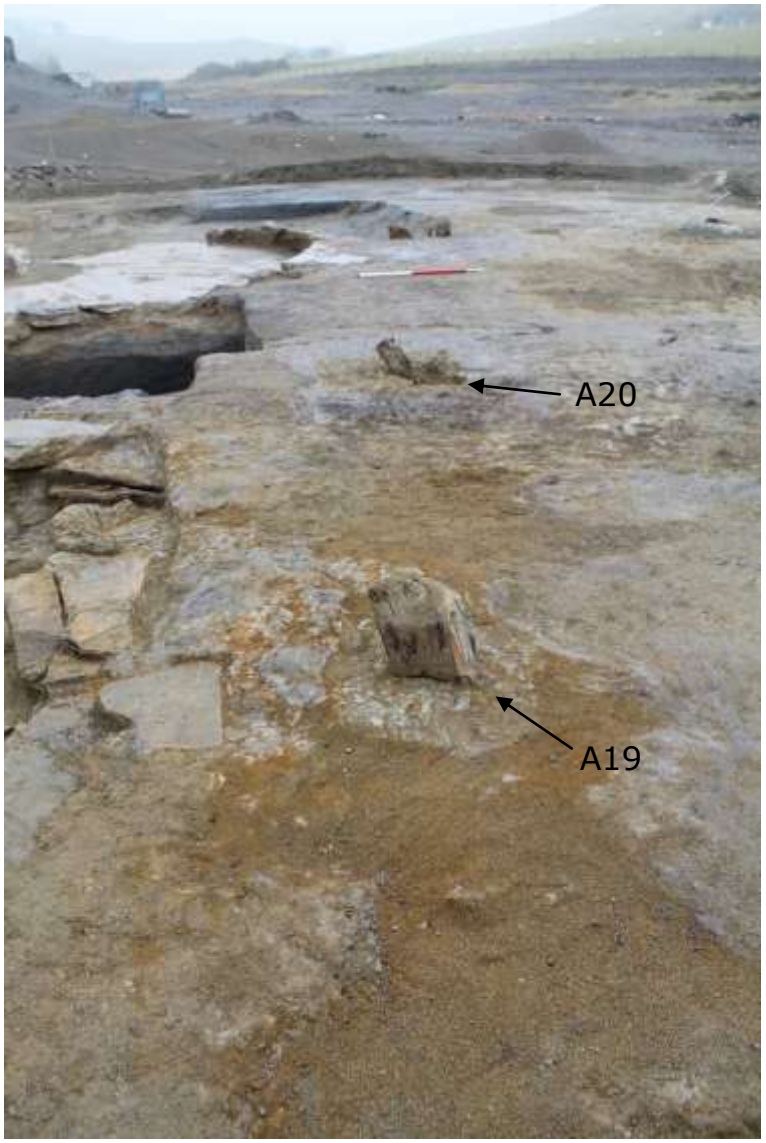
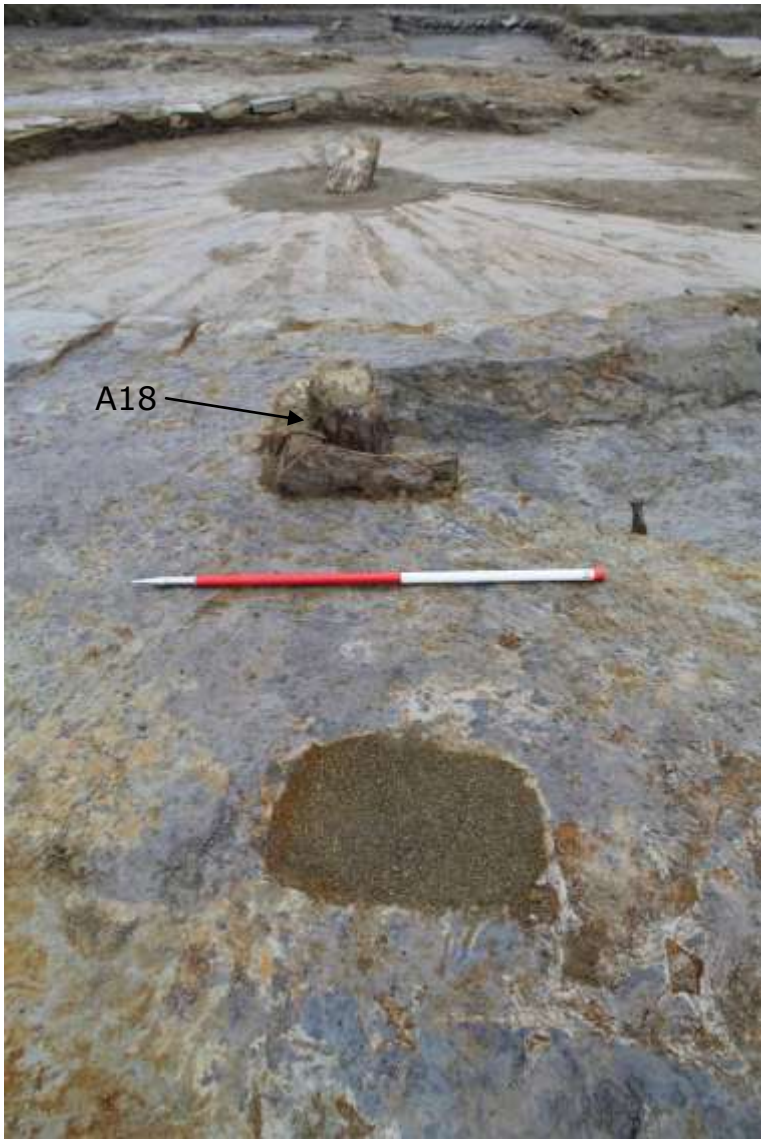


Photo 17: The eastern buddle (A6) after removal of all fill. Looking south. 2m scale

Photo 18: The outer stone wall of buddle (A6) showing the thin band of wood around the inner bottom edge of the wall. Looking northwest. 0.5m scale.

Photo 19: The central wooden post within buddle (A6). Looking north. 0.5m scale.

Photo 20: The remains of a probable wooden sluice (A7) located in the side of the buddle wall. Looking southeast.



Left: Photo 21 shows the remains of 2 cuts located to the southeast of buddle (A6), one of which contains a wooden post (A18). Looking northwest. 1m scale.

Right: Photo 22 shows the angled corner of a possible stone lined pit (A25), filled with very dark blue/grey silt. Looking northwest. O.5m scale.

Photo 23: Pit (A25) during excavation of its dark blue/grey silt fill.

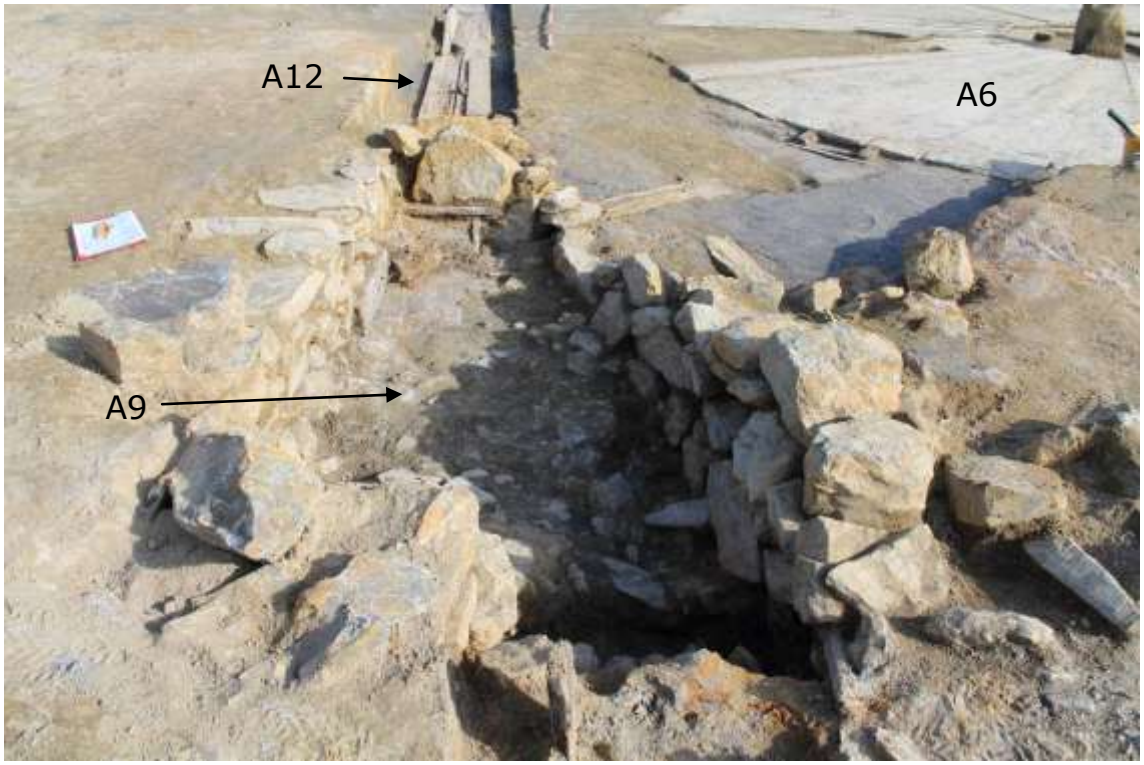


Photo 24: Chamber (A9); showing its relationship to wooden launder (A12) and buddle (A6). Looking southeast.

