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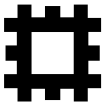
Loftus Alum Works, Redcar and Cleveland, Cleveland: an archaeological and historical survey

Abby Hunt, Trevor Pearson, Philip Sinton, Ann Carter, David Andrews, Nick Beckett, Steve Tovey and Mick Clowes

SURVEY REPORT

Archaeological Investigation Report Series AI/02/2004



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LOFTUS ALUM WORKS,

REDCAR AND CLEVELAND, CLEVELAND

An archaeological and historical survey

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Date of survey:	July-September 2003
Surveyed by:	Abby Hunt, Trevor Pearson, Philip Sinton, Ann Carter, Mick Clowes, David Andrews, Nick Beckett and Steve Tovey
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1. INTRODUCTION, SITE LOCATION AND SUMMARY

Between July and September 2003, English Heritage carried out an archaeological field survey and investigation of the disused alum works at Loftus, Cleveland (Figure 1). The investigation was carried out as part of a wider project investigating selected alum sites in North Yorkshire and Cleveland. This is a follow up to the recommendations in English Heritage's Monuments Protection Programme's Step Reports for the alum industry nationally (Gould 1993; Chitty 1996). Several of the alum works in the north-east of England are threatened by coastal erosion, hence the recommendation of a directed research programme of survey in advance of the sites' eventual destruction and loss. The survey of Loftus forms part of the Alum Industry Module of the Step 4 Industrials Recording Programme (Topping 2000), which selected two sites for survey: Loftus and Kettleness. Kettleness, situated some 20km to the south-east, was surveyed in the summer of 2002 (Jecock *et al* 2003). Due to the dangerous nature of the site's situation, field survey was coupled with aerial photographic transcription and photogrammetric work, which enabled the mapping of otherwise inaccessible features in 3-D.

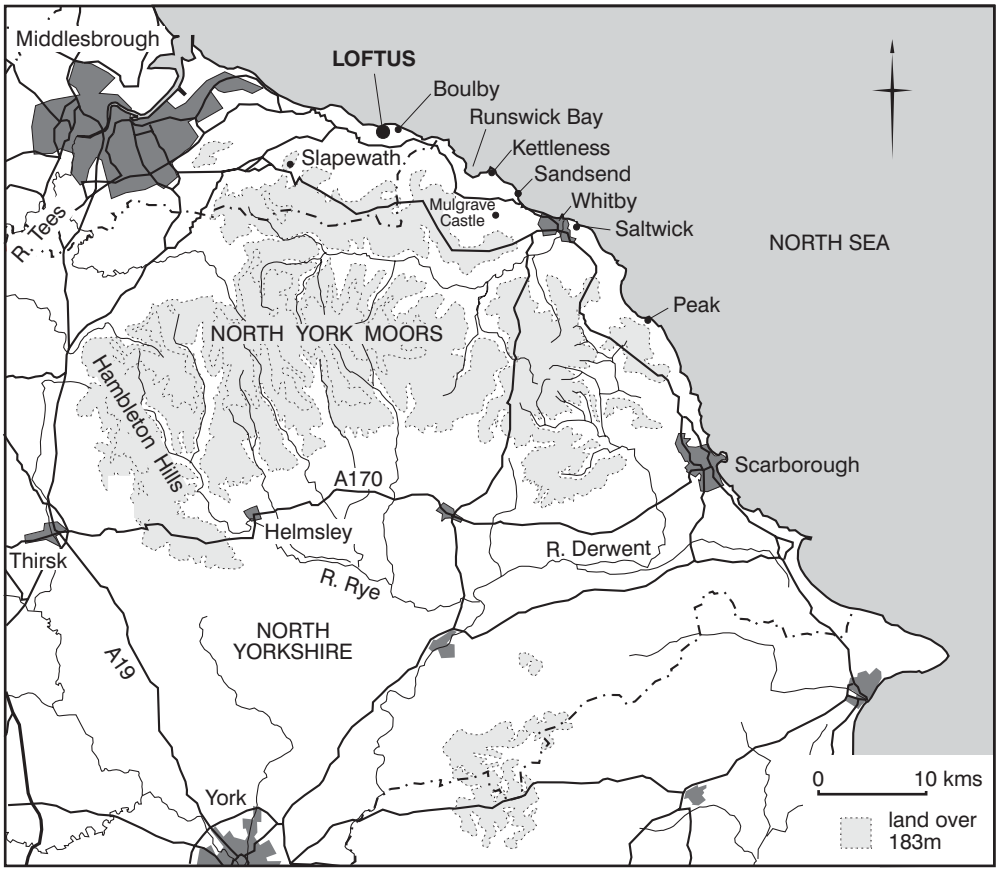


Figure 1. *Location of Loftus and other former alum works on the north-east Yorkshire coast*

The primary use of alum was in the textile industry, where it was employed as a mordant, or fixative, of natural dyes, thus preventing colour from running and fading. It was also used to a lesser extent, in the tanning industry, to produce soft and supple leather, and in the paper-making industry, to aid the retention of various additives, such as sizing agents. Alum is a

double sulphate of aluminium in conjunction with an alkali, either potassium or ammonium. Prior to the 15th century, alum was obtained from the naturally occurring mineral, alunite. However, alunite does not occur in the British Isles, which meant that alum had to be imported, at some expense, from the Mediterranean and Asia Minor. The 15th century saw the development of an alternative process in northern Europe, whereby aluminium sulphate was extracted from naturally occurring shales, to which the alkali was subsequently added. Knowledge of this methodology only spread slowly, and by the mid-16th century efforts were being made to locate outcrops of shale suitable for the production of alum in England. The process of alum production is described in more detail below (*see* Section 5). The first fully-functioning alum works was established at Slapewath, near Guisborough, Cleveland in 1604 (Pickles 2002, 9). From the inception of the industry in the early 1600s until the last remaining works closed in 1871, at least 24 alum works operated in the north-east Yorkshire area – although not all continuously or concurrently. As the 19th century progressed, great steps forward were made elsewhere in discovering methods of producing alum more efficient in the use of labour and resources. This spelt the end for the north-east Yorkshire sites which were based around the more traditional, labour-intensive methods. Production began to shift to a site near Glasgow where alum was being produced as a cost-effective by-product of the mining industry, with sulphuric acid added to mining spoil to create alum. Market conditions gradually squeezed the north-east Yorkshire alum works out of business, with the final one closing around 1871.

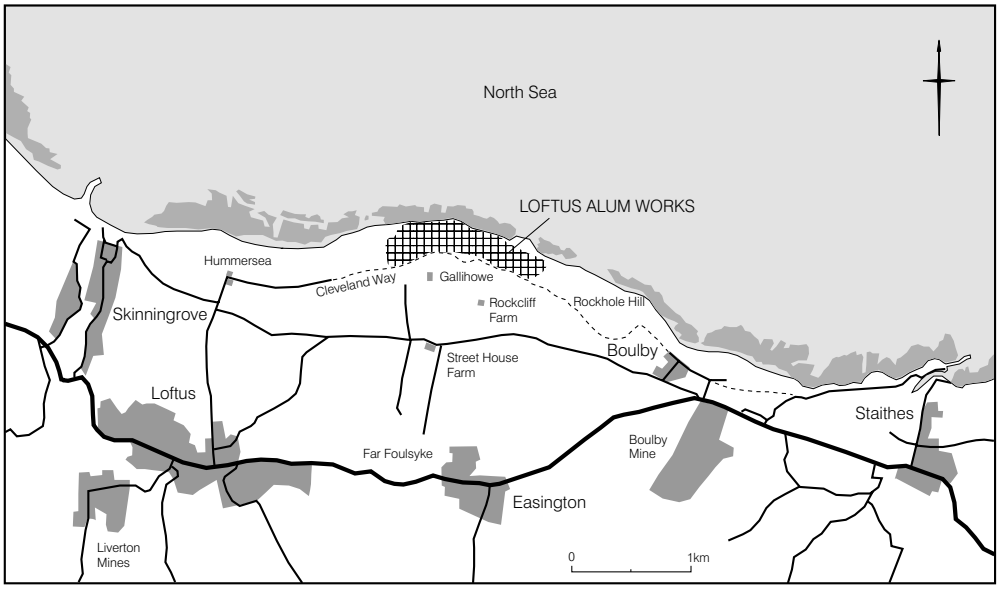


Figure 2. *Local environs of Loftus Alum Works*

The disused alum quarries that form the subject of this report are centred at National Grid Reference (NGR) NZ 741 202, some 2.5km to the north-east of the town of Loftus, itself 18km north-west of Whitby (Figure 2). The site is thought to have operated between the 1650s and 1860s, almost without a break. The alum shales were quarried from high up in the cliffs, with steps created in the cliff face to facilitate this process. The cliff edge was frequently used as a convenient location for the tipping of waste material. The final stages of the alum-making process at Loftus took place in the alum house. It is believed that there were three alum houses at Loftus during the site's working life. The first alum house is likely

to have been at the east end of the site, while the second was further to the west, close to the area of the land known as ‘The Warren’. The third and final alum house, of which fragmentary remains can still be seen today, was situated slightly above beach level at Hummersea Scar at NGR NZ 726 199, approximately 1.5km to the west. In total, the various elements of the alum works cover a stretch of coastline approximately 2km long. The majority of the land on which the quarries are situated is owned by the National Trust and is public access land. It is important to note that some of the quarries and features relating to the alum works continue right up to the cliff edge, where the surface is unstable and liable to collapse. It is not recommended that these parts of the site are approached and care should be taken on the rest of the site. The site can be viewed from the relative safety of the Cleveland Way footpath, which runs close to the top edge of the quarry edge to the south of the site.

The names Lingberry Hill, Lofthouse and Loftus have all been assigned to these alum works at various times. It is a commonly held assumption that the site originated as Lingberry Hill and that this expanded and evolved into Lofthouse Alum Works, the preferred name on 19th-centurymaps, before the cartographers adopted the name Loftus. The chronology of the site and its development is further explored in Section 7. For the purposes of clarity within this report, the site will be referred to as the Loftus Alum Works.

2. GEOLOGY, TOPOGRAPHY AND LAND USE

The cliffs upon which the Loftus quarries are situated are between 100m and 140m high on the seaward side, rising by another 40m at the rear, or south, of the site to a height in excess of 180m (Figure 3). The cliffs are primarily composed of Lower, Middle and Upper Lias shales of the Jurassic period, with a capping of Lower Oolite sandstones and shales. Below the sandstone capping, which measures up to 20m in depth in some places, the Upper Lias shales extend to a depth of some 60m. The area between the sea cliff and the inland cliff has been quarried away in order to extract the alum shales, which gives a terraced appearance to the terrain. Originally this area was occupied by a steep seaward facing slope, formed of softer shales, as can be seen in the profile of the narrow strip of unquarried land to the east of the site, separating Loftus and Boulby alum quarries. This slope would have been free of sandstone capping, facilitating the extraction of the shales. However, at the junction of the slope and the sandstone capping, some of the latter has been removed to access the underlying shales. This has created the almost vertical inland cliff, visible today, which is actually the remains of the main quarry face on the site.

Figure 3. *View of Loftus Alum Works from the west, showing the profile of the cliffs*

The alum workers would have extracted the top 27m or so of the Upper Lias shales, but are unlikely to have exploited lower strata, since the shale from the first 10m or so below the sandstone capping is richer in sulphur and would have produced the greatest quantity of alum. These figures would not have been known at the start of alum extraction at the site, and would presumably have been established over time through trial and error. As a result, earlier quarrying might have worked shales at a greater depth than those worked at a later period. The Upper Lias shales also contain a seam of jet rock some 45m below the surface, which Ordnance Survey map evidence shows was also extracted at Loftus (*see* Section 4). Nodules occasionally outcrop within these upper strata, which are known as cement doggers. These can be processed to make Roman cement. In addition, bands of ironstone appear

throughout the geological sequence at Loftus. These were also exploited and the extraction of the ironstone in this area was a separate major industry. The beach at the foot of the cliff is part of the Lower Lias shales strata.

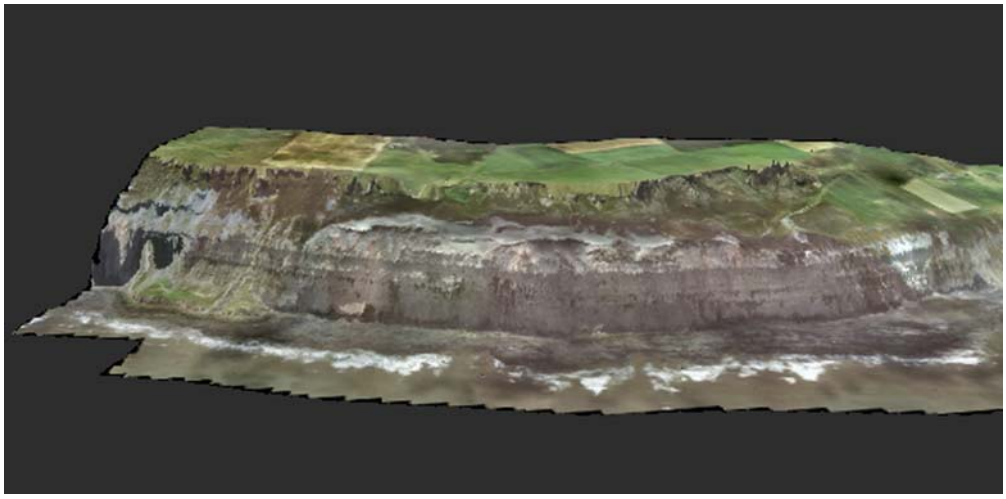


Figure 4. *Perspective view of Loftus Alum Works, generated by draping an orthophotograph of the site over a Digital Terrain Model (DTM)*

The Loftus Alum Works occupy some treacherous and difficult terrain (Figure 4). The quarries were cut into the cliff top and extend for approximately 1km, with the site varying in width from 260m at the west end to 90m at the east end. To the west of the quarries, the land slopes down to the west and the north, at first heavily covered in bracken, but then, some 250m further on, becomes enclosed pasture land with a strip of bracken-covered land *c* 50m wide continuing adjacent to the cliff edge. This area adjacent to the cliff edge widens out to *c* 150m and becomes mainly heathland, sloping relatively gently to the cliff edge. The cliffs here are much lower than those by the alum quarries, apparently caused by a change from solid rock to boulder clay. This geological change has also made this area more susceptible to slumping and several episodes of slippage can be seen in this stretch of the cliffs. The alum house, located just above beach level in the face of these cliffs, has been a victim of the boulder clay slumping, with the result that only fragmentary structural remains survive. The beach below is composed predominantly of rock with sand deposition occurring in places, although this is variable and dependent on the tide. At the time of the survey, the depth of sand covering the beach was minimal. Rather than a gradual, steady process of erosion, the cliffs along this particular stretch of coast are more susceptible to individual and sudden landslips, where substantial chunks of the sea-cliff can be lost in a single episode. Boulders are strewn along the beach, particularly in the eastern half of the site, and are generally concentrated at the foot of the quarry face at the rear of the alum quarries, the result of past collapses. Extensive swathes of boulder debris also exist at the rear of the alum quarries, where the primary quarry face has been quarried back and undermined, thus destabilising the sandstone capping above. As a result, blocks of the overlying rock, some of which are very large, have tumbled down into the quarries, creating broad areas of broken rock at the foot of the quarry face.

The quarries have lain idle since the 1860s, when they went out of use, and little has been altered during the intervening period. The landscape is one of bare shale, colonized in

places by rough grasses, bracken, heather and gorse. Some of the stone used in the structures within the alum works is believed to have been robbed out after the works closed for re-use in a number of local buildings, hence the relative dearth of surviving stone structures. A public footpath traverses the western part of the site. Aside from the public access, the land has simply been left to the elements for the past century and a half.

3. HISTORY OF RESEARCH

The present survey by English Heritage is the first to look at the Loftus Alum Works as a complete entity, although other work has concentrated on specific areas of the site. The scant remains of buildings at the eastern end of the quarries were fortuitously recorded in 1975. Keith Chapman was then working on the adjacent alum works at Boulby, recording and excavating the features there, when it was drawn to his attention that some of the stone from the buildings on the site at Loftus had recently been removed. As a result he took detailed measurements of stone-built features at the eastern end of the site and photographed them. Although not a comprehensive record of the whole site, these photographs still provide vital information about the rate of erosion at this end of the site and the change in the condition of the stone structures during the last 30 years or so (Figure 5).

Figure 5. *Photographs of a steeping pit in area 1; the upper one was taken in 1975, the lower in 2003. This demonstrates the rate at which stone has disappeared from the site in relatively recent times. 1975 photograph reproduced by kind permission of Mr K Chapman.*

In September 1993 Gary Marshall carried out a survey of the alum quarries for the National Trust, following their purchase of around 60 hectares (148 acres) of land containing about two thirds of the area of the quarries (Marshall 1993). The survey was not intended as a full landscape record, but has still proved very useful in locating the main features within the Loftus quarries. The principal features were recorded at 1:2500 and plotted on to a basic scale Ordnance Survey (OS) map. Marshall's report, which accompanies his survey, discusses the probability that the quarry was worked back in a series of terraces and postulates theories as to the working practices employed. In addition, it raises a number of management issues pertinent to that part of the site owned by the National Trust. The alum house at Hummersea was not examined during the course of Marshall's work as it was beyond the remit of the survey.

Survey work was also undertaken around Hummersea alum house and the foreshore in that area in 1993 by Tees Archaeology. The work comprised of a photographic record of the remains of the alum house and survey drawings of areas of the foreshore. Unfortunately the work has not been written up yet, so an interpretation of the findings is not available. However, the survey does contribute to the overall record of the site and will be important in the future for monitoring erosion and change to the archaeological remains. There are entries relating

to the alum works and associated features in the Tees Archaeology Sites and Monuments Record (SMR).

More recently, in July 2000, a survey of the Loftus Alum Works was carried out by Midway Watersports of Leeds, as part of a Nautical Archaeology Society qualification (Midway Watersports 2000). The focus of the survey was the remains of the alum house in the cliffs at Hummersea and the dock associated with it, the New Gut. The quarries were not included in the survey. The brief survey report identifies the New Gut, together with four or more post holes, burnt shale rafts and structural remains in the cliff face. A number of suggestions are offered as to the identification of some of the building remains in the cliff face, but no definite conclusions are reached. The survey was undertaken at a relatively basic level, as the group is one of amateur enthusiasts, who are restricted to completing the work in their spare time. Nevertheless, the locations of the post holes were recorded and the extent of the structural remains measured and drawn.

4. HISTORY OF THE SITE

4.1 17th Century

The alum works at Loftus was founded in the mid-17th century by local entrepreneur Zacharie Stewart, of Loftus-in-Cleveland. Having acquired sufficient land, Stewart persuaded three London tradesmen that Lingberry Hill was the ideal location for an alum works. A transcript of the lease for this land, dated to February 1656, exists in the Percy Burnett collection of papers in the Whitby Literary and Philosophical Society archive (Ref. 1209), as does the covenant between the four men establishing the works (Ref. 1210). The covenant also sets out the provisions that the co-owners were expected to fund, amongst them, the creation of a 'gutt' on the sea shore with an adjacent dock and the construction of an alum works of seven pans with associated buildings. An inherent problem with the process of alum manufacture from shale was that expenses were high and production low. Despite the heavy investment, Loftus had to close in 1664. This was only a temporary set back though, as it was up and running again in the 1670s. Further transcriptions of original documents show at least four changes of ownership of the quarter shares in the alum works in the 1660s and 1680s (Burnett Papers, Whitby Lit & Phil Soc, Refs. 1211, 1212, 1213, 1214 and 1216).

