

# LOWWOOD GUNPOWDER WORKS, HAVERTHWAITE, CUMBRIA

## Archaeological Excavation and Watching Brief



Client: Lowwood Products  
Company Ltd

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## Non-Technical Summary

Following the submission of a planning application to carry out improvements to the existing hydroelectric plant within the former Lowwood Gunpowder Works, Haverthwaite, Cumbria, which is a Scheduled Monument, Greenlane Archaeology was commissioned to carry out a programme of archaeological work prior to and during the associated groundworks. This followed on from a previous phase of archaeological evaluation and building recording. The initial part of this second phase of work comprised the excavation of an area adjacent to the turn in the leat where this was proposed to be modified, resulting in the removal of deposits alongside the leat. Following this, groundworks carried out as part of the development were monitored by archaeological watching brief.

The excavation revealed the form and construction of the original leat wall, running parallel to the current wall, and demonstrated that it must have been substantially rebuilt in the 19<sup>th</sup> century. In addition, a linear feature, most probably a palaeochannel, was identified to the south-west, running approximately parallel to the extant leat. This had been backfilled with a variety of deposits, of both industrial and domestic character, and in the base was an *in situ* tree stump.

The watching brief monitored four different areas; topsoil stripping and levelling for a new access track from the south-west and site compound, the excavation of abutments for a new bridge, the excavation of a new service trench, and excavation around the former powerhouse and leat end following demolition of the existing structures. The topsoil stripping essentially just revealed dumped domestic rubbish of 19<sup>th</sup> and 20<sup>th</sup> century date to the west of the leat and dumped industrial deposits to the east probably brought from the nearby Backbarrow iron furnace, and more of this was revealed in the service trench. The excavation of the bridge abutments revealed a section of culvert on the east side of the leat, which probably originally supplied a pair of incorporating mills a short distance to the east. Excavation around the powerhouse revealed the remains of a wall and a gate or bridge footing incorporating an edge runner stone, as well as a deposit containing apparent bloomery slag and thick ceramic material similar to crucible fragments.

This work in general revealed a number of features of interest, the most significant of which is perhaps the bloomery slag, which is thought likely to relate to the bloomsmithy. Documentary evidence suggests that one operated on the site from a short period in the early 17<sup>th</sup> century. The ceramic material is considered likely to represent clay packing placed around a tuyere (the nozzle through which air was blown via bellows into the hearth) used in the bloomsmithy and is therefore very unusual.

## Acknowledgements

Greenlane Archaeology would like to thank the Lowwood Products Company Ltd for commissioning and supporting the project, in particular James Barratt. Thanks are also due to Andrew Davison, Inspector of Ancient Monuments/Team Leader at English Heritage North West Region, and John Hodgson, Senior Archaeology and Heritage Advisor at the Lake District National Park Authority, for their comments during the fieldwork. Special thanks are due to David Clarke who drove the excavator on site.

The excavation was carried out by Dan Elsworth and Tom Mace, and the watching brief was carried out by Dan Elsworth. The report was written by Dan Elsworth and the illustrations produced by Tom Mace. The finds were assessed by Jo Dawson, who also edited the report. The flots from the environmental samples were assessed by Scott Timpany (Headland Archaeology), the sample of timber was examined by Ian Tyers (Dendrochronological Consultancy Ltd), and the industrial residues by Gerry McDonnell (Gerry McDonnell Archaeometals). The project was managed by Dan Elsworth.

# 1. Introduction

## 1.1 Circumstances of the Project

1.1.1 Prior to the submission of a planning application by Lowwood Products Company Ltd (hereafter 'the client') for a proposed programme of improvements to an existing hydro-electric facility at the former Lowwood Gunpowder Works, Haverthwaite, Cumbria (centred on NGR 334708 483707) English Heritage (EH) and the Senior Archaeology and Heritage Advisor at the Lake District National Park Authority (LDNPA) were consulted. Almost the entire site of the former gunpowder works, which was established in the early 19<sup>th</sup> century although the site had been utilised as iron works until the end of the 18<sup>th</sup> century, is now a Scheduled Monument (No. 27805) and so is statutorily protected. Following an initial phase of archaeological evaluation carried out by Greenlane Archaeology on four areas thought likely to be affected by the proposed development (Greenlane Archaeology 2010) a brief covering further work was issued by the Archaeology Service at the LDNPA (ASLDNPA 2011), which was approved by EH. This outlined that the archaeological work should comprise an excavation of the area where the leat was to be realigned, and a watching brief on other groundworks.

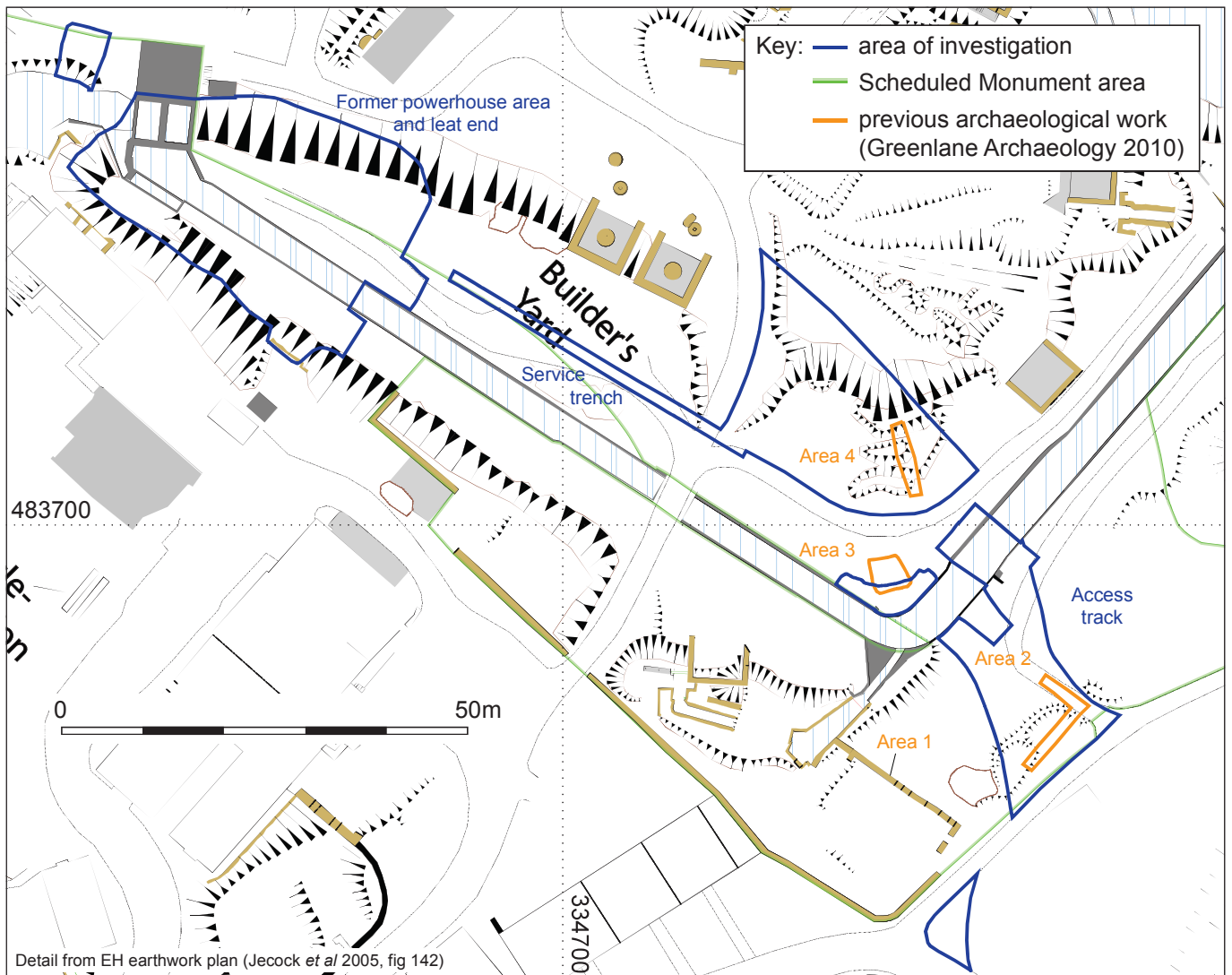
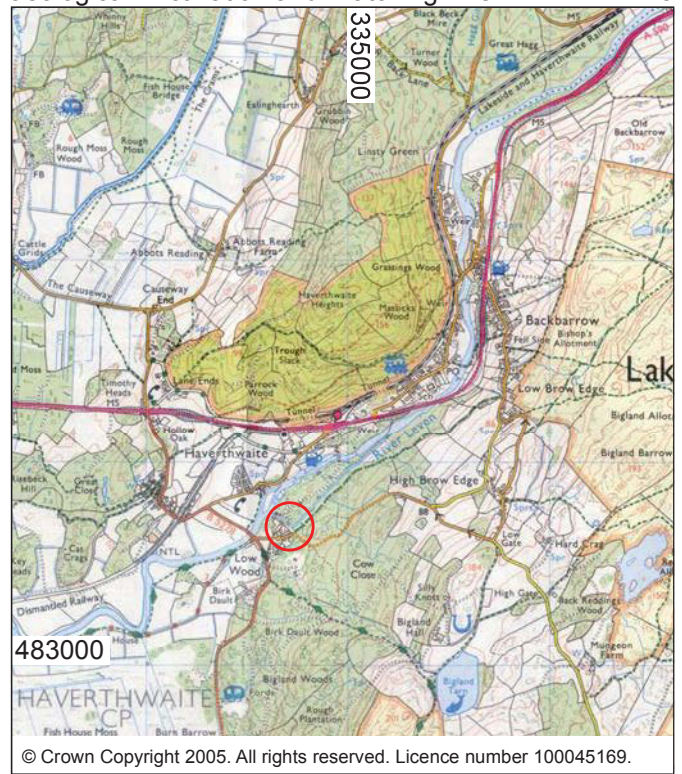
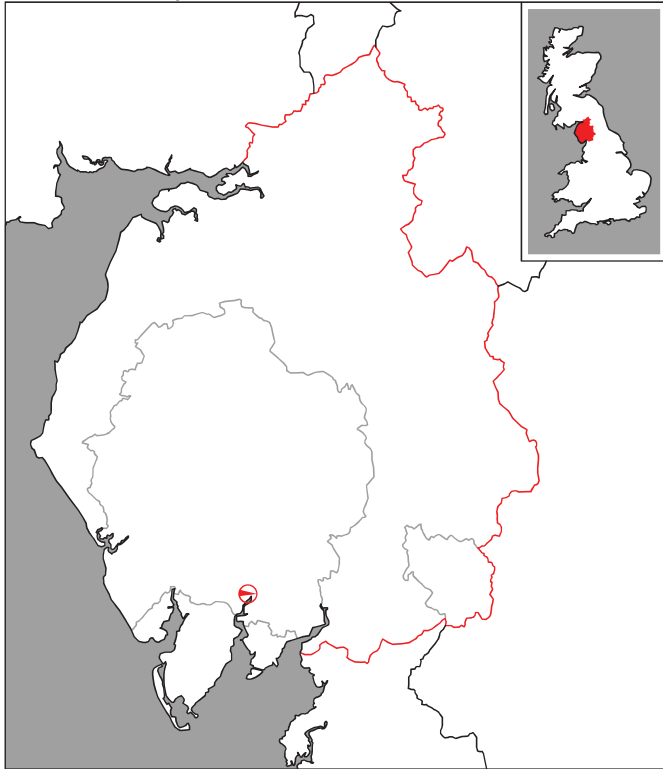
1.1.2 The site was subject to a detailed survey by English Heritage in 2004 (Jecock *et al* 2005), as part of a wider investigation into such monuments initiated in 1999. This established that, prior to the construction of the gunpowder works, the site is thought to have been the location of a bloomery forge in the 18<sup>th</sup> century, which was subsequently developed in 18<sup>th</sup> century with the establishment of a blast furnace, which remained in operation until at least 1785. Soon after the site was re-used for the establishment of a gunpowder works, which began operating in 1799, and continued, albeit with several phases of modification, until the 1930s.

1.1.3 Prior to carrying out the excavation, Scheduled Monument Consent for the whole development was applied for by the client's agent (Nic Smith of RG Parkins and Partners). This was granted by English Heritage on 25<sup>th</sup> January 2011 (Ref. S00006572), subject to the work agreed with the LDNPA taking place. The excavation was carried out in May 2011 and the watching brief between May and June 2011.

## 1.2 Location, Geology, and Topography

1.2.1 The Lowwood gunpowder works site covers an area of approximately 10 hectares, although the area examined was restricted to the south end of the site (Figure 1), where the majority of groundworks associated with the proposed improvements to the hydroelectric plant will take place. The whole site is located on a terrace on the east side of the River Leven, at approximately 13m above sea level (Figure 1). It is a short distance from the A590 and the village of Haverthwaite, to its north-west, with the village of Backbarrow approximately 1km to its north-east (Figure 1). The nearest town is Ulverston, approximately 6km to the south-west.

1.2.2 The local solid geology comprises Bannisdale slates and Coniston gritstones (Moseley 1979, plate 1), which, within the gorge formed by the River Leven, is overlain by river gravels but with occasional exposed rock outcrops (Jecock *et al* 2005, 7-8).



Client: Lowwood Products Company

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Figure 1: Site location

## 2. Methodology

### 2.1 Introduction

2.1.1 The project comprised the archaeological excavation of an area due to be destroyed by the proposed development and a watching brief during subsequent groundworks.

2.1.2 All aspects of the project were carried out according to the standards and guidance of the Institute for Archaeologists (IfA 2008a, 2008b).

### 2.2 Archaeological Excavation

2.2.1 An essentially crescent-shaped trench was excavated against the angle of the leat, which is almost 90°, representing the area that was due to be removed during the realignment of the leat; Area 3 in the earlier evaluation. It was approximately 9m long north-west/south-east and 7m long north-east/south-west and between 1.5m and 4m wide (Figure 2: Plan of area of excavation and test pit Figure 2). The following recording techniques were used:

- **Written record:** descriptive records of all deposits and features (see *Appendix 3*) were made using Greenlane Archaeology *pro forma* record sheets. In addition, a general record was made of the day's events;
- **Photographs:** photographs in both 35mm colour print and colour digital format were taken of all archaeological features uncovered during the excavation, as well as general views of the site, the surrounding landscape, and working shots. A selection of the colour digital photographs is included in this report and the remainder are included in the archive. A written record of all of the photographs was also made using Greenlane Archaeology *pro forma* record sheets (Greenlane Archaeology 2007a);
- **Drawings:** drawings were produced on site as follows:
  - i. A trench plan was produced at a scale of 1:50;
  - ii. appropriate sections and plans of individual features were drawn at a scale of 1:20.

2.2.2 The location of the excavation trench was recorded relative to the known location of nearby buildings and other structures that were evident on the previous survey plans (Jecock *et al* 2005) and Ordnance Survey maps. Heights above Ordnance Datum were recorded utilising a benchmark on the bridge over the River Leven (9.36m OD) and are shown in Figure 2 to Figure 5 and Figure 9.

### 2.3 Archaeological Watching Brief

2.3.1 Areas in which groundworks were taking place on the site were monitored, although the practicalities of access and health and safety considerations precluded some or all monitoring in certain areas, such as at the weir at the north end of the leat. In addition, the demolition of existing structures was not monitored. Any archaeological features identified were recorded in the following manner:

- **Written record:** descriptive records of all deposits and features were made. A full list of the contexts encountered is present in *Appendix 2*;
- **Photographs:** a photographic record was produced in 35mm colour print and colour digital format. A selection of the colour digital photographs is included in this report. A written record of all of the photographs was also made;
- **Drawings:** plans of the areas monitored were produced at a scale of 1:200 with additional drawings of features of interest produced scales of 1:20 and 1:50.

2.3.2 The locations of the areas monitored were recorded relative to the known location of nearby topography, buildings and other structures (see Figures 6 to 9).



## 2.4 Finds

2.4.1 **Processing:** artefacts were washed (or dried and dry brushed in the case of metal and glass), naturally air-dried, and packaged appropriately in self-seal bags with white write-on panels.

2.4.2 **Assessment and recording:** the finds were assessed and identified and a list of them was compiled (see *Appendix 4*).

2.4.3 **Industrial Residues:** the industrial residue was processed in the same manner as the other finds. The methodology used for the specialist assessment is presented in *Appendix 5*.

2.4.4 **Timber:** the sample of timber from the tree stump present in feature **1012** was briefly examined by eye.

## 2.5 Environmental samples

2.5.1 **Strategy:** seven samples were taken, primarily from the fill of negative cut features (see *Appendix 6* for a complete list). Of these four were considered worth further assessment on the grounds that they were thought most likely to produce useful results and following reinterpretation of the deposit types and stratigraphy.

2.5.2 **Processing:** each of the samples was wet sieved, the light fragments floated off and collected in 250µm and 500µm sieves with the coarse component separated through a 1cm mesh and by hand. The flots and retent were then naturally air dried. The flots were assessed through examination using a stereomicroscope at magnifications of x10 and up to x100 where necessary to aid identification. Identifications were confirmed using modern reference material and seed atlases including Cappers *et al* (2006). The details of their contents are contained in *Appendix 5* and a summary in *Section 4.2*. The retents were assessed through examination by eye, with artefacts and ecofacts extracted by hand.

2.5.3 **Assessment and recording:** artefacts and ecofacts were removed from both the flots and retents. The content of the flots was assessed by Scott Timpany (Headland Archaeology) and is summarised in Table 6 (*Appendix 6*), while the content of the retent was recorded on *pro forma* record sheets, and the information summarised in Table 5 (*Appendix 6*). The results are discussed in *Section 4.5*.

## 2.6 Archive

2.6.1 A comprehensive archive of the project has been produced in accordance with the project design (*Appendix 2*) and current IfA and English Heritage guidelines (English Heritage 1991; Brown 2007). The archive, which comprises the drawn, written, and photographic record, will be deposited with the Cumbria Record Office in Barrow-in-Furness (CRO(B)). A copy of the report will also be provided to the client, Greenlane Archaeology will retain a copy, five copies will be provided to the LDNPA HER, and a digital copy will be provided to English Heritage. A digital copy will be provided for the OASIS scheme (English Heritage 2007).

2.6.2 The client will be encouraged to transfer ownership of the finds to a suitable museum, in this case Kendal Museum, so that they will be available for further analysis in the future. The museum is, however, currently at close to full capacity, and it is unlikely that it would be willing to take anything unless it is of exceptional importance. If no suitable repository can be found the finds may have to be discarded, and in this case as full a record as possible will be made of them beforehand.

### 3. Historical and Archaeological Background

#### 3.1 Historical and Archaeological Background

3.1.1 **Introduction:** the former gunpowder works at Lowwood have been examined in some considerable detail, not only on account of the extensive report carried out by English Heritage (Jecock *et al* 2005), but also through research into its historical development through documentary sources (eg Palmer 1998). As a result the development of the site is well understood, although the lack of excavation, until now, means that there are gaps and there is relatively little detail relating to other periods of activity in the area. This historical background is intended to place the results of the excavation in their local and regional context, in particular that relating to the use of the site during its industrial heyday in the 18<sup>th</sup> and 20<sup>th</sup> century, and is based on information compiled for the earlier evaluation (Greenlane Archaeology 2010).