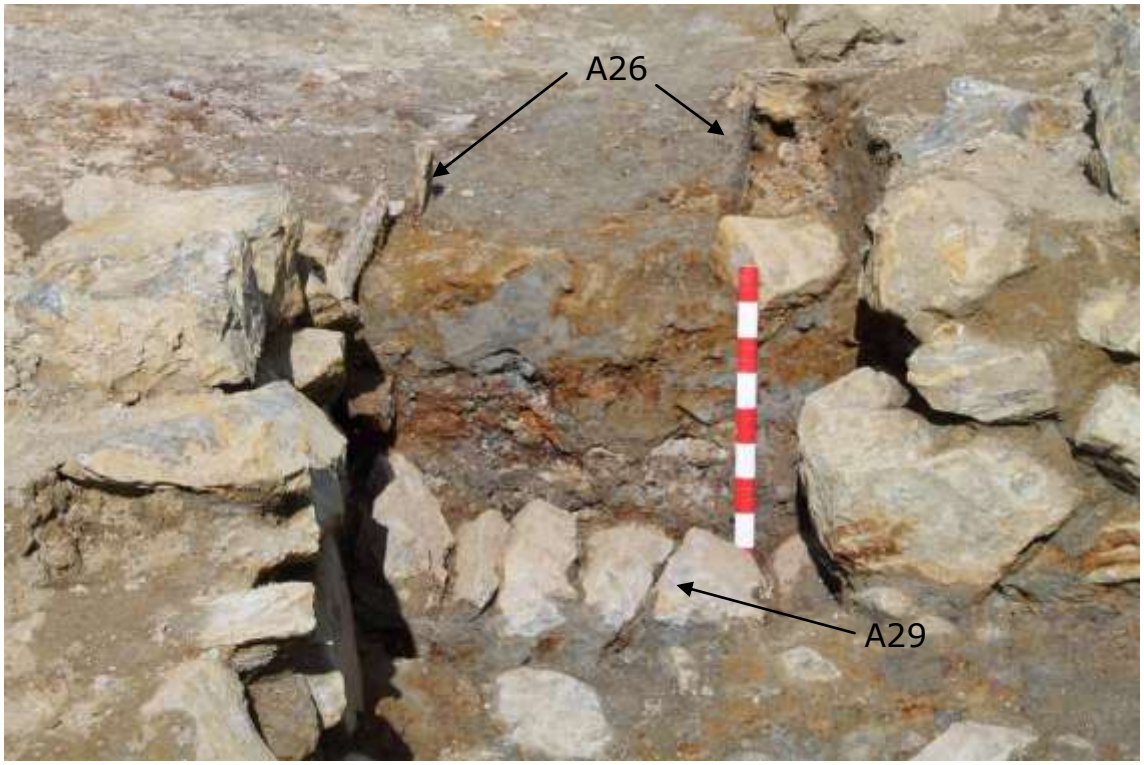


Photo 25: Showing the position of a probable sluice either side of which were the remnants of 2 wooden posts (A26). A line of tightly packed stones (A29) at much lower depth can be seen in the foreground. Looking northwest. 0.5m scale.

Photo 26: The long wooden launder (A12). Looking roughly north. 2m scale.

Photo 27: The rectangular piece of corroded iron plate (A28) centrally placed across the northern end of the launder (A12). Looking roughly north. 0.5m scale.

Photo 28: To the southwest of buddle (A1) was a very distinctive area of loose yellow sand (A23) that can be seen in the foreground. Looking northeast.

Photo 29: The linear wall (A11) aligned northeast-southwest separated the buddles from the area of rectangular pits Looking southwest. 2m scale.

Photo 30: Within the silt filling the rectangular pits could be seen a myriad of swirling bands of yellow, orange and blue/grey silt and sand.

Photo 31: Excavating by machine the fill of rectangular pit A15. Looking approximately west.

Photo 32: Shallow rectangular pit (A15) after excavation of its fill. Orientated northwest-southeast, it measured 9.40m long, 3.85m wide and 0.40m deep. Looking almost east. 2m scale

Photo 33: A sondage excavated at the southeast end of rectangular pit (A15). Looking southwest. 2m scale

Photo 34: At the eastern corner of rectangular pit (A15) was a gap in the outer stone wall. Looking southeast. 0.5m scale.

Photo 35: An overall view of Area A at the end of the excavation. Looking south.

Area B - Concrete and brick structures (Figure10 & 11)

4.1.48 Each archaeological structure or feature has been given a number prefixed by the letter B. Figure 10 shows Area B in plan with each feature individually labelled.

4.1.49 Area B is located 1.2m below Area A (Photo 36). This area was cleared by hand of substantial deposits of mine waste and modern rubbish to reveal a number of concrete, brick and stone structures. Within the material removed were a large quantity of metal objects (Photo 37), including shovel blades, machinery parts, tram rails, as well as wooden objects, stakes and posts and numerous lumps of broken concrete and bricks.

4.1.50 The drop of 1.2m in height between the 2 areas was retained by a substantial wall (A26) (Photo 38), of coursed dry stone rubble construction. This wall is shown on the 1st edition 1:2500 Ordnance Survey map surveyed in 1886 (Figure 14).

4.1.51 Under the build-up of mine waste and modern debris were the remains of an arrangement of rectangular concrete and brick compartments or chambers aligned northeast-southwest (B1-4) (Photo 39, Figure 10).

4.1.52 Figure 10 shows the positions and measurements of these structures. Their floors sloped steeply down from the open front to the back as shown in the cross sections illustrated in Figure 11. B1 & B3 were constructed from cast concrete. Chambers B2 and B4 either side of B3 were constructed from brick and concrete and both had a brick lined floor. There was some evidence that B1 & B3 also had a brick lined floor but that they had been removed.

4.1.53 It is possible that Chamber B1 had been flanked either side by a smaller chamber, mirroring the same arrangement of chambers B2-B4, but all evidence of them had been removed apart from an indication on the NE face of the east concrete wall of chamber B1 of the slope of a smaller chamber on this side.

4.1.54 All 4 remaining chambers B1-B4 were completely filled with very fine grit, variously coloured from red to grey, interspersed with thin layers of grey silt.

4.1.55 The east and west concrete sides of B1 & B3 were similarly aligned and showed evidence of having been broken at their respective ends so it is possible they were once joined.

4.1.56 In the southwest side of B3 there was a 0.38m shallow U-shaped hollow cut into the concrete. There was a corresponding hollow, though slightly shallower, cut into the raised concrete southwestern side of B1 (Photo 39, Figure 10).

4.1.57 To the northeast of these chambers (B2-4) was another slightly bigger chamber recorded during the 2012 watching brief (Shobbrook 2013). The floor of this chamber sloped in the opposite direction (Photo 40). This feature was not uncovered during the 2014 excavation.

4.1.58 Beneath structures (B1-4) in Area B were the remains of a stone cobble floored buddle (B5), the majority of which had been destroyed by the

construction of the concrete and brick chambers. At the southwest edge of the buddle was a fragment of wooden launder (Photo 41). The position of this buddle, as surveyed, indicates it is probably the most south westerly of a line of 3 circular buddles shown on the 1st edition 1:2500 Ordnance Survey map surveyed in 1886.

4.1.59 A small sondage was excavated to the northeast of buddle (B5) and orientated northeast to southwest was a short length of brick walling (B6) running under the buddle floor (Figure 10). The bricks were laid end to end and bonded with mortar.