Amongst the documents in the Percy Burnett collection is the transcript of an inventory 'of the Allum Works at Lingbury Hill', dated to July 1684 (Burnett Papers, Whitby Lit & Phil Soc, Ref. 1215, reproduced as Appendix 1). Whilst this document is valuable in its information about the various elements which made up an alum works in the 17th century, it is not able to show how these elements worked together or where they were located on the ground. It does show that at this date, the alum works had 7 pans, which were valued at £182 and an 'allum house' worth £120. Other significant elements of the works were a 'Staith' (£100) and 'The Calsigning place' (£147 13s 01d). Reference is also made to 'ways up cliff', indicating that it had been necessary to create access between the beach and the cliff top, presumably for easier transportation of materials being imported and exported. Unfortunately, although the location of the works is named as Lingbury Hill, its exact position is not clear from this document.

4.2 18th Century

Although the 18th century saw widespread fluctuations in the price of alum, which resulted in many works having to cease production, Loftus was apparently able to continue throughout this period uninterrupted. There were, however, times when the works was not operating at full capacity and records show that many of the workforce were employed on a part-time basis (Pickles 2002, 16). It was in the 18th century that steps were taken to combat the price fluctuations in the alum industry and to try and stabilise the situation. For example, a gentleman's agreement was made between the alum works at Sandsend, Lingberry (Loftus), Boulby and Carlton-in-Cleveland in 1736 to produce just 1500 tons, while Saltwick and Peak were paid not to produce any alum at all (Pickles 2002, 14). In the 18th century experiments were undertaken to try and improve the efficiency in order to reduce the costs

of alum manufacture, including, at Loftus, the use of Castleton coals for the boiling pans, but in fact this resulted in a 'severe loss' between 1746 and 1747 (Young 1817, 814).

In 1764, Sir Lawrence Dundas, 1st Earl of Zetland, purchased land in Loftus, which included the alum works. The earliest plan of the Loftus Alum Works has not been tightly dated, but it is probably from the 1770s, some time between Dundas's acquisition of the estate and his death in 1781 (Figure 6). A plan of the northern boundary of Sir Lawrence Dundas's Loftus estate, held in the North Yorkshire County Record Office (NYCRO), includes a 'view of the allum works thereon call'd Lingberry Works' (ZNK M1/18 MIC2120 Frames 183-8). Although somewhat schematic in appearance, the plan depicts the main elements of the alum works and includes a detailed drawing of the interior of the alum house. There is a key accompanying the plan, but unfortunately, parts of it are degraded on the original, thus rendering it unreadable. The plan shows just one principal area of quarrying with an associated range of steeping pits slightly to the north. A small building can just about be made out adjacent to these pits. This arrangement is quite compact and self-contained, certainly not as spread out and extensive as the extant remains. The fact that the quarrying was expanded to new areas and that fresh shales were constantly being sought out is demonstrated by a letter 'B' on the plan to the east of the existing quarry area, which, according to the key, is said to show the location of 'a new Allum Rock'.

Also labelled on this plan, to the west of the quarry area, is a 'plank house', further to the north-west of which is a 'kelp house' with a pair of tanks, perhaps for soaking the kelp, in front of it. The kelp house and the structure adjacent to the tanks within the quarry itself are joined to another building, close to the shore, by a line, probably a trough to transport liquid. Next to this building by the shore are two circular features, presumably ponds or cisterns. This building is not labelled, except with the letter 'p' which relates to the illegible section of the key, but is almost certainly the alum house. Along the shoreline to the west of these, located on what appears to be part of the beach, is another building, labelled 'Humbersty Kelp House'. Although the plan is somewhat schematic in its topographic depiction, the Humbersty Kelp House can be seen to lie on the beach at Hummersea (presumably a modern corruption of the earlier name). This is also the location of the latest alum house of Loftus Alum Works, believed to have been constructed around 1800 (Pickles 1975, 8). It is therefore possible that this alum house may have re-used the pre-existing building or have been built adjacent to it.

In the top right hand corner of this plan, is 'An Inside View of the Allum House'. This shows a range of small tanks, arranged in 15 groups of six, with a sixteenth group comprising two small tanks and one larger tank. To the left of these tanks are 8 barrels and above are 3 large rectangular tanks, one with an inset smaller tank, and a circular tank with a rectilinear tank attached to it. This plan appears to be fairly typical of alum houses generally, so it is possible assign functions to the various tanks. The features at the rear (top) of the alum house are brick arches in plan-view, the spaces in between being the area on which a pan would have rested; this arrangement allowed fire underneath, between the arches, to boil the liquid in the evaporating pans. There is space for 13 pans in this arrangement, which ties

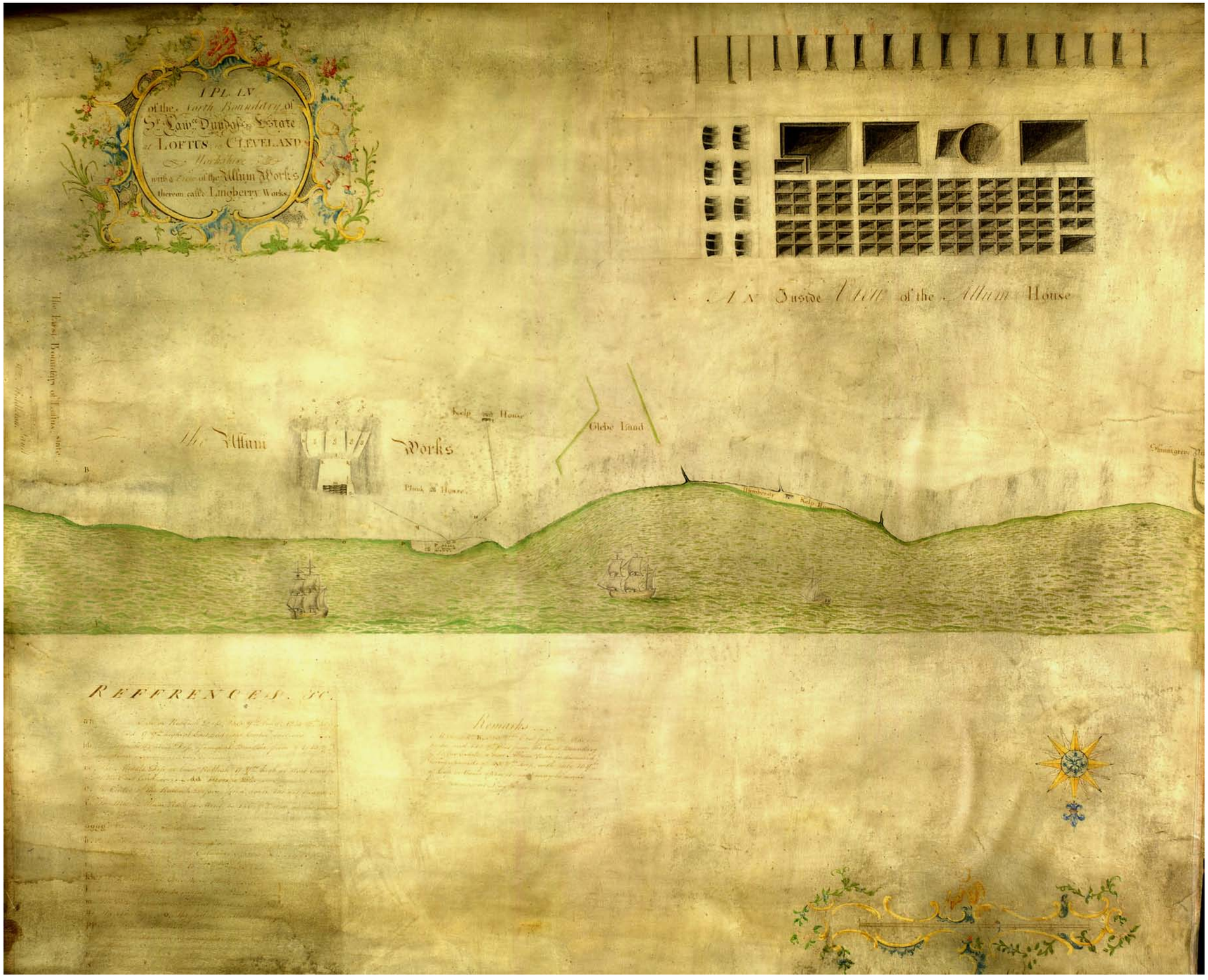


Figure 6. Map of the estate of Sir Lawrence Dundas including the Loftus Alum works, believed to date from the 1770s. (Original held in the NYCRO. Ref: ZNK M1/18 MIC2120 Frames 183-8). Reproduced by kind permission of the Marquess of Zetland.

in with documentary evidence stating that Loftus had 12 operating pans in 1791 (see below), with the thirteenth pan perhaps being used for reheating or dissolving the alum crystals during the roaching process. The large tanks shown below the arches are settling tanks, although why one is circular is uncertain, and the 16 groups of smaller tanks are the coolers. The barrels at the left-hand side of the alum house are presumably the roaching casks. This plan of the interior of the alum house shares a number of similarities with a plan of the Kettleness alum house believed to date to the late 18th century (reproduced in Jecock *et al* 2003, 17).

There are two 18th-century maps which depict the Loftus area. The earliest of these, Jeffery's map of Yorkshire dating to 1771 (NYCRO MIC 1919 Frame 262), shows an 'Allum Works' to the north of Street Houses. The only detail shown is two circles close to the cliff edge. What these circles represent is not clear, but one possibility is that they represent two main areas of production at Loftus, some distance from each other. The more westerly circle seems to be roughly in the Lingberry Hill area, but in the absence of any hard topographic or place-name evidence, it is difficult to be sure. Jeffery shows two buildings at Loftus, located approximately half way between Street Houses and the cliff edge, which would seem to be part of the alum works. This is actually some distance from the main body of the works though, and would have been on the cliff top. The identity of these buildings and the location of their corresponding ruins, if there are any, are impossible to ascertain. It is potentially significant that at this date, no place-name was associated with the alum works, either at Loftus or at Boulby.

In 1787, Tuke also produced a map of Yorkshire (NYCRO MIC 1919 Frame 157) (Figure 7). It is broadly similar to Jeffery's map in terms of the general depiction of the towns and roads in the area. On Tuke's map though, the alum works is referred to as 'Lofthouse Alum

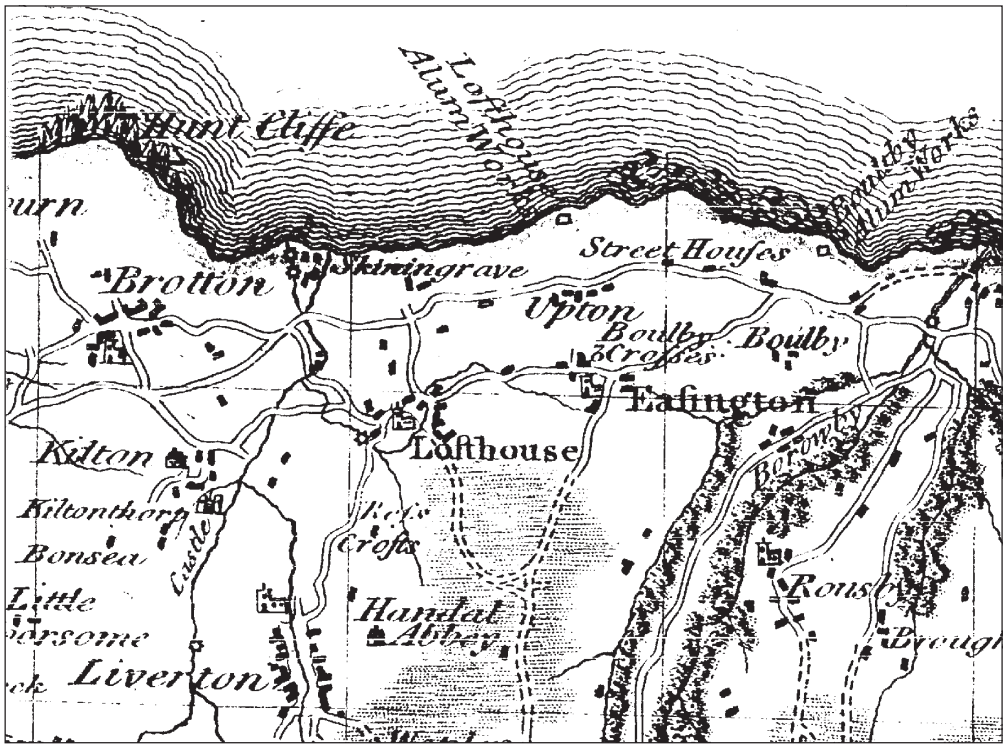


Figure 7. *Tuke's map of Yorkshire 1787. (Original held in the NYCRO. Ref: MIC 1919 Frame 157)*

Works', and unlike Jeffery's map, the works at Loftus is shown as a single, small rectangle to the north-east of Street Houses, which corresponds roughly with the more westerly circle shown on the earlier map. If it is to be assumed that the circles on the earlier map represent active parts of the alum works, then the inference can be drawn that by 1787 the works had become focused on the more westerly area, indicating a shift away from the Lingberry Hill area. There are no buildings shown associated with the works on this map, although this may be due to the different level of depiction, rather than indicating anything more significant.

A number of records relating to the alum works at Loftus survive in the North Yorkshire County Record Office. Many of these are financial records and technical information, but unfortunately there are very few plans. Given the scope of this report and the time available the records of wages and workers were not examined in detail, but some items of interest are summarized below. A batch of documents entitled 'Loftus Alum Works Papers 1766-1857' (ZNK VII 2 MIC 1431) contains many records of wages paid and the quantities of alum produced at various dates. Interestingly, accounts from November 1791 list the destinations of alum exported from the works, which included Ostend, Hull, London, and Venice (ZNK VII 2 MIC 1431 Frame 148). Also from this date, a document lists the alum works owners and the number of pans that they were operating; in the case of Sir Thomas Dundas, he had one works (Loftus) with 12 pans (ZNK VII 2 MIC 1431 Frame 153). Also documented are the dimensions of the pits in the Loftus alum works. The old pits were 72 feet long by 18 feet broad (approximately 22m by 5.5m), the largest new pits 58 feet by 18 feet (17.5m by 5.5m) and the small new pits 51 feet by 18 feet (15.5m by 5.5m). It also records that the pits had between 4 and 8 inches (10 and 20cm) difference between the depth at the two ends, allowing easier transfer of liquor into and out of the pits (ZNK VII 2 MIC 1431 Frame 833).

4.3 19th Century

A plan from 1807 shows a 'sketch of the drains for collecting and conveying water to the alum house etc.' (ZNK M1/24 MIC 2120 Frame 214). This is a large-scale map centred on Hummersea Bank, to the west of the alum quarries and inland from Hummersea beach. It depicts a water system made up of a series of drains and conduits drawing water from natural springs and taking it to 'Snarley Pond', from where it is carried off along the 'New conduit for the water to the Alum House'. This heads off in a north-westerly direction, and would have continued down towards Hummersea beach – the recorded location of the post-1800 alum house. Also labelled on this map are the 'Road to the Alum House' and the 'Road to the Alum Works', showing that, by 1807, the alum works had adopted the layout that still partially exists today in the surviving remains, with the alum house at Hummersea and the quarries some distance to the east. It is almost certain that the Snarley Pond shown on the map corresponds with 'Snilah Ponds' shown on later Ordnance Survey maps of the area. Unfortunately, the extent of the map is limited and it does not include the alum works or provide any additional information about the layout and form of the works at this date.

Loftus Alum Works was first depicted by the Ordnance Survey (OS) in 1853 at the scale of 6-inches to the mile (Ordnance Survey 1856a & b) (Figure 8). Given the scale, the amount

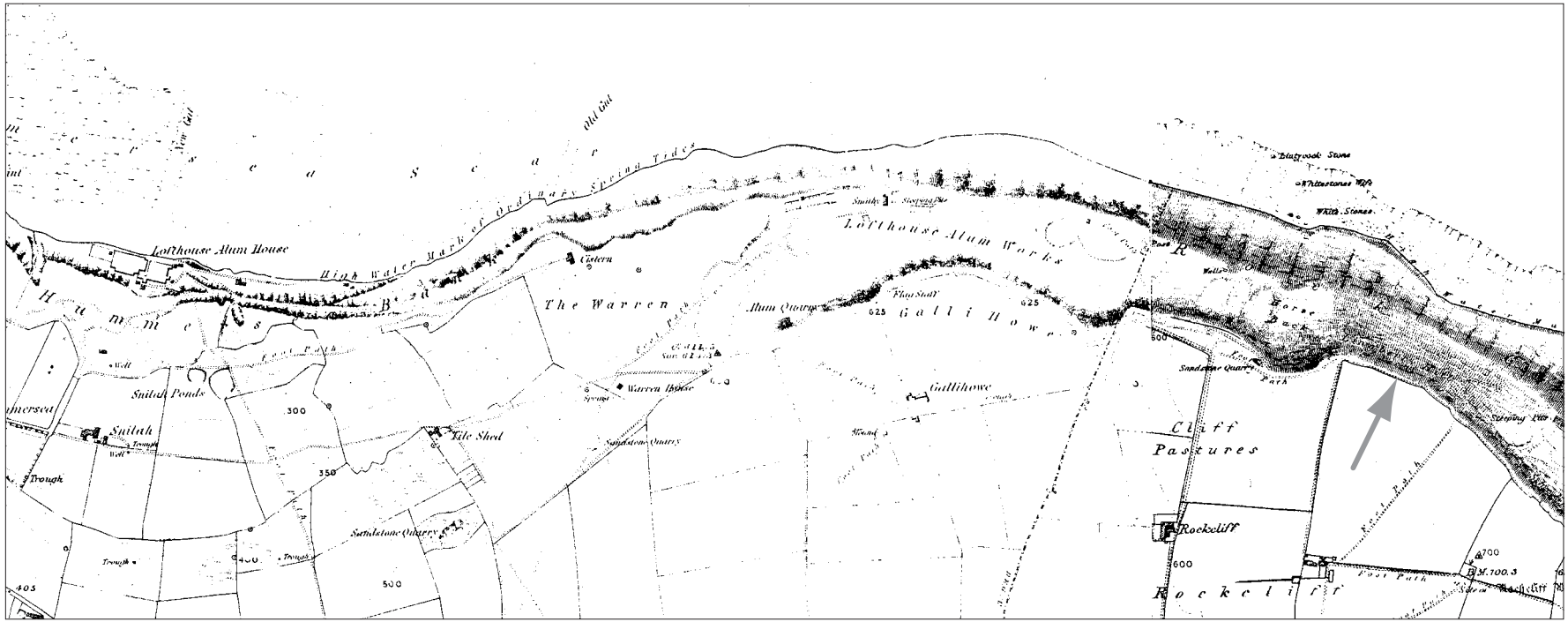


Figure 8. *Extract from the Ordnance Survey first edition 6-inch to the mile (1:10560) map of Loftus, surveyed in 1853. The grey arrow at the right-hand side of the map indicates the area labelled as 'Lingberry Hill'. Not to scale. (Reproduced from the 1856 Ordnance Survey map)*

of detail is limited, but it does provide an important snapshot of the alum works in the final stages of its functional life. Towards the eastern end of the quarries a small rectangle labelled 'Walls' is depicted, which is presumably the remains of an earlier structure, possibly a steeping pit that is no longer in use. Beyond this, towards the middle of the quarries, is a small building, whose function is not given. More structures are shown at the western end of the quarries, suggesting that at this date, the main focus of production was in this area. Two ranges of pits, one of which is labelled as 'Steeping Pits', and three structures, one of which is a smithy, are also depicted. Beyond the western end of the quarry, in an area of land called 'The Warren', is a small 'T'-shaped building labelled as a 'Cistern'. One footpath links this building to Snilah Ponds, some 650m to the west, while another joins it to the alum house on the foreshore, around 150m to the north of Snilah Ponds. The map also shows other footpaths that zig-zag down the cliff to the alum house. It is perhaps the depiction of the alum house that is of particular interest, as this map shows the full extent of the structure. It appears to have consisted of two large buildings with an attached annexe to the west and a number of small ancillary structures nearby. However, the main structures are not shaded in, which is the OS method of depiction for roofed buildings, so at this date, the buildings may already have been de-roofed. A path leads from the east end of the alum house in an easterly direction along the foreshore for approximately 250m. About halfway along this path is an 'L'-shaped structure, whilst further to the east, beyond the end of the path, is a pair of small structures. None of these structures is labelled, so their function is unknown. Two man-made docks, cut into the bedrock forming the foreshore, associated with the alum works are also shown, labelled 'New Gut' and 'Old Gut'.