3.1.2 **Prehistoric Period (c11,000 BC – 1<sup>st</sup> century AD):** while there is some limited evidence for activity in the county in the period immediately following the last Ice Age, this is typically found in the southernmost part on the north side of Morecambe Bay. Excavations of a small number of cave sites have found the remains of animal species common at the time but now extinct in this country and artefacts of Late Upper Palaeolithic type (Young 2002). Again, the county was also clearly inhabited during the following period, the Mesolithic (c8,000 – 4,000 BC), as large numbers of artefacts of this date have been discovered during field walking and eroding from sand dunes along the coast, but these are typically concentrated in the west coast area and on the uplands around the Eden Valley (Cherry and Cherry 2002). Slightly closer to the site, however, a large number of finds of this date were discovered during excavations carried out in the park belonging to Levens Hall in the 1970s, and, although largely ignored at the time, they were subsequently published (Cherry and Cherry 2000). In addition, a small amount of Mesolithic material has been found at the north end of Windermere during excavations on the Roman fort site (see for example Finlayson 2004). These discoveries, particularly that at Levens, demonstrate that further remains of similar date are likely to exist in the local area, and conforms with the notion that river valleys, lakesides, and coastal areas are a common place for such remains to be discovered (Middleton *et al* 1995, 202; Hodgkinson *et al* 2000, 151-152).

3.1.3 In the following period, the Neolithic (c4,000 – 2,500 BC), large scale monuments such as burial mounds and stone circles begin to appear in the region and one of the most recognisable tool types of this period, the polished stone axe, is found in large numbers across the county, having been manufactured at Langdale to the north of the site (Hodgson and Brennand 2006, 45). During the Bronze Age (c2,500 – 600 BC) monuments, particularly those thought to be ceremonial in nature, become more common still, and it is likely that settlement sites thought to belong to the Iron Age have their origins in this period. These are not well represented in the area around the site, although an enclosure on Hoad hill near Ulverston perhaps has its origins in this period (Elsworth 2005), as might another one at Skelmore Heads near Urswick, although evidence for activity in the Neolithic was also associated with this (Powell 1963). Stray finds of Bronze Age date are throughout the county, however, although none are recorded within the study area. Sites that can be specifically dated to the Iron Age (c600 BC – 1<sup>st</sup> century AD) are very rare; the enclosures at Ulverston and Urswick may represent hillforts, a typical site of this period, but they have not been dated. At Levens, burials radiocarbon dated to the Iron Age have been discovered (OA North 2004a), but these remain a rarity both regionally and nationally. There is, however, likely to have been a considerable overlap between the end of the Iron Age and the beginning of the Romano-British period; it is evident that in this part of the country, initially at least, the Roman invasion had a minimal impact on the native population in rural areas (Philpott 2006, 73-74).

3.1.4 **Romano-British - Early Medieval period (1<sup>st</sup> century AD to 11<sup>th</sup> century AD):** there no known remains of Roman date in the local site environs, although masonry identified below the water at Newby Bridge has been postulated as being part of a harbour, perhaps connected to the Roman fort at Ambleside (Shotter 2004, 42). The fort at Ambleside has seen numerous phases of investigation and it is evident that it was occupied for a considerable period with the initial establishment of a turf and timber structure in the 1<sup>st</sup> century AD, perhaps later abandoned, followed by renewed activity in the early 2<sup>nd</sup>

century, which continued in some form until perhaps as late as the fourth century (see summary in Drury and Dunwell 2004, 71-73). What connection there was to the area to the south around Morecambe Bay is uncertain, although a recent reappraisal of the evidence has suggested that there was some Roman occupation of the Furness peninsula and a wider network of roads connecting sites of the period than is generally accepted (Elsworth 2007).

3.1.5 The period following the end of effective Roman administration in Britain in the 5<sup>th</sup> century is not well represented in the archaeological record of the area, which is a common situation throughout the county. Fragments of Anglian cross-shaft found at church sites, the example at Kendal is perhaps the closest (Collingwood 1904), and place-name evidence are typically all the information that there is. In this case, the place-name evidence suggests that the nearest settlement, at Haverthwaite, potentially has its origins in the Norse period comprising the words for oats and clearing (Ekwall 1922, 217). There is also fleeting evidence for early Christian activity in the area; an earlier monastery is recorded at Heversham in the 10<sup>th</sup> century when the Abbot Tildred is said to have been fleeing eastwards in advance of the approaching Vikings (Sawyer 1978), and an *eccles* place-name recorded at Conishead Priory might indicate that it too might have had much earlier Christian origins (Elsworth forthcoming). Again, at Levens, a group of burials found in 1911 century might also indicate an early Christian site on account of their orientation (McKenny-Hughes 1912).

3.1.6 **Medieval period (11<sup>th</sup> century AD to 16<sup>th</sup> century AD):** physical evidence for the medieval period proper is again poorly represented in the area, the first reference to Haverthwaite only being in 1336 when it is listed amongst demesne lands held by Furness Abbey that could be used as 'free warren' (the right to kill game without penalty within a designated area) (Ekwall 1922, 217, citing Atkinson 1886, 173). All of the nearest larger settlements and towns to the site were well established by this time, and the region was becoming known for its industry, in particular textiles, especially the woollen trade, focussed largely but not exclusively on Kendal, and the iron industry, which was well represented in Furness during this period although this resource had clearly been exploited from a much earlier date (see Bowden 2000, 6).

3.1.7 **Post-medieval period (16<sup>th</sup> century AD to present):** industrial activity comes to dominate the area around and including the site from the end of the medieval period onwards, and it is during this period that specific details relating to the Lowwood site become available for the first time. Much of this information is summarised from the previous English Heritage report (Jecock *et al* 2005). The earliest evidence, although uncertain in detail and from a now apparently lost source (or sources) indicates that a bloomery forge was erected at 'Burnbarrow' between 1603 and 1609 (*op cit*, 12). The exact location of this forge is uncertain, but there is enough evidence to suggest that it was at Lowwood. By 1614 the forge had become the property of a William Wright, who had interests in other forges in the area, but continuing problems at Burnbarrow, not least disputes over water rights, forced him to abandon it by 1620-1622 after which he sold it to the Bigland family, on whose land it stood, in 1661 (*ibid*). Subsequently, in 1728, an agreement was drawn up with Richard Ford of Cunsey forge to construct a blast furnace on what was evidently a promising site, although this came to nothing (*ibid*). Such a plan clearly retained its potential, as in 1747 a lease was agreed for 51 years for the Lowwood Company to establish a blast furnace (*op cit*, 13). The buildings required for this enterprise were duly built, and included, in addition to the furnace, charcoal barns and workers cottages (*ibid*). The furnace continued in operation throughout the majority of the 18<sup>th</sup> century, although it was sold to the company operating the rival Backbarrow furnace in 1782, which promptly closed it down in 1785 (*ibid*). The site seems to have been effectively mothballed at this time, rather than demolished, although its condition soon deteriorated (*op cit*, 14).

3.1.8 Again the potential usefulness of the site must have remained for in 1799 a lease was agreed for the manufacture of gunpowder at Lowwood, following the granting of a licence very shortly beforehand (*op cit*, 14). Indeed, buildings for the gunpowder works were evidently already under construction in 1799 and extensive alterations such as the extension of the main leat to meet a new weir to the north (*op cit*, 16-17). The works was very soon prospering and by the early decades of the 19<sup>th</sup> century a considerable number of new buildings had been constructed, including 14 additional incorporating mills (*op cit*, 18). The gunpowder works continued to operate successfully throughout the remainder of the 19<sup>th</sup> century, despite several large explosions within parts of the site, before being sold to its rival WH Wakefield & Co

in 1882 for £8,000 (*op cit*, 29). They quickly made a number of improvements to the site, not least arranging connections to the railway, and improving plant and safety, although they too suffered fatal accidents (*op cit*, 30-37). WH Wakefield and Co continued to operate the site until 1918 when it merged with other black powder manufacturers to form Explosives Trades Ltd, later Nobel Industries Ltd, before that was taken over by ICI in 1926 (*op cit*, 38). Again, improvements to the site were made at this time, in particular the conversion of the majority of the paired incorporating mills to a single suspended runner mill operation (*ibid*). Despite all this falling demand led to the closure of the works in 1935, the new incorporating mill plant was dismantled for re-use in Ardeer in Scotland, and the site was sold to Augustus While (*op cit*, 39). Following its closure the site was requisitioned by the Government during World War II, although the purpose to which it was put is uncertain, although traces of Nissan huts are evident (*op cit*, 234). From 1935 the family and trustees of Augustus While have utilised the site for energy generation, through the use of a water turbine probably already present on the site (*op cit*, 235). A replacement hydroelectric station was constructed in 1952, which involved the creation of a new section of leat formed in a huge embankment that seemingly buried some existing structures on the site (*ibid*), constructed from dumped slag (*op cit*, figure 142). Anecdotal information indicates that this material was brought from the Backbarrow Ironworks, to the north of Lowwood, which closed in the 1960s (1964 according to some sources (LUAU 1992; 1998; OA North 2004b) or 1967 according to Mike Davies-Shiel (2007)) although it is not certain whether material was brought while the ironworks were still operating or after they had closed.

## 3.2 Previous Work

3.2.1 As mentioned above (see *Section 3.1*) the site has been subject to an extensive survey by English Heritage (Jecock *et al* 2005), but there has been no other investigative work at the site other than that carried out in the preceding phase of work relating to this development. This revealed a number of new pieces of information about the site, specifically that although there was little evidence of activity in the area on the east side of the leat (Area 2), there were a number of features and deposits on the west side in Areas 3 and 4. Much of this activity was clearly industrial in nature, some undoubtedly connected to the use of the site as a gunpowder works, but much there was evidence for a considerable amount of later (20<sup>th</sup> century) dumping of material taken from the nearby Backbarrow Ironworks. Some evidence possibly relating to the ironworks at the Lowwood site was also present, as well as apparently domestic deposits (Greenlane Archaeology 2010).

## 3.3 Summary

3.3.1 The historical background shows that there is relatively minimal evidence of significant archaeology in the immediate environs of the site until the beginning of the 17<sup>th</sup> century, although Haverthwaite clearly existed by the mid 14<sup>th</sup> century and there are significant late prehistoric and Roman sites in the local area. During the post-medieval period the site was intensively used by a number of industries exploiting the water power available in the valley, initially those associated with the iron industry, but latterly a large gunpowder works, which continued to operate for over 130 years. The subsequent use of the site has also exploited the power of the river, with the installation of water turbines for electricity, culminating in an extensive remodelling 1952, which buried earlier remains at the south end of the site.

## 4. Fieldwork Results

### 4.1 Introduction

4.1.1 The fieldwork comprised two elements: an archaeological excavation of the section due to be removed during the realignment of the bend in the leat (Area 3 in the preceding evaluation), and the monitoring of other groundwork in several areas by archaeological watching brief. The first of these tasks were carried out some time before the watching brief, and the methodology is described in *Section 2* above. A description of the results is presented below.

### 4.2 Archaeological Excavation

4.2.1 Prior to the excavation commencing an engineering test pit had been excavated (without being monitored) to the north-east of the excavation area (see Figure 2). Some observations were made from this however: it was apparent that the original stone leat wall was still *in situ*, albeit buried beneath a considerable amount of overburden, and that the present concrete and brick leat wall had been built against its south-east side, effectively forming a second skin or cladding layer, although approximately 1m taller than the original (Plate 1). Clay deposits were also evident behind (to the north-west) of the original stone leat wall, presumably forming a water tight boundary (Plate 2).



**Plate 1 (left): Leat wall exposed in the test pit**

**Plate 2 (right): Deposits against the leat wall in the north-facing section of the test pit**

4.2.2 The excavated area comprised an approximately crescent-shaped trench adjacent to the corner of the existing leat, intended to cover the section that will be removed as part of the current scheme of works. The upper deposits, comprising a layer of concrete block, brick, and stone rubble up to 0.5m thick (**1001**) and a possibly re-deposited mid brownish grey sandy clay up to 0.2m thick (**1002**) were removed by machine (Plate 3 and Plate 4). Beneath these a number of features and deposits were exposed,



focussed in the north-east and north-west ends of the trench, although in the central area only orangey-brown firm sandy clay natural was encountered (**1025**). Because of the apparently varying nature of the natural across the trench a small sondage was excavated into this deposit, which confirmed that it was relatively uniform in that area and at least 0.35m thick.



**Plate 3 (left):** Overburden being removed by machine from the north-east end of the excavation area

**Plate 4 (right):** Overburden being removed by machine from the north-west end of the excavation area

4.2.3 In the north-east end, a thin layer of mid orange sand with a small amount of rounded gravel content (**1003**) was present across some of the area, and covered the north end of a linear spread of angular stones in a matrix of mid grey brown sandy/silty clay (**1004**; Plate 5). This was approximately 0.5m wide, orientated north-east/south-west, parallel to the extant concrete and brick leaf wall (**1015**), and extended for at least 5m to the south from the north edge of the trench, although its south-western end was less distinct and seemingly composed only of grey clay. Immediately to the south-east of **1004** the top of a stone wall, constructed from four or five courses of angular slate blocks without mortar and 0.5m tall by at least 0.2m wide, was exposed (**1019**), running parallel to the extant leaf wall (**1015**) and partially capped with a layer of concrete, 0.05m thick (**1021**). This stone wall evidently represents the original leaf wall, with the later one built inside it to the south-east, as revealed in the existing test pit (see Section 4.2.1 above). A small sondage was excavated across deposit **1004** against **1019**, which revealed that **1004** was up to 0.4m thick. Beneath it was a mixed deposit of essentially mid yellow sandy clay, although with lenses of grey clay, up to 0.15m thick and 0.4m wide, and a smaller area of firm pink clay up to 0.2m wide and 0.2m deep (**1018**; Plate 6). Between this and the original leaf wall was a layer of loose dark reddish brown rounded gravel 0.1m wide and 0.45m thick (**1022**), which appeared to have been created by water penetrating through the stone leaf wall and washing out the fine content of the deposits behind it. The various layers of clay essentially comprised the fill of a u-shaped cut (**1024**) against the leaf wall, which was sat on a layer of greenish grey clay with 50% rounded cobble inclusions less than 0.1m thick. **1024** was cut into a fairly loose mid orange/brown sandy gravel (**1017**), which probably represents a variation on natural **1025** disturbed during the excavation of **1024**.





**Plate 5 (left): Linear feature 1004**

**Plate 6 (right): Sondage through 1004 showing underlying clay deposits and leat wall**

4.2.4 At the north-west end of the trench the removal of the overburden revealed a layer of apparently re-deposited natural orange sandy clay (**1005**), and what initially appeared to be a pair of pits, one over 1.5m wide north-west/south-east (which was covered by **1005**), the other approximately circular and 0.6m diameter (**1012**; Plate 7). Further excavation revealed that the larger of these was in fact a tipped spread of dark grey sandy silt and containing a relatively large amount of slag, 0.2m thick (**1006**), dipping down slightly to the south. This in turn covered two further deposits, a soft mid grey silty-sandy clay 0.1m thick (**1009**) and a very loose deposit of orangey-brown rounded gravel up to 0.4m thick (**1010**), which were filling a linear feature over 1m wide and 0.5m deep orientated north-east/south-west (**1024**; Plate 8). This in turn was cut into a firm mid yellowish-orange sand (**1013**), which appeared to be natural. To the west of this pit **1012** was filled with a loose mid orange-brown rounded gravel (**1007**) to a depth of approximately 0.5m. In the base of this pit there was a large piece of degraded timber, apparently a tree stump, with a root extending to the south-east (Plate 9). It was apparent that pit **1012** cut through the sequence of deposits filling **1024** but was itself situated within it, this cut evidently extending beyond the north-west end of the trench judging by the presence of the re-deposited natural (**1005**), which seemed to be specifically covering it.





**Plate 7: Deposit 1006 and feature 1012 as initially revealed**



**Plate 8 (left): Section through feature 1023 showing filling deposits**



**Plate 9 (right): Tree stump exposed in 1007**



Plan of Area of Excavation and Test Pit

Detail from EH earthwork plan (Jecock et al 2005, fig 142)



Key	
	brick
	concrete
	slag
	wood
	spot height
	(1005) deposit



Area 3 (Greenlane Archaeology 2010)