4.1.60 In the northwestern corner of the area was a possible wheel pit (B7) defined to the northwest and southwest by carefully constructed stone walls (Figure 10 & 11) (Photo 42). The northeast side of the wheel pit was defined by the retaining wall in the northeast corner and to the east of this a stone built, wide rectangular wall (B8) protruded into the pit. Further excavation showed the southeast edge of the pit was demarcated by a coarse rubble wall (B10) (Photo 44) but in the time available it was not possible to fully define the northeast limits of this feature. However, it appeared that the rubble wall may well have continued north-eastwards.

4.1.61 Photo 43 shows the northeast facing section of the southwest wall of the possible wheel pit, during excavation. Figure 12 illustrates the same section but after further mine waste had been excavated from the pit.

4.1.62 At 0.70m below the top of the surviving southwest wall was an arrangement of pine planks above an earlier stone wall (B9) that both projected out from the wall above at an angle (B8) (Photo 42). In plan it was apparent that this section of projecting wall (B9) lies parallel to the eastern edge of the wall (B8) opposite.

4.1.63 Figure 12 illustrates how the majority of the southwest wall was not keyed into the northwest end wall. However, the section drawing shows that at approximately 0.30m below the protruding wooden plank the joint ends and the stones are keyed into each other.

4.1.64 The wheel pit was excavated for a further 0.50m below the point where the section was drawn and it was during this exercise that the southeast rubble wall (B10) was exposed. Unfortunately the bottom of the pit was not reached within the time constraints of the excavation. Even at this depth modern plastic was still being discovered which would clearly suggest that the pit had been backfilled quite recently.

4.1.65 Figure 12 shows the position of 2 small recesses within the brickwork at the back of the wall on opposing sides of the structure.

4.1.66 The area to the southwest of B4 shown as a blank space represents unexcavated mine waste.

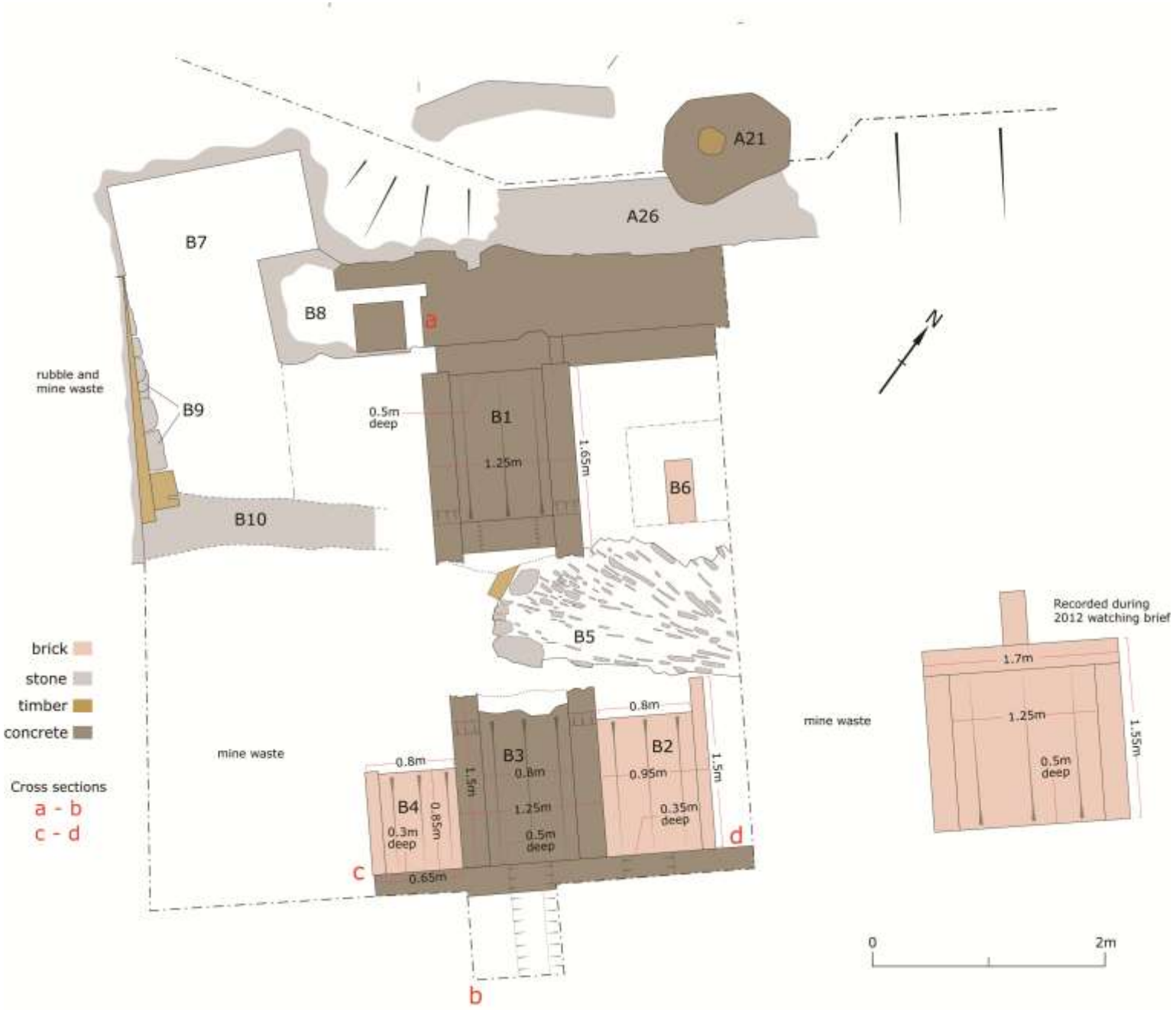


Figure 10:

Plan of Area B showing the individually numbered archaeological features**.**

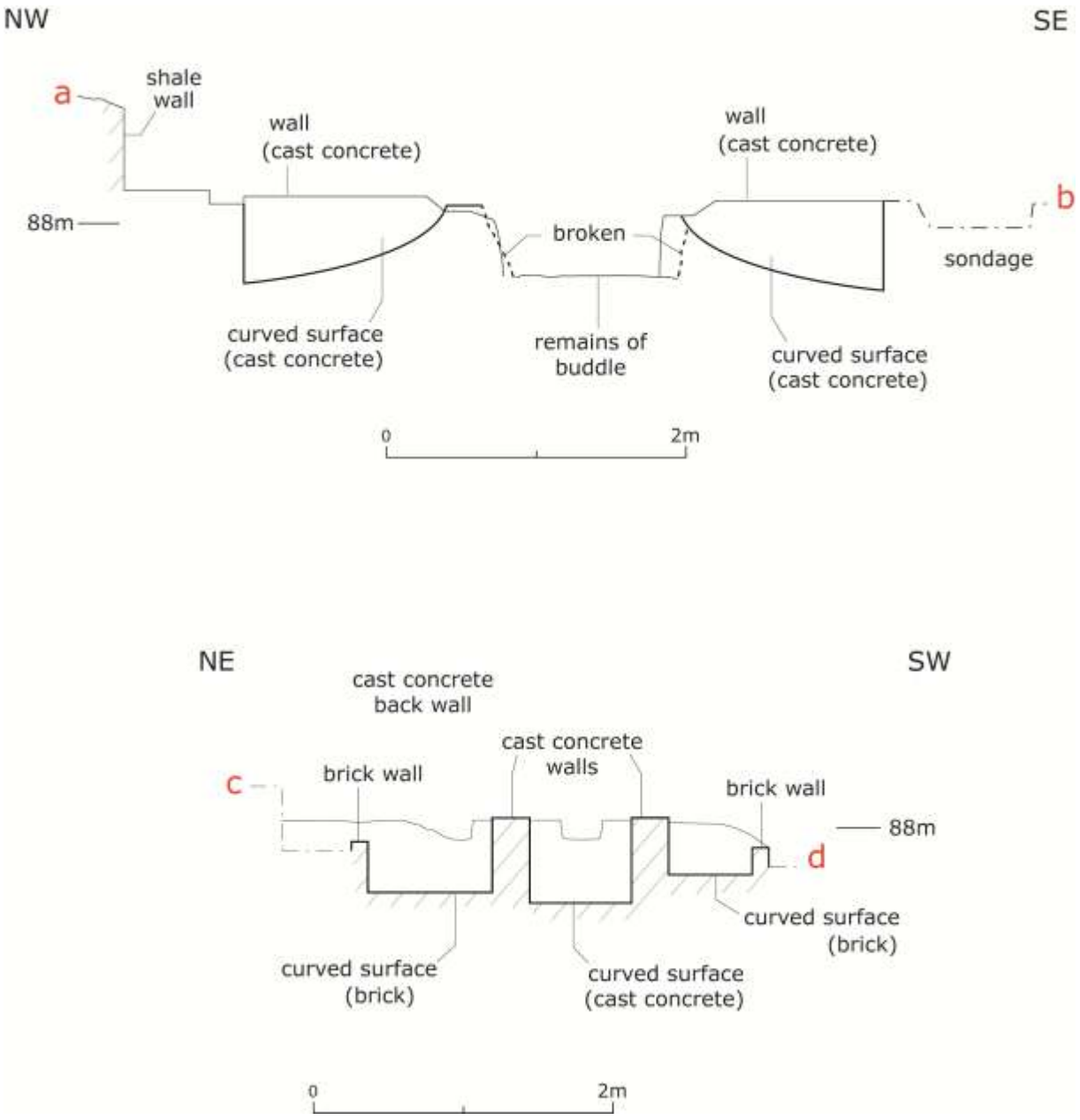


Figure 11: Cross sections through the sloping concrete and brick structures. The positions of the sections are shown in Figure 10.