A sketch map of 1864 drawn to show the parts of the Loftus royalty leased from the Earl of Zetland (NYCRO ZNK M2/1 MIC1954 Frame 10) includes the area around Snilah Ponds and the alum house. It is a crude representation, but it confirms that the alum house was composed of two separate buildings, although it does not show any ancillary buildings in the vicinity. This map would have been drawn around the time of the final closure of the alum works, the exact date of which is not certain, but it is likely to have been sometime in the 1860s.

A late 19th-century engraving of the western elevation of the alum house at Hummersea by W Y Veitch was originally published in a book on Middlesbrough and District (Cleveland Naturalist's Field Club 1881, facing page 66, reproduced in this report as Figure 9). Although drawn around fifteen years after the works' closure, the alum house is shown as more or less intact. It stands on a raised area, probably of material that had slumped onto the foreshore and was protected from erosion by the walls shown on the engraving, elevating it above the high water level. The engraving shows the building to be composed of a number of ranges, which agrees with the depiction on the OS First Edition map, although it is otherwise difficult to reconcile the detail shown on the engraving with what appears on the map. To the rear of the western end of the alum house is a building with an integral tall chimney, with windows lighting the upper storey and two small doorways at ground level. Adjoining this is another building aligned north-south with a large opening in the seaward end of its west wall, presumably for loading purposes, and a smaller doorway at the other end of this wall.

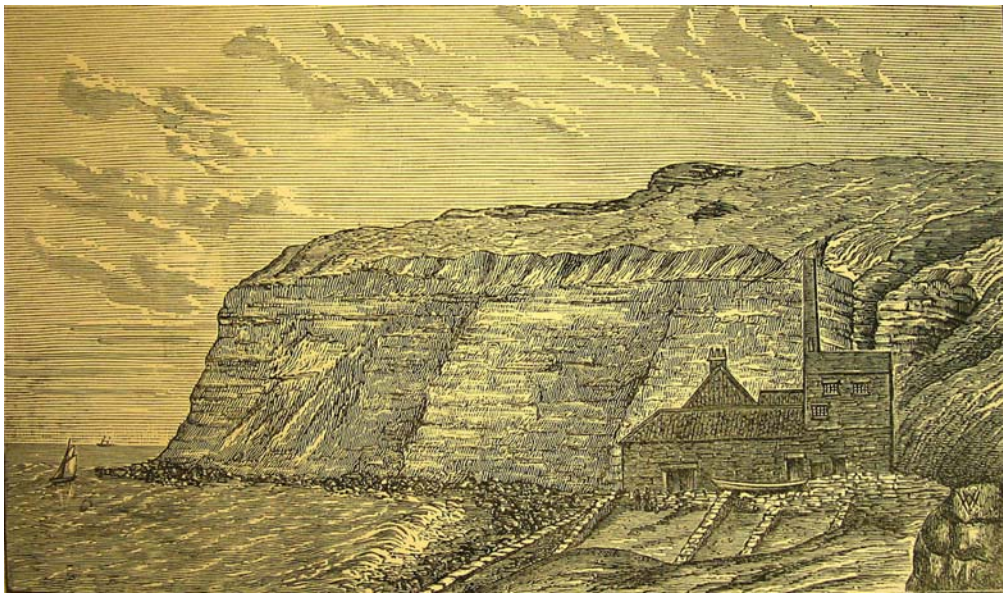


Figure 9. *Engraving of the alum house at Hummersea dating to c1880. By kind permission of the Dean and Chapter of York and York Minster Library.*

Beyond this building, it is just possible to see the roof of a third building on an east-west alignment with small chimneys at the apex of the roof. Another roofline can be seen adjacent to this at right angles, but no other detail is visible. In the foreground of the engraving is a gentle man-made slope, enabling vehicular access to the alum house from the beach. This would have allowed carts easy access to the alum house, both to deliver raw materials and to collect the alum. On this slope are four low stone walls, which appear to be defining two access routes, or slipways, up to the alum house. The more northerly pair of walls seems likely to correspond to the 'annexe' attached to the western end of the alum house, as depicted on the OS First Edition map surveyed in 1853. The engraving shows a boat, apparently a long, low rowing boat at the top of the slope, lying alongside the alum house. It is likely that the boat was included for artistic purposes and probably does not relate to the functioning of the alum house, particularly as it dates to some fifteen years after the works' closure.

During the course of research for this investigation, photographs taken some time in the 1890s, believed to be of the ruins of the alum house, were discovered in a private collection. The exact origin and date of the photographs are unknown, although they appear not to all be contemporary with one another, as they chart the gradual disintegration of the structure. The earliest of the photographs (Figure 10) shows a three-storey building, roofless but predominantly intact, with a tall chimney to its seaward side, which clearly corresponds with the building and associated chimney illustrated in the 1881 engraving of the site. However, the interpretation of this structure as the remains of the alum house is somewhat problematic. Alum houses are generally held to have been large, single-storied buildings and are unlikely to have been three storeys high. The combination of the chimney and the height of the building suggests another industrial use, possibly a building incorporating some kind of kiln or boiler to provide power for machinery within the building. If machinery was located on more than one floor, this would account for the presence of windows at the upper levels. One possibility is that this building was used for cement manufacture and incorporated a kiln, as cement is known to have been produced at Loftus in tandem with the

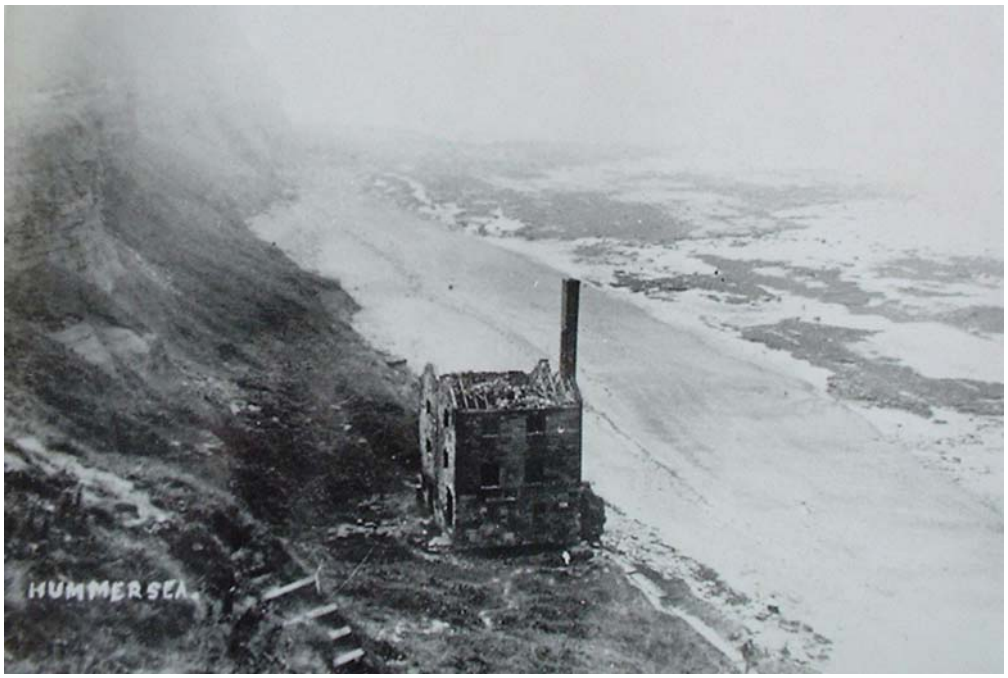


Figure 10.
Photograph of the alum house at Hummersea, believed to date to the 1890s. Reproduced by kind permission of Mr K Chapman.

alum extraction (Morris 1984, 39-41), although it does seem rather large if used solely for this purpose. Alternatively, it may have been a structure used for the burning of kelp, which would have then been supplied to the works for use in the production of alum. This issue is discussed further below, in Section 7. The photograph shows no evidence of any other buildings or ruins in this area. This strongly suggests that the other buildings shown on the engraving forming part of the alum house complex had been demolished or lost to coastal erosion by the end of the 19th century. At the north-east corner of the building is what appears to be a protruding chunk of masonry, possibly indicating the former existence of an adjoining structure, however, the photograph is not particularly clear. There also appear to be some timbers protruding from the cliff face in the foreground of the photograph but it is

Figure 11.
Photograph of the alum house at Hummersea, possibly dating to c1900. Reproduced by kind permission of Mr K Chapman.

difficult to be sure of exactly what they are or what they represent. What is clear from the image is that the structure illustrated was situated on a flat area that seems to have been cut back into the cliff, apparently for the specific purpose of accommodating the building.

A slightly later photograph of this structure (Figure 11) shows the building in a similar condition, but there are signs that further decay had begun to set in, with the stonework at the corners of the structure starting to crumble. In addition, the roof timbers are not as complete as in the previous photograph. To the east of the building is evidence of a path, which would presumably have allowed access from the cliff top and may have been the remains of one of the original paths between the two parts of the alum works, as shown on the OS First Edition map.

By 1893, when the OS 1:2500 map was re-surveyed (Ordnance Survey 1894a & b), the alum works had been closed for almost 30 years. As might be expected after a period of disuse, the site was beginning to deteriorate and this is evident from the fact that the alum house and adjacent structures are only partially depicted on this edition of the map (Figure 12). This representation of the buildings suggests that a landslip may already have engulfed the rear and eastern sides of the alum house complex. Some detail is still discernible though, such as a small circular feature to the rear of the western part of the buildings. This may correspond to the chimney illustrated in the aforementioned engraving, but equally it could represent a circular cistern, possibly within a roofless building. A pair of parallel lines adjoining the west of the building would appear to represent the low stone walls defining the slipway, or track, also shown in the engraving. Snilah Ponds are marked on this edition of

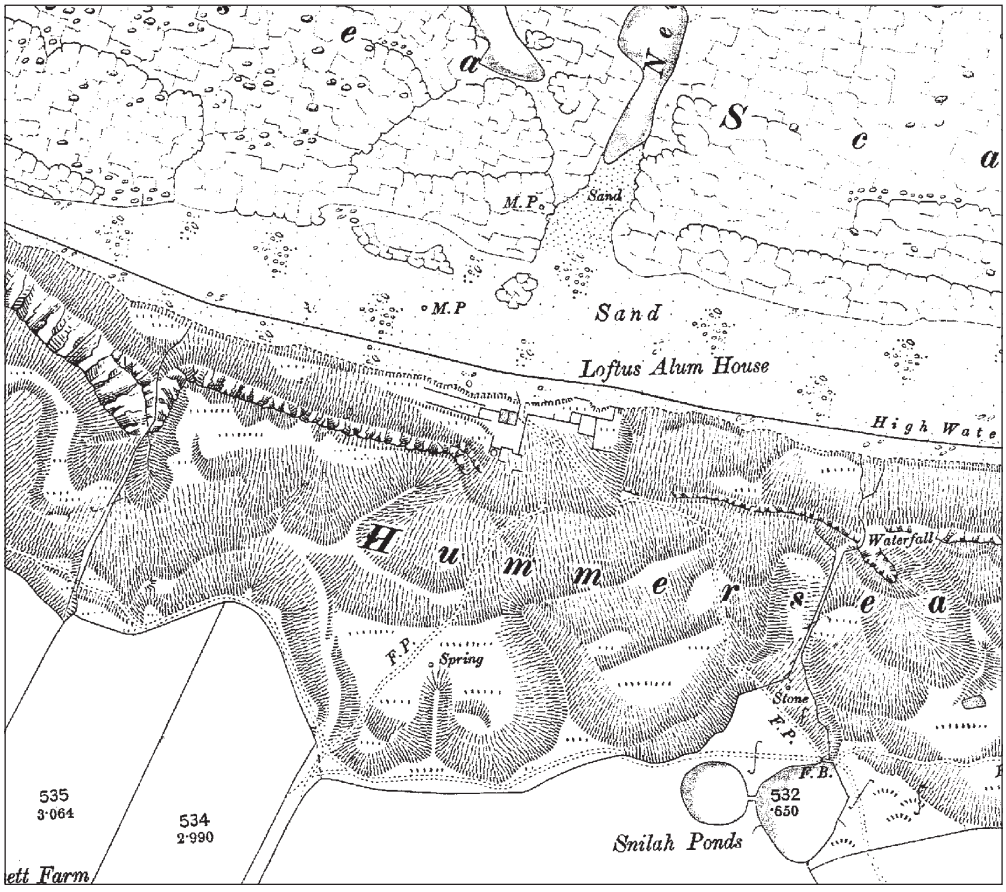


Figure 12. *Extract from the Ordnance Survey 1:2500 map of Loftus and Hummersea, re-surveyed in 1893. Not to scale. (Reproduced from the 1894 Ordnance Survey map)*

the map, with a channel joining the two ponds, suggesting some kind of management of the water flow between them. Further to the east, the pair of cisterns close to the cliff edge in The Warren is still shown, although the building is now roofless, enabling two circular cisterns to be depicted within it. They are now labelled as 'Old Cisterns', indicating their redundancy by 1893. They are still contained within a small building, but it is no longer shaded as it was on the first edition map, suggesting that it had lost its roof by this date. Also within The Warren, towards the centre of the field, are two rectilinear features, which have the appearance of ponds or reservoirs, although they are not labelled.

Along the cliff edge towards the western end of the alum quarries on the 1893 edition of the OS map (Ordnance Survey 1894a) are three areas labelled as 'Old Jet Workings'. These were not shown on earlier maps, so there is the possibility that jet was not extracted until after 1853 and had ceased by 1893. However, it may be that the scale of the earlier map did not allow the relatively small areas of jet extraction to be shown in sufficient detail, particularly as they occurred close a range of steeping pits, and were thus omitted. The scale of the 1893 edition of the OS map has allowed the banks, scarps and spoil heaps of the quarry workings to be shown clearly. However, there are no structures associated with the quarries depicted on this map, which would suggest that any buildings were dismantled at the time of the site's closure. Also depicted on this map are two depressions on the cliff top above the eastern end of the quarries. The more easterly of these is a linear depression some 90m long with a further depression beyond its south-western end; the pair is labelled as 'Old Reservoirs'. To the west of these is a broader more irregular depression truncated by the cliff edge. There are no clear links shown on the map between these features and the alum quarries below.

4.4 20th Century

Possibly dating to around 1900 is a further photograph of Hummersea Bay, which includes the standing structure. The photograph is taken from the western end of the alum quarries, a location that was some distance away from the building, which means that little of the detail of the structure and the area immediately surrounding it is visible. What it does show though is the topography of the area around the structure and the site of the alum house. It seems that the platform upon which the structure stands was less defined by 1900 (when compared with previous photographs), possibly as a result of a landslip from the cliffs behind the building. Although the photograph is not particularly clear, it appears that the chimney had been demolished or had collapsed by this date.

By *c* 1910, a further photograph demonstrates that the structural remains were significantly degraded, and existed only as fragmentary upstanding ruins (Figure 13). Only parts of the southern and western walls were left standing, and these appear to have been in a precarious state. Few of the building's features are discernible, although a doorway can just be made out at the bottom of the western wall. The amount of rubble visible around the base of the surviving ruins suggest that the building had collapsed rather than the stone having being robbed for other uses. Despite the condition of the ruins, the photograph appears to show

people within the building, possibly having a picnic, with little fear of the tall, unstable sections of stone wall above them.

Figure 13. *Photograph of the alum house at Hummersea, possibly dating to c1910. Reproduced by kind permission of Mr K Chapman.*

A further edition of the 1:2500 OS map was published in 1915, having been revised in 1913 (Ordnance Survey 1915a & b), however, it is very similar to the previous edition of the map and very few changes are shown. The quarries themselves are depicted as virtually unchanged from the previous edition of the map. The main difference is in the extent of the alum house and other structures shown. Only a few walls of the buildings were visible at this date, the rest having disappeared below slipped material from the cliff above. Similarly, the building containing the cisterns further east in The Warren is also shown as incomplete, with its eastern and southern walls missing.

5. THE PROCESS OF ALUM MANUFACTURE

The process of alum manufacture has been discussed at length in a number of other publications (Young 1817, 812-4; Almond 1975; Rout 1997 & 2002; Marshall 2002; Jecock *et al* 2003), so only a brief overview of the main stages is given here. Generally, the technique is fairly well understood, but despite a reasonably high level of research, there are still many questions over the specifics of some stages in the process. From the various contemporary accounts it appears that the process of alum making was not cast in stone, with each site adapting the various stages to their own resources and restrictions. In addition, the industry evolved over time, changing and improving as technological knowledge improved. The process of alum manufacture was not a quick one, and it could take up to one year from the time that the shales were extracted to when the finished product was finally shipped out (Almond 1975, 11).

Quarrying

Perhaps the simplest stage, in technological terms, of the alum making process was to obtain the raw alum shale. The cliffs at Loftus are capped with a thick layer of sandstone, thus the initial step was to remove this capping, or overburden. The shale below is quite soft and friable and therefore relatively easily dislodged. The quarrying could thus be undertaken with iron picks, with the quarried shale being transferred to a wheelbarrow for movement to other parts of the site (Almond 1975,11). This activity was labour intensive and would have required a lot of unskilled labour to hew the shale from the quarry face and barrow it around the site. Contemporary evidence, both written and pictorial, has informed current thinking that the quarries were worked in broad terraces, progressively enlarging and deepening the quarry and giving the site a stepped profile.