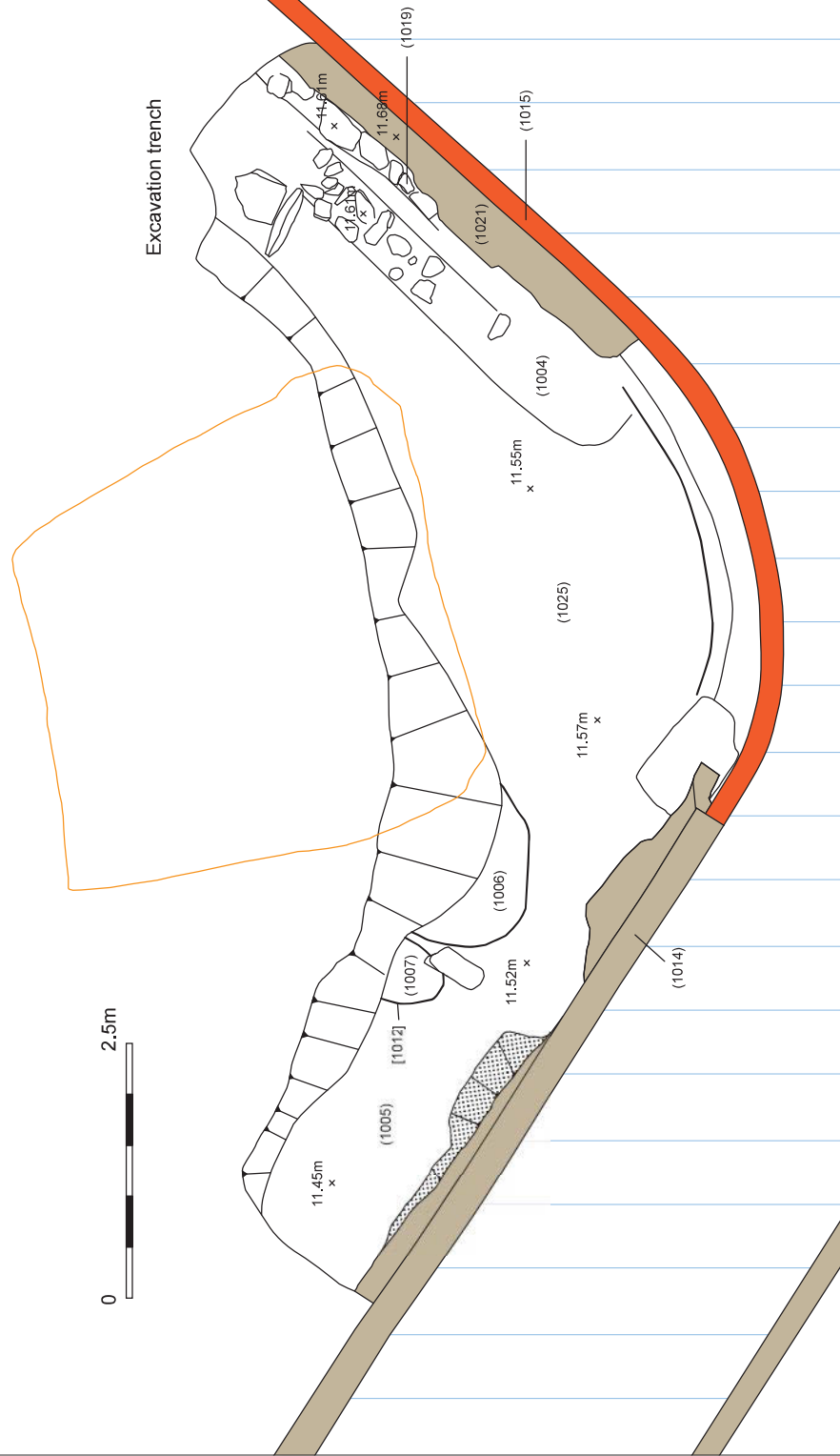
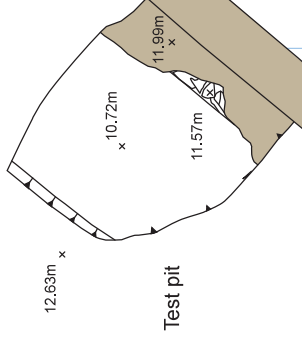
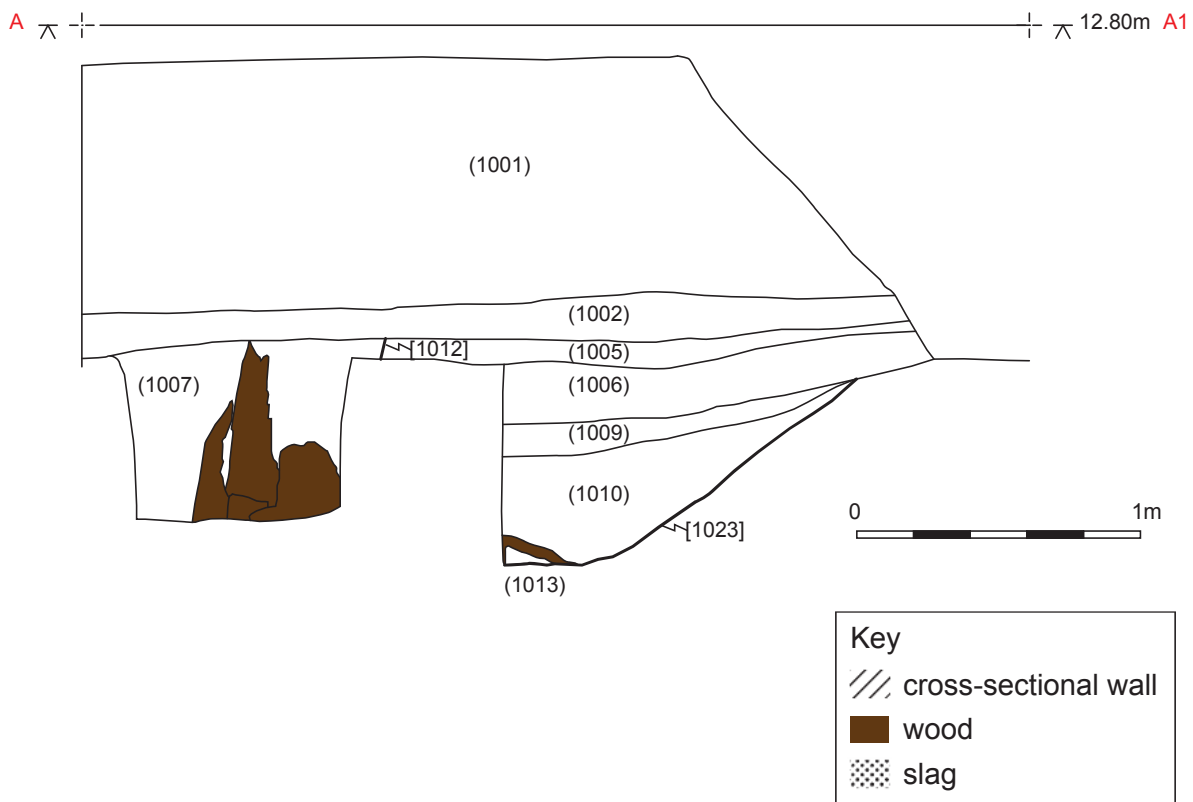


Figure 2: Plan of area of excavation and test pit



South-west facing section A-A1



North-west facing section B-B1

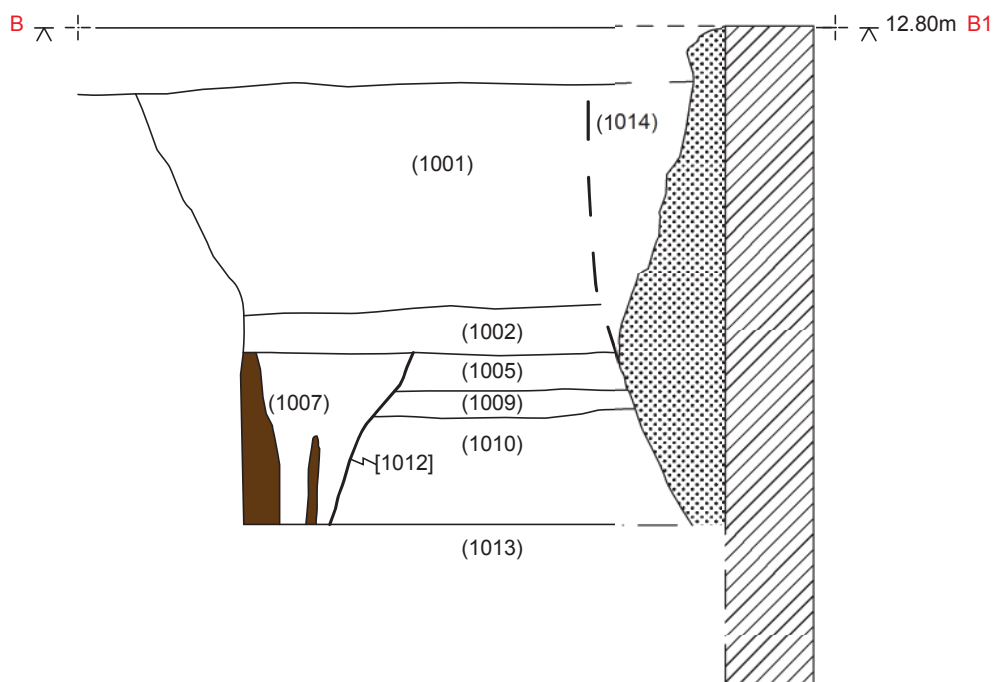
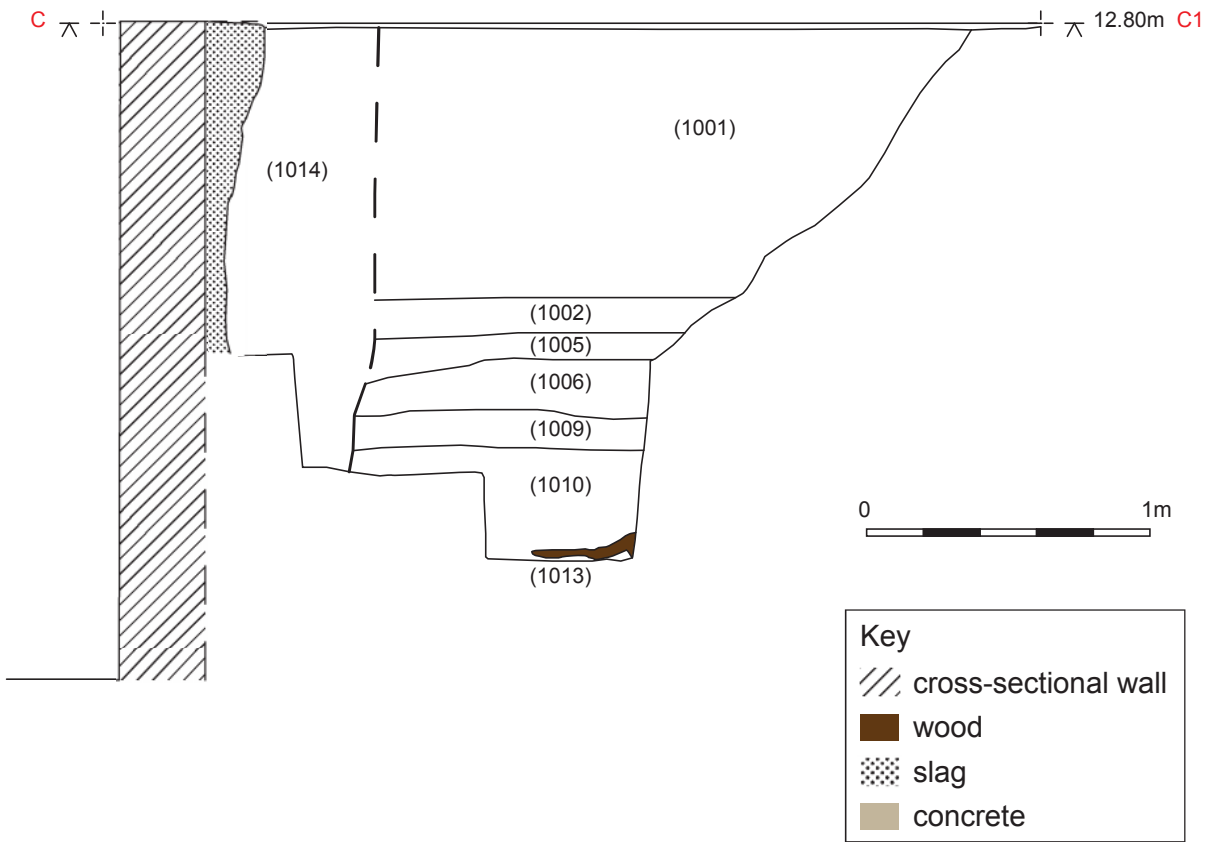


Figure 4: Sections A-A1 and B-B1

### South-east facing section C-C1



### North-east facing section D-D1

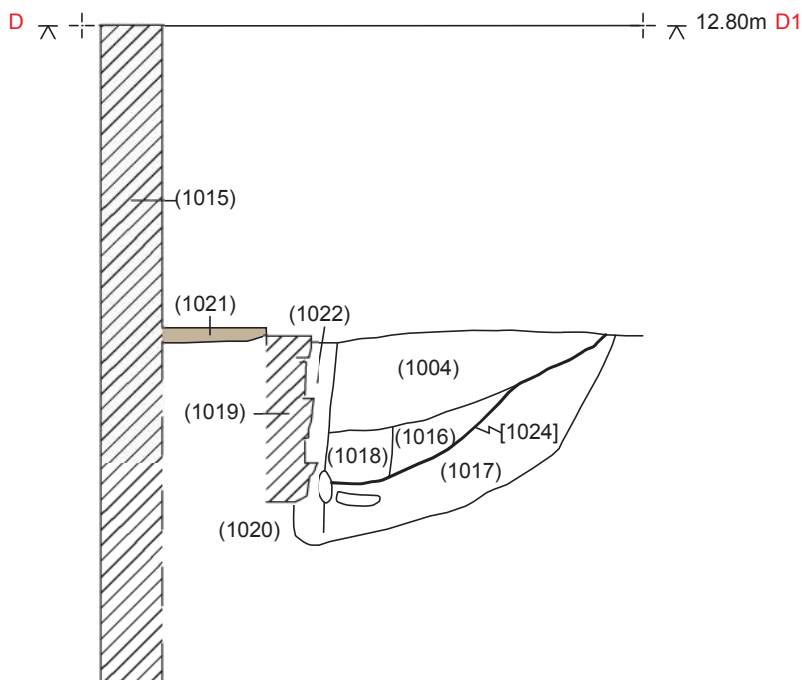


Figure 5: Sections C-C1 and D-D1

### 4.3 Archaeological Watching Brief

4.3.1 **Introduction:** the watching brief monitored four different elements of ground works on the site, which were typically carried out by a tracked 360° excavator with a toothed bucket: the stripping of vegetation, topsoil, and overburden and excavation associated with the creation of a new access track from the road to the south-west of the corner of the leat and a site compound, the excavation of a service trench supplying the site compound, the excavation of bridge abutments for the new access track, and excavation carried out around the former powerhouse (Figure 1).

4.3.2 **Access track and site compound:** vegetation and overburden was initially stripped from the area forming the site compound, essentially around Area 4 as defined during the evaluation (Greenlane Archaeology 2010), and a deeper cut was formed along the north-east side to create the track connecting the road to the south-east with the track leading to the site of the powerhouse and end of the leat (Plate 10). This comprised a large amount of brick and concrete rubble, with some metal and plastic but also concreted slag (**01**). Beneath this was a raised area of concreted slag, with lenses of compacted iron-rich material and firm orange sand (all part of **02**). Topsoil, comprising a dark brown loose sandy-silty clay with large amounts of humic material (**06**) was subsequently stripped from a small triangular area adjoining the road to the south-east. Beneath this a dark orangey-brown sandy clay subsoil (**07**) was revealed during hand excavation carried out to locate a service pipe. In general, however, only the topsoil and vegetation was removed, although in the area against the road this did include a lens of mortar-rich rubble comprising yellow fire bricks, slate, and some glass.



Plate 10 (left): Topsoil stripping around Area 4 and creation of the access track

Plate 11 (right): Topsoil stripping around Area 2, revealing deposits 10, 11, and 12

4.3.3 The continuation of the access track, across what had been Area 2 during the evaluation, again removed a similar deposit of topsoil (**08**), which was noticeably thicker to the north-west (up to 0.5m) and included much of the rubble present in this area, the majority of which comprised angular stones but red brick, roofing slate, glass, and some fire brick was also present. There was very little subsoil (**09**) in this area, although it was essentially the same as **07**. The line of the wall corresponding to the area of rubble and shown on early maps of the area comprised little more than a double row of boulders (**13**) set onto the ground with little evidence for a foundation cut. To the north-west, adjacent to the leat wall, was an



area of concreted slag (**10**) dumped on top of the topsoil (**08**). This continued almost to the leat wall to the south-west, but there was another deposit of stone rubble in a loose brown sandy clay matrix with pieces of timber, apparently fragments of window frame, between it and the wall to the north-east (**11**). On top of the slag (**10**), at the junction with the topsoil (**08**), there was a further thin layer of dumped mortar-rich building rubble (**12**) with slate flags and pieces of iron guttering, which was on top of topsoil **08** (Plate 11).

4.3.4 **Service trench:** this was excavated from an existing telegraph pole and the temporary electrical junction point within the former builder's yard area, towards the area stripped for the site compound to the south-east. There was no overburden as such, the entire area comprising part of a large mound of concreted limey blast furnace slag and the excavation of the trench confirmed this (**03**; Plate 12). However, within this deposit variations were evident with large lenses of dark brown sandy/gritty material, loose ashy material, and mid orange firm sandy deposits, representing obvious layers tipped from the east (Plate 13). The slag deposits continued until the track to the east, at which point a mid orange-brown (although more grey towards the top) sandy clay with 30% rounded cobbles up to 0.5m thick (**04**) was encountered, which apparently ran underneath the slag (**03**). Further east still a loose dark grey deposit containing large amounts of angular stone and glassy slag (**05**) was present, and also on top of **04** (Plate 14). This appears to be a continuation of the dumped deposits of slag further to the east (**02**) and it is likely that **04** represents the original ground surface or a layer deposited to form the current track.



Plate 12 (left): Excavating through slag to create the service trench

Plate 13 (right): Dumped deposits visible in the section of the service trench



**Plate 14: Possible original ground surface (04) and slag deposit (05) at the west end of the service trench**

4.3.5 **Bridge abutments:** the concrete block and brick walls of the extant leat and some of the material immediately behind them had been removed with a breaker prior to monitoring taking place, and it was apparent where the wall had been broken through that it was constructed from reinforced shuttered concrete (Plate 15). On the north-west side of the leat the original stone leat wall was evident, as per the earlier excavation, and was c0.7m tall and constructed from four or five courses of drystone slate slabs. It was also apparent that the extant concrete block wall had a further concrete block wall built on a foundation of fire bricks and concrete between it and the original stone wall on the north-east side (Plate 16). Otherwise the range of deposits exposed in the north-west abutment is similar to that seen in the excavation – layers of overburden essentially on top of natural clay, although a thin layer of dark grey material and the interface was observed. Of more significance was an apparent wall of drystone build, revealed in section at the south-west end of the cutting, and a better preserved wall exposed in the south-west section. These appeared to form the two sides of a culvert, the open area between filled with loose gravelly clay and firm clay lenses, extending from the original leat wall and apparently contemporary with it (Plate 17). The better preserved side had five or six courses remaining, with the wall having a distinctly angled plan and an apparent ‘slot’ formed between upright slabs and the leat wall (Plate 18).





**Plate 15 (left):** The north-west abutment following the demolition of the leat wall

**Plate 16 (right):** The section through the leat wall on the north-east side of the north-west abutment cut



**Plate 17 (left):** Culvert encountered in the north-west abutment cut

**Plate 18 (right):** Detail of culvert construction and 'slot' on south-east side

4.3.6 The cut for the abutment on the south-eastern side of the leat revealed in more detail the deposits encountered during the initial watching brief in this area. Specifically, it was apparent that deposit **11** comprised material dumped to backfill the cut made for the concrete block leat wall, which had an approximately 1m wide roughly v-shaped profile (Plate 19). The slag deposit (**10**) was apparently cut by this and up to 0.7m thick, and below it was a similar sequence of deposits to that revealed further to the south-east: a layer of topsoil up to 0.7m thick (as per **08**), and a layer of mid brownish orange subsoil 0.2-0.3m thick (as per **09**) on top of a mid-orange clay, which was presumably the underlying natural (Plate 20). In addition, there was a thin lens of re-deposited mid orange clay between the topsoil and subsoil containing a small amount of blast furnace slag.





**Plate 19 (left): North-east section of the south-eastern abutment cut**

**Plate 20 (right): General view of the south-eastern abutment cut**

**4.3.7 Former powerhouse area and leat end:** a small area had been excavated to the west of the former powerhouse in order to provide access to the river at this point without being fully monitored (Figure 6). This comprised a cut ranging from 4-5m wide east/west and 5m long north/south, sloping down from the north to form a ramp into the river. A sequence of deposits was revealed in section (Plate 21) comprising an upper layer of loose orangey-brown clay and rubble up to 0.7m thick with large amounts of rounded boulders and at least one slate flagstone (**14**). Beneath this was a firm mid orange-brown clay subsoil 0.15m thick (**15**) containing 10% rounded cobbles, a small amount of glassy blast furnace slag, and with three large iron rods projecting from it (Plate 21). This was in turn on top of a dark greyish-black silt up to 0.4m thick (**16**) containing large amounts of slag and thick pieces of ceramic material, and beneath this was a pale buff-orange firm clay at least 0.1m thick (**17**), which contained blue glassy slag.