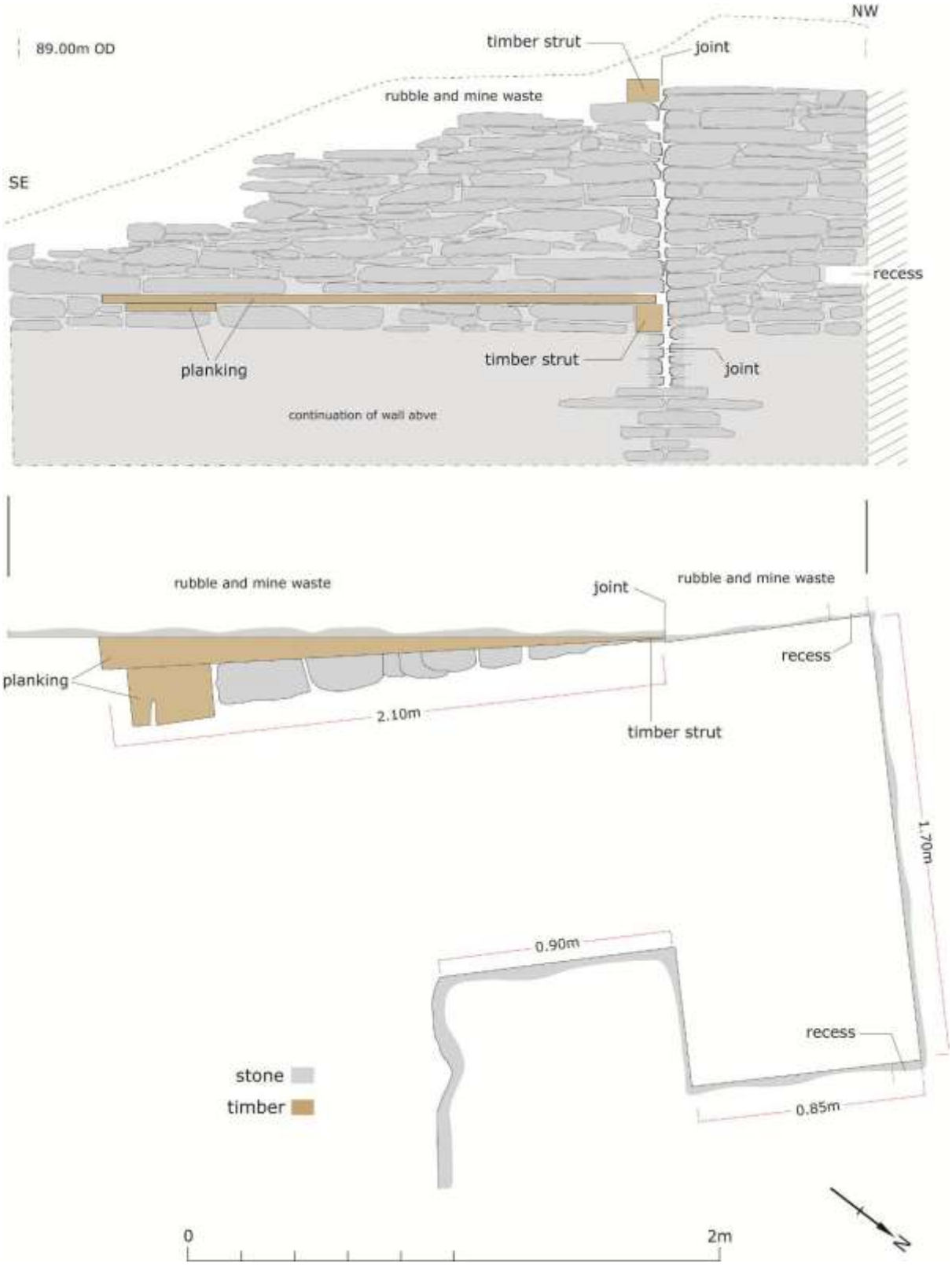


Figure 12: Plan and northeast facing section of possible wheel pit (B7); partially excavated.

Area B - photographs

Photo 36: Area B after an initial clean showing 1.2m drop in height from Area A above. Looking west.

Photo 37: A selection of the objects found during the removal of mine waste and modern debris from Area B.

Photo 38: The drop of 1.2m in height between the 2 areas was retained by a substantial wall (A26). Looking northeast. 1m scale.

Photo 39: Under the build-up of mine waste and modern debris were the remains of 2 lines of rectangular concrete and brick chambers aligned northeast-southwest facing each other (B1-4). Looking southwest. 1m scale.

Photo 40: Post-excavation view of brick structure (7000) recorded during the 2013 watching brief. Looking southwest. 2 x 1m scales.

Photo 41: The remains of a stone cobble floored buddle (B5), the majority of which had been destroyed by the construction of the concrete and brick chambers. Looking northeast. 1m scale.

Photo 42: In the northwestern corner of the area was a possible wheel pit (B7) defined to the northwest and southwest by stone walls. Looking northwest. 1m scale.

Photo 43: The southwest wall of the possible wheel pit (B7), during excavation. Looking southwest. 1m scale.

Photo 44: The coarse rubble wall (B10) that defines the northeast limits of the possible wheel pit (B7). Looking northeast. 2m scale.

4.2 Photographic Survey of the Crushing and Stamp Mill

4.2.1 The photographic survey was undertaken on 26th March 2014. Figure 13 shows the location from which each photograph was taken and the direction the photographer was facing.