Calcining

Although the alum shales are relatively soft and friable in their raw state, further treatment was required to render the aluminium sulphate, present in the shale, soluble in water. This was achieved by burning, or calcining, the shale. The burning occurred in large piles, or clamps, made up of alum shale placed on a layer of fuel, usually brushwood. A contemporary witness described how the clamps were built to a height of 4 feet (*c* 1.2m), ignited, and then further piles of alum were added until the clamp was as much as 100 feet (*c* 30.5m) high and up to 200 feet (*c* 61m) in length (Young 1817, 812). The ignition of the clamps had to begin before they reached too great a height otherwise the flow of air would have become constricted, thus impeding the combustion of the material. The clamps were left to burn for a considerable length of time, a matter of months rather than days. It was necessary to maintain a steady level of combustion within the clamp, and this was often achieved by covering any gaps with a layer of damp shale. Weather conditions, such as high winds, could encourage the fire to burn too fiercely. The clamp was allowed to cool over a period of months, during which time, chemical reactions were still occurring, enriching the amount of aluminium sulphate present. Young (1817, 812) observed that the clamps and the resulting alum were often ‘8 or 9 months in forming’. One of the few known depictions of a functioning

alum works is a watercolour of 1843 by H B Carter, which shows two large calcining clamps smouldering in the foreground of the painting (reproduced in Miller (ed) 2002, rear cover and inside front cover).

Steeping

The burnt clamps were finally dismantled and the calcined shale was transported, again via barrows, to steeping pits filled with water, where the soluble salts were dissolved out. The liquid resulting from this process was known as alum liquor. In order to achieve as saturated a solution as possible, it is believed that burnt shale was generally washed several times. This multiple-stage, counter-current process has been discussed and examined in some detail by Alf Rout (2002, 21-23). The actual number of stages in this process would probably have varied through time and at different works. The steeping pits may have been built without any covering, a situation that would have been advantageous in hot weather, when evaporation was aided, but conversely, rainy weather would have diluted the liquor. However, evidence at Kettleness suggests that a lip along the inner edge of a tank would have housed some kind of cover (Jecock *et al* 2003, 45). This process would have necessitated the transference of liquor or shale between tanks. Pumps were utilised to move the liquor, a fact that is confirmed by the inclusion of '10 pumps' in a 1684 inventory of the alum works at Lingberry Hill (Percy Burnett Papers, Ref 1215). However, physical evidence of these has yet to be found. Given the positioning of the quarries, at Loftus in particular, spent shale was probably simply tipped over the edge of the cliff on the seaward side of the site, or may alternatively have been dumped in disused parts of the quarry.

Water supply

Steeping required each alum works to have a large and reliable supply of fresh water. Because demand was periodic, reservoirs or holding ponds were often constructed to store water collected from local springs and streams. There has been little or no discussion in the archaeological literature of how water was actually conveyed from the reservoirs to the pits, possibly reflecting the rarity of survival of significant evidence.

Settling

Once concentrated, the alum liquor was run or pumped off via stone troughs into one or more settling tanks or cisterns to allow fine shale particles and other solid impurities to fall out of suspension and was then transferred to the alum house. The settling cisterns tended to be built in pairs, as is the case at Loftus. Evidence also suggests that they were covered with wooden boards to protect the liquor from rain and further contamination. Once the liquor had clarified in the cisterns it was generally conveyed to the alum house in a trough, often made of wood, or possibly through lead pipes. Gravity was used to enable the conveyance of the alum liquor from the cisterns to the alum house, which may often have been situated some distance away from the quarries and settling tanks, for reasons discussed below. In some cases, therefore, the trough extended over a considerable distance, crossing difficult, uneven terrain.

The Alum House

The processing that occurred in the alum house required large amounts of coal and alkali. As a result, the alum house was usually sited at a location which minimised the distance over which these raw materials had to be transported. In the case of coastal works, this would have entailed establishing the alum house close to a dock, giving the works a significant advantage over inland sites, which would have been reliant on more expensive road transport. Indeed, this is the case at Loftus, where the final alum house was located just above beach level at Hummersea, approximately 1km from the western end of the alum quarry and about 100m below it.

The remaining processes, namely concentration, crystallization and washing, all took place in the alum house. The alum liquor was mixed with a proportion of previously concentrated liquor (known as 'mothers') before being further concentrated by boiling off the water in lead-lined pans until it had reached a certain specific gravity. At this stage either burnt kelp (to provide potassium sulphate) or urine (ammonium sulphate) was added. Urine was more commonly used up until the mid-18th century, but this was superseded by the use of burnt kelp, which was itself soon supplanted by the use of muriate of potash (potassium chloride). The liquor was decanted from the settlers into wooden tubs, where it was allowed to cool over a number of days. As it cooled, it crystallised on the side and floor of the tubs. Any solution remaining in the tub was then collected and re-cycled into the process as 'mothers'. The alum crystals at this stage still contained impurities and may have been brownish in colour. To remove these final impurities, the crystals were washed or roached, that is, re-dissolved in the minimum amount of hot water and the resulting solution run off into casks (or 'roaching tuns') to cool and re-crystallise. After about 16 days, the tuns were dismantled to reveal a solid crystalline block with a liquid centre. The block was then drilled to allow the remaining water to run out before being sawn up and ground down into powder.

Transport

Coastal alum works were able to import raw materials and export the finished product via the sea, which would have kept costs down. The production of alum required large quantities of heavy and/or bulky raw materials, such as coal and alkali, which meant that transport links were of great importance when considering the location of the alum house. As a result, alum houses were either positioned in or above bays where vessels could safely beach, or harbour works were provided where the coast was rockier and more exposed. The rutways often found cut into the rocky foreshore at a number of places on the north-east Yorkshire coast are connected with a variety of industries including alum production. These rutways would have been created to guide the carts unloading or loading ships beached on the foreshore along safe routes, particularly at night or in poor conditions.

6. DESCRIPTION AND ANALYSIS OF THE FIELD REMAINS

A complete survey plan of the Loftus Alum Works and its immediate environs at 1:2500 (Figure 41) and a further survey plan of the area of quarrying at 1:1000 scale (Figure 42) are included in a wallet at the rear of this report. The sheer size of the area covered by the site does not lend itself to description as a single entity, so for the purposes of this section, the site will be divided up into a series of discrete areas. The quarry area will be divided into six main sections, shown on an annotated version of the survey plan (Figure 14), while the area of 'The Warren', the alum house at Hummersea and the features on the foreshore will all be examined separately. Surviving evidence of the processes will be considered for each area in turn. The description of the quarries will start from the eastern end, an area which has commonly been assumed to be the earliest part of the works, given its proximity to Lingberry Hill, an assertion further explored in Section 7.

6.1 The Quarries

In order to access the alum-rich shales, some areas of sandstone capping (*see* Section 2) have had to be removed. Below this, the quarrying at Loftus follows a broad pattern, which forms three principal terraces. There is a main level of quarrying, which is now largely boulder covered. Dumps of overburden and large spoil-heaps within the quarries result from the exploitation of this main level. Below this, an intermediate level houses the bulk of the visible quarrying remains, with a further lower level of quarrying occurring in places, adjacent to the cliff edge. Parts of this lowest level have been lost to cliff erosion.

Virtually all the evidence relating to the upper level of quarrying, which survives as an inland cliff overlooking the whole length of the quarried area, has either been quarried away or is concealed beneath a covering of large boulders. This would have been created by the initial quarrying at the site and it would have been from the upper level that the shales richest in aluminium sulphate content would have been extracted. This upper level may have been worked in curved sections, as in places there are examples of spines of unquarried rock and shale protruding from the main face. These can be seen at the far eastern end of the site just beyond area 1 and also abutting the large spoil heap in area 5. The material may have been left *in situ* to give some degree of stability to the quarry face as the quarrying progressed deeper. This may have occurred elsewhere along the inland cliff face, but subsequent rock falls have obliterated it.

6.1.1 Area 1 (Figure 15)

Area 1 is situated at the far eastern end of the site. To its south is a broad swathe of debris from previous rock falls, mainly composed of boulders of varying sizes, which have accumulated to a substantial depth, and are generally covered with thick bracken and heather, making the area difficult to negotiate on foot. Given the treacherous nature of this area, it was decided not to survey it in great detail, particularly as any surviving features are likely to be obscured by fallen material. Unlike the other areas of quarrying adjacent to the cliff face at Loftus, area 1 has been worked at just two levels, with no evidence of the

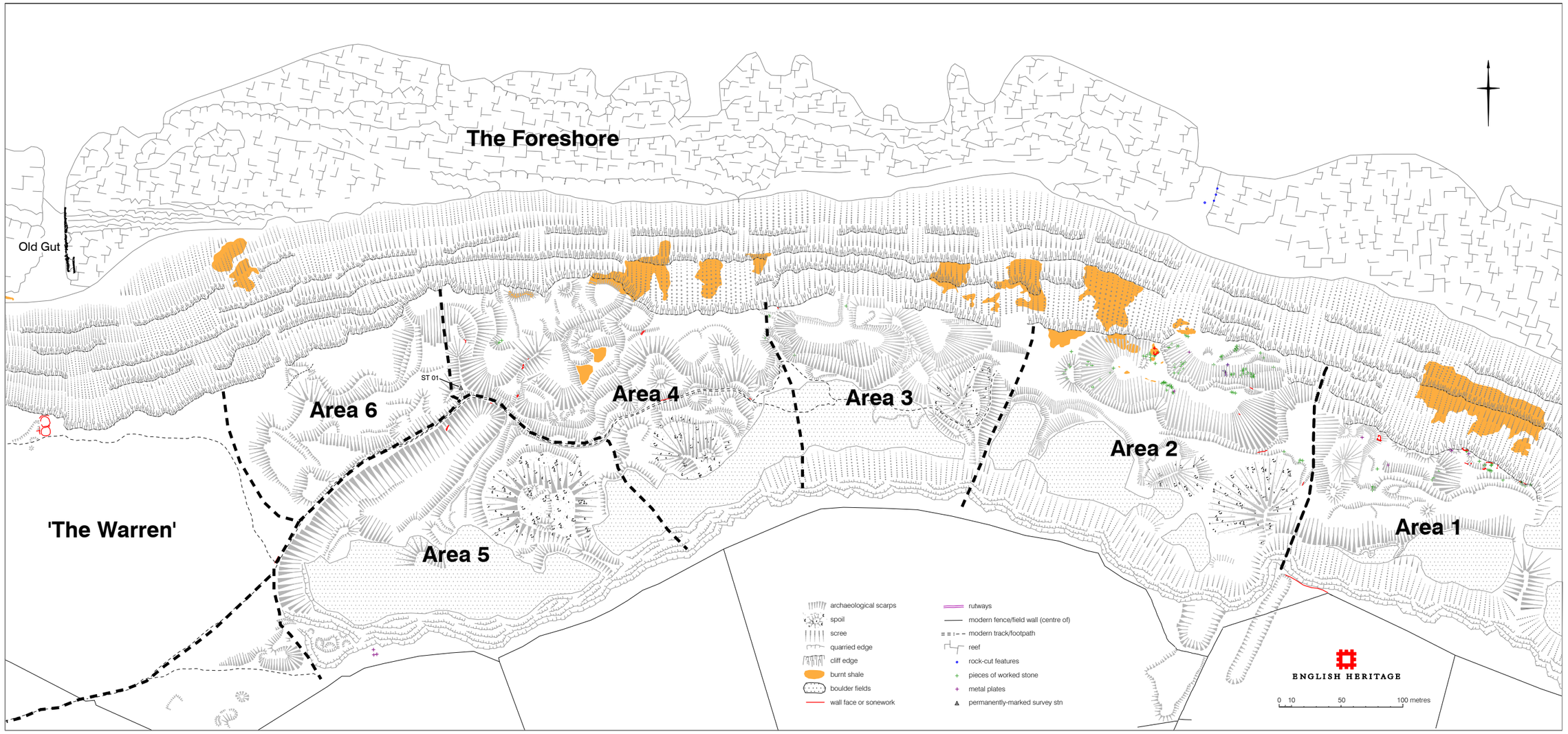


Figure 14. *Plan of the Loftus alum quarries annotated to show the numbered areas as referred to in the text*

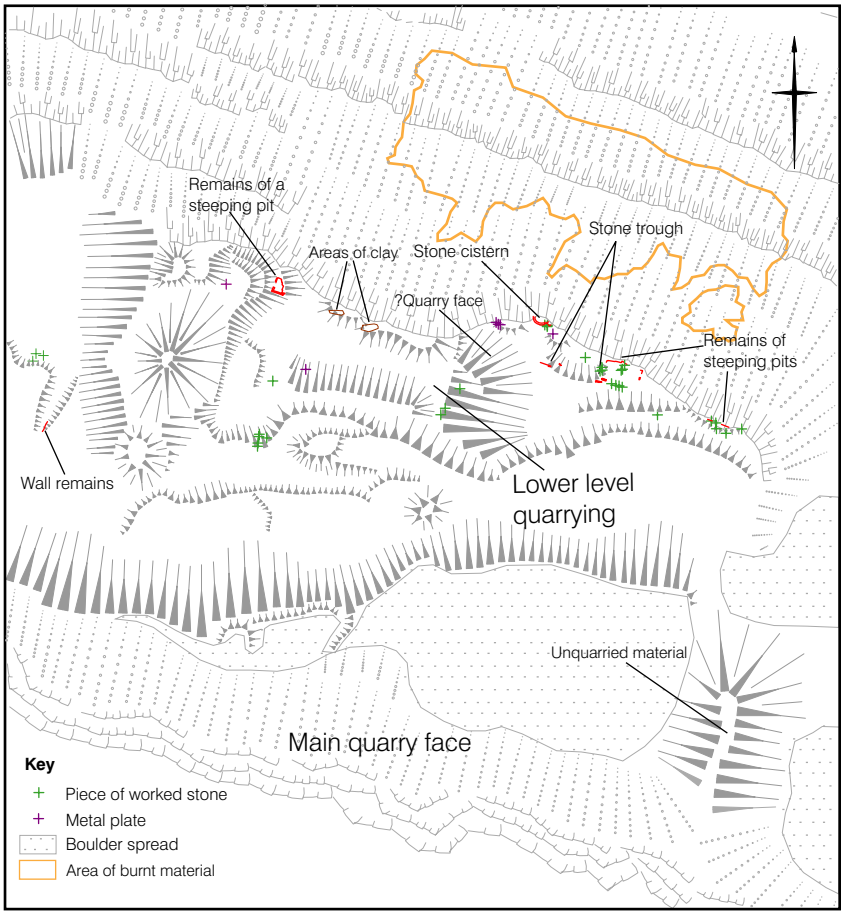


Figure 15. *Annotated plan of features in area 1 described in the text, reduced from the 1:1000 site plan*

intermediate level of quarrying that can be seen as a 'stepped' effect within the other quarries to the west. The quarry floor relates directly to the main quarry face at the rear of the area.

Quarrying

In front of the spread of boulders, to the south, a relatively low slope defines a generally flat platform between the rubble and the lower level quarry features. In front of this, towards the middle of area 1, is a very steep slope, which is cut into the *in situ* shales, and represents the worked face of a quarry some 5m deep. Visible along the top of this cut is a thin band of reddish material, which appears to be burnt shale. At the foot of the lower level quarry face is a talus slope, a gentle slope that represents the accumulation of loose shale weathered from the quarry face. A similar slope to the east, again composed of eroded shale, leads to a level area some 5m lower. A very steep, north-south cut-feature, defining the eastern half of the lower level quarrying, at right angles to the cliff edge may represent a section of worked quarry face, but the limited extent of this feature suggests that it was probably not particularly productive. There does not appear to have been an intermediate level of quarrying in this area.

Calcining

Along the cliff edge are areas of reddish material, which correspond with further expanses on the cliff edge below, recorded from aerial photographs. This is interpreted as discarded burnt alum shale, perhaps from removing the capping of calcining heaps, that was tipped

over the cliff edge, which here is mixed with a relatively high density of worked-stone rubble. It is difficult to say, in the absence of any positive evidence, whether any calcining was actually undertaken in this part of the quarry. Space is now limited in this area, possibly as a result of erosion of land over the cliff edge, but even if this is the case, this is still not one of the larger areas of the site. If calcining had occurred, the existence of extensive flat areas, or possibly large flat-topped mounds which would have acted as the base for calcining clamps, might be expected.

Steeping Pits

It is at this far eastern end of the alum quarries that some of the most complete structural remains survive, but these are in a very poor state of preservation and parts are in imminent danger from further cliff erosion. The seaward cliff edge is some 130m high at this point and is very unstable, so a close inspection of any structural remains was difficult during this survey, although it was possible to record some fragments of stone which appear to still be *in situ*. At the far eastern end of area 1, a line of stones protruding from the cliff edge was recorded, in two fairly short sections of approximately 1m and 2m long respectively (Figure 16). These are clearly the remains of a sandstone slab floor laid on top of a bed of yellowish clay, which would have provided a layer of waterproofing. Loose sandstone blocks close to this feature are likely to have been fragments of this same structure, while reddish shale covering parts of the structure is burnt alum shale. Some 20m further west along the cliff, the northern edge of another structure was recorded, with a return at its western end and the suggestion of another to the south. The material covering the remains of this structure, like the previous one, also has a reddish hue, presumably indicating that it has been burnt. Worked sandstone blocks lying close to these *in situ* remains appear to have originally formed part of the structure but have been dislodged. These two groups of remains are likely to be the surviving parts of a range of steeping pits, even though they are on a slightly stepped alignment.

Figure 16. *Stone slabs, originally part of a steeping pit floor, protruding from the cliff edge at the eastern end of area 1*

A short distance back from the cliff edge, south-west of the latter section of the steeping pits, pieces of worked stone which formed part of a long, narrow stone trough were recorded. Two sections of the trough seem to survive *in situ*, but the intervening section has been removed or covered by loose shale. Assuming that the trough originally ran between the two surviving sections, then it must have been at least 17m in length. The westerly section of the trough has a square-cut notch in one edge at its eastern end, measuring some 25cm long by 10cm deep (Figure 17). This would probably have housed a metal plate which could have acted as a sluice gate to control the flow of liquid. An orange residue within the recess may possibly be traces of rust from the original sluice. A further stretch of trough could have been aligned at right angles to the notch, and then carried liquid towards a cistern, which partially survives in the cliff edge nearby.

Figure 17. *Section of stone liquor trough with square-cut notch*

The remains of a stone cistern (Figure 18) lie slightly to the north-west of the trough remains and sandstone floors protruding from the cliff face. It is of double-wall construction with traces of a waterproof lining of clay between the two walls. The surviving part of the cistern represents less than a third of its original extent, the rest having eroded over the cliff edge. Some of the stone comprising the inner wall of the cistern is a reddish colour, presumably as a result of a chemical reaction with the original contents of the cistern, rather than because of any burning activity. The 1970s photographs of the site include one of this cistern (Figure 19), and when compared with a more recent photograph of the same feature

Figure 18. *Remains of a circular cistern in the cliff edge. A gap can be seen between the two walls of the structure.*

Figure 19. *Photograph of the circular cistern from the 1970s. Reproduced by kind permission of Mr K Chapman.*

(Figure 18), it shows the rate of loss over 30 years. Another photograph in this collection seems be of a second, similar cistern that was also located in this area, perhaps forming a pair. They may have been similar in design and function to the two cisterns recorded at the edge of The Warren, (see below, Section 6.2). Both sets of cisterns are discussed below in Section 7.