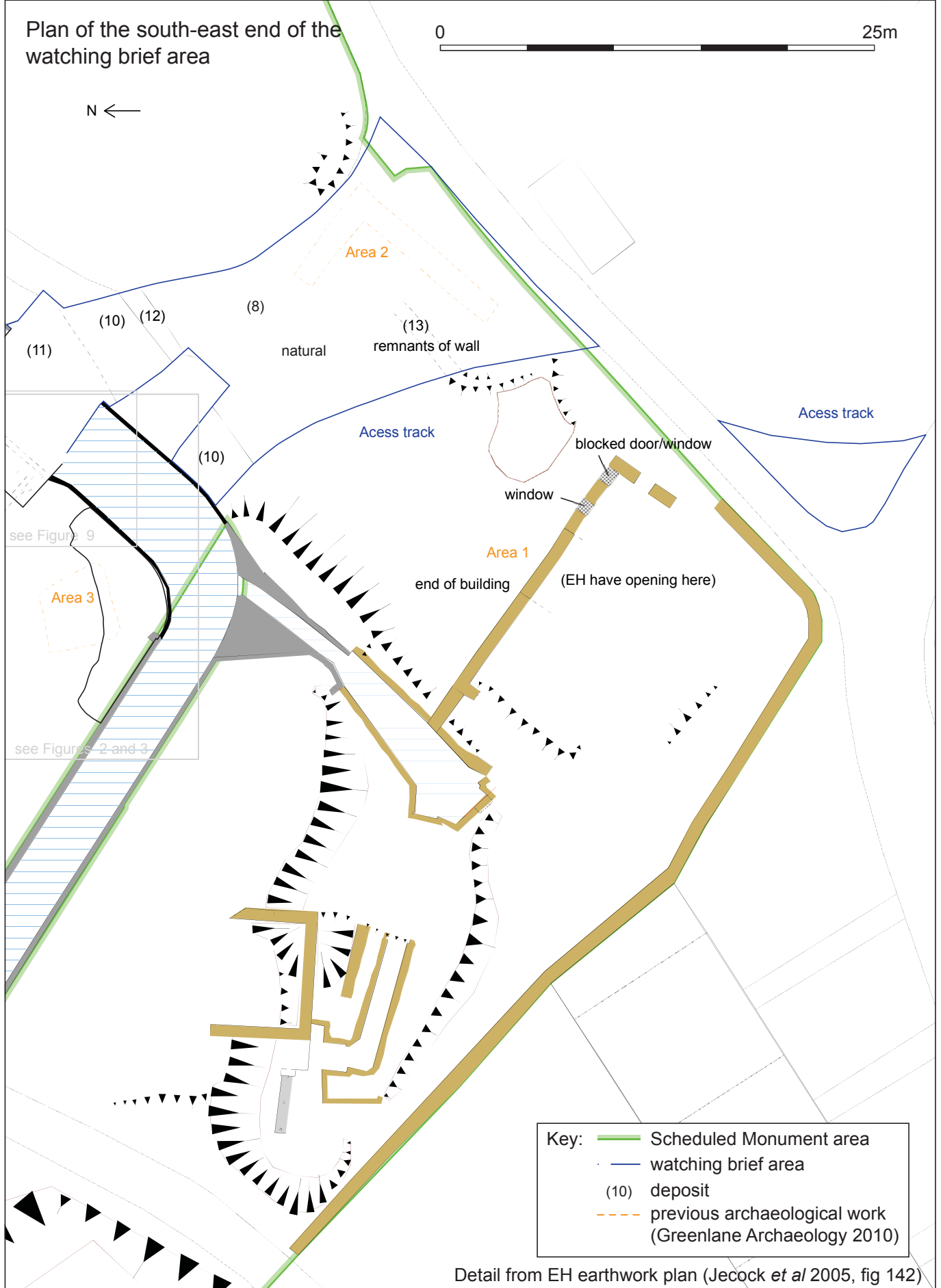
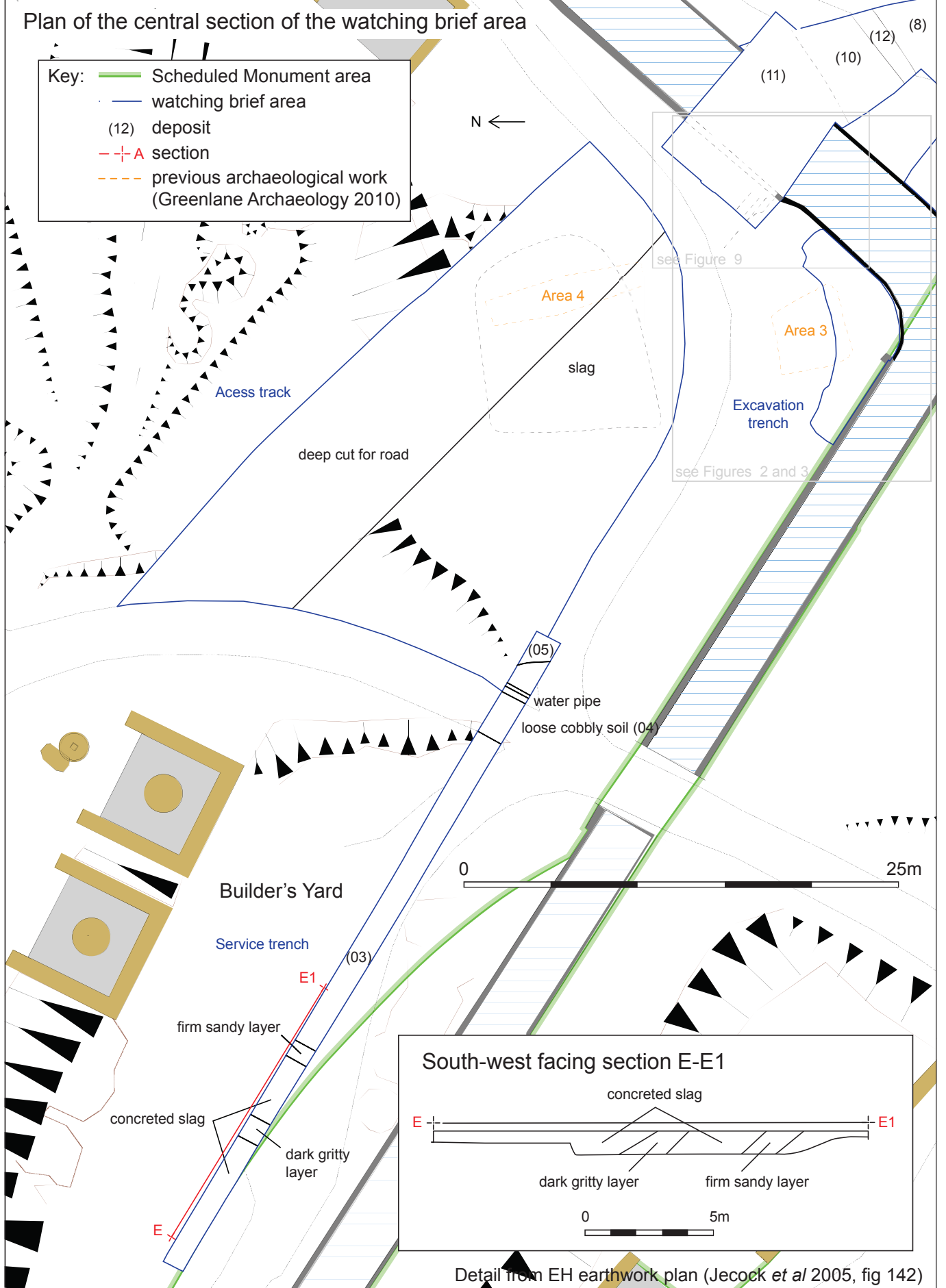


Figure 8: Plan of the south-east end of the watching brief area



**Figure 7: Plan of the central section of the watching brief area and section E-E1**

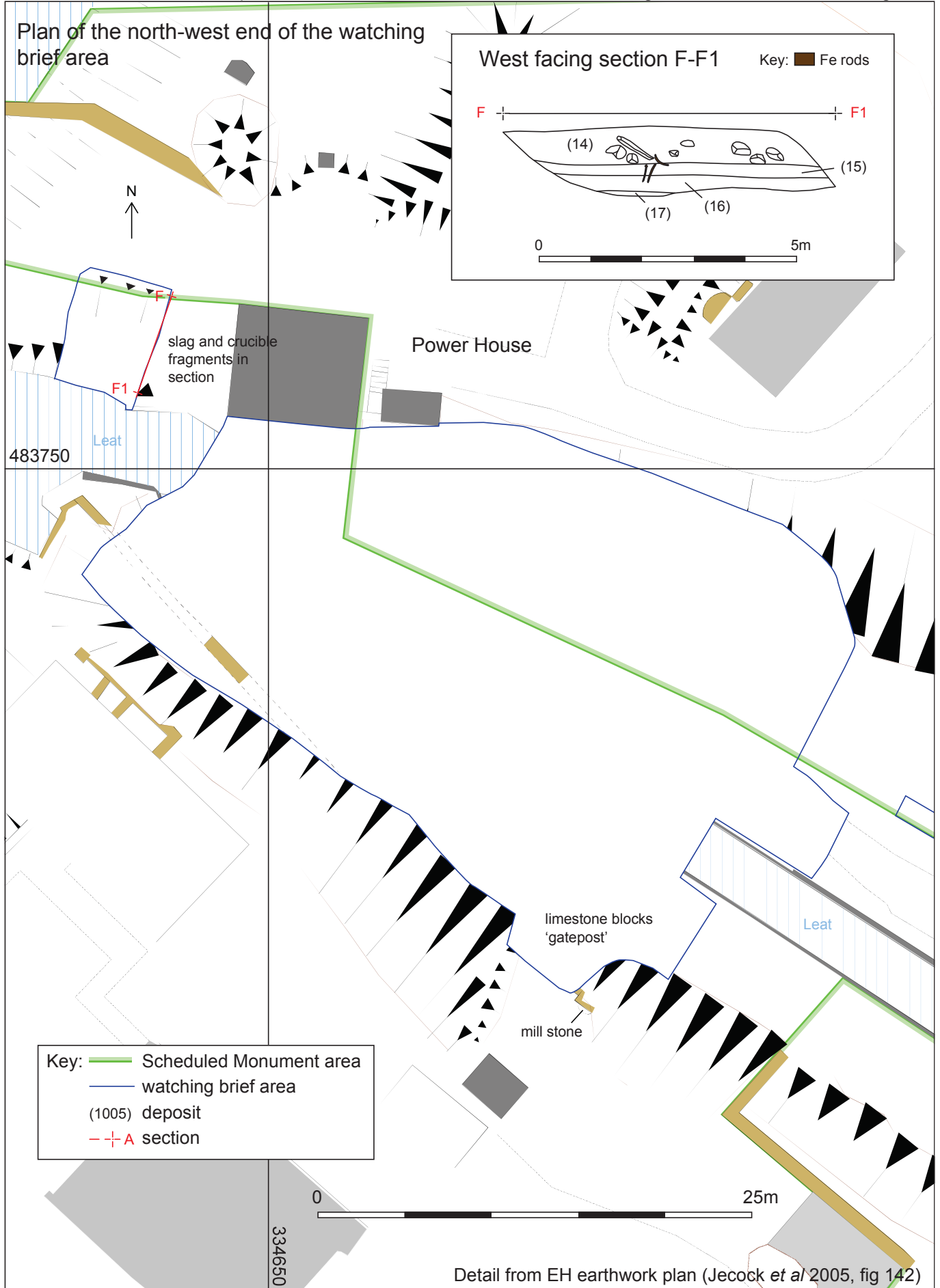
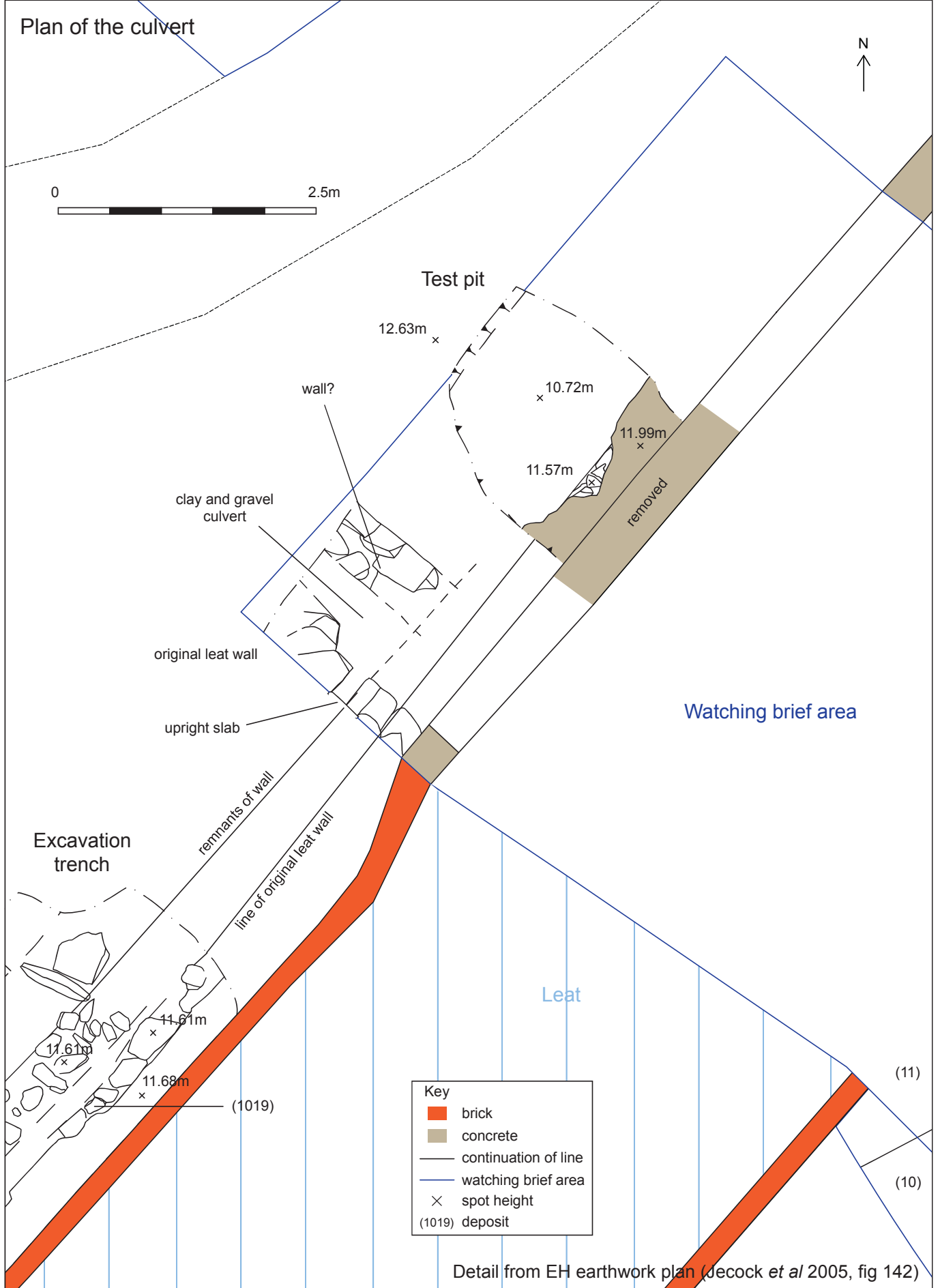


Figure 6: Plan of north-west end of the watching brief area and section F-F1



Client: Lowwood Products Company Ltd

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**Figure 9: Plan of the culvert**





**Plate 21 (left):** Detail of deposits in the west-facing section of the excavated area west of the powerhouse

**Plate 22 (right):** Section through the dumped slag deposits at the north-west end of the leat

4.3.8 The original end of the leat serving the previous hydroelectric generation plant was also extensively modified largely through the demolition of the existing structures associated with it. However, some excavation associated with this was also monitored. This confirmed that the existing leat structure was situated entirely within a large mound of concreted limy slag, which was at least 2.5m deep and within which several tip lines could be seen (Plate 22). In addition, where the excavation broke through part of a wall on the south-west side, a number of features were exposed: it was apparent that this wall had been standing when the slag was deposited on the site, as it was built up against its north-east side. The wall incorporated what appeared to be the jamb of a massive gate or perhaps a bridge footing, built of large limestone blocks with a rusticated finish, including a projecting ridge on top and sat on top of a re-used edge-runner stone from an incorporating mill (Plate 23). On the west side of the excavations around the original end of the leat the natural ground level, evident as a mid orange-brown clay, was apparently encountered, on top of which was a thin layer of dark greyish-black material, presumably representing the original ground surface (Plate 24). The remains of a wall of drystone slate construction, buried by the slag and built on top of the original ground surface, continued the line of an extant wall to the north-west.



**Plate 23 (left): Remains of wall with slag built against it and incorporating limestone built 'gate pier' on re-used edge-runner stone**

**Plate 24 (right): Deposits and wall remains exposed along the west side of the leat cut**

## 4.4 Finds

4.4.1 In total, 393 finds were recovered: 172 during the excavation, and 221 during the watching brief (plus a further six unstratified pieces recovered from the spoil heap but considered likely to come from context **16**), and a full list of these is presented in *Appendix 4*. As might be expected, all of the finds are of certain or likely post-medieval date, with the majority comprising pottery, although large quantities of window glass and metal artefacts (both iron and copper alloy) were also recovered. Industrial residue in the form of various types of iron working slag was also present in many contexts. The majority of the finds recovered from the excavation, with the exception of those present in the overburden deposits, came from deposits essentially comprising the backfill of feature **1023**, and included material resulting from industrial activity, which contained large amounts of slag, as well as apparently domestic rubbish such as pottery and even roof slates. While these deposits are clearly post-medieval and apparently 19<sup>th</sup> century, the more closely dateable finds suggest a minimum deposition date of post-1830 (Neale 2005, 16-17; see *Appendix 4*). Small amounts of pottery were also recovered from the disturbed deposit below cut **1024** (**1017**), again suggestive of an at least 19<sup>th</sup> century date. The area to the east of the leat contained a large amount of domestic pottery, including some very large pieces, indicative of dumping of rubbish on a relatively large scale.

4.4.2 In addition, an assessment was made of the majority of the slag recovered during the project, and fragments of what appeared to be thick ceramic vessels (considered at the time to perhaps be crucible fragments) from context **16**. The results of this assessment are presented in *Appendix 5*.

4.4.3 A small sample of timber was also cut from the tree stump present at the base of pit **1012**, effectively within channel **1023**, in order to attempt to identify the species and suitability for further analysis, such as dendrochronological dating. This initial assessment revealed it to be a softwood, with a large amount of bark remaining, probably a native species such as pine, yew, or juniper, although an introduced species such as spruce, larch, or fir is possible. It appeared quite recent and likely to have been introduced to the site, and is similar to types used in gardens.

## 4.5 Samples

4.5.1 Samples were taken from seven deposits: six during the excavation and one during the watching brief, as outlined in *Section 2.5*. Of these four were considered worth further assessment. Their contents are summarised in *Appendix 6* (Table 5 and Table 6). Several of the samples were apparently waterlogged to some degree but it was not considered sufficient to consider fully waterlogged.