4.2.2 A 1m scale was used during the survey.

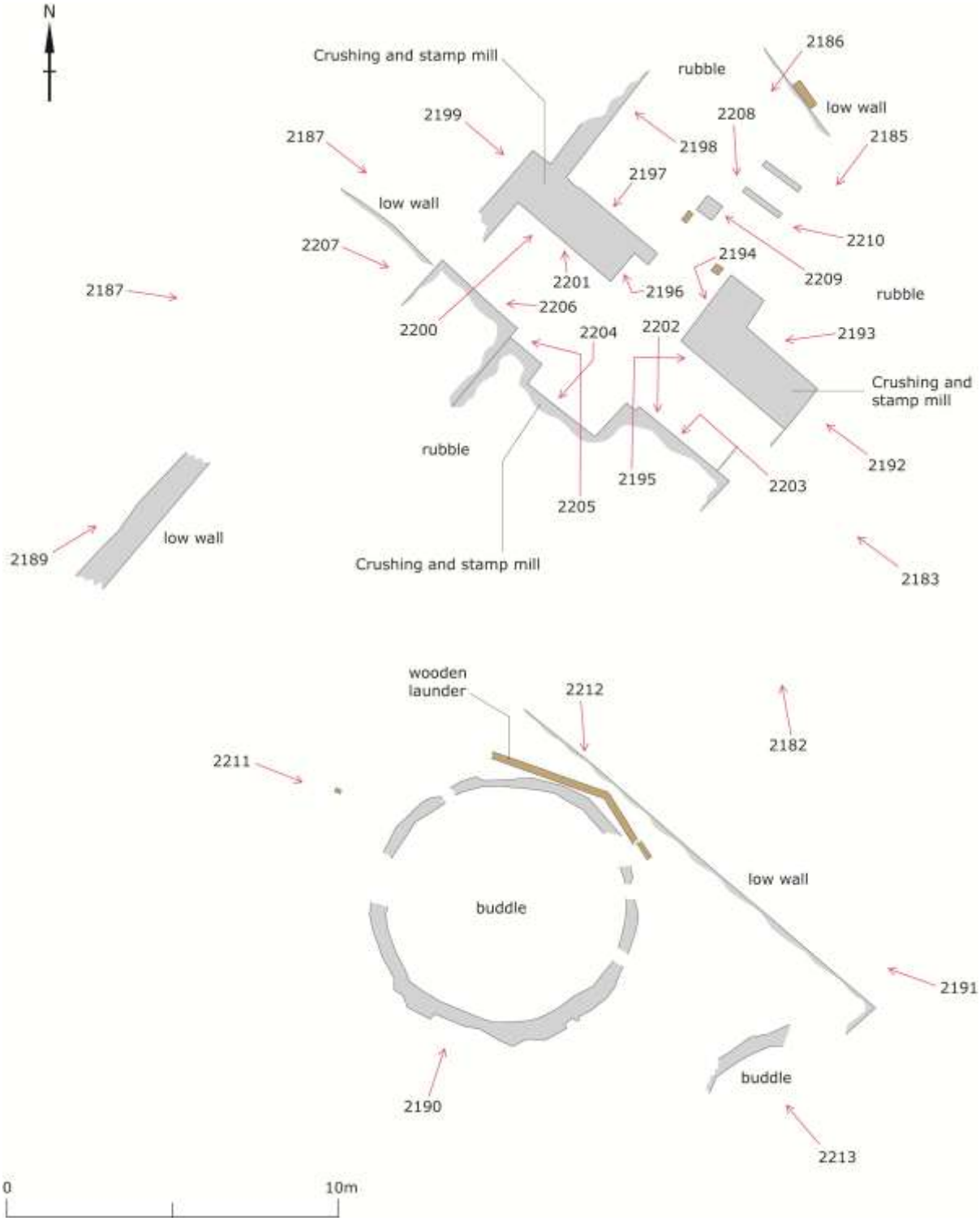


Figure 13: Plan of the Crushing and Stamp Mill photographic survey.

Photographic Survey photographs

Photographic Survey 2182

Photographic Survey 2183

Photographic Survey 2184

Photographic Survey 2185

Photographic Survey 2186

Photographic Survey 2187

Photographic Survey 2188

Photographic Survey 2189

Photographic Survey 2190

Photographic Survey 2191

Photographic Survey 2192

Photographic Survey 2193

Photographic Survey 2194

Photographic Survey 2195

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Photographic Survey 2198

Photographic Survey 2199

Photographic Survey 2200

Photographic Survey 2201

Photographic Survey 2202

Photographic Survey 2203

Photographic Survey 2204

Photographic Survey 2205

Photographic Survey 2206

Photographic Survey 2207

Photographic Survey 2208

Photographic Survey 2209

Photographic Survey 2210

Photographic Survey 2211

Photographic Survey 2212

Photographic Survey 2213

Photographic Survey 2214

4.3 Survey and Recording of unrecorded above ground structures prior to re-profiling.

4.3.1 There are two areas of visible remains exposed at ground surface to the north and south of the 2012 evaluation Trenches 4 and 5; some of which were recorded by the Welsh Mines Preservation Trust in 2012. These include at least 6 buddles and numerous walls.

4.3.2 The visible remains were surveyed using an Electronic Distance Measurer, supplemented with photographs and written records.

4.3.3 Figure 4 shows a composite plan of the archaeological features recorded during the 2012 evaluation (Poucher 2012), the 2013 watching brief (Shobbrook 2013) and those features identified by the Welsh Mines Preservation Trust (Levins 2012). The major archaeological features identified during these pieces of work are prefixed with an F on the plan and are listed in Table 2 below. Areas A and B, excavated in 2014, are described separately in section 4.1. The standing ruined buildings were described in the 2012 archaeological assessment (Murphy 2012).

Feature No	Brief Description	Grid Reference	Image
F1	Circular buddle, stone cobble floor, central wooden post, remnant of outer stone wall edge. Investigated by Welsh Mines Preservation Trust. Shown on the 1st ed 1:2500 OS map surveyed in 1886. *Visible on ground surface.*	SN 72187 74305	
F2	Circular buddle, complete outer stone wall, no surviving evidence for stone or timber floor. Investigated by Welsh Mines Preservation Trust. Shown on the 1st ed 1:2500 OS map surveyed in 1886. *Visible on ground surface.*	SN 72197 74318	

F3	Remnant of circular buddle, northern stone wall, no surviving evidence for floor, *c.* 0.50m deep. Investigated by Welsh Mines Preservation Trust. Shown on the 1st ed 1:2500 OS map surveyed in 1886. *Visible on ground surface.*	SN 72204 74313	
F4	Linear wall – possibly connected with former Lisburne Buddle identified by Moissenet in 1860. Investigated by Welsh Mines Preservation Trust Shown on the 1st ed 1:2500 OS map surveyed in 1886. *Visible on ground surface.*	SN 72202 74319 – mid point	
F5	Wooden launder – runs around east side of buddle (F2), top of launder constructed from lengths of pine planks and even old saw blade. Investigated by Welsh Mines Preservation Trust and DAT. *Visible on ground surface.*	SN 72199 74321	

F6	Crushing and Stamp Mill. Recorded by DAT. Shown on the 1st ed 1:2500 OS map surveyed in 1886. *Visible on ground surface.*	SN 72200 74336	
F7	Remnant of circular buddle – only eastern outer wall remains, identified as Zenner Rotating Buddle by Welsh Mines Preservation Trust. Shown on the 1st ed 1:2500 OS map surveyed in 1886. *Now buried.*	SN 7220 7438	
F8	Remains of a jigger. Investigated by Welsh Mines Preservation Trust *Now buried.*	SN 72215 74383	
F9	Circular buddle – nearly complete outer stone wall, no surviving evidence for floor, *c.* 0.36m deep. Investigated by Welsh Mines Preservation Trust. Shown on 1st ed 1:2500 OS map surveyed in 1886. *Now buried.*	SN 72223 74384	

F10	Circular buddle, nearly complete outer stone wall, no surviving evidence for floor, *c.* 0.52m deep. Investigated by Mines Preservation Trust and DAT. Shown on the 1st ed 1:2500 OS map surveyed in 1886. *Now buried.*	SN 72227 74397	
F11	Circular buddle, incomplete stone outer stone wall visible, surviving evidence that buddle floor was constructed from stone. Investigated by DAT. Shown on the 1st ed 1:2500 OS map surveyed in 1886. *Now buried.*	SN 7223 7440	
F12	Brick chamber with sloping floor - recorded during 2013 watching brief (Area 5, context 7000, Shobbrook 2013) *Now buried.*	SN 7225 7428	

F13	Wall – orientated NE-SW, recorded during 2012 evaluation (T2, context 202, Poucher 2012). Shown on the 1st ed 1:2500 OS map surveyed in 1886. *Now buried.*	SN 72267 74286	
F14	Possible reservoir embankment and base for former tramway, recorded during 2012 evaluation (T2, context 211-3, Poucher 2012). Shown on the 1st ed 1:2500 OS map surveyed in 1886. *Now buried.*	SN 72268 74255	
F15	Arched stone culvert - recorded during 2013 watching brief (Area 4, context 4000, Shobbrook 2013) *Now buried.*	SN 72292 74234	
F16	Inspection chamber to culvert (4000) photo shows two narrow gauge rails that supported the iron cover - recorded during 2013 watching brief (Area 5, context 7002, Shobbrook 2013) *Now buried.*		

F17	Tramway remains, recorded during 2012 evaluation (T5, context 506, Poucher 2012) *Now buried.*	SN 72188 74355	
F18	Remains of tramway that connected Wemyss mine to Frongoch - recorded during 2013 watching brief (Area 2, context 1002-6, Shobbrook 2013) Shown on 2nd ed 1:2500 OS map surveyed in 1904. *Now buried.*		

4.4 Watching Brief

4.4.1 The watching brief was carried out during the Phase II remediation works where groundworks had the potential to expose, damage or destroy underlying archaeological remains. These groundworks included the excavation of the 3 drainage channels (Figure 4) and works in the area of the Crushing and Stamp Mill (F6).

4.4.2 An earlier phase of the work involved building a surface drain around the mine to direct water to a new, lined pond. This has reduced the amount of water that flows through the contaminated mine waste and controlled the amount leaving the site.

4.4.3 The Phase II remediation project aimed to further reduce the amount of surface water that comes into contact with the contaminated mine waste. The extensive area of mine waste tips were heavily landscaped and then capped with compacted layers of clay. A series of shallow lagoons were created along the west side of the mine area that will form a wetland area to further purify the water flowing from the site. Water flowing across the site is directed to the lagoons via a number of shallow drainage channels excavated during Phase II.