Towards the western end of area 1, is another partially exposed sandstone floor with traces of a low wall around its southern and western edges, which stands no more than three courses high. Much of the structure has eroded or is covered by loose shale, but the clear indication is that this was once a steeping pit. A short distance to the south-east of these remains, two areas of clay were recorded (Figure 20). Their roughly rectangular shape suggests that these were clay bases upon which steeping tanks were built, in order to waterproof them. Given the spacing of the two areas of clay, it is likely that they were part of a range of steeping tanks, which would also have included the aforementioned pit. The cliff in between this range of pits and those at the eastern end of this area has eroded quite badly, so it is possible that more pits, or other structures, once existed here, a suggestion

Figure 20. *Clay base upon which a steeping pit would have stood. In the distance the structural remains of a steeping pit can be seen, which was probably part of the same range.*

further strengthened by the proliferation of worked-stone debris on the cliff face below. The inference to be drawn from the evidence observed here is that a range of steeping pits and a cistern, or pair of cisterns, were used for the primary processing of the alum shales extracted from, and possibly calcined in, this area.

Other Associated Features

A section of walling, constructed of the ubiquitous sandstone blocks used elsewhere in the works, stands between areas 1 and 2. All that survives of this wall is a 3m section standing to a maximum of 3 courses high. There is undoubtedly more of the wall in existence, but it is now hidden beneath accumulated loose shale and vegetation. It seems to have been built against a cut into the alum shales situated to the east of the wall. There is no evidence of a return of the wall or any traces of stonework opposite, however, much loose shale has collected in this part of the site, which may have resulted in some features being obscured. The wall is almost certainly *in situ*, but without exposing more of it, its function and purpose are impossible to ascertain.

Above areas 1 and 2 at the top of the inland cliff face are a pair of features (*see* Figure 21) which correspond with those shown on the 1894 edition of the OS map of this area (as discussed in Section 4). These are a long rectangular depression, just under 100m long, to the east and a further depression to the west which is also rectangular, and some 40m long, but is broader and its northern end has been truncated. Both of these features have, in the past, been interpreted as reservoirs which supplied the alum works with water (Marshall 1993, 4). The eastern feature certainly seems to have been used as a reservoir, although the method of conveying the water from the top of the cliff to the site below is unclear. On top of the bank forming the northern end of the reservoir are the remains of a field wall, which suggests that the reservoir may have been connected with the farm to the south rather than with the alum works to the north. However, in the absence of any evidence of pipes or sluices, it is difficult to be sure what the reservoir was supplying. The western feature is much less well-defined in appearance and is probably natural rather than man-made. The depth of the sandstone capping in this area is minimal and it may be that this depression is actually the result of overlying boulder clay slumping to fill a gap in the rock capping up to the cliff edge, which would explain the 'truncated' look of the feature.

6.1.2 Area 2 (Figure 21)

There are three levels of quarrying in area 2, the main level, an intermediate level and a smaller, lower level towards the east of the area (Figure 22). Separated from area 1 by a broad plateau, area 2 is more extensive and more enclosed. A near vertical face created during the quarrying of the intermediate level encircles the rear (south) of the area.

Quarrying

There are few extant features of note relating to the quarrying within the intermediate level, which is dominated by the quarry face and a long slope of eroded shale abutting the foot of it. This upper level was quarried to a maximum depth of approximately 24m. The lower level of quarrying was taken down a further 8-9m. Adjacent to the cliff edge, at an oblique angle,

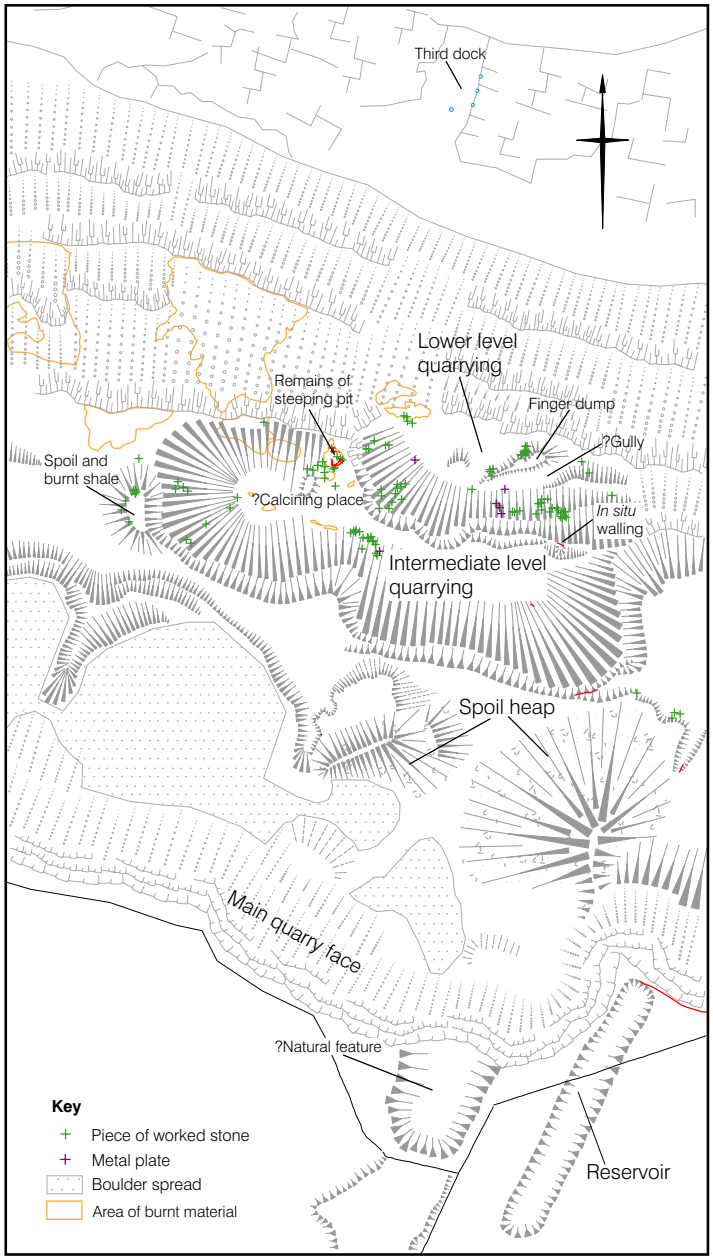


Figure 21. *Annotated plan of features in area 2 described in the text, reduced from the 1:1000 site plan*

Figure 22. *Photograph of area 2 from the west. The lower level of quarrying can be seen at the left of the photograph and the intermediate level in the middle.*

is an elongated-teardrop shaped mound, which seems to define some sort of gully from the quarry floor to the cliff edge. This gully, to the west of this mound, is a route along which waste material from the processes could have been transported for deposition over the cliff edge. The mound itself is a finger-dump and contains pieces of worked stone.

South-east of area 2 is a very large, steep-sided mound, approximately 20m high. It is largely composed of fine rubble mixed with earth, perhaps the spoil from the removal of the overburden to reach the alum shales. Given the size of the heap, it may be that this was the primary spoil-heap from the excavation of the main quarry face in area 2, but it could also have been used for spoil from area 1. However, the debris from the latter may have been tipped either over the cliff, or further to the east into that part of the site which lies beyond the surveyed area which appears not to have been quarried. A slightly smaller spoil heap lies to the west of the very large mound. This part of the site, as with the previous area, has a spread of boulder debris behind it at the foot of the main quarry face. It does not seem likely that this is obscuring any major features, although it may be covering evidence of initial quarrying or worked-out shale seams.

Calcining

At the western end of this quarry, situated at the top of the quarry face, is a mound of material, much of which appears to be spoil derived from the quarrying. There is a cap of reddish burnt shale on top of the mound, which creates a clear interface with the debris lower down in the mound, suggesting that it was deliberately dumped on top of the other material. Where the calcining took place to create this burnt material is unclear. One suggestion with regard to the process of calcining on the site is that the intermediate area of the quarry may have been deliberately quarried out to create a level floor upon which to build the calcining clamp. This would have allowed the shale to be tipped from the upper level of the quarry to form the clamp, and means that the reddish material visible all along the cliff face can be explained as waste burnt shale discarded from the calcining floor. Also in favour of this suggestion is the fact that the deeper the shales, the smaller the yield of alum per tonne, so this section of the quarry is unlikely to have been used to supply large quantities of shale for processing or to have provided shale at much commercial value.

Steeping pits

Part of the floor of a steeping pit consisting of a number of sandstone slabs laid on of a base of yellowish clay, apparently *in situ* and akin to the remains in area 1, is located on a knoll of unquarried shale close to the cliff edge and a short distance from the top of the lower level quarry face (Figure 23). Numerous stones and worked stone fragments close by are likely to be the remains of the rest of the pit, or possibly the remains of others located nearby. As with most of the structural remains at Loftus, an area of reddish material overlies the steeping pit floor and can be seen in the area around it, possibly traces of the last load of burned shale put into the pit. A number of loose, worked sandstone blocks, some fragmentary, were recorded on the slope of eroded shale, concentrated towards the middle and at the western end of the intermediate quarry. The scatter of stones suggests that they are most likely to be what is left of a structure, or structures, which has slumped into the quarry from

above. A much higher density of worked stone blocks and fragments of blocks was recorded in the lower level of the quarry.

Figure 23. *Photograph showing the surviving sandstone slab floor of a steeping pit in area 2*

Like the intermediate level, the lower level of the quarry also has a sheer south face with a more gentle slope of eroded shale at its base, and it was on the longer more gentle slope that most of the stonework was observed during this survey. More stonework was found on top of a fairly large, elongated-teardrop shaped mound of deposited shale, as described above, close to the cliff edge. Pieces of iron plate, which were either used to allow barrows to pass along the tops of the steeping pit walls or acted as sluice gates in the troughs conveying liquid through the site (*see* Figure 17), were also found on and near the mound. The evidence strongly points towards the existence of buildings in this area, but aside from the *in situ* steeping pit floor at the west of end area 2, none of the remains are in their original location. The proliferation of worked stone pieces on the eroded shale slope of the lower quarry suggests that the buildings may have originally been located in the intermediate quarry, but have collapsed and fallen down into the lower part, possibly destabilised by natural erosion. In support of this theory is the existence of a short stretch of stone wall, close to the top of the intermediate quarry face, which sits within a C-shaped depression. The exploitation of the lower levels of shale would have resulted in the abandonment of the structures in the intermediate level and presumably the construction of new structures in a more convenient location. Some of the dressed stone rubble in the teardrop-shaped finger dump in the lower level of the quarry may have come from the abandoned structures from the level above.

6.1.3 Area 3 (Figure 24)

The main quarry face continues along the rear of this area. However, the principal worked quarry face in area 3 is at the intermediate level and occupies its western part, almost

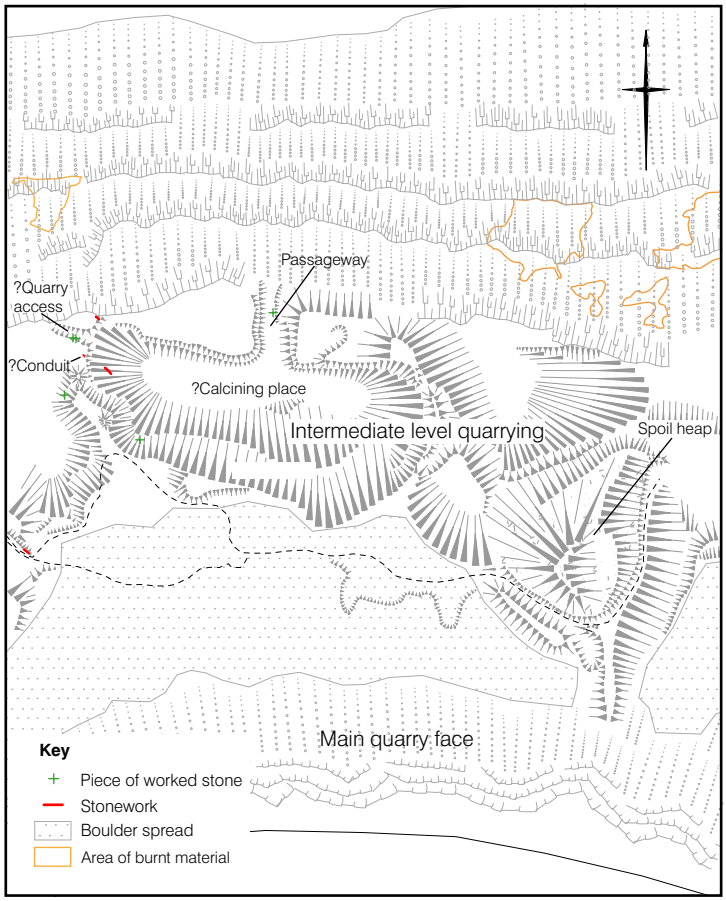


Figure 24. *Annotated plan of features in area 3 described in the text, reduced from the 1:1000 site plan*

completely encircling a kidney-shaped area (Figure 25). A further area of quarrying, which forms an irregular C-shape, occupies the eastern part of area 3. These are referred to as quarries, although they may have been created specifically for use as calcining places. There is no evidence of any lower level quarrying activity here.

Figure 25. *View of area 3 from the south-east, showing the principal, kidney-shaped quarry*

Quarrying

The rear face of the western, kidney-shaped area of quarrying is similar to those seen in other parts of the site, although this is one of the highest with a sheer drop of some 16m, before becoming a more gentle slope of eroded alum shale, which drops a further 3-5m to the quarry floor. Unlike the other episodes of alum quarrying at Loftus, this particular quarry also has a worked face to the north, adjacent to the cliff edge, although this is much shallower than the rear face. The quarry appears to have been worked in such a way that a buffer zone of *in situ* shale was left between the quarried area and the cliff edge. This might have helped to prevent erosion over the cliff edge which would have occurred if the shales had been worked right up to the edge. There is a cut in the middle of this baulk of alum shale, creating a passageway that leads to the cliff edge. Within this is a rough alignment of stone rubble was recorded during this survey, possibly indicating the former route of a stone trough or similar feature. Spread over the cliff top at the end of this passageway is a substantial amount of burnt material, suggesting that it provided access from the quarry to the cliff edge for the disposal of debris. This further adds to the suggestion that calcining and steeping were undertaken within the quarry. Access to this part of the quarry seems to have been through a corridor to the west, also cut into the shales. The gentle gradient of the access suggests that it was designed to allow barrows easy access to the quarry.

In the eastern part of the intermediate quarrying level in area 3, the distance from the top of the quarry face to the quarry floor is approximately 12m. There are no surviving features of note within this section, although the eastern slope of the quarry, which is primarily formed from eroded shale, does have a fairly high density of broken stone on its surface. This stone has not been worked and is possibly the remains of small-scale ironstone extraction, rather than debris from alum manufacture or discarded building stone. Above the quarry face is a clear interface between the top of the cut shale and a dump of rubbly material on top of it, which is the north-west edge of a spoil heap, discussed below.

The spoil heap is not as large as the example to the east of area 2, but it is still up to 9m high in places. As mentioned above, its north-west edge sits on top of the worked face of the adjacent quarry. This clearly demonstrates that the spoil heap post-dates the quarry and must have been formed of material extracted from elsewhere. To the rear of this spoil heap, there is a spine of debris which buts up to the cliff face, but part of this appears to have been formed of material falling from the cliff above. A path through the site has been cut into the south and east sides of the spoil heap. The path is not shown extending this far on the OS map of 1893 (Ordnance Survey 1894a), and is thus likely to post-date the alum quarrying at the site.

Calcining

The primary evidence for calcining in area 3 is a deposit of reddish, burnt material, mainly on and around the cliff edge. As described above, there is a passageway leading to the cliff edge that seems to have been used as a barrow route for disposing of debris over the edge. One possibility is that the calcining took place within the quarry itself, and that the two baulks of shale adjacent to the cliff edge were left deliberately to afford some degree of

protection to the clamps, in order to control the burning. Again though, there are no physical remains surviving of a calcining clamp and the evidence is merely circumstantial.

A very short section of masonry, consisting of three aligned blocks of stone, in the western face of the principal area of quarrying is the only evidence of any revetment in this area. It is not *in situ*, but is more likely to have slumped down the slope from its original position. Whilst this is only a small section of masonry, it does hint at the earlier existence of more substantial revetting in this area. Whether or not this was connected with the calcining of shales within this quarry is unclear, but given the floor area available for the construction of calcining clamps, it is a possibility.

Steeping pits

Unlike both areas 1 and 2, there is no evidence that area 3 ever contained any steeping pits, and there is an almost total absence of worked stone fragments on the surface. A piece of loose stone was, however, observed during this survey on a slope at the far western end of the quarry and a pair of worked stones were recorded in the southern face of the cut defining the access slope to the quarry from the west. In the eroded alum shale slope just to the south-east of the access slope, there are two further sections of stonework visible, which seem likely to have slipped down the slope from an original position above. On the flat area adjacent to the western end of the quarry, is a piece of stonework, partially covered by loose shale. A void underneath it suggests that the stone was a capping stone covering a narrow conduit, which seems to have been cut later by the shallow quarry face. Although scant, this evidence strongly suggests that water was being transported around this part of the site and was being supplied to this quarry. Unfortunately, the paucity of further evidence means that it is difficult to hypothesise the wider extent and form of such a system of conduits.

6.1.4 Area 4 (Figure 26)

This area lies to the west of area 3, and has a somewhat different physical appearance. The remains have been colonised by vegetation to a much greater degree and in very few areas are the grey shales, typical of the eastern end of the site, visible to the same extent. The distinctions between areas of quarrying are also less clear at this end of the site and there is a much higher density of earthworks. The main track through the site bisects the eastern part of area 4, and in places its northern edge has been revetted, presumably to offer some stability in view of the adjacent quarrying. Situated slightly lower than the main path, there is a break in the slope and a linear flat area, which may possibly be the route of an even earlier path. This may have been re-routed in response to further quarrying, or was perhaps moved up the slope to a more stable area.