4.5.2 **Plant remains:** the plant remains recovered from the flots were similar in all samples. Elder (*Sambucus nigra*) and bramble (*Rubus fruticosus*) fruits were present in all samples in occasional to abundant quantities. Smaller quantities of goosefoot sp. (*Chenopodium* sp.), buttercup sp. (*Ranunculus* sp.) and fumitories (*Fumaria* sp.) were also observed in samples (see Table 1). Wood fragments, including those of bark, twig and roots were present in the sample assemblage. While moss fragments were present in one sample (01) and fungal sclerotia in two samples (01 and 06). Plant remains were less common in the retents, with typically only small amounts of wood and roots. Sample 01 contained a relatively large amount of both, but it is likely that the wood was derived from the decaying tree stump present in this deposit.

4.5.3 **Charcoal fragments:** charcoal fragments were present in small quantities within the flots from all of the samples, with the exception of Sample 07, where a common quantity was recorded (see Table 1). No fragments were recovered of a size suitable for identification and radiocarbon dating, with a maximum size of 0.7cm recorded. Charcoal fragments were observed by eye to be mainly non-oak with two samples (01 and 06) also containing oak fragments. Charcoal was relatively common in all of the retents.

4.5.4 **Other finds:** together with the plant remains the flots were also found to contain a number of other materials. Small quantities of metal working debris (MWD) in the form of slag were recovered from two samples (06 and 07) with prill also present in one sample (07). Cinder fragments were found in all but one sample (01) in rare to abundant quantities, while coal was present in rare quantities in all samples (see Table 1). Ecofacts were also present with unburnt bone fragments recovered in common quantities in Sample 07 and a small quantity (rare) of burnt bone in Sample 01. Land snails were present in small quantities in two samples (01 and 06), although diversity was low with only 2 to 3 species observed. Insect fragments were also recorded in three samples (01, 03 and 06), again in small quantities, including fly larvae cases within one sample (01). All of the retents contained other finds, with coal or cinders very common, but also fragments of post-medieval pottery, glass, and industrial residue (in the form of various types of slag as well as hammerscale and prill). In addition, copper alloy and iron objects, typically nails, were present in Samples 06 and 01. Sample 07 in particular had a high industrial residue content, and was presumably derived from an almost entirely industrial process (although even it contained a small amount of post-medieval pottery).

4.5.5 **Discussion:** the plant remains assemblage recovered from the flots is similar to that of previous sample assessment work from the site (Timpany 2010), with high number of elder and bramble fruits recovered. The assemblage consists mainly of plants associated with disturbed ground or wasteland/overgrown vegetation with fumitories, buttercups, goosefoots and bramble all growing in these kinds of environments (Clapham *et al* 1962; Stace 1997). The presence of elder fruits in large quantities within the assemblage indicates the nearby location of this tree-type.

4.5.6 The presence of burnt and unburnt bone fragments within the samples indicates some distribution of discarded food waste across the site, while the presence of cinder, charcoal and coal may also relate to fuel debris. There is some evidence of metalworking in the area with the presence of slag and prill in the sample, which may relate to the former iron furnace. These findings are also similar to those from the previous work (Timpany 2010). The artefacts recovered from the retents also indicate possible domestic activity at or nearby the site, as well as corresponding to the remains found during the previous work with finds such as the copper alloy nails in Sample 06.

4.5.7 Together with the plant remains recovered there is the possibility to gain further information from the site through the assessment of the insect and land snail remains present in the sample assemblage. There appeared to be a limited diversity of land snails with only two to three species observed in the samples but they may be able to add more environmental information to that of the plant macrofossils. Insect remains were also noted as occurring in the samples and could be looked at to garner further ecological information. Of particular note was the presence of fly larvae cases within Sample 01, which suggests the presence of foul and rotting material within this context **1007**. Such fly larvae cases have been recorded from cess deposits in Aberdeen and Edinburgh (e.g. Kenward and Hall 2001; Timpany and Haston 2008).



4.5.8 **Conclusion:** plant remains recovered from the flots are indicative of an area of abandoned/overgrown ground with a number of disturbance and waste land taxa recovered including bramble, goosefoot and elder. There is evidence of waste including food, fuel and industrial debris scattered across the site, from the recovery of materials such as bone fragments, MWD and charcoal and cinders. The presence of insect and land snail remains suggests there is some potential for further ecological information to be garnered from the samples. Of particular interest was the presence of fly larvae which may indicate faecal or cess material within Context **1007**.

## 5. Discussion and Conclusion

### 5.1 Discussion

5.1.1 **Excavation:** the excavation revealed two main features of interest; the line of the original leat wall on the east side (**1019** and associated deposits), and the presence of a backfilled channel (**1023**), perhaps running parallel to it on the west side of the site. The leat wall was of a similar construction throughout, where it survived, with a later capping of concrete (**1021**), and it had been augmented with a later leat wall of concrete block and brick construction (**1015**). The latter must correspond with the alterations created for the original hydro electric scheme in 1952. The dating of the layer of concrete is more difficult but as it was sealed below deposit **1002** is likely to be 20<sup>th</sup> century although it must have been at surface level when initially laid. The sections of leat wall that were exposed cannot have formed part of the original 18<sup>th</sup> century structure as the deposits of clay and other material forming a waterproof layer to the west were laid on top of a deposit of disturbed natural (**1017**) that contained pottery of at least 19<sup>th</sup> century date, suggesting that the leat wall belonged to a later phase of rebuild or that the original leat was not actually in this position, although the map evidence would seem to contradict this. That such rebuilding must have taken place is likely for two reasons; firstly, the creation of the paired incorporating mills in the early 19<sup>th</sup> century (perhaps the period between 1828 and 1848; Jecock *et al* 2005, 210-213) must have required some reorganisation of the leat wall to provide access for the culverts needed to power them (further evidence for this was revealed during the watching brief, see *Section 5.1.3* below). Secondly, since the leat was almost drained while during the watching brief it was possible to examine its structure in more detail at different points. It was apparent that there were two main types of build style evident; Style 1 comprising long slabs and rounded boulders (Plate 25), and Style 2 consisting almost entirely of well-dressed slabs (Plate 26). Rebuilding clearly must have taken place, even if only as part of general maintenance.



**Plate 25 (left): Example of leat wall showing build Style 1**



**Plate 26 (right): Example of leat wall showing build Style 2**

5.1.2 The second feature of interest revealed during the excavation was what appeared to be a wide channel (**1023**), within which were a variety of deposits the dating of which suggests that this feature was being deliberately filled no earlier than the 1830s. The purpose or function of this channel is uncertain. It is conceivable, given the lack of clarity in the earliest plans of the site, that it in fact represents the original line of the leat used to power the blast furnace and created in c1748 (*op cit*, 201-204). However, its distinct lack of construction or even clay lining would seem to indicate that this cannot be the case. Details of the original construction method used in c1748 are uncertain, but a comparable example, the leat supplying the mill and blast furnace at Newland near Ulverston, had a clear lining of thick clay (Greenlane Archaeology 2009). It seems perhaps more likely, especially given the loose gravel at the base of the feature (**1010**) that it represents some form of palaeochannel, perhaps only active at times of heavy rain. The deposits filling it were both domestic and industrial in nature, indicating that it was

perhaps being used as a convenient place to dump rubbish for both the operators of the gunpowder works and those living nearby. The range of apparent features filled with similarly dumped material encountered during the excavation most likely represent a continuation of this activity rather than separate features. The presence of an apparently *in situ* tree stump and root at the base of feature **1023** is somewhat difficult to explain. Although it could have been growing naturally in this partially filled channel it is possible it was planted on the site as a part of the blast protection; trees are shown in close proximity to the location of the excavation trench on the plan of 1846, which were thought to have served this purpose before being replaced with a solid structure by 1863 (*op cit*, 185), and the type of wood is suggestive of a species that had been introduced to the site. The small pit adjacent to **1012** is also difficult to explain, although the presence of environmental remains commonly associated with rotting food or faecal matter might suggest it represents an animal burrow excavated against the roots of the tree.

**5.1.3 Watching Brief:** the watching brief revealed a number of significant things. In the area to the east of the leat where the new access track was constructed it is apparent that the structural remains recorded in the English Heritage survey were very insubstantial and that dumping of rubbish had been taking place on the site since at least the late 19<sup>th</sup> century, suggesting that this was essentially out of use by that time. The trench excavated for the western bridge abutments was also of interest as it revealed a substantial stone structure, apparently a culvert. This is almost certainly the culvert that supplied incorporating mills 29 and 30 (as numbered in the English Heritage survey), and it clearly demonstrates, like the results of the excavation, that the leat wall was rebuilt to incorporate this addition, most probably between 1828 and 1848 (*op cit*, 89). The form of construction, which is very similar to build Style 2 as observed in the existing leat wall, has some similarities with the existing remains of other incorporating mills of this type, in particular the setting of the pen trough (*op cit*, 90). The apparent 'slot' observed in the masonry of the culvert entrance is likely to relate to a water management structure such as a sluice gate. The monitoring carried out in the area around and to the west of the powerhouse revealed the depth of the deposit of concreted slag to be in excess of 2.5m in places but that some elements of the original ground level were still preserved beneath it. The section of boundary wall cut through to the south of the original leat end revealed a large structure built of limestone blocks, presumably a gate or base of a bridge or similar, incorporated into which was a re-used edge-runner stone, which means that it is unlikely to pre-date the period in which the majority of these were added, between 1828 and 1848. It is interesting to note that early maps of the site show this as a major point of access into the site as early as 1846 (*op cit*, 21) and later the route of a tramway so it is likely this structure relates to this in some way.

**5.1.4** Perhaps the most significant feature revealed during the watching brief was the deposit to the west of the previous power house (**16**), which contained large quantities of what is apparently bloomery slag and fragments of thick clay 'vessel' resembling crucible fragments (see *Appendix 5* for details). This material seems very likely to have derived from the bloomsmithy thought to have been present on the site between c1603-1622, indeed, the suggested location is only a short distance to the north-east of where this deposit was located (*op cit*, 200-201 and 203). There is, however, a noticeable problem with the dating of this deposit. The only find from within it was a glass button, which, while difficult to date with any certainty, is very unlikely to be early 17<sup>th</sup> century (see *Appendix 4*). In addition, the retent of the sample recovered from context **16** also contained small fragments of post-medieval pottery, likely to be no earlier than the 18<sup>th</sup> century and was stratigraphically later than a deposit (**17**) that contained glassy blast furnace slag, although material of this type was apparently produced through earlier processes (Historical Metallurgy Society nd). A probable explanation of this is that the bloomery slag was being removed for reprocessing either at the furnace at Lowwood or at Backbarrow. The reprocessing of bloomery slag, which had a very high iron content, is known to have taken place (English Heritage 2011, 3 and *Appendix 5*). Nevertheless, its presence on the site at Lowwood is the first physical evidence that the earlier bloomsmithy was located here. Of especial significance within this deposit is the partially vitrified ceramic material, initially thought to be crucible fragment but considered more likely to be the remains of clay packed around the tuyere that became fired (see *Appendix 5*). Such material is not thought to have been identified before, and is not apparently recorded during any previous investigations into bloomsmithies of this period in the county (Davies-Shiel 1970; Tylecote and Cherry 1969; 1970; Miller 2005; 2007).

## 5.2 Conclusion

5.2.1 The results of the excavation revealed a number of features of relevance to the understanding of the development of the gunpowder works, specifically that the 18<sup>th</sup> century leat that it made use of must have been remodelled on at least one occasion to accommodate the incorporating mills added in the early 19<sup>th</sup> century. In addition, the backfilled channel, probably of natural origin, contained an interesting mix of finds, which, when considered alongside those revealed during the earlier evaluation, suggests a mixture of domestic and industrial rubbish was being opportunistically dumped here. The watching being revealed several more interesting features, not least the remains of a culvert supplying one of incorporating mills and other features again appearing to relate to the extensive remodelling of the site that went on in the early 19<sup>th</sup> century, but also a deposit containing material thought to relate to the early 17<sup>th</sup> century bloomsmithy. However, even this showed signs of having been reworked at a later date, further indicating the extent to which the site was repeatedly modified during the 19<sup>th</sup> century and later.

## 5.3 Recommendations

5.3.1 In general the excavation and watching brief provided minor details relating to the history of the site's development, and it is unlikely that further investigation of the features or finds encountered would add a great deal of further information. Only one group of finds significant enough to potentially merit further investigation was recovered, the apparent bloomery slag from deposit **16**. It is recommended that this be subject to further analysis, as detailed in *Appendix 5*, and deposited in an appropriate museum.

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## Appendix 1: Project Brief



### BRIEF FOR ARCHAEOLOGICAL WORK

*At Lowwood Gunpowder Works*

**27<sup>th</sup> January 2011**

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# Brief for an Archaeological Works

Location: Lowwood Gunpowder Works

Proposed: Refurbishment of Hydro Electric Plant

## Summary

An application has been approved by the Lake District National Park Authority and English Heritage for the refurbishment of the hydro electric generating plant at the Lowwood Gunpowder Works, Haverthwaite, Cumbria (Planning Reference: 7/2010/5368 and Scheduled Monument Consent dated 25 January 2011). The site of the proposed development is situated within the scheduled remains of a gunpowder works dating from the later 18<sup>th</sup> century. The site was also the location for a bloomery forge in the 17<sup>th</sup> century and a charcoal blast furnace in the first part of the 18<sup>th</sup> century. It is probable that the proposals will affect remains relating to early iron smelting and/or gunpowder manufacture.

Prior to planning permission Lowwood Gunpowder works were subjected to an archaeological evaluation. This was carried out in order to determine the likely effect of the proposed development in locations where groundwork, road construction and other operations may affect the remains. The evaluation report recommended that further work on the site was essential prior to and during development.

Therefore, it is a condition of the planning permission that before the development commences, the applicant should secure the implementation of a programme of archaeological work in accordance with a written scheme of investigation which has been submitted by the applicant and approved by the National Park Authority and English Heritage. This recommendation is in line with government advice as set out in the CLG Planning Policy Statement 'Planning and the Historic Environment' (PPS 5) and Policy NE 16 of the Lake District National Park Local Plan.

The applicant has appointed Greenlane Archaeology as his archaeological contractor to carry out this work. No fieldwork should commence until approval of a written specification, based on this Brief, has been approved by the Lake District National Park Authority and English Heritage

## 1. Location

1.1 The site is centred around national grid reference SD 349 839, in the parish of Haverthwaite. The total area of the proposal affects just over 1 hectare, which is presently in mixed use, including hydro electric power generation and storage of building materials and machinery.

1.2 The underlying geology of the site is Silurian slates and shales of the Bannisdale formation.

## 2. Archaeological Background

2.1 The site of the proposed development lies within the area of the Lowwood Gunpowder Works which operated between 1798 and 1935. Extensive remains survive from all stages of this industrial process

from storage and preparation of ingredients to final product. Earlier use of the site included a bloom smithy of the 17<sup>th</sup> century (exact location unknown) and a charcoal blast furnace that was established in 1747. The site has been subject to a detailed programme of research and survey by English Heritage (English Heritage, 2005) and is designated as a Scheduled Monument. A Conservation Management Plan for the site is being prepared and is at an advanced stage.

Further details of this site and adjacent remains can be obtained from the Lake District National Park Authority, Murley Moss, Oxenholme Road, Kendal, LA9 7RL. Tel. 01539 792712/Fax. 01539 740822/ Email [archaeology@lakedistrict.gov.uk](mailto:archaeology@lakedistrict.gov.uk)

### **3. Requirement for archaeological work**

3.1 The proposed development would severely damage or destroy any archaeological remains which may be present on the site. It is a condition of the planning permission that the applicant should secure the implementation of a programme of archaeological work in accordance with a written scheme of investigation which has been submitted by the applicant and approved by the Lake District National Park Authority and English Heritage.

3.2 The objective of the work should be to obtain an adequate record of any archaeological deposits or finds which will be disturbed or exposed by work associated with the development.

### **4. Techniques**

Land use at the time fieldwork is carried out will influence the methods used. The techniques chosen should be selected to cause the minimum amount of destruction and should comply with all relevant health and safety regulations. It is envisaged that the following work would be required:

4.1 The location of the re-aligned leat (Area 3) is to be further investigated. Whilst previous work demonstrated that this area contained deposits and features of archaeological significance, it was not fully excavated. This was partly due to the depth of the upper deposits within the trench and ground water penetration. Therefore, it has been recommended that prior to any further work taking place, the leat should be fully drained and the underlying deposits should be recorded and sampled as necessary. The upper deposits may be removed by a machine under archaeological supervision.

4.2 All groundwork for the development including topsoil stripping/ footings/ service trenches/ trench cutting must be carried out under archaeological supervision. This includes the widening of the access track (Area 2), the line of the proposed access track (Area 4) and other areas including the site compound at the north of the site. Any archaeological features encountered must be cleaned by hand and a stratigraphic record made. Finds and environmental samples should be retrieved as appropriate. A reasonable period of uninterrupted access should be allowed to the archaeologist for all necessary archaeological recording.

4.3 The position of all trenches and observations should be recorded on a site plan, at an appropriate scale. All significant deposits should be fully recorded on appropriate context sheets, photographs, scale plans and sections. A general photographic record should also be maintained.

## 5. Proposal

A **detailed** proposal, including the following, should be prepared by potential contractors in accordance with the recommendations of the MORPHE Project Managers Guide and Project Planning Note 3 (<http://www.english-heritage.org.uk/publications/morphe-project-managers-guide/>) and submitted to the National Park Senior Archaeology and Heritage Adviser and English Heritage for approval:

5.1 A description of the proposed methods of observation and recording system to be used.

5.2 A description of the finds and environmental sampling strategies to be used.

5.3 A description of the post excavation and reporting work that will be undertaken.

5.4 A projected timetable for all work on site, including machine hire time and staff structure and numbers of people to be employed on site per day.

5.5 A projected timetable for all post excavation work, including staff numbers and specialist sub-contractors (through to final publication of results).

5.6 The names of the project director, supervisors, specialists and any sub-contractors to be employed on the project (including details of qualifications and experience of the key project personnel).

5.6 A separate itemised estimate of costs (core/project staff, specialist fees, travel/subsistence, site works, equipment/materials, archive preparation and copying, report preparation, finds storage fees, overheads, contingency, specified other costs).

5.7 Any significant variations to the proposal must be agreed by the National Park Senior Archaeology and Heritage Adviser in advance.

## 6. Site Monitoring

6.1 The National Park Senior Archaeology and Heritage Adviser will be responsible for monitoring the work. A minimum of one week's notice of the commencement of fieldwork must be given by the archaeological contractor to the Lake District National Park Authority so that arrangements for monitoring can be made.

## 7. Reporting Requirements

7.1 The work should result in a report including as a minimum:

- a location plan at an appropriate scale, related to the national grid;
- a concise, non-technical summary of the results;
- a description of the methodology employed;
- a summary of the historical and archaeological background;
- plan(s) and section(s) at an appropriate scale showing location and position of trenches dug, features and finds located;
- section drawings should include heights OD;
- plan(s) should include OD spot heights for all principal strata and features;
- a list of and date for any significant finds recovered;
- photographs where appropriate;
- a description of archaeological features and deposits identified;
- a description of any environmental or other specialist work undertaken and the results obtained;
- an interpretation of the results and of their potential archaeological significance;
- a full bibliography of sources consulted and a list of any further sources identified but not consulted;
- an index to the project archive;
- a copy of the brief and agreed project design and an indication of any variations.