Crushing and Stamp Mill (F6, Figure 4)

4th March 2015

4.4.4 The Phase II works included landscaping the area right up to the edges of the Crushing and Stamp Mill (Photo 45).

4.4.5 It was agreed that this could have a detrimental effect upon the unstable structure and under archaeological supervision the walls of the ruin were supported on the east side of the mill and within the internal area of the mill by large deposits of tailings (Photo 46). The tops of the walls were left exposed protruding through the tailings so the position of the mill would still be visible in the future (Photo 47).

4.4.6 It was agreed on site that the area of exposed buddles (F1-5) to the west of the Stamp and Crushing Mill would be left open and not covered with tailings (Photo 48).

Drainage Channels (Figure 4)

5th April 2015

4.4.7 Excavation of drainage channel (1) was undertaken whilst an archaeologist was in attendance. This channel passed between excavation area (A) and the Stamp and Crushing Mill (F6) through an area defined as of High Archaeological Potential (Murphy 2012a).

4.4.8 Excavation of the channel was carried out by mechanical excavator using a toothless bucket. The channel was approximately 0.50 – 0.80m deep and 1.20m wide. Excavation began at the southern end of the proposed channel.

4.4.9 The majority of the layers through which the channel was excavated were various coloured deposits of ore-processing waste including sands, fine compacted silts, medium and large pieces of rock, as well as dark organic material (Photo 49). Within the deposits were occasional pieces of wood, some of which appear to be fragments of former wooden stakes or planks.

4.4.10 At Grid Reference SN 722233 743185 was a discrete area of stone that after cleaning appeared to be a stone filled circular pit, shaft or well (Photo 50). The stone spread measured approximately 2.00m north to south and 1.10m was visible protruding from the east trench edge. Stones had

definitely been placed around the perimeter of the feature but the stones were not bonded with any material. Voids were visible between the stones and elsewhere infilled with silts, sands, timber fragments and modern plastic.

4.4.11 Once recorded the stone was removed to the level required for the drainage channel. It was apparent that the circular cut continued downwards and that it had been backfilled in very recent times.

4.4.12 Within the channel as it curves around to the northwest were signs of the evaluation trench (T4) excavated in 2012 (Poucher 2012), evidenced by the nearly north-south strip of rubble backfill seen in section (Photo 51). However, no indications of similar features such as the parallel ditches (context no's 406 & 408) recorded in T4 were visible during the excavation of this channel.

4.4.13 No further significant archaeological features were recorded during the excavation of drainage channel (1).

4.4.14 The first section of drainage channel (2) was excavated beginning at the southern end of the channel (Photo 52). The depth of the channel varied from 0.5m to 0.2m deep and 1.2m wide. It was shallower at its southern end where excavation revealed bands of dark organic material and compacted grey silts that probably represent the build-up of alluvial deposits within the former mine reservoir. The boundary of the reservoir is depicted on the 1st and 2nd edition Ordnance Survey 1:2500 maps and at grid reference SN 722574 742644 was a linear band of light coloured silt and broken rock that corresponds to the location of the reservoir boundary that also form part of the base for the former tramway seen on historic mapping (Photo 53).

4.4.15 As the excavation of the drainage channel (2) progressed the deposits through which the channel was excavated become much more mixed and no significant archaeological features were recorded (Photo 54).

4.4.16 The excavation of the drainage channel could not be completed on this day as a large mound of clay was in the way and had yet to be moved.

15th July 2015

4.4.17 The excavation of drainage channel (2) was continued to the northeast of that previously excavated. The depth of the channel averaged approximately 0.5m in depth. In section beneath a thin layer of silt and sandy mine waste was a much darker mixed deposit that contained a lot of peaty, humic material containing roots and pieces of worked timber. The excavated channel cut into these deposits by approximately 0.30m (Photo 55). Towards the northern end of the channel a band of stony grey silt was recorded. No significant recorded archaeological deposits were recorded in the excavated channel.

4.4.18 A large pit was excavated for a sump towards the southern end of drainage channel (1) within the area of the former mine reservoir. In the exposed sections of the pit could be seen thick layers of dark grey silt that doubtless represent the alluvial deposits that built up within the reservoir (Photo 56).

16th July 2015

4.4.19 The excavation of drainage channel (3) was carried out beginning at its eastern end. The channel was excavated to an average depth of 0.50m (Photo 57).

4.4.20 The channel was excavated through multiple deposits of waste ore processing material including sands, fine compacted silts and distinct areas of medium and large sized pieces of rock.

4.4.21 At SN 72137 74321 several wide bands of loosely compacted medium and large pieces of rock were seen running diagonally across the excavated channel (Photo 58). On the northern side of these bands there was a distinct change to yellow and orange fine grit and sand. No further significant archaeological features were recorded.

Watching Brief Photographs

Photo 45: The Phase II works included landscaping the area right up to the edges of the Crushing and Stamp Mill (F6). Looking roughly west.

Photo 46: Backfilling the internal area of the Crushing and Stamp Mill with large deposits of mine waste. Looking north.

Photo 47: The tops of the Crushing and Stamp Mill walls were left exposed so the position of the mill would still be visible. Looking north.

Photo 48: The area of buddles (F1-5) and the Crushing and Stamp Mill (F6) after the completion of the Phase II landscaping. Looking northeast.

Photo 49: Excavation of drainage channel (1). Looking northeast.

Photo 50: Top of a stone filled circular pit, shaft or well recorded during the excavation of drainage channel (1). 0.50m & 1m scales.

Photo 51: Indications of the evaluation trench (T4) excavated in 2012 (Poucher 2012), evidenced by the nearly north-south strip of rubble backfill seen in the section of the excavated drainage channel (1).

Photo 52: The initial excavation of drainage channel (2). Looking southeast.

Photo 53: A linear band of light coloured silt and broken rock that corresponds to the location of the reservoir boundary. 1m scale.

Photo 54: The mixed deposits of mine waste revealed during the excavation of drainage channel (2). Looking north.

Photo 55: The resumed excavation of drainage channel (2). Looking roughly northeast. 2 x 1m scales.

Photo 56: In the exposed sections of the pit, excavated as a sump, could be seen thick layers of dark grey silt that doubtless represent the alluvial deposits that built up within the former mine reservoir. Looking northeast.

Photo 57: The excavation of drainage channel (3). Looking northwest.

Photo 58: Several wide bands of loosely compacted medium and large pieces of rock were seen running diagonally across the excavated drainage channel (3). Looking northwest. 2 x 1m scales.