Quarrying

The quarrying within area 4 can be divided into two sections, as the eastern part is slightly different in character from the western part. The main path runs through the middle of the eastern part, on a course that seems to be a later diversion. The path is shown on the OS First Edition map of 1853 curving more sharply than now towards the cliff edge before taking a westerly route parallel to the cliff. On the southern side of the present path, below the

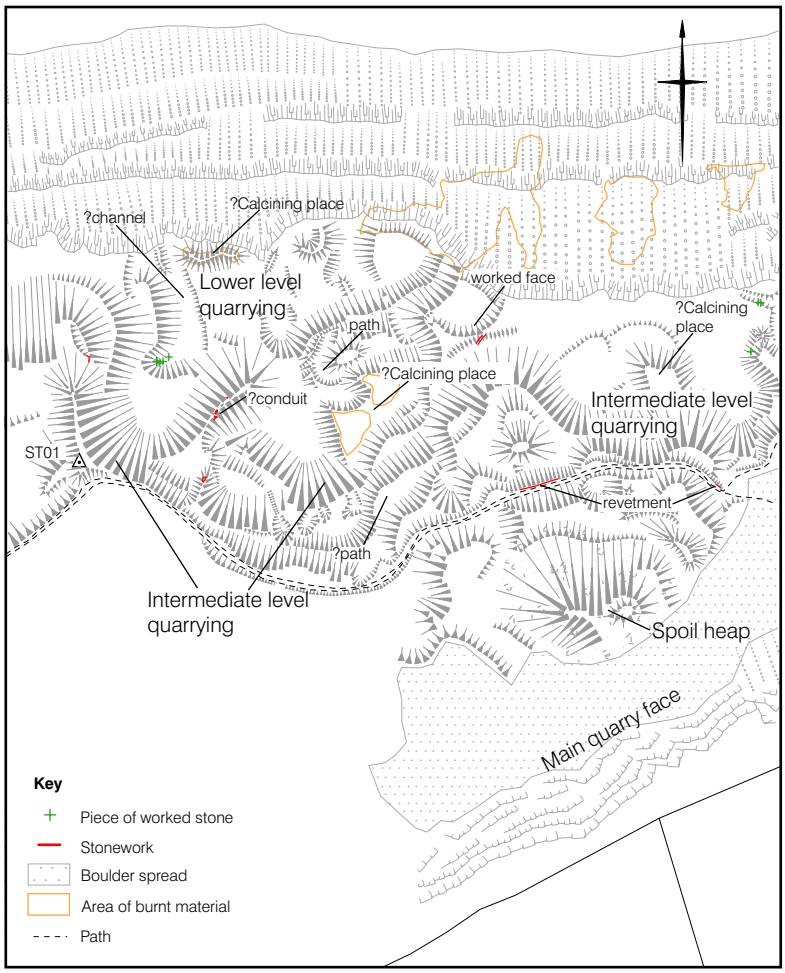


Figure 26. *Annotated plan of features in area 4 described in the text, reduced from the 1:1000 site plan*

main quarry face, is a spoil heap, which stands between 8m-10m high. Between this and the path are other slopes, some of which are continued below the path, to the north, demonstrating the later date of the route of the path. Below the path, a long, sinuous, steep slope represents the course of the intermediate quarry face. At the foot of the intermediate quarry face is a short section of worked face, which stands somewhat in isolation. A faint bank was recorded above the worked face, in the middle of which is a piece of masonry, although what this relates to is unclear.

The western part of area 4 is larger than the eastern part, and has been worked on two levels. The main feature of the intermediate level of the quarry is a steep slope at the rear of the area. The slope snakes around to create two lobes in the quarry face, divided by a spine of unquarried material. This spine does not seem to contain a particularly high density of shale, which could explain why it was left intact. Alternatively it could have been left to create two distinct sections, possibly for calcining as the rear quarry face affords a good degree of protection from the wind. Stretching across the front of these quarries, to the north, another worked face indicates a drop down to the lower level in this part of the quarry. There are few features of note on the quarry floor in this area, but a long slope, on a north-south alignment, at the western end defines one side of a shallow channel, which leads to the cliff edge.

Calcining

In the middle of area 4, below the path through the site and at the foot of the intermediate quarry face, is a platform, defined by a slope to the north and west. Patches of reddish, burnt material on this platform, which are some of the most extensive within the areas of quarrying on the site, suggest that alum shale was burnt in the vicinity. The platform may have been the base for a calcining clamp, a suggestion which is given further weight by the existence of a curved path leading up to its north-eastern edge. Smaller platforms are visible cut into other slopes in this area, for example, below the path in the western part of area 4 (Figure 27), but these may have been too small to have been used as calcining places.

Figure 27. *Platform (indicated by the arrow) within area 4*

Another calcining place may have been located on the cliff edge to the north-west of area 4. An irregular bank, made up of a significant amount of burnt shale material, seems to be defining the rear half of two curved areas, the front of which appear to have eroded over the cliff edge. To the east of this, another steep bank, consisting of a high density of white, burnt shale, defines a circular feature, half of which also seems to have fallen over the edge of the cliff. The nature of the material that forms this feature again suggests that it was used specifically for burning, possibly a calcining place. At the far eastern end of the lower level of the quarry, scarps define another flat area, upon which is an area of reddish burnt material. This platform would again have been a suitable location for a calcining clamp, so it may be that in this part of the quarry there were a number of calcining clamps along the cliff edge. Such an arrangement would have allowed the waste products from the process to be easily disposed of over the cliff edge. If, as map evidence suggests, there were steeping pits located on the floor of the lower level of the quarry, then these clamps would have been conveniently located for the easy transfer of calcined shale into the pits.

Steeping pits

Absent from this part of the quarry were any distinct remains of steeping pits, as witnessed elsewhere. There are, however, plenty of flat platforms and level areas amongst the slopes in this section of the quarry, which may have housed steeping pits, but firm evidence is

lacking. Cartographic evidence, in the form of the depiction on the OS First Edition map, shows that there was a range of steeping pits situated close to the possible cliff edge calcining places (discussed above), on the floor of the lower level quarry. The lack of any stonework indicating the location of any such pits may be connected to the fact that stone was removed from the site in the 1970s. It is believed that machinery to remove stone was brought in from the west end of the site, thus making it more likely that the western end was completely denuded, while the more inaccessible material at the east end was left partially *in situ*.

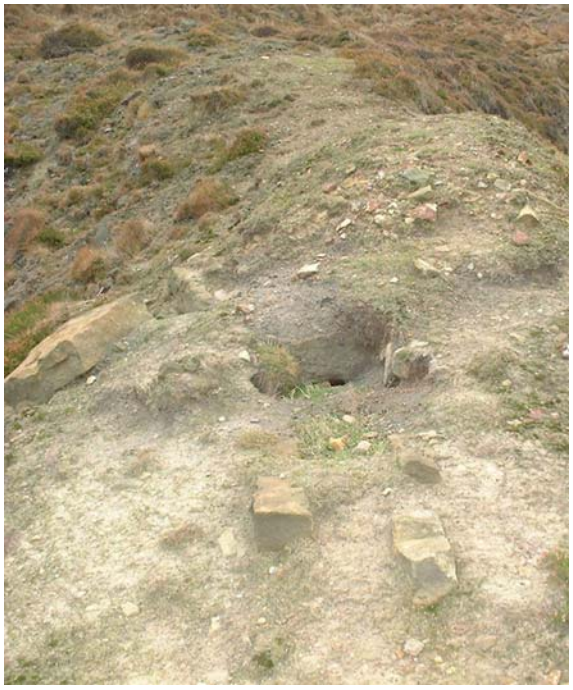


Figure 28. *Remains of a conduit in a spine of unquarried material in area 4*

The only fragment of evidence which appears to relate to the transportation of water in this part of the site is a short section of conduit, apparently *in situ,* on the top of a spine of unquarried material to the east of the base station (ST01) (Figure 28). The origin of the stone-capped channel is unclear, as is its destination.

6.1.5 Area 5 (Figure 29)

Area 5 is defined by two main components, a very large spoil heap and a long, deep quarry, which lie to the south of the main path through the site. The sandstone capping in this area is much thicker than in other parts of the site, measuring approximately 20m, and it may be for this reason that quarrying was not continued further to the west, as the removal of such quantities of stone would have been uneconomical.

Quarrying

Although part of the quarry floor is quite boggy, with a small amount of standing water amongst the vegetation, there is little doubt that this was an alum quarry. The north-western quarry face in this area is shown on the OS First Edition map where it is labelled 'Alum Quarry' (Ordnance Survey 1856a). The north-western side of the quarry has been cut down from the ground surface to a depth of 12-13m, whilst at the south-eastern side it is 6m between the quarry floor and the access path cut into the slope, representing the top of the quarry face. The south-western end of the quarry is not as well-defined as the other parts, as it is covered by a substantial amount of boulder rubble from the cliff face above.

Within the quarry itself, the only features of any significance are two stretches of masonry. The first of these, situated towards the top of the north-western quarry face, is about 3.5m long and appears to be *in situ* (Figure 30). This may represent the remains of a revetment wall, as this face of the quarry is very steep and is not particularly stable. Another section

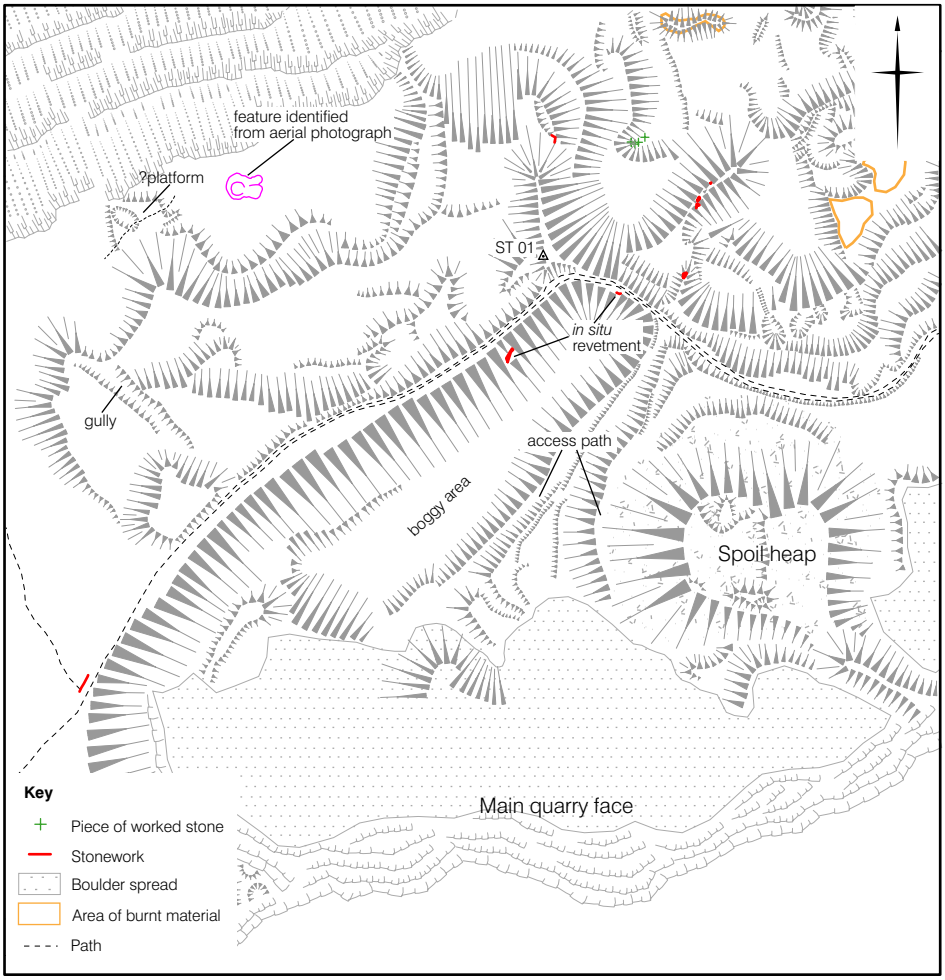


Figure 29. *Annotated plan of features in areas 5 and 6 described in the text, reduced from the 1:1000 site plan*

Figure 30. *Remains of revetment walling in the north-western quarry face of area 5*

of apparently *in situ* masonry exists in the north-eastern face of the quarry, some 2m in length and consisting of three courses. This too is presumably the remains of a larger revetment wall, which would have been needed to reinforce the quarry face, as the main access track follows its top edge in this area.

Adjacent to the quarry is a very large spoil heap, as much as 19m high in places and with a flat top. The base of the spoil heap has been cut into to create platforms and access paths. Between the quarry and the spoil heap are paths that give access to both features. It is possible that the spoil heap was predominantly created from material cleared from the upper working floor of the main quarry face to allow the opening of the intermediate quarry, which now dominates area 5, in order to access the shales below. There are paths adjacent to, and cut into the side of, the spoil heap, which could have been used as barrow-runs to enable the gradual build up of the mound. Bearing in mind that the large quarry in area 5

would not have been open at this point, the height difference between the growing spoil heap and the working floor would not have been particularly great. This would have allowed material to be added to the heap, using barrows, relatively easily. On top of the mound, there are discrete dumps of material, which presumably represent the last loads of waste to be deposited on the spoil heap.

Calcining

The evidence for calcining activity elsewhere at Loftus is mainly the presence of deposits of reddish burnt shale. However, in Area 5 there are no such deposits, and the only possible evidence is that provided by sections of masonry observed within the quarry faces, and described above. Calcining is generally understood to have taken place on flat areas of ground, sometimes surrounded by faces of unquarried shale. In some cases, in order to stabilise these unquarried sections, a revetment wall was constructed. This is probably best demonstrated by the surviving examples at the western end of the Boulby alum quarries, which lie a short distance to the east of Loftus. It would appear that this may have been the case within the large quarry in Area 5. This is the only place within the quarries at Loftus where any evidence of revetment of unquarried shale faces was recorded. However, the factor that perhaps discounts this theory is the amount of water present on the quarry floor, which would not have been conducive to the burning of shales.

There is no surviving evidence to suggest that there were any steeping pits located in this area.

6.1.6 Area 6 (Figure 29)

To the west of the spine of land on which the base station, labelled ST01, was set up, an area of uneven ground shows evidence of some man-made features. However, it seems fairly unlikely that any large-scale alum extraction was carried out in this area. It is possible that small amounts of exploratory work were undertaken here, but it is unlikely that this was expanded into anything more substantial. It seems highly probable that this area may have been associated with later jet extraction. The OS Second Edition map identifies this area as ‘Old Jet Workings’ (Ordnance Survey 1894a). A number of platforms seem to have been cut into the hillside in this area, but the slopes which define them are not so steep as those seen further to the east, and are thus unlikely to be quarry faces. In addition the ground surface in this area seems to be predominantly composed of a mixture of earth and small stones, with little evidence of substantial shale outcrops.

Towards the western part of area 6, is gully which has been cut into a gently sloping area between two scarps. It appears to have been a man-made channel which directed water over a series of slopes below. In the absence of any other associated evidence, it is difficult to know why it was constructed. However, if jet was being extracted from the cliff face, then it may have been necessary to supply water to the area for use in this process. Alternatively it could have been constructed for drainage, possibly even to drain water away from mine entrances, now blocked and no longer visible. Close to the cliff edge, to the north of the end of the channel, is a rectangular platform with a shallow depression on top of it, which was

originally thought to be a possible building platform. However, on the ground, there is no evidence of a stone structure having been located on the platform, with no significant stonework in the vicinity. There are still the possibilities that some form of more temporary structure may once have stood here, perhaps a wooden shed, or that part of the jet extraction process was carried out here. A short distance to the east of this platform, on an area of rough, but generally level ground, a feature was identified on aerial photographs of the site, which showed as a patch of differential vegetation colouring. From the air, it had the appearance of an east-west keyhole-shaped depression, with access from the east. When this was examined on the ground, it was found that the feature is actually no more than a large gorse bush growing in a depression. No evidence of any revetment, stonework or earthwork banks around the depression was found during this survey, so it seems unlikely that this was a substantial structure.

6.2 'The Warren'

The area between the western end of the quarries and Snilah Ponds is labelled 'The Warren' on the OS First Edition and subsequent maps. It was under a heavy covering of bracken at the time of this survey, making it impossible to examine the ground surface in any great detail, which is why it was decided to limit the area of the survey to the western edge of area 6. As a result, features in The Warren area have been plotted from aerial photography and maps, and then checked on the ground.

Two large depressions were recorded in the centre of this area of land, one of which was rectangular, about 32m long and 10m across, and the other a sub-square feature. The rectangular depression seems likely to have been a reservoir. It is depicted on the OS Second Edition map as having water in it (Ordnance Survey 1894a). An attempt was made to examine it on the ground, and amongst the head-high bracken it was just about possible to ascertain that the eastern end was sloping, but the vegetation prevented the identification of any associated water management features. The sub-square feature was less easy to locate on the ground, although a slight depression was just about discernible in approximately the right area. This may also have been a reservoir, particularly as a square feature, apparently with water in it, is also shown close to the rectangular reservoir on the OS Second Edition map (Ordnance Survey 1894a). It was not possible to trace any other features identified from aerial photographs in this area. These include linear features close to the rectangular reservoir and sub-square feature that may be the remnants of earlier field boundaries, or may even be associated with the reservoir. A small feature further to the west was similarly untraceable, but could possibly be the remains of a temporary structure associated with the former land divisions in this area.

Located close to the cliff edge, at the south-west of The Warren, are two circular stone cisterns (Figure 31). The northern cistern has a diameter of approximately 7m, while the southern one is 8m across. This discrepancy between the sizes of the cisterns may be due to the fact that they are now fairly overgrown, and some of the stones from their rims are missing, giving them irregular outlines. Close to the cisterns, are sections of stonework, which appear to be *in situ*. Map evidence shows that in the 1850s, there was a roofed

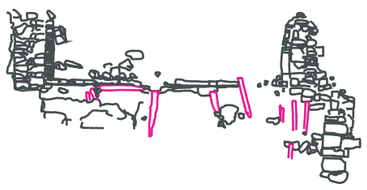
Figure 31. *The southern cistern of the pair at the edge of The Warren. The stone lining of the cistern can just be seen beneath the heavy bracken cover.*

building at this location annotated 'Cistern' (Ordnance Survey 1856a). By the early 20th-century, the building is known to have lost its roof, and two of the walls had disappeared. To the west, the top edge of a scarp seems to define a path leading towards the cisterns. These covered cisterns would have been used to allow the alum liquor to settle before being transferred on to the alum house. The liquor would have carried to the latter via a trough, but no traces of this now survive in the vicinity of the cisterns.

6.3 The Alum House At Hummersea

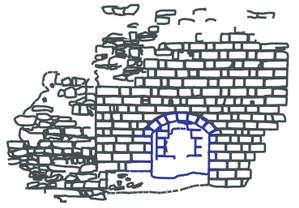
Building remains are visible embedded in the cliff face above the beach at Hummersea. These are believed to be the remains of the alum house that was built around 1800. Given the location of the structural remains, it was decided not to include them in the main body of the survey, as their cliff face location precludes use of GPS as a recording medium. However, the structural remains of the buildings were recorded by the Photogrammetric Survey team based at English Heritage's York office (Figure 32). This enabled the buildings to be recorded in 3-D and to be fixed to the National Grid.