7.2 The objective account of the archaeological evidence recovered should be clearly distinguished from the interpretation of those features. The methodology used should be critically reviewed.

7.3 One copy of the report should be sent to English Heritage and 2 copies and a full digital version should be deposited with the Lake District National Park Authority, on the understanding that it will be made available as a public document after an appropriate period (not exceeding 6 months from the completion of fieldwork).

7.4 The results of the work should be published in an appropriate journal or other publication and should include an account of any structures located and full details of significant finds, illustrated as appropriate. Details of the place and date of publication must be notified to the Lake District National Park Authority. **Developers and archaeological contractors should be aware that fulfilment of this part of the brief is mandatory and that the Lake District National Park Authority will not issue approval for a specification that does not include details for its implementation.**

7.5 The Lake District Historic Environment Record (LDHER) supports the Online Access to Index of Archaeological Investigations (OASIS) project. The overall aim of the OASIS project is to provide an online index to the mass of archaeological grey literature that has been produced as a result of the advent of large-scale developer funded fieldwork. The archaeological contractor must therefore complete the online OASIS form at <http://ads.ahds.ac.uk/project/oasis/>. Contractors are advised to contact the LDHER prior to completing the form. Once a report has become a public document by submission to or incorporation into the HER, the LDHER may place the information on a web-site. Please ensure that you and your client agree to this procedure in writing as part of the process of submitting the report to the archaeological officer at the LDHER.

## 8. Deposition of Archive and Finds

8.1 The archaeological archive arising from the watching brief should be deposited in an appropriate local institution, in a format to be agreed with that institution. The National Park Authority must be notified of the



arrangements made. Any finds of archaeological interest should be appropriately conserved and deposited in an appropriate institution. Any finds which cannot be so deposited should be fully analysed and published.

## 9. Further Requirements

9.1 The conditions of the Scheduled Monument consent dated 25<sup>th</sup> January 2011 must be fulfilled.

9.2 The Code of Conduct of the Institute of Field Archaeologists must be followed.

9.3 It is the archaeological contractor's responsibility to establish safe working practices in terms of current health and safety legislation, to ensure site access and to obtain notification of hazards (eg. services, contaminated ground).

9.4 The involvement of the Lake District National Park Authority and English Heritage should be acknowledged in any report or publication generated by this project.

## 10. References

English Heritage 2005 *Lowwood Gunpowder Works and Ironworks and the workers' hamlet of Low Wood, Cumbria: an archaeological and architectural survey.*

Greenlane Archaeology 2010 *Lowwood Gunpowder Works, Haverthwaite, Cumbria.*

## Appendix 2: Project Design

# LOWWOOD GUNPOWDER WORKS, HAVERTHWAITE, CUMBRIA

Archaeological Excavation and Watching Brief Project Design



Client: Lowwood Products Company Ltd

NGR 334708 483707

February 2011

# 1. Introduction

## 1.1 Project Background

1.1.1 Prior to submission of a planning application by Lowwood Products Company Ltd (hereafter 'the client') for a proposed programme of improvements to an existing hydro-electric facility at the former Lowwood Gunpowder Works, Cumbria (centred on NGR 334708 483707) English Heritage (EH) and the Senior Archaeology and Heritage Advisor at the Lake District National Park Authority (SAHA LDNPA) were consulted. Almost the entire site of the former gunpowder works is now a Scheduled Monument and so it is statutorily protected. The site was subject to a detailed survey by English Heritage in 2004 (Jecock *et al* 2005), as part of a wider investigation into such monuments initiated in 1999. This established that, prior to the construction of the gunpowder works, the site is thought to have been the location of a bloomery forge in the 18<sup>th</sup> century, which was subsequently developed in 18<sup>th</sup> century with the establishment of a blast furnace, which remained in operation until at least 1785. Soon after the site was re-used for the establishment of a gunpowder works, in 1799, which continued to operate, albeit with several phases of modification, until the 1930s.

1.1.2 Following initial consultation with English Heritage and SAHA LDNPA a programme of archaeological work was carried out, principally the excavation of evaluation trenches in four areas of the site, but also including a rapid desk-based assessment, site visit, and building recording (Greenlane Archaeology 2010a). This revealed that while Area 2 contained no remains of archaeological interest, and Area 4 was covered by dumped deposits of slag, thought to have been brought from the nearby blast furnace at Backbarrow, in Area 3 deep deposits and features probably relating to the gunpowder works were encountered, albeit of late date.

1.1.3 As a result of this further archaeological work has been requested as part of the proposed development, comprising the complete excavation of those deposits in Area 3 that would be otherwise destroyed by the intended re-alignment of the leat, and maintaining an archaeological watching brief on other areas of groundworks within the Scheduled Monument area. A brief outlining this work was provided by the SAHA LDNPA (ASLDNPA 2011) in response to which Greenlane Archaeology produced this project design.

## 1.2 Greenlane Archaeology

1.2.1 Greenlane Archaeology is a private limited company based in Ulverston, Cumbria, and was established in 2005 (Company No. 05580819). Its directors, Jo Dawson and Daniel Elsworth, have a combined total of over 18 years continuous professional experience working in commercial archaeology, principally in the north of England and Scotland. Greenlane Archaeology is committed to a high standard of work, and abides by the Institute for Archaeologists' Code of Conduct. The excavation and watching brief will be carried out according to the Standards and Guidance of the Institute for Archaeologists (IfA 2008a; 2008b).

## 1.3 Project Staffing

1.3.1 The project will be managed and the work supervised by **Dan Elsworth (MA (Hons), AIFA)**, with appropriate assistance as necessary. Daniel graduated from the University of Edinburgh in 1998 with an honours degree in Archaeology, and began working for the Lancaster University Archaeological Unit, which became Oxford Archaeology North (OA North) in 2001. Daniel ultimately became a project officer, and for over six and a half years worked on excavations and surveys, building investigations, desk-based assessments, and conservation and management plans. These have principally taken place in the North West, and Daniel has a particular interest in the archaeology of the area. He has recently managed a number of archaeological excavation projects in the county including an evaluation and excavation in Kendal (Greenlane Archaeology 2008a; 2008b; 2008c); building recording projects on industrial sites in Ulverston and Barrow-in-Furness (Greenlane Archaeology 2009, 2010b), and desk-based assessments on numerous sites. He also supervised the previous archaeological work on the site (Greenlane Archaeology 2010a).

1.3.2 All artefacts will be processed by Greenlane Archaeology, and it is envisaged that they will initially be assessed by Jo Dawson, who will fully assess any of post-medieval date. Any medieval pottery will be assessed by Tom Mace at Greenlane Archaeology. Other finds will be assessed by specialist sub-contractors as appropriate. The Senior Archaeology and Heritage Advisor and EH will be notified of any other specialists, other than those named, who Greenlane Archaeology wishes to engage, before any specialist contracts are awarded, and their approval will be sought.

1.3.3 Environmental samples and faunal or human remains will be processed by Greenlane Archaeology. It is envisaged that environmental samples will be assessed by Scott Timpany at Headland Archaeology, faunal

remains by Aouli Tourunen, also at Headland Archaeology, and human remains by Malin Holst at York Osteoarchaeology.

## 2. Objectives

### 2.1 Archaeological Excavation

2.1.1 To fully excavate the area due to be destroyed by the proposed re-alignment of the leat, in order to identify, date (where possible), characterise, and record all of the features and deposits of archaeological interest present.

### 2.2 Watching Brief

2.2.1 To monitor groundworks undertaken on site in order to identify any surviving archaeological remains and to investigate and record any that are encountered.

### 2.3 Report

2.3.1 To produce a report detailing the results of the excavation and watching brief, that will present the results of both and their interpretation in relation to the known historical and archaeological development of the site.

### 2.4 Archive

2.4.1 Produce a full archive of the results of the excavation and watching brief.

## 3. Methodology

### 3.1 Archaeological Excavation

3.1.1 The excavation methodology, which is based on Greenlane Archaeology's excavation manual (Greenlane Archaeology 2007), will be as follows:

- The site will be checked with a Cable Avoiding Tool (CAT) in order to establish the presence of live electrical services. Any existing service plans will also be consulted in order to identify the presence of other services;
- The modern overburden will be removed by machine under the supervision of an archaeologist until the first deposit beneath it is reached;
- All deposits below the modern overburden will be examined by hand in a stratigraphic manner, using shovels, mattocks, or trowels as appropriate for the scale. Deposits will only be sampled, rather than completely removed, below the first identified level of archaeological interest, unless specified by the Senior Archaeology and Heritage Advisor at the Lake District National Park Authority, with the intension of preserving as much *in situ* as possible;
- The position of any features, such as ditches, pits, or walls, will be recorded and where necessary these will be investigated in order to establish their full extent, date, and relationship to any other features. Negative features such as ditches or pits will be examined by sample excavation, typically half of a pit or similar feature and approximately 10% of a linear feature;
- All recording of features will include hand-drawn plans and sections, typically at a scale of 1:20 and 1:10, respectively, and photographs in both 35mm colour print and colour digital format;
- All deposits, trenches, drawings and photographs will be recorded on Greenlane Archaeology *pro forma* record sheets;
- All finds will be recovered during the excavation for further assessment as far as is practically and safely possible. Should significant quantities of finds be encountered an appropriate sampling strategy will be devised and agreed following consultation with the Senior Archaeology and Heritage Advisor at the Lake District National Park Authority;
- All faunal remains will also be recovered by hand during the excavation, but where it is considered likely that there is potential for the bones of fish or small mammals to be present appropriate volumes of samples will be taken for sieving;
- Deposits that are considered likely to have, for example, preserved environmental remains, industrial residues, and/or material suitable for scientific dating will be sampled. Bulk samples of between 20 and 60



litres in volume (or 100% of smaller features), depending on the size and potential of the deposit, will be collected from stratified undisturbed deposits and will particularly target negative features (e.g. gullies, pits and ditches) and occupation deposits such as hearths and floors. An assessment of the environmental potential of the site will be undertaken through the examination of samples of suitable deposits by specialist sub-contractors (see *Section 1.3.3* above), who will examine the potential for further analysis. All samples will be processed using methods appropriate to the preservation conditions and the remains present;

- Any human remains discovered during the excavation will be left *in situ*, and, if possible, covered. The Senior Archaeology and Heritage Advisor at the Lake District National Park Authority will be immediately informed as will the local coroner. Should it be considered necessary to remove the remains this will require a Home Office licence, under Section 25 of the Burial Act of 1857, which will be applied for should the need arise;
- Any objects defined as 'treasure' by the Treasure Act of 1996 (HMSO 1996) will be immediately reported to the local coroner and securely stored off-site, or covered and protected on site if immediate removal is not possible;
- Following completion of the archaeological excavation, the trench will not be reinstated or backfilled as it is anticipated that the remainder of the deposits within it will be removed to facilitate the re-alignment of the leat.

3.1.2 Should any significant archaeological deposits be encountered during the excavation these will immediately be brought to the attention of the Senior Archaeology and Heritage Advisor at the Lake District National Park Authority so that the need for further work can be confirmed. Any additional work and ensuing costs will be agreed with the client and according to the requirements of the Senior Archaeology and Heritage Advisor at the Lake District National Park Authority, and subject to a variation to this project design.

## 3.2 Watching Brief

3.2.1 The groundworks are to be monitored, with one archaeologist on site. If there are multiple machines operating on site it may be considered necessary to have more than one archaeologist on site.

3.2.2 The watching brief methodology will be as follows:

- All ground works such as areas of ground reduction, excavation for footings, or clearance to form site compounds will be excavated under supervision by staff from Greenlane Archaeology;
- All deposits of archaeological significance will be examined by hand if possible in a stratigraphic manner, using shovels, mattocks, or trowels as appropriate for the scale;
- The position of any features, such as ditches, pits, or walls, will be recorded and where necessary these will be investigated in order to establish their full extent, date, and relationship to any other features. If possible, negative features such as ditches or pits will be examined by sample excavation, typically half of a pit or similar feature and approximately 10% of a linear feature;
- All recording of features will include detailed plans and sections at a scale of 1:20 or 1:10 where practicable or sketches where it is not, and photographs in both colour print and colour digital format;
- All deposits, drawings and photographs will be recorded on Greenlane Archaeology *pro forma* record sheets;
- All finds will be recovered during the watching brief for further assessment as far as is practically and safely possible. Should significant amounts of finds be encountered an appropriate sampling strategy will be devised;
- All faunal remains will also be recovered by hand during the watching brief as far as is practically and safely possible, but where it is considered likely that there is potential for the bones of fish or small mammals to be present appropriate volumes of samples will be taken for sieving;
- Deposits that are considered likely to have, for example, preserved environmental remains, industrial residues, and/or material suitable for scientific dating will be sampled. Bulk samples of between 20 and 60 litres in volume (or 100% of smaller features), depending on the size and potential of the deposit, will be collected from stratified undisturbed deposits and will particularly target negative features (e.g. gullies, pits and ditches) and occupation deposits such as hearths and floors. An assessment of the environmental

potential of the site will be undertaken through the examination of samples of suitable deposits by specialist sub-contractors (see *Section 1.3.4* above), who will examine the potential for further analysis. All samples will be processed using methods appropriate to the preservation conditions and the remains present;

- Any human remains discovered during the watching brief will be left *in situ*, and, if possible, covered. English Heritage will be immediately informed as will the local coroner. Should it be considered necessary to remove the remains this will require a Home Office licence, under Section 25 of the Burial Act of 1857, which will be applied for should the need arise;
- Any objects defined as 'treasure' by the Treasure Act of 1996 (HMSO 1996) will be immediately reported to the local coroner and secured stored off-site, or covered and protected on site if immediate removal is not possible;
- Where practicable spoil removed using the machine will be visually checked for finds and scanned with a metal detector in order to recover metal finds;

3.2.3 Should any significant archaeological deposits be encountered during the watching brief these will immediately be brought to the attention of the Senior Archaeology and Heritage Advisor at the Lake District National Park Authority so that the need for further work can be confirmed. Any additional work and ensuing costs will be agreed with the client and according to the requirements of the Senior Archaeology and Heritage Advisor at the Lake District National Park Authority, and subject to a variation to this project design.

### 3.3 Report

3.3.1 The results of the excavation and watching brief will be compiled into a report, which will include the following sections:

- A front cover including the appropriate national grid reference (NGR) and Scheduled Monument Consent application number;
- A concise non-technical summary of results, including the date the project was undertaken and by whom;
- Acknowledgements;
- Project Background;
- Methodology, including a description of the work undertaken;
- Results of the excavation and watching brief including descriptions of any deposits identified, their extent, form, and potential date, and an assessment of any finds or environmental remains recovered;
- Discussion of the results including an assessment of the significance of any archaeological remains present within the study area, and an outline of the potential for post-excavation assessment and publication;
- Bibliography, including both primary and secondary sources;
- A copy of the brief and of this project design;
- Illustrations at appropriate scales including:
  - a site location plan related to the national grid;
  - copies of early maps, plans, drawings, photographs and other historic sources as necessary in discussing the results of the excavation and watching brief;
  - a plan showing the position of the excavation area and areas monitored by watching brief;
  - plans and sections of the excavation area and areas monitored by watching brief showing any features of archaeological interest;
  - photographs of the excavation and watching brief, including both detailed and general shots of features of archaeological interest;
  - illustrations of individual artefacts as appropriate.

### 3.4 Archive

3.4.1 The archive, comprising the drawn, written, and photographic record of the excavation and watching brief, formed during the project, will be stored by Greenlane Archaeology until it is completed. Upon completion it will be

deposited with the Cumbria Record Office in Barrow-in-Furness (CRO(B)). The archive will be compiled according to the standards and guidelines of the IfA (Brown 2007), and in accordance with English Heritage guidelines (English Heritage 1991). In addition details of the project will be submitted to the Online Access to the Index of archaeological investigations (OASIS) scheme. This is an internet-based project intended to improve the flow of information between contractors, local authority heritage managers and the general public.

3.4.2 A copy of the report will be deposited with the archive at the Cumbria Record Office in Barrow-in-Furness, one will be supplied to the client, and within two months of the completion of fieldwork, five copies will be provided for the LDNP Historic Environment Record (HER). A digital copy of the report will be submitted to English Heritage. In addition, Greenlane Archaeology will retain one copy, and digital copies will be deposited with the OASIS scheme as required.

3.4.3 The client will be encouraged to transfer ownership of the finds to a suitable museum. Any finds recovered will be offered to Kendal Museum. However, the museum is currently close to capacity, so an alternative repository may need to be found for the finds. If no suitable repository can be found the finds may have to be discarded, and in this case as full a record as possible would be made of them beforehand.

3.4.4 A note outlining the results of the project will be prepared for the *Transactions of the Cumberland and Westmorland Archaeological and Antiquarian Society*. If significant remains are encountered it is envisaged that this would lead to further work, in which case the results might be considered worth more detailed publication. In this case a new project design produced and this would be subject to a separate costing.

## 4. Work timetable

4.1 Greenlane Archaeology will be available to commence the project as soon as it is convenient to the client. It is envisaged that the project will comprise tasks in the following order:

- Task 1: archaeological excavation;
- Task 2: watching brief;
- Task 3: production of draft report including illustrations;
- Task 4: feedback, editing, and production of final report;
- Task 5: finalisation and deposition of archive.

## 5. Other matters

### 5.1 Access

5.1.1 Access to the site will be organised through co-ordination with the client and/or their agent(s).

### 5.2 Health and Safety

5.2.1 Greenlane Archaeology carries out risk assessments for all of its projects and abides by its internal health and safety policy and relevant legislation. Health and safety is always the foremost consideration in any decision-making process.

### 5.3 Insurance

5.3.1 Greenlane Archaeology has professional indemnity insurance to the value of £500,000. Details of this can be supplied if requested.

### 5.4 Environmental and Ethical Policy

5.4.1 Greenlane Archaeology has a strong commitment to environmentally and ethically sound working practices. Its office is supplied with 100% renewable energy by Good Energy, uses ethical telephone and internet services supplied by the Phone Co-op, has floors finished with recycled vinyl tiles, and is even decorated with organic paint. In addition, the company uses the services of The Co-operative Bank for ethical banking, Naturesave for environmentally-conscious insurance, and utilises public transport wherever possible. Greenlane Archaeology is also committed to using local businesses for services and materials, thus benefiting the local economy, reducing unnecessary transportation, and improving the sustainability of small and rural businesses.