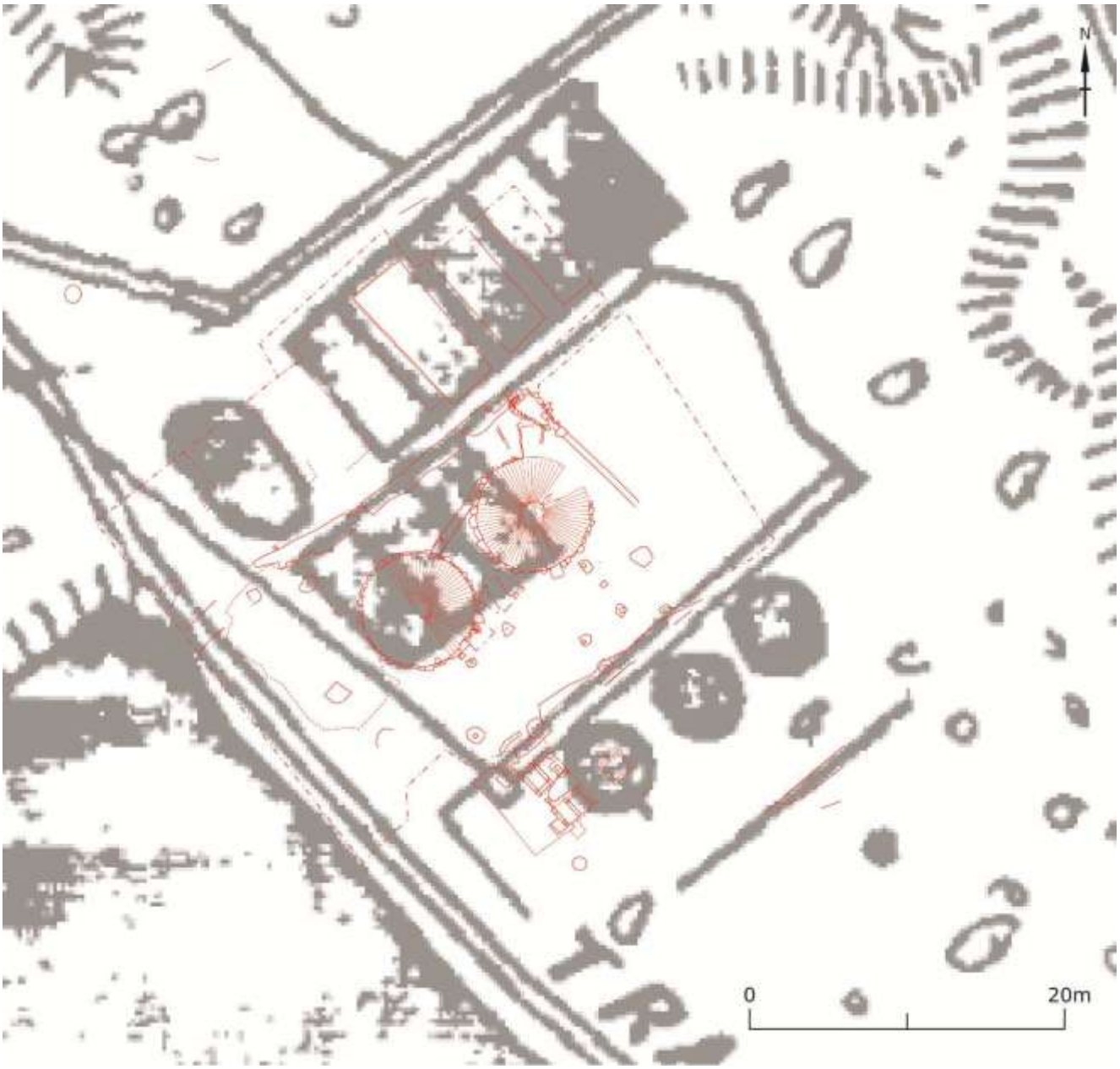

Figure 14: Detailed extract from the 1st edition 1:2500 Ordnance Survey map surveyed in 1886, overlaid with archaeological features recorded in Areas A and B in red**.**

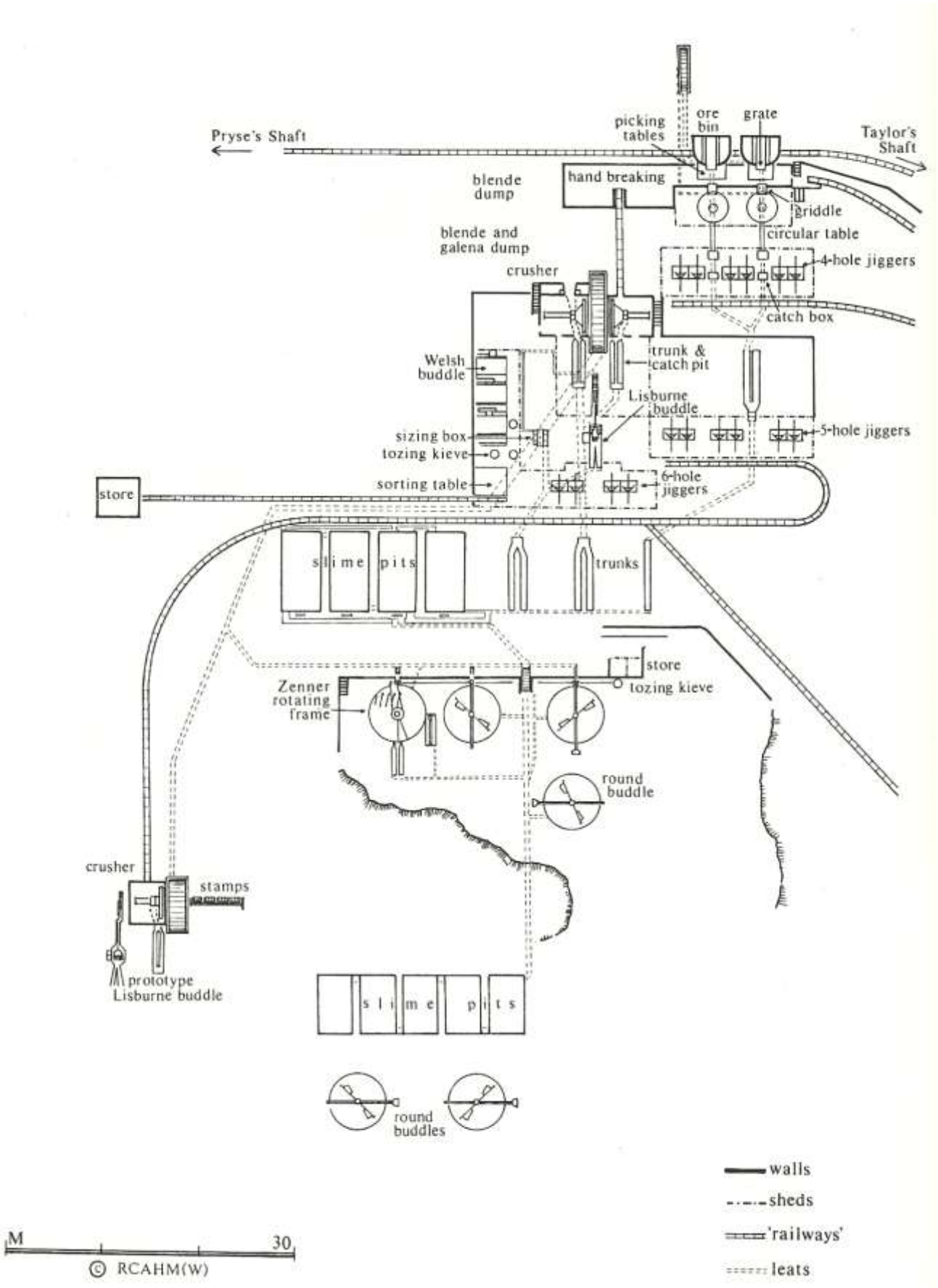

Figure 15: RCAHMW re-drawing of Moissenet's plan of Frongoch in 1860 (based on Bick 1986).

5 DISCUSSION

5.1 The open area excavation recorded in detail a number of well-preserved mining features including buddles, rectangular slime pits and wooden launders; all representative of dressing floor processes in the 19th and 20th centuries.

5.2 It would appear that the buddles and slime pits had been abandoned whilst in operation; as they still contained the processed ore from their last period of use. The buddles are not shown on historic mapping but the rectangular slime pits are illustrated on Moissenet's plan of 1860 (Figure 15) and on the 1st edition 1:2500 Ordnance Survey map surveyed in 1886.

5.3 Beneath the excavated buddles was evidence of the survival of earlier slime pits which were not recorded on Moissenet's plan of 1860 but were recorded on the 1st edition 1:2500 Ordnance Survey map surveyed in 1886 (Figure 15).

5.4 Further to the southwest the ground dropped by just over a metre and at this level a group of concrete and brick structures were recorded. Their construction had partially destroyed a former stone floored buddle and below this buddle could be seen a linear brick wall. The function of the concrete structures remains enigmatic but they probably date from the 1920s-50s reworking of waste tips. Close by was what appeared to be evidence of a former wheel pit. The concrete features are not recorded on historic mapping but it is likely that the remnant of stone buddle in this area is the buddle shown in approximately this position on the 1st edition 1:2500 Ordnance Survey map surveyed in 1886.

5.5 Taking all the recorded data into account the following developmental sequence has been proposed by Robert Protheroe Jones, the Principal Curator of Industry, Department of History & Archaeology, Amgueddfa Cymru – National Museum Wales'

Comparison of Moissenet's 1860 plan with the surveys of RCAHMW (figs 16 and 17 in Bick, 1986) confirms that his plan generalised the locations of the dressing floor plant and presented them in far more regular parallel rows than existed in reality. Allowing for this distortion, the row of five slime pits shown by Moissenet align well with the five shown on the 1st edition 1:2500 Ordnance Survey map surveyed 1886, and with the row of five slime pits excavated during 2014. Immediately to the south of the row of five slime pits, Moissenet showed two circular buddles; by the time the 1st edition 1:2500 Ordnance Survey map was surveyed in 1886, these had disappeared and the site of the western one was occupied by a row of three slime pits. These three slime pits are presumably those recorded beneath the pair of excavated buddles. Thus the pair of excavated buddles post-date 1886 – this explains why their positions relative to the row of five slime pits differ significantly to the positions of the pair of buddles shown by Moissenet. The remains of a stone-floored buddle exposed beneath the brick structures on the lower bench to the south of the pair of buddles aligns well with the westernmost of the three buddles shown on the 1st edition 1:2500 Ordnance Survey map surveyed in 1886 but not shown on Moissenet's 1860 plan.