The structural remains in the cliff face at Hummersea fall into three principal sections. The westernmost of these is located under, and adjacent to, the steps leading down to the beach from the public footpath, at NZ 7262 1997 and appears to be a kiln. Much of the rear part of the structure has been covered by boulder clay that has slipped down from above, however, the front face is visible. There is an arched entrance in the front face of the structure with a recess behind it which continues back for at least a metre (Figure 33). The arch is approximately 8m above sea level, and slightly less above beach level, so an investigation of the interior of the recess was not possible in the course of this survey. Within the recess, however, there is clear evidence of burning, as the stone is somewhat blackened. The side walls return into the cliff face, demonstrating that the arch was located in an exterior front wall and that the rest of the structure is now embedded within the cliff, possibly due to



?Remains of housing for boiling pans

Bricked-up arches - ?originally supporting evaporating pans



Possible kiln or boiler

Figure 32. *Photomontage of the remains of the alum house in the cliff face at Hummersea (top) with a rectified transcription of the structural remains (bottom) by the English Heritage Metric Survey team.*

Figure 33. *Photograph of the arch adjacent to the steps down to Hummersea Beach. This may be the remains of a kiln or boiler, possibly associated with the building shown in 19th century photographs.*

boulder clay slippage engulfing it. The 19th-century photographs of the so-called alum house show a chimney at the northern end of the main building, but there are no images of the building's northern face, so it is impossible to tell if there was an arch built in to the exterior of the chimney breast. If this was the case, then it is possible that this structure represents the remains of the main part of the alum house shown in the photographs and engraving (Figures 9-11 & 13).

Just under 30m to the east of the possible kiln, at NZ 7266 1996, is another group of structures. These consist predominantly of at least four brick-built arches, all of which have been bricked up (Figure 34). Metal plates were observed among the brick filling of the most

Figure 34. *The remains of bricked-up arches in the cliff face at Hummersea, formerly part of the alum house complex*

easterly arch. The arches are now more or less flush with the cliff face, and the suggestion is again that they continue further back to the south, but are now covered with material which has slipped from the cliff above. Two of the arches are fairly well preserved, but the ones to the west survive less well. Dressed sandstone blocks adjoin the base of the easternmost arch, and photographs from 1993, supplied by Trevor Pearson, show that this layer of sandstone blocks must once have continued to the west, underneath the adjacent arch and possibly even further beyond. These earlier photographs also show that there was originally more extensive brickwork surrounding the arches, particularly at the eastern end, which has since collapsed and presumably been washed away by the sea at high tide. The

brickwork infilling the arches has also decayed in the last 10 years, leaving stonework visible at the rear of the interior of the second arch from the east. The brickwork filling the arches, and traces of the sandstone block floor below, survive better in the two arches to the west. There are also traces of sandstone blocks above the arches, but it is difficult to be sure what they represent as they are now so fragmentary. These arches are far more typical of the remains of an alum house, and may have been for fires situated below boiling pans to allow fires to be built and controlled underneath.

The third group of building remains lie approximately 15m to the west of the brick arches, and are centred on NZ 7267 1996. Like the other remains in the cliff face, a proportion of the rear of the original structure has been covered with boulder clay which has slipped down from the cliff above. What survives is a section through a building, presumably created when part of the front of the structure eroded on to the beach below, as there is no evidence of a front wall (Figure 35). The basic outline of the building's cross-section shows two brick built side-walls, which survive to approximately 2m high and are just under 8m apart, with a floor, apparently made of stone slabs and approximately 10.5m above sea level, in between them. The interior of the structure has been filled with earthen debris from the cliff above.

Figure 35. *Further structural remains of the alum house complex*

Beneath the floor of the structure are some upright timbers, possibly timber piles for foundations, while one length of timber lies horizontally under the floor. This building may once have housed a metal pan, and these may be the remains of the housing for the boiling pans in the alum house complex. To the exterior of the relatively thin brick side-walls, there is also evidence of the structure having been revetted with sandstone blocks. The uneven appearance of the stonework at the west end of the structure, together with the occurrence of further stone blocks below and to the west of the structure, suggests that another building once abutted it to the west. This is further supported by the existence of a line of thin stone slabs, on a similar level to the floor of the structure, continuing to the west, between this structure and the brick arches. To the exterior of the eastern brick wall are more fragments

of sandstone blocks, which lie adjacent to a cut into the natural rock of the cliff face, demonstrating that the topography was modified to accommodate the alum house.

6.4 Foreshore Features

The end of August 2003 saw unusual tidal conditions that created some of the largest breakers seen in the area for a number of years (Mrs J Etches, pers comm). As a result of this, a great deal of seaweed was deposited on the foreshore between Hummersea and Skinningrove, which was still there at the time of this survey. This obscured a large proportion of the foreshore archaeological remains, making it difficult to trace features, such as rutways and post holes, in their entirety. However, it has been possible to plot the foreshore features from aerial photographs.

6.4.1 Docks

Prior to the field investigation of the foreshore below the alum works at Loftus, two docks were identified from cartographic evidence. Both 'Old Gut' and 'New Gut' are labelled on the 1853 OS First Edition map, and are shown as cuts in the natural bedrock. The Old Gut is centred on NGR NZ 734 201, some 750m to the east of the New Gut. On the ground, the cut in the bedrock that forms Old Gut is lined along its eastern edge by an arrangement of substantially sized stones (Figure 36). The stones, which are laid on end, form a north-south 'wall' approximately 52m in length. Parallel to the western side of this wall, at its

Figure 36. *The Old Gut as seen from the cliff above. Large stone blocks clearly define the eastern side of the dock.*

southern end, is a another line of stones, similarly constructed, but measuring only 13m in length. The area between these two sections of walling does not show any significant features, merely bedrock with some loose stones on top of it, but these are likely to have been washed up by tidal action. It is possible that a platform existed between these two

lengths of walling, used for loading and unloading. Supporting this suggestion is the fact that the stone used for the short section of wall and the southern part of the longer wall appears to have been deliberately squared off, with more regular, flat-topped blocks, in contrast to the rounder, more irregular blocks to the north. Towards the northern end of the longer wall, about 6m from the end, is a square-cut hole in the bedrock immediately adjacent to the wall. Measuring about 1.5m across, the purpose of this hole would presumably have been for a substantial timber associated with the dock, possibly forming part of a crane. A length of wood was observed at the base of the eastern wall, some 14m from its southern end. However, it seems unlikely that the timber would have survived the ravages of the North Sea since the 18th or 19th centuries. The western side of the man-made inlet appears to have been left as it was, with no evidence of any walls or post holes, as exist at its eastern side. When plotted on a map, it can be seen that the Old Gut is located on the foreshore, directly below the pair of cisterns at the edge of The Warren. The inference to be drawn from this is that the dock and the cisterns (and possibly the alum house, which was probably located in the vicinity of the Old Gut) were contemporary and may have been used in tandem. This hypothesis is discussed in more detail below (*see* Section 7).

The other known dock at Loftus, the New Gut, is located further west, centred at NZ 726 200. It is a mere 100m to the north of the alum house. The New Gut shows little evidence of having been deepened, and has the appearance of a naturally created inlet (Figure 37). However, both the eastern and western edges show evidence of having been artificially straightened. There is no evidence of stone walling within this dock akin to that lining the

Figure 37. *The New Gut is less clearly defined than the Old Gut, but the incoming tide shows the general extent of the dock*

Old Gut. In terms of structural remains, the survey of this area completed by Midway Watersports in 2000 recorded between four and six post holes cut into the bedrock. As mentioned at the start of this section, the conditions on the foreshore were not conducive to field observation due to the quantity of seaweed present, it was therefore not possible to locate the post holes during this survey. However, the post holes were observed by English Heritage staff during a visit in 2000 when control was established for the rectification of aerial

photographs of the site (C Dunn, *pers comm*). The New Gut is located opposite the remains of the post-1800 alum house, making it likely that these two features were contemporaneous and functioned together.

Evidence of a third dock on the foreshore was also located during the visit to the site in 2000, and was later confirmed by a second examination on the ground and plotted from aerial photographs. John Buglass originally noted this feature in 1995 and it is recorded in the Tees Archaeology SMR as an unnamed inlet (ref. 3576). The third dock is less obvious than the Old Gut, with no substantial stones defining it, perhaps indicating that it is older, having been smoothed by tidal action over time. It is located towards the eastern end of the site, on the foreshore directly below area 2 of the quarries, at NZ 743 202. The dock consists of a broad, shallow cut into the bedrock, although this is now filled with boulders, which have

Figure 38. *Post holes (indicated by arrows) along the eastern side of a probable third dock associated with Loftus Alum Works. The line of the cut for the main dock access, now filled with boulders, can just be seen as a straight line towards the right of the photograph.*

fallen from the cliff above or have been washed into the dock (Figure 38). In the eastern edge of this cut is a line of at least four roughly semi-circular post holes, which vary from 0.5m-0.8m in diameter. The first three post holes, closest to the foreshore, are evenly spaced, at 4.5m apart, but the fourth is only 1.5m away from the third. The surviving evidence certainly suggests that a dock of some description existed here, probably pre-dating, and possibly replaced by, the Old Gut. The original lease states that the investors were expected to create a 'gutt' and provide a dock or harbour. Given that it is likely that the initial efforts to extract alum were made at the east end of the site, it may be that these post holes are the remnants of the site this 17th-century dock.

6.4.2 Rutways

Numerous grooves in the foreshore below the alum quarries and the alum house are the remains of rutways that were used by carts transporting the processed alum between the

Figure 39. *Example of a rutway observed on the foreshore near Hummersea Beach*

alum house and the docks (Figure 39). They would also have been utilised to unload coal from ships delivering supplies to the works. Due to the dense seaweed cover at the time of this survey, these features were recorded from aerial photography. The rutways are cut into the exposed bedrock of the foreshore, and are generally a standard distance of 4 feet and 4 inches (approximately 1.3m), which matches the distance between the wheels of a typical agricultural cart, of a type probably used to transport the alum (Owen 1986, 25). The concentration of these rutways is on the foreshore to the west of the alum house, leading towards Skinningrove. There are apparently no records of the use of Skinningrove for the transport of alum, as the Old and New Guts served this purpose for the Loftus Alum Works. Other fragments of rutways were recorded from aerial photographs175m to the west of the Old Gut, but in far smaller numbers.

The rutways would have functioned in a similar fashion to railways, with carts travelling along the pre-cut tracks. This would have enabled the transportation of alum during periods of rising tide, as the ruts would have guided the cart along the correct path, and also in darkness, steering the carts clear of any dangerous crevices and rocks. A record of the 'Old Gut Tramway' exists in the Tees Archaeology Sites and Monuments Record (Ref. 3570), describing traces of slots and holes in the foreshore associated with the tramway. No such features were observed, possibly obscured by the heavy covering of seaweed, but it seems very unlikely that a tramway would have been constructed in an area that was submerged by the high tide for extended periods of time. Materials used in the construction of such a tramway, such as iron and wood, are likely to have been easily corroded and rotted by the sea water, making such an arrangement unlikely. However, there is a large area between the Old Gut and the alum house where there is now no evidence of any rutways, and such a feature may once have existed there.

6.4.3 Miscellaneous Features

On part of the foreshore that was relatively clear of seaweed, just under 200m to the west of the New Gut, a square-cut feature was recorded at NZ 7247 2013 (Figure 40). It lies a short distance from a larger, north-south cut in the natural bedrock, defining a channel. The pit is approximately 2.5m square, and has notches cut into three of its corners. The narrow man-made channel joins the pit on its eastern side and links it to a second larger channel to its west. This arrangement may have allowed water to run into or out of the pit as the tide is

Figure 40. *Square pit observed on the foreshore a short distance from the site of the alum house at Hummersea*

rising or subsiding. The location of the pit suggests that it is unlikely to be closely connected with the Loftus Alum Works, it may even be a more recent creation, possibly associated with the local fishing industry, in particular shellfish.

7. DISCUSSION AND CONCLUSIONS

The English Heritage survey of the Loftus Alum Works has enabled the component parts of the works to be drawn together and the site to be considered as a whole, in spite of its massive size, for the first time. The extent and imposing nature of the remains of the alum industry aptly demonstrate the impact that it had on this stretch of coastline and the thoroughness with which the area was exploited. In spite of the size of the site, neither the archaeological nor the documentary evidence is as wide-ranging as was first hoped, and in some cases raises more questions than are answered. The greatest hindrance to the survival of archaeological remains is the fact that quarrying, by its very nature, destroys evidence of earlier activity as deposits are exploited ever deeper or as it is buried under overburden or waste. As a result what we are left with is a snapshot of the final stages of activity at the site, while much of the evidence for the earlier stages of quarrying at Loftus has been obliterated by the later expansion of the works. The significant surviving remains of the alum works have been examined and described in preceding sections and the documentary evidence has been presented. Therefore, the following discussion will bring together all this evidence, consider what is now known about the site and raise the questions that still need to be answered.

The sequence of quarrying at Loftus is somewhat complicated and difficult to unravel. It would doubtless have started with the removal of the sandstone capping from the site, which is unlikely to have been of uniform thickness. It is most likely that this was then utilised for building stone both on and off the site. Once the sandstone had been cleared, the shales would have been worked downwards, possibly in steps in order to keep the worked face stable and manageable, to form the initial level of quarrying. Presumably any spoil from this activity could have been deposited over the cliff edge. The only evidence to remain from this stage of the quarrying is the worked face at the rear (south) of the site. There is little that can be ascertained from this face, as the boulders littering the quarry floor, presumably from rock falls post-dating the alum works, obscure any remaining evidence.

It appears that the quarrying was taken down further, possibly at the same time as the upper level was being worked back, creating an intermediate level. It is at this intermediate level where the larger quarries are found and the large spoil heaps are located. The spoil heaps are difficult to explain, as their location would have required the transportation of a great quantity of spoil uphill, either directly up the spoil heap itself, or a long journey out of the west end of the quarries and up on to the top of the inland cliff so that the waste could be deposited from above. It is possible that wooden gantries may have been built to make the spoil heap easier to access from the working floor level, but this would still have involved a great deal of effort. However, in the absence of any other explanation, this would seem the most likely situation. The quarries may also have been the sites of calcining places, as they would have provided large flat floors upon which calcining clamps could be constructed, with shales being tipped in from above once it had been extracted from the upper quarry face. It seems unlikely that the shale quarried during the creation of the calcining places would

have been discarded, as any shale rich enough in aluminium sulphate would probably have been processed. It may be that the shale extracted in the creation of a calcining place was transported to a different, pre-existing calcining place for burning.

Areas 2 and 4 have a further level of quarrying below the intermediate level. The archaeological remains in area 2 suggest that the lower level was opened once the intermediate level had been fully exploited and was no longer in use. The survival of a short section of stone walling at the edge of the intermediate level and the scattering of worked stone at the foot of the worked face of the lower area suggests that structures from above had fallen into this lower area, possibly when they were cut through by the new quarry face. The lower level of area 2 is at a depth of *c*116m above sea level, which is some 60m below the original ground surface. It is therefore quite possible that this was used for alum extraction, as alum-bearing shales, although perhaps not of the best quality, are found at depths of up to approximately 60m below the ground surface. The depth of the lower level in area 4 is *c*108m, which is around 80m below the original ground surface. In this area, it may be that this lower level was in fact opened up to exploit the lower-lying jet shales, which would concur with the evidence of the 1893 OS map (as discussed in Section 4, Ordnance Survey 1894a). As mentioned previously (in Section 2), early alum workers were unlikely to have known the exact depths at which the shale ceased to produce a reasonable proportion of alum, so in the process of trial and error, some areas may have been opened up to a deeper level. Area 1 also has a lower level of quarrying, at *c*133m above sea level and around 60m below the height of the cliff top, but does not have an intermediate level. It may be presumed, therefore, that there was no calcining place specifically associated with this area, and that the shales from the main quarry face above may have been transported to the calcining places in area 2 instead. The large quarry in area 5 similarly shows no evidence of a directly associated calcining place. The shales may, in this case, have been transferred to calcining places within area 4. In general though, this pattern of the main quarry face with an associated calcining place, or on nearby, does seem to fit with the surviving evidence on the site.

Although the site is now known inclusively as Loftus Alum Works, it is clear that over time the focus of the site has changed and moved. This is perhaps best demonstrated in the depiction of the site on the 1770s plan (Figure 6), which shows that the quarrying was, at this date, being undertaken as one discrete unit. Unfortunately the map is not topographically accurate enough to allow a precise location of the depicted quarry to be ascertained, but it seems likely that it was located in either area 2 or 3. To the east of the quarry shown on the plan a letter 'B' represents 'a new Allum Rock … … having upwards of 45 yards deep with only 10 yards of cap or cover upon it'. This suggests that there was an intention to expand the alum quarries to the east, perhaps into area 1.

The extent and location of the principal areas of alum extraction and processing were not tied to a single location, a fact that is highlighted by the different names applied to the site. At its inception, the site was known as Lingbury Hill, a name still applied to it in 1684 when the inventory was compiled. The Dundas estate plan refers to the alum works as the 'Lingberry Works', but a short time afterwards, Tuke calls the alum works 'Lofthouse' on his map of

1787. This name is still in existence in the mid-19th century, as the OS First Edition map of 1853 (Figure 8) calls it the 'Lofthouse Alum Works' and the 'Lofthouse Alum House', but by 1893 and the Second Edition of the OS map, it has become Loftus Alum Quarries. It is tempting to see this changing nomenclature as evidence of the movement of the focus of the quarries. On both OS maps, the area of land between the Boulby and Loftus alum quarries is labelled 'Lingberry Hill', presumably the origin of the early name of the site, but this is very steep, uneven land, unsuitable for an alum works and its associated structures. It is conceivable that the early focus of the works was at the eastern end of the site and that the works were therefore given the name 'Lingbury' after the adjacent hill. This connection between the shift in operations and the site name is supported by the fact that the OS First Edition map of 1853 shows the buildings which appear to be most current, such as the ranges of steeping pits, situated at the western end of the quarries. By this date, and apparently for some 60 years previously, the alum works was known as Lofthouse, possibly due to the fact that the works was now closer to the town of Loftus, rather than Lingberry Hill.

With the focus of the alum extraction shifting over time, it might be expected that the processing buildings would have moved with it, especially as the shales seem to have been worked in discrete units with all the necessary associated buildings close at hand. Possibly the most important, or at least the most substantial, of all the processing buildings was the alum house, where the bulk of the processing was undertaken. As mentioned previously in this report, the surviving remains of the alum house are related to those of the final alum house associated with the works, which was believed to have been constructed in *c*1800. Although there must have been other alum houses serving the works in the preceding 140 years, there is no physical evidence of these surviving. However, other evidence suggests that there were probably at least two earlier alum houses at Loftus. The first one of these is known to have existed from the 1684 inventory for the Lingbury Hill alum works, which lists 'The Allum House' and values it at £120. Its location is not specified by the document, but other evidence, namely the existence of the third dock on the foreshore (*see* Section 6.4.1), suggests that it was at the eastern end of the site. The proximity of the alum house to a dock was an important factor at coastal sites, so it may be assumed that this third dock, situated directly below area 2, served an alum house located close by. The alum house may have been erected in the lower level of the quarrying in area 2 or alternatively on the foreshore adjacent to the dock. If it was the latter, then it would have been at the mercy of the elements and in a somewhat precarious position at the foot of some very high, and unstable, cliffs. A platform would have presumably been necessary to raise the building above the tide level on the foreshore and to create a base for stable foundations but there is no surviving evidence for one, which may make this location the less likely option. There is hardly any more evidence for a former structure in the lower level of area 2, but there is a proliferation of worked stone blocks scattered on the quarry floor which may be significant. The inventory of 1684 lists 'The Rock house and Ways up cliff', valued at £20, which suggests that there was either a route up the cliff, or some mechanism for transporting goods up and down the cliff. This is only a tentative theory regarding the location of the earliest alum house, but it does fit with the scant evidence that exists for this period.