## 6. Bibliography

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## Appendix 3: Summary Context List

Context	Type	Area	Description	Interpretation
<b>1001</b>	Deposit	Excavation	Loose dark-brown matrix comprising mix of rubble, mostly concrete blocks, red brick and stone	Dumped rubble probably associated with 20 <sup>th</sup> century rebuild of leat wall
<b>1002</b>	Deposit	Excavation	Mid brownish-grey sandy clay, 5% angular boulders	Earlier soil or subsoil horizon buried by <b>1001</b>
<b>1003</b>	Deposit	Excavation	Mid orange sand, very thin, 5% rounded gravels	Uncertain – perhaps naturally occurring due to water movement
<b>1004</b>	Fill	Excavation	Linear deposit of mid grey-brown sandy/silty clay, 50% angular and sub-angular cobbles with lenses of clean pale grey clay	Layer sealing face of leat wall or leat lining
<b>1005</b>	Deposit	Excavation	Mid orange-brown firm sandy clay, 10% rounded gravels	Re-deposited natural(?) capping underlying layers filling channel <b>1023</b>
<b>1006</b>	Fill	Excavation	Dark grey silty sand	Dumped deposit forming upper fill of channel <b>1023</b>
<b>1007</b>	Fill	Excavation	Loose mid orange-brown rounded gravel, probably derived from <b>1010</b>	Fill of pit <b>1012</b>
<b>1009</b>	Fill	Excavation	Soft mid grey silty/sandy clay	Middle fill of channel <b>1023</b>
<b>1010</b>	Fill	Excavation	Very loose mid orange-brown rounded and angular gravel, becoming finer at base, 20% sand, and with numerous voids	Lowest deposit of channel <b>1023</b>
<b>1012</b>	Cut	Excavation	Circular pit, c0.6m in diameter and containing remains of tree stump	Pit
<b>1013</b>	Deposit	Excavation	Mid yellow-orange sand	Natural
<b>1014</b>	Structure	Excavation	Wall along south-west side of trench constructed from concreted blast furnace slag, concrete blocks, and fire bricks, with shuttered concrete forming outer face	Extant leat wall
<b>1015</b>	Structure	Excavation	Wall around south corner constructed from modern red bricks	Rebuilt leat wall
<b>1016</b>	Fill	Excavation	Mid yellow silty/sandy clay, 10% angular gravel	Part of deposits sealing face of leat wall or forming leat lining
<b>1017</b>	Deposit	Excavation	Mid orange-brown sandy gravel	Disturbed natural
<b>1018</b>	Fill	Excavation	Pink clay	Part of deposits sealing face of leat wall or forming leat lining
<b>1019</b>	Structure	Excavation	Wall constructed from slate slabs, apparently drystone built and with up to four courses remaining	Original leat wall
<b>1020</b>	Deposit	Excavation	Greenish-grey clay, 50% rounded cobbles	Bedding for leat wall
<b>1021</b>	Deposit	Excavation	Whiteish-grey concrete containing 50% rounded gravel	Concrete capping wall <b>1020</b>
<b>1022</b>	Deposit	Excavation	Dark reddish brown rounded gravel, very loose	Perhaps essentially natural in origin, caused by water getting behind leat wall and washing out smaller particles
<b>1023</b>	Cut	Excavation	Linear, over 1m wide and 0.5m deep with shallow sloping sides	Palaeochannel?
<b>1024</b>	Cut	Excavation	1m wide and 0.4m deep, with shallow sloping sides	Cut for leat wall <b>1019</b>
<b>1025</b>	Deposit	Excavation	Mid orange-brown sandy clay	Natural
<b>01</b>	Deposit	WB	Concreted limy blast furnace slag	Dumped deposit of slag

<b>Context</b>	<b>Type</b>	<b>Area</b>	<b>Description</b>	<b>Interpretation</b>
<b>02</b>	Deposit	WB	Concreted mid orange-brown, with high iron content	Dumped deposit of scrap iron
<b>03</b>	Deposit	WB	Concreted limy blast furnace slag	Dumped deposit of slag
<b>04</b>	Deposit	WB	Loose mid orange-brown sandy clay, 30% rounded cobbles	Original ground surface or track
<b>05</b>	Deposit	WB	Dark grey sandy material with angular stone and vesicular slag	Dumped deposit of slag
<b>06</b>	Deposit	WB	Dark brown loose sandy/silty clay with humic material	Topsoil
<b>07</b>	Deposit	WB	Dark orange-brown sandy clay	Subsoil
<b>08</b>	Deposit	WB	Dark brown loose sandy/silty clay with humic material and rubble	Topsoil
<b>09</b>	Deposit	WB	Dark orange-brown sandy clay	Subsoil
<b>10</b>	Deposit	WB	Concreted limy blast furnace slag	Dumped deposit of slag
<b>11</b>	Deposit	WB	Mix stone and clay with some timber	Dumped rubble
<b>12</b>	Deposit	WB	Lime rich deposit of angular stone, with some flags and pieces of iron guttering	Dumped building rubble
<b>13</b>	Structure	WB	Row of large rounded boulders	Wall footing
<b>14</b>	Deposit	WB	Loose orange-brown clay and rubble	Re-deposited natural?
<b>15</b>	Deposit	WB	Mid brown-orange firm sandy clay, with some glassy slag and rounded cobbles	Buried soil
<b>16</b>	Deposit	WB	Dark greyish-black silt with lots of slag	Dumped industrial residue
<b>17</b>	Deposit	WB	Pale buff-coloured firm clay with glassy slag	Dumped industrial residue?
<b>18</b>	Structure	WB	Pair of slate-built walls extending from original leat wall	Culvert
<b>19</b>	Structure	WB	Slate built wall continuing line of wall to west of powerhouse	Boundary(?) wall

## Appendix 4: Summary Finds List

Context	Material type	Qty	Description	Date range
01	Composite	2	Fe bolt, nut, and washer, attached to white electrical porcelain insulator (broken in two but complete). Insulator has impressed mark (not very clear) which includes a trade-marked insulator image and the text 'P. 1874'. It is a threaded Unipart pintype insulator, post-1865 since 1865 saw the first patent for internal threaded insulators (NIA n.d.). It is likely that the 'P. 1874' relates to the year it was patented, so it is post-1874	Post-1874
01	Ceramic	1	Electrical porcelain (dark brown-glazed grey-bodied) insulator, incomplete. Possible mark on unglazed surface, very unclear (square within a circle). It is a porcelain lag screw insulator. "Porcelain lag screw insulators were (and are) commonly used to attach power and communications lines to buildings. These style insulators were also generally available at hardware stores and have seen much use in privately installed wiring" (NIA n.d.)	Late 19 <sup>th</sup> – 20 <sup>th</sup> century
01	Ceramic building material	1	White-glazed floor tile corner, very Fe-stained	19 <sup>th</sup> – 20 <sup>th</sup> century
01	Pottery	1	Black-glazed red earthenware crock rim	Late 17 <sup>th</sup> – early 20 <sup>th</sup> century
02	Fe	10	2 different thick band coiled springs of metal (boring waste?), 3 cast iron curved fragments from large water/drainage pipes (?), 1 rod/handle, 3 scraps, 1 blue enamelled L-shaped-cross-section fragment – all very corroded	Late 18 <sup>th</sup> – 20 <sup>th</sup> century
03	Ceramic building material	1	White stoneware (?) toilet/cistern fragment	Late 19 <sup>th</sup> – 20 <sup>th</sup> century
04	Pottery	1	Ironstone plate base	Mid 19 <sup>th</sup> – 20 <sup>th</sup> century
04	Industrial residue	9	Blast furnace slag, silicate slag, and clinker	Post-medieval
05	Pottery	1	Black-glazed red earthenware crock base, possibly with post-firing heating on base	Late 17 <sup>th</sup> – early 20 <sup>th</sup> century
06	Ceramic	3	Refitting red earthenware flower pot fragments	Mid 18 <sup>th</sup> – 20 <sup>th</sup> century
06	Pottery	1	Black-glazed red earthenware crock/pancheon base	Late 17 <sup>th</sup> – early 20 <sup>th</sup> century
06	Pottery	1	Brown-glazed grey-bodied stoneware bottle base, with impressed maker's mark: 'Lovatt & Lovatt / Langley Mill / Notts.'	1895-1913 (Godden 1991, 398)
06	Pottery	1	Glazed buff-coloured stoneware bottle base fragment	19 <sup>th</sup> – early 20 <sup>th</sup> century
06	Pottery	2	Bone china tea cup fragment with edge of handle terminal, and tea cup (?) base with gilded trefoil pattern	19 <sup>th</sup> – 20 <sup>th</sup> century
06	Pottery	1	Ironstone relief-moulded hollow-ware rim	Mid 19 <sup>th</sup> – 20 <sup>th</sup> century
06	Pottery	1	White earthenware with brown transfer-printed pattern	Late 19 <sup>th</sup> – early 20 <sup>th</sup> century?
06	Pottery	1	Pearlware 'Willow' transfer-printed rim, with relief-moulded beaded edge decoration	Late 18 <sup>th</sup> – 19 <sup>th</sup> century?

Context	Material type	Qty	Description	Date range
06	Glass	1	Colourless bottle/jar base with punt mark 'FGC / FMF / 2 / 016'. Made by Forsters Glass Works, St Helens, established 1902 (Toulouse 1971, 205). FMF possibly Food Manufacturers Federation (?), although not able to find reference for when this was established.	Early 20 <sup>th</sup> century
07	Pottery	3	Glazed buff-coloured earthenware: bottle base, fragment, cream pot base and handle terminal, with brown (slip-coated?) exterior	Mid 19 <sup>th</sup> – early 20 <sup>th</sup> century?
07	Composite	1	Carbon battery rod plus washers, including Fe and Cu alloy corrosion	20 <sup>th</sup> century
07	Animal bone	1	Butchered large mammal bone fragment with sawn end	Not closely dateable
07	Pottery	1	Thinnish-walled brown-glazed red earthenware hollow-ware body fragment with white slip stripes	Late 17 <sup>th</sup> – early 20 <sup>th</sup> century
07	Pottery	3	Factory-produced buff-coloured earthenware: base, body, and black slip-banded body	Mid 18 <sup>th</sup> – 20 <sup>th</sup> century
07	Pottery	10	White earthenware: pink slip-coated hollow-ware base plus body fragment from same vessel, 'Willow' transfer-printed base and plate rim from different vessels, 'Asiatic Pheasants' transfer-printed plate rim, blue transfer-printed body fragment, sponge-printed plate base, factory-produced slipware blue banded body fragment, plain body, plain strap handle	19 <sup>th</sup> – 20 <sup>th</sup> century
07	Glass	1	Green bottle fragment	19 <sup>th</sup> – 20 <sup>th</sup> century?
07	Glass	1	Very light turquoise bottle fragment	19 <sup>th</sup> – early 20 <sup>th</sup> century
07	Glass	1	Light blue bottle fragment	19 <sup>th</sup> – early 20 <sup>th</sup> century
07	Industrial residue	3	Blast furnace slag and clinker	Post-medieval
08	Glass	4	Colourless bottle/jar base and sides refitting. Punt mark '12 / CWS / FMF'. CWS stands for Co-operative Wholesale Society. In the 20 <sup>th</sup> century glass was manufactured in Sandy Lane, Worksop, Nottinghamshire, at the Co-operative Wholesale Society Glass Works, which specialised in making milk bottles. The company was taken over by Rockware in 1988, and closed in 2008. FMF possibly Food Manufacturers Federation (?), although not able to find reference for when this was established.	20 <sup>th</sup> century, pre-1988 (Nottinghamshire County Council 2009, 12)
08	Pottery	16	Glazed buff-coloured stoneware: complete jam jar with '12' impressed on base, groove for tie-on lid, and vertical impressed lines; 2 rims and 2 body fragments from similar jam jars; refitting or partially refitting plain jar rim, body, and base x 7; small body fragment from single large hollow-ware vessel x 3 (of which 2 refitting)	19 <sup>th</sup> – early 20 <sup>th</sup> century
08	Pottery	1	Olive-glazed buff-bodied stoneware hollow-ware base fragment	19 <sup>th</sup> – early 20 <sup>th</sup> century
08	Pottery	11	Bone china: refitting gilded saucer rim to base fragments x 7 (approximately half saucer present), 'Broseley' transfer-printed relief-moulded saucer rim x 1, applied lilac sprig hollow-ware body fragment x 1, plate/saucer bases x 2	19 <sup>th</sup> – 20 <sup>th</sup> century
08	Pottery	4	Ironstone: refitting base and body fragment from plain mug/jug x 3; relief-moulded mug/jug fragment with lower handle terminal present (possibly same vessel) x 1	Mid 19 <sup>th</sup> – 20 <sup>th</sup> century



Context	Material type	Qty	Description	Date range
08	Pottery	16	White earthenware: blue sponge-printed x 3, 'Willow' transfer-printed x 4 (including handle fragment), factory-produced banded slipware x 3, red painted x 1, brown transfer-printed x 1, plain x 4	19 <sup>th</sup> – early 20 <sup>th</sup> century
08	Pottery	9	Brown-glazed red earthenware coarseware from minimum of 3 vessels: base and body non-refitting from same vessel, pancheon rim and body refitting, everted rim and 4 body fragments from thinner-walled vessels	Late 17 <sup>th</sup> – early 20 <sup>th</sup> century
08	Pottery	32	Black-glazed red earthenware coarseware: refitting pancheon (lugged) rim to base x 11; refitting lugged pancheon rims x 2; rim x 1, body x 1, base x 2 from similar vessels; fragments x 8 (many probably from 1 <sup>st</sup> pancheon listed); heavy hollow-ware base fragments (2 refitting, others different vessels) x 4; jar bases with over-fired glaze x 2 (different vessels), thinner-walled hollow-ware body fragment x 1	Late 17 <sup>th</sup> – early 20 <sup>th</sup> century
08	Industrial residue	1	Blue vesicular glassy slag lump	Post-medieval
08	Glass	1	Very light blue bottle fragment	19 <sup>th</sup> – early 20 <sup>th</sup> century
08	Clay tobacco pipe	1	Plain stem fragment, 5/64" borehole diameter	18 <sup>th</sup> – 19 <sup>th</sup> century
08	Industrial residue	1	Vesicular slag (?) lump	Post-medieval
09	Pottery	1	Black-glazed red earthenware crock body	Late 17 <sup>th</sup> – early 20 <sup>th</sup> century
09	Pottery	1	White earthenware base (?) fragment	19 <sup>th</sup> – 20 <sup>th</sup> century
11	Pottery	1	Black-glazed red earthenware crock/pancheon body fragment	Late 17 <sup>th</sup> – early 20 <sup>th</sup> century
11	Pottery	1	Brown-glazed red earthenware coarseware rim with white slip	Late 17 <sup>th</sup> – early 20 <sup>th</sup> century
11	Ceramic building material	1	Very fragmentary ridge (?) tile fragment (very little surface present)	19 <sup>th</sup> – 20 <sup>th</sup> century?
11	Pottery	3	White earthenware small fragments: rim, black transfer-printed base, 'Asiatic Pheasants' transfer-printed fragment	Mid 19 <sup>th</sup> – 20 <sup>th</sup> century
11	Pottery	1	Factory-produced buff-coloured earthenware with blue slip stripe	Mid 18 <sup>th</sup> – 20 <sup>th</sup> century
11	Pottery	2	White earthenware: blue sheet pattern transfer-printed saucer rim, plain fragment	19 <sup>th</sup> – 20 <sup>th</sup> century
11	Pottery	1	Thinnish-walled brown-glazed red earthenware	Late 17 <sup>th</sup> – early 20 <sup>th</sup> century
12	Pottery	1	Factory-produced buff-coloured earthenware bottle mouth	19 <sup>th</sup> – 20 <sup>th</sup> century
12	Pottery	1	Refined black-glazed red earthenware coffee (?) pot lid fragment with knob and air hole	18 <sup>th</sup> – 20 <sup>th</sup> century
12	Glass	1	Green bottle shoulder fragment	19 <sup>th</sup> – 20 <sup>th</sup> century
12	Ceramic building material	1	Buff-coloured glazed tile rim	Late 19 <sup>th</sup> – 20 <sup>th</sup> century
12	Cu alloy	1	2-part button with loop attachment on cone shank	18 <sup>th</sup> century?
12	Industrial residue	1	Green vesicular slag	Post-medieval
15	Pottery	3	White earthenware refitting cup rims plus fragment	Mid 19 <sup>th</sup> – 20 <sup>th</sup> century

Context	Material type	Qty	Description	Date range
16	Glass	1	Milk glass button half with four holes. Wholly glass buttons are generally modern in date (Peacock 1996, 23), although pressed milk glass became popular from the late 19 <sup>th</sup> century (Mountfield 1978, 161)	Late 19 <sup>th</sup> – 20 <sup>th</sup> century
16	Industrial residue	28	Blast furnace slag, clinker, silicate slag, bloomery tap slag, 'crucible' fragment	Medieval – post-medieval
17	Industrial residue	10	Blast furnace slag	Post-medieval
<i>u/s (probably 16)</i>	Industrial residue	6	'Crucible' fragment	Medieval – post-medieval
1002	Industrial residue	39	Blast furnace slag, clinker, hearth or furnace lining, metal, silicate slag, ore	Post-medieval
1002	Glass	3	Colourless bottle fragments. 1 mouth fragment with internal screw-top stopper-type closure and mould seam to top rim. Base and body from cylindrical bottle	20 <sup>th</sup> century
1002	Pottery	1	Creamware/pearlware (very iron stained), inner surface of foot rim	Mid 18 <sup>th</sup> – early 19 <sup>th</sup> century
1002	Pottery	1	Rockingham-type ware teapot(?) fragment	Mid 18 <sup>th</sup> – 20 <sup>th</sup> century
1002	Pottery	1	Glazed earthenware coarseware(?) – too badly stained black to properly identify	Post-medieval
1002	Mixed	3	Peachy-pink coloured compressed fibre (cardboard?) washers with copper staining, one with central hole, both with clear impressions, plus part of cu alloy washer (metal with high Fe content?)	Late 19 <sup>th</sup> – mid-20 <sup>th</sup> century?
1002	Fe	8	Corroded melted scrap x 1, corroded sheet fragments x 5 (2 with rivets, one wrapped around wire-possibly rim of bucket), corroded gravelly lump x 1, composite Fe and timber object x 1 ) wire sticking into knotty timber)	Not closely dateable
1002	Cu alloy	1	Shaped strip, bent and apparently complete, purpose unknown	Not closely dateable
1002	Clay tobacco pipe	1	Stem fragment, 6/64" borehole diameter	18 <sup>th</sup> – 19 <sup>th</sup> century
1003	Industrial residue	2	Blast furnace slag	Post-medieval
1003	Pottery	1	Brown-glazed red earthenware jug(?) strap handle	Late 17 <sup>th</sup> to 19 <sup>th</sup> century?
1005	Clay tobacco pipe	1	Stem fragment, 6/64" borehole diameter	18 <sup>th</sup> – 19 <sup>th</sup> century
1006	Industrial residue	6	Non-diagnostic slag	Not closely dateable
1006	Pottery	1	Creamware mug/tankard(?) vessel base with lower foliate(?) handle terminal scar	Mid 18 <sup>th</sup> – early 19 <sup>th</sup> century
1006	Pottery	1	Brown-glazed red earthenware coarseware hollow-ware body fragment body fragment unusual in that exterior has white slip coating (not internal)	19 <sup>th</sup> to early 20 <sup>th</sup> century
1007	Fe	1	Highly corroded rod/bar(?) fragment	Not closely dateable
1007	Industrial residue	1	Very small glassy slag vesicular fragment	Post-medieval
1007	Wood	2	Broken pieces of tree stump	Not closely dateable
1009	Pb	1	Strap fragment, folded over	Not closely dateable