The following developmental sequence is indicated:

***1860**: row of five slime pits feeding a pair of buddles. This plant comprised the second stage of processing the slimes from the main dressing floors after the slimes had been further crushed and stamped, and had been processed by a Lisburne buddle (Bick, 1986, p.51, summarising Moissenet, 1860). As the Lisburne buddle had been introduced in 1855 (Bick, 1986, p.50), it is highly likely that this plant was built in the period 1855-1860. The location of the waterwheel that powered the pair of buddles is not known but the proximity of the reservoir might suggest that the wheelpit lay to the east of the buddles in an area not excavated. The wheelpit would have been occupied by one of the 'six small waterwheels on the flooring' listed in the 1878 lease inventory (Bick, 1986, p.26).*

***1886:** row of five slime pits either feeding, or augmented by a further three slime pits (replacing the pair of buddles), feeding three buddles on the lower bench. The date that these changes occurred is not known but was probably prior to 1878 when the lease inventory listed '9 round buddles ditto' [i.e. 'on the flooring'] (Bick, 1986, p.26).*

***Post-1886**: five slime pits feeding a pair of buddles (replacing the three slime pits); status of the three buddles on the lower bench uncertain but likely to be abandoned. This alteration occurred late in the working life of the Frongoch dressing floors, which went out of use when the Wemyss dressing mill was built by new owners who acquired the mine in 1898. The prices realised by ores had fallen considerably in the late 1870s and early 1880s but the price of zinc recovered from the mid-1880s. It is possible that the rise in zinc prices in the late 1880s encouraged the alteration of this part of the plant with the aim of achieving additional recovery of ore provided by treating slimes. The slide in metal prices, especially zinc, from 1890/91, coupled with the declining output of the mine and the lack of capital of the owners by this period, is unlikely to have encouraged significant plant alterations. Accordingly, it seems likely that the construction of this pair of buddles occurred in the period 1887-1890.*

***1904:** all foregoing plant disused and presumably covered by ore processing waste as not shown on 2nd edition Ordnance Survey map. This reflected the replacement of the Frongoch dressing floors by the Wemyss dressing mill which was built by new owners who acquired the mine in 1898.*

***Date uncertain but post-1886:** brick and concrete structures built on lower bench. Their construction suggests an early to mid-twentieth century date. It is possible they are related to one or possibly more of the following: (i) work by the new owners 1898-1903, (ii) the 1917-1930 reworking of tips which were transported by aerial ropeway to a new mill built at Gwaith-goch Mine, 2.5km to the south west; (iii) small scale work including froth flotation in the early 1950s. The first of these seems unlikely as the new company promptly abandoned the Frongoch dressing floors in favour of the new Wemyss Mill, making it unlikely that they would have undertaken construction work here. The third of these also seems unlikely, as that enterprise's small scale dressing plant was located immediately south of Vaughan's New Shaft. This leaves the 1917-1930 reworking. The style of construction accords well with this period. The aerial ropeway terminal appears to have been located either at Vaughan's New Shaft ore bins, or possibly immediately south east of the 25 inch steam winder and crusher house, as concrete loadings at the latter location align with the known ropeway route shown on inter-war Ordnance Survey 1 inch: 1 mile maps*

and with its projection to Vaughan's New Shaft (RCAHMW in Bick, 1986, pp.31, 36, suggested a 'c.1900' date for these loadings but did not appear to consider their coincidence with the aerial ropeway alignment).

The purpose of the brick and concrete structures on the lower bench of the excavated area is unclear but their form suggests that they supported machinery: though they are mostly lighter than typical machinery loadings. Stumps of wooden and steel posts on the adjoining upper bench indicate a roofed area post-dating the 1886 and 1904 Ordnance Survey maps but their form might date them to either of the 1917-1930 or the early 1950s periods of activity. Fragments of machinery found in the backfill of the brick and concrete structures included steel stirrers appropriate for small flotation cells. Various small cast iron pinions, including bevel pinions, also found here could equally well derive from round buddles as from flotation cells and so are not so useful in indicating what type of plant they originated from. It is possible that these finds derive from the roofed area on the upper bench and that they were powered by machinery positioned on the brick and concrete structures located on the lower bench. If so, then a small scale flotation plant may have been situated here either during either the 1917-1930 or the early 1950s reworking, although the latter is mitigated against by an account that states that the latter reworking utilised flotation cells immediately south of Vaughan's New Shaft (Bick, 1986, pp.22, 24). As flotation requires very finely crushed ore, a ball or tube mill would have been required. It is difficult however to reconcile a flotation plant at Frongoch in this period with the knowledge that the concern built a substantial crushing and flotation plant at the far end of the aerial ropeway at Gwaith-goch mine. The excavated structures might possibly represent a preliminary trial plant erected to prove the viability of treating the Frongoch tips prior to the aerial ropeway coming into operation. If this supposition is correct, then the structures would date to c.1917-19 as the ropeway was complete by the latter year (Bick, 1986, pp.22-23).

5.6 This evidence of deeply stratified archaeological deposits in the excavation area led Natural Resources Wales to modify the remediation scheme to avoid further disturbance and preserve *in situ* these surviving mining features.

5.7 The final piece of archaeological mitigation was a watching brief during the remaining phase of remediation works. This was carried out in March and April 2015 and due to the changes to the remediation scheme to avoid areas of potential archaeological deposits, few archaeological remains were recorded.

5.8 The archaeological fieldwork carried out at Frongoch Mine has enabled the design of both phases of the remediation project to be altered to protect the remarkable well-preserved mining features *in situ*, whilst at the same time preserve in record details of many of the mining features revealed during the remediation works.

5.9 It is not within the remit of this project to write a detailed history of Frongoch Mine but it is hoped that the information recorded during the archaeological fieldwork commissioned by Natural Resources Wales will greatly benefit further study.

6. SOURCES

6.1 Cartographic

Anon	1847	Tithe Award map for the parish of Llanfihangel y Creuddyn
Ordnance Survey	1888	1st ed 1; 2500 Cardiganshire XI.11/15 surveyed 1986
Ordnance Survey	1905	2nd ed 1; 2500 Cardiganshire XI.11/15 surveyed 1904
Ordnance Survey	1953	6-inch map of Cardiganshire
RCAHMW 1984		Moissenet's plan of Frongoch in 1860

6.2 Published

Bick, D., 1986, *Frongoch Lead & Zinc Mine, British Mining No 30,* Northern Mine Research Society Monograph.

6.3 Unpublished

Murphy, F., 2012a, *Frongoch Metal Mines Remediation Project: Archaeological Assessment* Dyfed Archaeological Trust Report No.2012/11

Murphy, F., 2012b, *Frongoch Metal Mine Geotechnical Test Pits: Archaeological Watching Brief* Dyfed Archaeological Trust Report No.2012/17

Levins, G., 2012, *First Report of Survey and Archaeological Excavations at Frongoch Mine 11/12 August 2012* Welsh Mines Preservation Trust

Poucher, P., 2012, *Frongoch Metal Mines Remediation Project: Archaeological Evaluation*
Dyfed Archaeological Trust Report No.2012/65

Shobbrook, A, 2013, *Frongoch Metal Mine, Phase 1, Ceredigion, Archaeological Watching Brief 2013,* Dyfed Archaeological Report No 2013/46

FRONGOCH METAL MINE, CEREDIGION

ARCHAEOLOGICAL FIELDWORK 2014-2015

RHIF Y DIGWYDDIAD/ EVENT RECORD NOs 108529 & 108530

RHIF YR ADRODDIAD / REPORT NUMBER 2015/30

Mehefin 2015

June 2015

Paratowyd yr adroddiad hwn gan / This report has been prepared by

Fran Murphy

Swydd / Position: Project Manager DAT Archaeological Services

Llofnod / Signature..... Dyddiad / Date 21/12/2015

Mae'r adroddiad hwn wedi ei gael yn gywir a derbyn sêl bendith
This report has been checked and approved by

James Meek

ar ran Ymddiriedolaeth Archaeolegol Dyfed Cyf.
on behalf of Dyfed Archaeological Trust Ltd.

Swydd / Position: Head of DAT Archaeological Services

Llofnod / Signature ..... Dyddiad / Date 22/12/2015

Yn unol â'n nôd i roddi gwasanaeth o ansawdd uchel, croesawn unrhyw sylwadau sydd gennych ar gynnwys neu strwythur yr adroddiad hwn

As part of our desire to provide a quality service we would welcome any comments you may have on the content or presentation of this report

ymddiriedolaeth archaeolegol

DYFED

archaeological trust