Context	Material type	Qty	Description	Date range
1009	Glass	5	Very light turquoise flat pane fragments	Post-medieval
1009	Industrial residue	1	Cinder	Not closely dateable
1009	Industrial residue	2	Blue and green glassy slag, one very small, other larger	Post-medieval
1009	Industrial	1	Burnt stone or potash	Not closely dateable
1009	Pottery	3	White earthenware (blue 'Willow' transfer printed serving dish rim; cup handle fragment, body fragment)	19 <sup>th</sup> – 20 <sup>th</sup> century (Willow 19 <sup>th</sup> century)
1009	Pottery	1	Brown-glazed red earthenware fineware (factory-produced) hollow-ware body fragment with lathe cut(?) wave pattern	Mid 18 <sup>th</sup> century to early 20 <sup>th</sup> century
1009	Pottery	2	Brown-glazed red earthenware fineware (1 stained fragment – hollow-ware rim with white slip trailing)	Late 17 <sup>th</sup> to early 20 <sup>th</sup> century
1009	Clay tobacco pipe	1	Bowl fragment; borehole diameter could not be recorded	18 <sup>th</sup> – 19 <sup>th</sup> century?
1009	Wood	3	1 thick piece of bark, 1 broken fragment with cu alloy screw inserted into it	Not closely dateable, one with screw post-1800
1010	Pb	2	1 larger scrap sheet, folded. 1 smaller piece with multiple punched holes some with Cu alloy staining	Not closely dateable?
1010	Clay tobacco pipe	3	One stem/bowl junction with heel, 5/64" borehole diameter; two stem fragments, one with 5/64" and one with 6/64" borehole diameter	18 <sup>th</sup> – 19 <sup>th</sup> century
1010	Pottery	6	Brown-glazed red earthenware (coarse hollow-ware fragments: crock body x 1, white slip coated interior x 1, external white slip-trailed line x 1. Thinner-walled hollow-ware fragments x 2 (1 with white slip-trailed line externally), dish/platter fragment with white slip-trailed line internally)	Late 17 <sup>th</sup> to early 20 <sup>th</sup> century, slip-coated piece 19 <sup>th</sup> to early 20 <sup>th</sup> century
1010	Pottery	2	Black-glazed red earthenware (coarseware body fragments)	Late 17 <sup>th</sup> - early 20 <sup>th</sup> century
1010	Pottery	4	Pearlware/white earthenware (iron stained) blue shell-edged plate rim x 1, painted earth colours body fragments x 2, basin or chamber pot rim x 1	Late 18 <sup>th</sup> – early 19 <sup>th</sup> century
1010	Pottery	12	White earthenware (or earlier – iron stained), small plain fragments	Mid 18 <sup>th</sup> – 20 <sup>th</sup> century
1010	Pottery	6	White earthenware (or earlier – iron stained) blue transfer-printed patterns x 5, blue shell-edge x 1	c1820s-1830s
1010	Pottery	2	Brown transfer-printed patterns	Post 1829-1830 (Neale 2005, 17)
1010	Pottery	3	Miscellaneous factory-produced fine earthenwares (iron-stained), including factory-produced slipware	Mid 18 <sup>th</sup> – 20 <sup>th</sup> century
1010	Pottery	1	Coarse earthenware (iron-stained)	Mid 18 <sup>th</sup> – 20 <sup>th</sup> century
1010	Pottery	1	Fine, brown-glazed red(?) earthenware (factory-produced) tea pot handle	Mid 18 <sup>th</sup> – 20 <sup>th</sup> century
1010	Pottery	1	Stoneware (brown-glazed grey bodied rouletted)	Mid 18 <sup>th</sup> – mid 20 <sup>th</sup> century
1010	Glass	2	Flat plate, colourless	19 <sup>th</sup> – 20 <sup>th</sup> century
1010	Cu alloy	3	Nails	19 <sup>th</sup> century
1010	Cu alloy	1	Ratcheted fitting, from wind stay?	Late 18 <sup>th</sup> – 20 <sup>th</sup> century?
1010	Fe	3	Corroded gravelly fragments (bar fragments x 2, socketed object x 1)	Not closely dateable

<b>Context</b>	<b>Material type</b>	<b>Qty</b>	<b>Description</b>	<b>Date range</b>
<b>1010</b>	Industrial residue	5	Blast furnace and other slag	Post-medieval
<b>1010</b>	Stone	2	Slate roof tiles, local Westmorland green slate, 1 with peg hole	Post-medieval?
<b>1010</b>	Wood	4	1 sawn block, 2 pegs (for tiles?), 1 iron nail in	Not closely dateable
<b>1014</b>	Pottery	2	Creamware(?) rim and body fragment	Mid 18 <sup>th</sup> – early 20 <sup>th</sup> century
<b>1014</b>	Glass	1	Burnt fragment	Post-medieval
<b>1017</b>	Industrial residue	1	Clinker	Post-medieval
<b>1017</b>	Pottery	3	White earthenware (iron-stained), 1 with turquoise glaze externally, 1 with blue transfer print	19 <sup>th</sup> – 20 <sup>th</sup> century
<b>1018</b>	Industrial residue	1	Non-diagnostic slag	Post-medieval

## Appendix 5: Slag Assessment

### Assessment of the slags recovered from Lowwood Gunpowder Works near Haverthwaite, Cumbria

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Gerry McDonnell

6/16/2010





# Assessment of the slags recovered from Lowwood Gunpowder Works near Haverthwaite, Cumbria

## 1. Introduction

This assessment report describes the material classified as slag recovered from the excavation/watching brief at Lowwood, Cumbria. A brief overview of the material is provided, followed by a detailed description and quantification. XRF analyses of possible crucible fragments are considered. The significance of the material is discussed and recommendations made for further work.

## 2. Slag Classification

The slags were visually examined and the classification is based solely on morphology. In general metalworking debris is divided into TWO broad groups. First are the diagnostic slags and debris which can be attributed to a particular industrial process; these comprise ores and the ironworking slags, i.e. smelting and smithing slags, non-ferrous crucibles etc. The second group, are the non-diagnostic slags, which could have been generated by a number of different processes but show no diagnostic characteristic that can identify the process. In many cases the non-diagnostic residues, e.g. hearth or furnace lining, may be ascribed to a particular process through archaeological association. The residue classifications are defined below. The count and weight of each slag type present in each context was recorded.

### 2.1 Diagnostic Ferrous Slags and Residues

Ore - red stone occurring as fused fragments with blast furnace slag

Blast Furnace slag – smelting slag produced by the operation of a blast furnace, fuelled either by charcoal or coke. It is vitreous, predominantly green/black in colour although some pieces are blue.

Bloomery Tap Smelting Slag - this smelting slag is characterised by flowed surfaces. It is black in colour and occurs in a range of sizes.

Metal – metallic iron fragments, that lack a distinctive morphology of an artefact and may be fragments e.g. of cast iron.

### 2.2 Diagnostic Metalworking Residues

Crucible - a clay vessel for melting either non-ferrous alloys or ferrous alloys to cast objects.

### 2.3 Non-Diagnostic Slags and Residues

Silicate Slag - randomly shaped pieces of iron silicate slag. It has one face that is typical of bloomery iron smelting or black smithing slag, the other face is similar but with entrapped fragments of white stone (limestone ?) and red stone (ore or sandstone ?). It is not clear from which process it derives from

Hearth or Furnace Lining - the lining of an industrial hearth, furnace or kiln that has a vitrified or slag-attacked face. It is not possible to distinguish between furnace and hearth lining.

Clinker - a silicate rich slag, black in colour, low density clinker appearance. Some has entrapped fragments of some pieces white stone (limestone) and red stone (ore or sandstone)

## 3. Overview

The slag recovered from the site includes blast furnace slag, bloomery smelting slags and waste from a firebox, as well as possible crucible fragments.

## 4. Results

A total of 0.7kg of blast furnace slag was recovered from 7 contexts (Table 1). The majority was green/black in colour indicative of a charcoal fuelled blast furnace, however all the fragments from

Context 17 were blue in colour. A total of 3.4kg of bloomery tap slag was recovered from one context (Context 16). The slag could have been brought to the site to act as a feed for the blast furnace, rather than as evidence of a bloomery site close by. A very small quantity of ore, which was partially fused with blast furnace slag, was recovered from one context (29g, Context 1002), and one fragment of iron metal was recovered from the same context.

The clinker, lining and silicate slag are considered together and possibly represent waste from a hearth, or firebox, e.g. from a steam powered engine. The entrapped pieces of stone being fragments of the lining of the firebox or hearth. It is possible that the silicate slag which is richer in iron compared to the clinker could be bloomery smelting slag, but the presence of similar stone inclusions as the clinker indicate that it is an iron rich form of clinker.

Six fragments of possible crucible were recovered, two from an unstratified context (listed here as Context 9999), and four from Context 16. The use of crucibles is not expected on a blast furnace site. All six fragments were similar in appearance, the crucible wall is thick (1.5cm) with a gentle curve indicating a large diameter vessel. With the exception of one of the fragment recovered from Context 9999, none showed evidence of adhering metallic particles. None of the crucible fragments were vitrified, which occurs when the crucibles are subjected to the high temperatures required to melt metals and alloys. To address the key questions as to whether (a) the ceramic fragments are parts of crucible or some other ceramic artefact and (b) if they are crucible fragments which metals or alloys were they used for, all fragments were analysed by X-ray Fluorescence (XRF).

The instrument used was a Bruker S1 Turbosdr hand-held XRF instrument operating at 40kV. Samples were analysed for 30 live seconds, the spectrum is stored and a normalised composition determined using a bespoke Bruker Fundamental Parameters Programme (FP). All elements heavier than calcium (Ca, Z=20), can be detected. The data is returned as elemental percentage, but clearly the elements are present as oxides and other compounds in the clay fabric, so the data gives a relative percentage of each element detected. The major compound in clay is silica which is not detected. The calculated two-sigma error on each element was calculated and overall shows values of the order of +/- 0.2%. The data was generated in a comma delimited file and then exported to an Excel spreadsheet, where the data was examined and relevant tables were generated. A reading was taken from the interior surface of a crucible and a second one from the exterior surface. The metal was held within the crucible, but at the high temperatures required to melt the alloy (>900°C) the metals diffuse into and through the crucible wall. Due to the low volatilisation temperature of zinc (910°C), this element readily diffuses into the crucible fabric. It would be expected that a higher concentration of metals would be detected on the inside of the crucibles compared to the exterior surfaces.

The mean values for the elements of interest for the interior and exterior surfaces are shown in Table 2, (the full data is presented in Appendix 1). This shows that the copper content is slightly enhanced on the interior surface, whereas the zinc is enhanced on the exterior surface. The levels of these elements is very low, for example brass making crucibles recovered from a 19<sup>th</sup> C foundry in Birmingham had Cu levels of c30% or more on the interior surface. This suggests that Cu etc. are present in the fabric of the crucibles and that the crucibles have either not been used or were used for making casting from liquid iron. One exception is a fragment from Context **9999** which displayed metallic corrosion on the interior face and 23% Cu was detected. If the exterior and interior values from this sample are removed from the data set then the average values fall significantly (Table 3). The data also shows that Cu, Zn and Pb are enhanced on the interior face, although the levels overall are very low.

An alternative and better interpretation of the 'crucible fragments' is that they are clay packing from around the metal tuyere of the blast furnace, that become fired during the furnace campaign. This would explain the metallic corrosion surface on the sample from Context **9999**.

context	Bf slag		clinker		lining		metal		silicate slag		Bloomery tap slag		ore		other		crucible		
	count	weight	count	weight	count	weight	count	weight	count	weight	count	weight	count	weight	count	weight	count	weight	
04	5	57	2	31					2	19									
07	2	37							1	68									
16	4	134	2	13					3	203	17	3379			4	224			
17	10	185																	
1002	10	212	23	509	3	27	1	22	1	127			1	29					
1003	2	57																	
1006																			
1010	4	29													1	5	stone?		
1017			1	5															
9999																		2	104
	37	711	28	558	3	27	1	22	7	417	17	3379	1	29	1	5	0	6	328

Table 1: Slag Listing by Context (weight in grams)

	Fe	Cu	Zn	As	Sn	Sb	Pb
interior mean	81.0	6.6	1.9	0.1	0.4	1.4	0.3
exterior mean	81.4	4.1	2.3	0.4	0.8	2.5	0.7

**Table 2: Mean values of the major elements of the interior and exterior surfaces of the crucible.**

	Fe	Cu	Zn	As	Sn	Sb	Pb
internal mean	83.4	3.4	2.3	0.1	0.4	1.5	0.3
external mean	84.2	2.5	1.9	0.3	0.9	2.6	0.2

**Table 3: Mean values of the major elements with one sample with high values removed.**

## 5. Summary

There is blast furnace slag, partially reacted ore and tuyere packing deriving from the blast furnace period of the site. The bloomery slag may derive from the same period, imported as feed for the furnace or represent evidence for earlier activity on the site. There is also debris from a fire box, e.g. from a steam engine or a hearth.

## 6. Significance

The tuyere packing material is rare and publications of the excavations of other blast furnaces should be checked for occurrence on other sites. The bloomery slag is evidence of either earlier activity or feedstock for the blast furnace. The clinker etc. is evidence for the use of a firebox, possibly steam power. The blast furnace slag is an exemplar of Lake District technology.

## 7. Recommendations

The material should be retained. If finance was available the slags should be characterised by archaeometallurgical analysis to contribute to the growing knowledge concerning the evolution of iron technology on a national and regional scale. An XRF study of the bloomery slag, the silicate slag and clinker may provide data to indicate whether the silicate slag is a form of bloomery slag or is associated with the clinker.



**gerry mcdonnell archaeometals**

Dr Gerry McDonnell  
Thursday, 16<sup>th</sup> June 2011

## Appendix 1

Context	Fragment	internal	external	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Zr	Nb	Ag	Cd	Sn	Sb	Au	Hg	Pb	Bi
<b>16</b>	frag internal	y		0.3	0.0	87.0	0.0	0.2	2.7	1.5	0.1	1.8	0.2	1.6	2.4	0.0	2.1	0.0	0.0	0.1	0.0
<b>16</b>	frag internal	y		0.4	0.0	84.2	0.0	0.3	3.3	3.0	0.0	2.8	0.0	2.1	3.4	0.0	0.5	0.0	0.0	0.0	0.0
<b>16</b>	frag internal	y		0.3	0.0	83.1	0.0	0.2	2.6	4.2	0.1	2.4	0.2	1.3	2.5	0.6	2.1	0.0	0.4	0.0	0.0
<b>16</b>	frag internal	y		0.2	0.1	88.1	0.0	0.4	0.0	1.3	0.0	1.6	0.0	1.1	2.1	1.7	2.8	0.0	0.0	0.1	0.1
<b>9999</b>	frag internal	y		0.0	0.5	74.8	0.0	0.0	8.6	1.5	0.1	4.2	0.0	3.4	5.2	0.0	0.0	0.0	0.0	1.3	0.4
<b>9999</b>	frag internal	y		0.3	0.0	68.6	0.0	0.0	22.7	0.0	0.1	2.3	0.0	1.6	2.9	0.2	1.0	0.0	0.0	0.3	0.0
<b>16</b>	frag external		y	0.4	0.0	82.6	0.0	0.0	3.2	1.0	1.0	2.9	0.0	1.8	3.3	0.0	1.5	1.4	0.5	0.4	0.0
<b>16</b>	frag external		y	0.0	0.9	85.9	0.0	0.3	0.6	2.9	0.1	1.5	0.0	0.9	1.7	1.7	3.1	0.0	0.3	0.0	0.0
<b>16</b>	frag external		y	0.4	0.5	85.6	0.0	0.0	0.0	1.9	0.0	3.3	0.0	2.0	3.3	0.0	1.8	0.0	0.0	0.2	0.4
<b>16</b>	frag external		y	0.2	1.1	82.7	0.0	0.0	4.1	0.8	0.3	1.8	0.0	1.3	2.3	1.0	3.7	0.4	0.2	0.2	0.2
<b>9999</b>	frag external		y	0.1	0.1	84.3	0.0	0.0	4.5	2.9	0.1	1.3	0.1	0.6	1.0	1.9	2.9	0.0	0.0	0.2	0.1
<b>9999</b>	frag external		y	0.6	0.0	67.2	0.0	0.0	12.1	4.2	0.9	3.2	0.0	2.3	3.4	0.0	1.7	0.0	0.9	3.3	0.2



## Appendix 6: Environmental Samples

Sample	Context	Volume (litres)	Description
1	1007	30	Fill of pit 1012
2	1005	10	Re-deposited natural
3	1006	60	Dumped deposit, industrial residue?
4	1004	10	Sandy deposit
5	1017	20	Disturbed natural
6	1010	20	Base fill of channel 1023
7	16	2.5	Industrial residue

Table 4: Environmental samples list

Sample number	1	Sample number	3	Sample number	6	Sample number	7
Volume (litres)	4	Volume (litres)	4	Volume (litres)	7	Volume (litres)	1.5
Bone (Burnt)	+	Bone (Burnt)	-	Bone (Burnt)	-	Bone (Burnt)	+
Charcoal	+++	Charcoal	+++	Charcoal	++	Charcoal	++
Cinders/coal	+++	Cinders/coal	+++++	Cinders/coal	+++++	Cinders/coal	+++++
Cu alloy object	-	Cu alloy object		Cu alloy object	+	Cu alloy object	-
Fe	++	Fe		Fe	++	Fe	-
Fe object (nail)	+	Fe object (nail?)	-	Fe object (nail)	+	Fe object (nail)	-
Glass	+	Glass	-	Glass	++	Glass	-
Glassy/vesicular slag	++++	Glassy/vesicular slag	+	Glassy/vesicular slag	+++	Glassy/vesicular slag	+++++
Hammerscale	+	Hammerscale	+	Hammerscale	+	Hammerscale	+
Pottery (post-med)	-	Pottery (post-med)	+	Pottery (post-med)	+	Pottery (post-med)	+
Prill	+	Prill	+	Prill	+++	Prill	++++
Marine mollusc	+	Marine mollusc	-	Marine mollusc	-	Marine mollusc	-
Mortar	+++++	Mortar	+	Mortar	+	Mortar	+
Other slag	-	Other slag	+	Other slag	-	Other slag	+++++
Roots	++	Roots	+	Roots	-	Roots	+
Wood	++	Wood	-	Wood	+	Wood	-

Table 5: Volume and contents of retents

(Key: + = 1-5, ++ = 6-20, +++ = 21-50, ++++ = 51-100, +++++ = >100)

Sample no.	1	3	6	7
Twig and root fragments	+++	+++	++++	++
Bark fragments	+++	-	-	-
<i>Rubus fruticosus</i>	+++	++	+++	+
<i>Sambucus nigra</i>	++	++++	+++	+
<i>Chenopodium sp.</i>	+	-	-	
<i>Fumaria sp.</i>	-	-	-	+
Fungal sclerotia	+	-	+	-
Moss fragments	+	-	-	-
Charcoal	+	+	++	+++
Land snails	++	-	++	-
Insect fragments	++	+	++	-
Burnt bone	+	-	-	
Unburnt bone	-	-	-	+++
Coal	+	+	+	+
Cinder	-	+	+	+++
Slag	-	-	+	+++
Prill	-	-	-	+++

Table 6: Contents of flots/waterlogged samples and

(Key: + = rare, ++ = occasional, +++ = common, ++++ = abundant)