There would have been other processing buildings associated with shale extraction, and these would probably have been located in the vicinity of the alum house, so that the distances for transporting the alum liquor were not too excessive. In the case of the first alum house, the most likely location for the associated processing structures, such as the steeping pits and settling tanks, is the lower level of area 2 or possibly even in area 1. As mentioned above, a high density of worked stone in the lower level of area 2 suggests that there were structures here. Similarly, area 1 displays evidence of former structures, and the remains of the circular cistern in the cliff face could be a settling tank, possibly one of a pair, which served the original alum house.

The main evidence for the existence of a second alum house is the 1770s Dundas estate plan (Figure 6) which shows a building a short distance to the north-west of the depicted quarries. Despite the key being illegible, this is almost certainly an alum house. The depiction of the structure shows that it was located on an apron of land, apparently at the foot of the cliff. It may not have been on the foreshore itself, but perhaps on some kind of built-up platform, possibly created out of material from an earlier cliff fall. Although the alum house is depicted on a plan, it is still difficult to ascertain its exact position. However, the topography generally matches more modern maps of the area, and it seems that the alum house was located to the north-west of areas 4 and 5, in close proximity to the Old Gut. Again, the alum house may not necessarily have been located on the cliff top, but might have been further down the cliff, especially if there was a suitable ledge for its construction. This location would have allowed the relatively easy transport of raw materials to the alum house and for the finished product to be taken away from the alum house via the Old Gut. The second alum house and the Old Gut are believed to have remained in use for some years following the construction of the third alum house at Hummersea in *c*1800 (Pickles 1975, 8). This may be the origin of the traces of rutways recorded on the foreshore between the New and the Old Guts. The steeping pits and settling tanks that served this alum house are likely to have been located at the western end of the site. To the south-east of the alum house depicted on the 1770s plan are a quarry face and a range of pits, the location of which probably corresponds to somewhere within, or close to, area 4. These may be one of the pair of ranges of pits which are depicted on the First Edition OS map of 1853 (Ordnance Survey 1856a), perhaps the more westerly range. The 1770s plan of the site also shows two circular features adjacent to the southern side of the alum house, which could be interpreted as settling tanks.

The final alum house to serve the Loftus Alum Works was located slightly above beach level at Hummersea, to the south of the New Gut. Evidence from the 1770s plan shows that there was a kelp house in the general area now occupied by the remains of the alum house. It may be that the alum house utilised or even incorporated part of the pre-existing kelp house. The westernmost feature that survives in the cliff face (Figure 33) appears to be of a kiln or similar structure. This may be the remnant of a structure within the alum house or it could be a feature which was once part of the kelp house, as kelp is likely to have been burned within such a structure. The other possibility is that this was in fact not directly connected with the alum industry, but was actually related to the cement producing industry

which is known to have been carried out in tandem with the alum industry in this area (Morris 1984, 39-41). Again, the juxtaposition of this alum house with a dock (the New Gut) demonstrates the importance of having good links between the processing and transport systems. The benefit of this location for the alum house is that the beach is much longer, flatter and sandier here, making it less treacherous than the boulder strewn beach to the east where the previous alum houses were located. The positioning of the alum house in this location by *c*1800 strongly suggests that by this date the focus of the works had shifted towards the western end of the site, with the quarries in areas 4 and 5 probably also belonging to this later period.

From this combination of documentary and archaeological evidence it has been possible to establish a rough chronology for the working of this site which, over its 200 years of operation, carved a large chunk out of this stretch of coastline. The evidence suggests that the shales were broadly worked from east to west over time, although it is still possible that areas were re-used, perhaps as calcining places, or that previously worked seams of shale were later extended further. However, there simply is not the surviving evidence to be certain about such possibilities. The alum house was certainly moved in a westerly direction over time though.

What is perhaps surprising about a site the size of Loftus, particularly when compared with neighbouring quarries at Boulby and Sandsend, further down the coast, is the lack of structural remains. For a site the size of Loftus Alum Works, that was active, almost uninterrupted, for two centuries, there is very little left of the buildings that would have been so essential to the productivity of the site. A number of structures will undoubtedly have suffered from erosion, as witnessed by the few structures which only just survive on the cliff edge. As discussed above, there would have been some movement of operations within the quarries and it may be that as the quarrying shifted, it was more economical to dismantle buildings and re-use materials where possible rather than build replacement structures using new stone, metal or wood. Therefore, some of the earlier structures may have disappeared during the active life of the site. In addition, a certain degree of more recent human activity is likely to have had an impact on the survival rate of the structures. Stone is known to have been removed from the site in the last thirty years or so and even more recently, some of the remaining stone has been moved around to create bike jump-ramps and to spell out visitors' names on the shale slopes. Although many buildings have been destroyed, some structures may still survive intact beneath wind-blown shale, vegetation and possibly even under the boulder debris at the foot of the main inland quarry face. Whether or not this is the case could probably only be proved through a programme of excavation.

Although the remains of Loftus Alum Works cover a vast area, only a relatively small proportion of the site would have been worked at any one time. This survey has enabled a chronology for the working of the site to be postulated, but it is difficult to give an absolute date to each stage of the site's development. Conditions on the site, such as the thick covering of scrub and undergrowth and the large areas of boulder debris, mean that it was difficult to survey some parts in detail. Whether or not there is much more detail concealed beneath these

obstructions remains to be seen. There may be scope, however, for further discoveries in The Warren, which is almost completely obscured by a thick covering of bracken. The reservoir in this area, for example, may have internal details or adjoining features which might provide a clue on to its function. Similarly, clearance of bracken in the area around the settling cisterns may reveal whether there are any surviving sections of the liquor trough between them, the quarries and the alum house and allow detailed recording of the cisterns themselves.

Targeted excavation has proved useful at other former alum working sites, and it would doubtless prove useful at Loftus, enabling detail to be added to the already established general picture of the site's history and operation. Further investigation of the alum house, for example, may shed light on the precise nature of the remains and the extent of any further parts of the alum house complex. The structures within the quarries may also benefit from excavation, to establish their extent, the way in which they functioned and any connections between groups of buildings. Clearly, there is scope for further work at Loftus, using other archaeological techniques, which would hopefully add detail to the existing knowledge of the site. However, despite its size and complexity, the present survey has shown the importance of regarding Loftus Alum Works as a single entity consisting of a number of distinct parts, and hopefully this will be a common theme in any future work both on this site and on other former alum producing sites.

8. SURVEY METHODOLOGY

The survey was carried out within OS National Grid co-ordinates using a Trimble dual-frequency Global Positioning System (GPS). The base station was set up over a permanent marker (ST01) in order to bring in the European Terrestrial Referencing System (ETRS89) latitude/longitude co-ordinates via the OS active station GPS network. While the base station was logging the satellite data necessary to make the calculation, a second 'roving' receiver (Trimble 4700 or 4800), working in real-time kinematic mode, was used to record the archaeological features. The resulting data were processed using Trimble Geomatics Office (TGO) software and the OS National GPS network website in order to convert it to OS National Grid values. This was then plotted at 1:1000 via KeyTERRA-FIRMA software.

Working photographs of the site were taken by Abby Hunt using a digital camera (1.3 mega pixels) and are retained at English Heritage, York.

Aerial photographic transcription was carried out by Ann Carter of English Heritage's York office, in conjunction with the ground survey at Loftus. This enabled the plotting of features in dangerous or inaccessible locations on both the cliff edge and foreshore, and the accurate mapping of the line of the modern cliff edge. Photography for the aerial survey mapping of sites of the Alum industry was specially taken for the project by Simmons Aerofilms on 19th July 2000, at a scale of 1:3000. A ground survey using Trimble GPS equipment was undertaken in October of that same year to provide control information for use by the aerial survey. Points of detail identified on the photography were used to create this control information. Mapping from the photography was undertaken using a Leica Helava digital photogrammetric workstation (DPW). The photography was set up on the DPW using 16 control points supplied by the GPS survey. Using SOCET SET v.4.4.0 software, aerial triangulation was carried out on two strips of the photography: a total of twenty frames. Following the bundle adjustment, the XYZ RMS errors were 0.031, 0.026, and 0.016 metres respectively. The maximum error at any one point was 6.4 cm in x. Viewing of the stereo-models was by means of polarising glasses and the digital mapping from the photography was carried out using Leica PRO600 interfaced with Microstation CAD software.

Work on mapping the site at Loftus began on 27th May 2003 using frames 9650-9656 from Run 1 of the photography, and frames 9626-9638 from Run 2. An area of approximately 3.5km by 1.5km was mapped over a period of 61.5 days. Initially it had been expected that work would concentrate on areas within 10 m of the tops and bottoms of cliff and quarry faces, as well as the foreshore: areas thought to hold most danger or problems for the field teams. However, once fieldwork had begun, the field team requested that other areas be tackled by aerial survey for the sake of ease, speed and safety, for example, the extensive area of boulders on the site.

A photogrammetric transcription of the remains of the alum house at Hummersea was carried out by English Heritage's Photogrammetric Team. The production of the drawing of the residual buildings at Hummersea involved two processes - fieldwork followed by office

work. The fieldwork consisted of acquiring stereo-photography and suitable control. The photography was taken using a Rollei 6006 120 format semi-metric camera which has been customised for photogrammetric work. A larger medium-format fully metric camera would have been preferable for the work but the need to carry the camera down the steep cliff meant that its use was impractical. Control was acquired by intersecting theodolite observations from two survey stations to points of natural detail. It is usual practice to affix small plastic targets to the subject but the steepness and instability of the cliff meant this could not be achieved safely. The survey stations were referenced to National Grid using GPS.

Once the photographs had been processed they were scanned using a dedicated photogrammetric scanner. Each stereo-model was then set-up on a Digital Photogrammetric Workstation (DPW). This involves using the DPW to remove distortion caused by the camera lens or film stretching, to replicate the original tilts of the camera to account for variations in scale across the image and then to locate the 3-D view in the correct co-ordinate system. Once this has been done an operator can produce accurate drawings in CAD by tracing round the relevant detail using a measuring mark controlled by two hand wheels and a foot wheel – one for each of the three axes.

It is also possible to automatically produce a Digital Terrain Model (DTM) using the DPW. This can then be used to individually correct the scale and position of each pixel in an image in order to produce an orthophotograph. An orthophotograph is an image which like a map is an orthographic projection. This means that distances and areas can be accurately 'scaled off'. At Loftus the variations in depth were too great to allow the production of an orthophotograph so the photographs have simply been montaged using Photoshop.

A survey archive consisting of the field plan, hard-copy printouts of the final electronic drawings, plus supporting background information, such as the project design and correspondence has been deposited in the NMRC, Swindon, under collections reference AF 00118, where it is available for public consultation upon request. Applications for copyright should be made to NMRC, Great Western Village, Kemble Drive, Swindon SN2 2GZ (reference number: NZ 71 NW 23).

9. ACKNOWLEDGEMENTS

Archaeological field survey was carried out by Abby Hunt, Trevor Pearson and Philip Sinton, following an initial reconnaissance visit to the site in 2000 by Christopher Dunn, Marcus Jecock, Amy Lax and Mick Clowes to record control points to geo-reference the stereo-photography. Aerial photograph transcription was undertaken by Ann Carter. Nick Beckett, David Andrews and Steve Tovey undertook the photogrammetric work on Hummersea alum house. Mick Clowes prepared the orthophotographs and the perspective view photograph of the whole site. The report was researched and written by Abby Hunt and edited by Christopher Dunn. Trevor Pearson and Marcus Jecock also commented on the text. Philip Sinton and Abby Hunt prepared the illustrations for the report.

English Heritage gratefully acknowledges The National Trust, for permitting access to their land. Mr Keith Chapman kindly loaned some slides of Loftus from the 1970s, allowed the digital reproduction of the images and discussed his knowledge of the site with the author. Dr and Mrs Etches provided useful background information and allowed English Heritage to use their land for easier access to the site. Mr Roger Pickles kindly searched the Whitby Literary and Philosophical Society collections and extracted the relevant information. The staff of the North Yorkshire County Record office were very helpful in the search for documents concerning Loftus Alum Works and provided a digital photograph of the 18th-century map of the site (Figure 6). Thanks are also due to the staff of the York Minster Library for allowing the digital photography and reproduction of an 1881 engraving of the alum house at Hummersea (Figure 9). Trevor Pearson provided images of the site taken in 1993 during the course of the survey by Gary Marshall.

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APPENDIX 1

Amongst the Percy Burnett papers at the Whitby Literary and Philosophical Society Library is a transcription of a 1684 inventory of 'the Allum Works at Lingbury Hill' (Burnett Papers, Whitby Lit & Phil Soc, Ref. 1215). Roger Pickles kindly supplied a typescript of the inventory which is reproduced below.

INVENTORY OF THE ALLUM WORKS AT LINGBURY HILL (as at 2d day of July 1684) PB1215			
	£	**s**	**d**
The Green Liqour Cisterne	7	10	00
The Two Lee Cisterne	7	05	00
14 Lee Tubbs	1	10	00
One Stone Cisterne in the lee house	1	00	00
Two Mother Cisterns	8	00	00
One Washing Cisterne	4	00	00
Two Setlers one of wood ye other stone	2	05	00
Twenty Eight Coolers at 13s: & clay & Raming	22	10	00
618 Yards of Troughs about ye Works	10	06	00
7 Tuns in ye Washing house	4	00	00
One Bing 3 Washing Tubs 2 Buckitts 5 skoops	1	08	00
2 Iron Panes 3 Colerakes one Iron Colerake 2 Pan hammers 3 Axes one Spade One Shovell in ye ffire house one ffire Shovell	1	07	06
9 Cwt of Lead	4	10	00
4 Plates and Six Iron Bars	5	10	00
4 Gavelocks 2 Laddles 2 great hammers	0	10	00
One Lead Pott with grates and frame and 2 Strickles a Wood Trough for Casting Pans	1	00	00
1 Pair bellows one Sledge 2 hammers & other implements	3	10	00
34 Barrows & 12 New Wheeles	10	00	00
The Allum house	120	00	00
The Kilp house and Lee house Smiths Shop and Teafall	18	00	00
The Rock house and Ways up cliff	20	00	00
10 Pumps	10	00	00
One half Chalder	0	02	06

INVENTORY OF THE ALLUM WORKS AT LINGBURY HILL (as at 2d day of July 1684) PB1215 ctd...			
	£	**s**	**d**
2 pair of Skales & half lb lead	1	05	00
The staith the Goat and cart way	100	00	00
ffor ffaceing the cliffe	16	00	00
4 Pitts and 2 Russeters	50	00	00
The Calsigning place 15750 yds. At 2 and a quarter pence	147	13	01
The boaring frame & a sett of wombles	1	00	00
6 Tuns of Urine	2	18	00
420 Yards of Planks	4	07	06
3 Cord of Wood	1	00	00
3 pair of Cratches	0	05	00
70 Pitts of Burnt mine	63	00	00
Bareing of Rubbish Pond & Water ways	93	04	00
553 & quarter cha: Coales at 13s p ch:	359	12	03
36 Tuns 14 & quarter lb: Kilp at 35s	64	04	11
200 Deales	10	00	00
7 Pans with lead and places	182	00	00
Bricks at the Door	2	00	00
A Coble	0	12	00
	1363	**05**	**09**

APPENDIX 2

List of NMR numbers linked to the survey

SITE NAME	COUNTY	DISTRICT	PARISH
Loftus Alum Works	Cleveland	Redcar and Cleveland	Loftus

SITE NAME	NGR	NMR No.
Loftus Alum Works	NZ 7410 2020	NZ 71 NW 23
Loftus alum quarries	NZ 7400 2020	NZ 72 SW 35
Hummersea Alum House	NZ 7265 1996	NZ 71 NW 29
Old Gut	NZ 7340 2014	NZ 72 SW 36
New Gut	NZ 7263 2004	NZ 72 SW 37
Dock	NZ 7434 2021	NZ 72 SW 38
Reservoirs	NZ 7435 1985	NZ 71 NW 30

APPENDIX 3

SURVEY STATION INFORMATION

ENGLISH HERITAGE

SITE NAME	Loftus Alum Works		
Station number	ST 01	**Status**	
Type of mark	Brass rivet in stone	**NMR number**	NZ 71 NW 23
Date of survey	July-Sept 2003	**SAM/RSM no.**	-
Office of origin	York	**Surveyors**	AH, TP, PS

OS National Grid	Eastings	Northings	Height
	473727.671	520046.872	134.170

ENGLISH HERITAGE

NATIONAL
MONUMENTS
RECORD

The National Monuments Record
is the public archive of English Heritage.
It contains all the information in this report - and more:
original photographs, plans old and new,
the results of all field surveys, indexes
of archaeological sites and historical buildings,
and complete coverage of England in
air photography.

World Wide Web: http://www.english-heritage.org.uk

National Monuments Record enquires: telephone 01793 414600

National Monuments Record Centre, Great Western Village, Kemble Drive,
Swindon SN2 2GZ

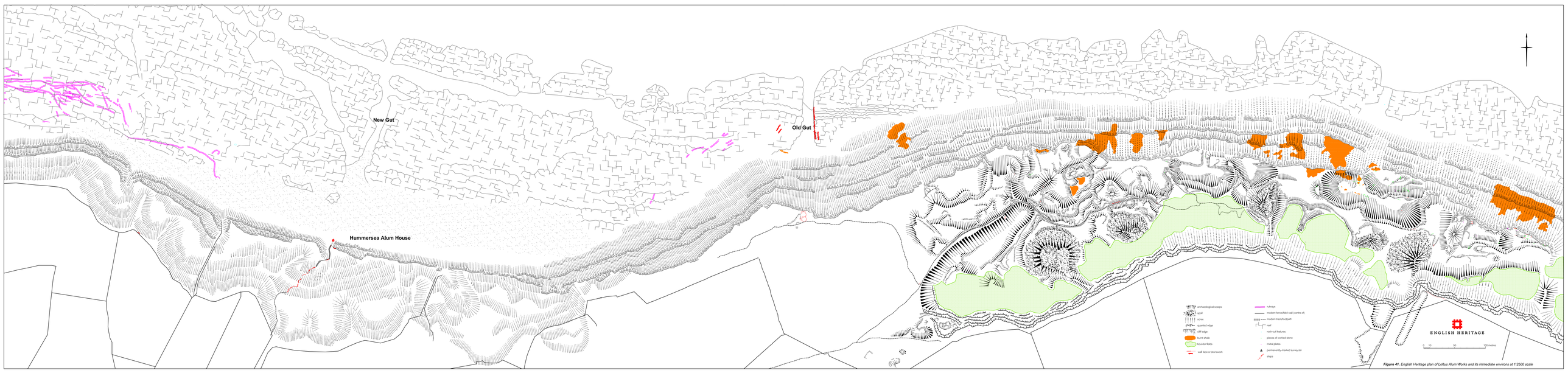

***Figure 41**, English Heritage plan of Loftus Alum Works and its immediate environs at 1:2500 scale*

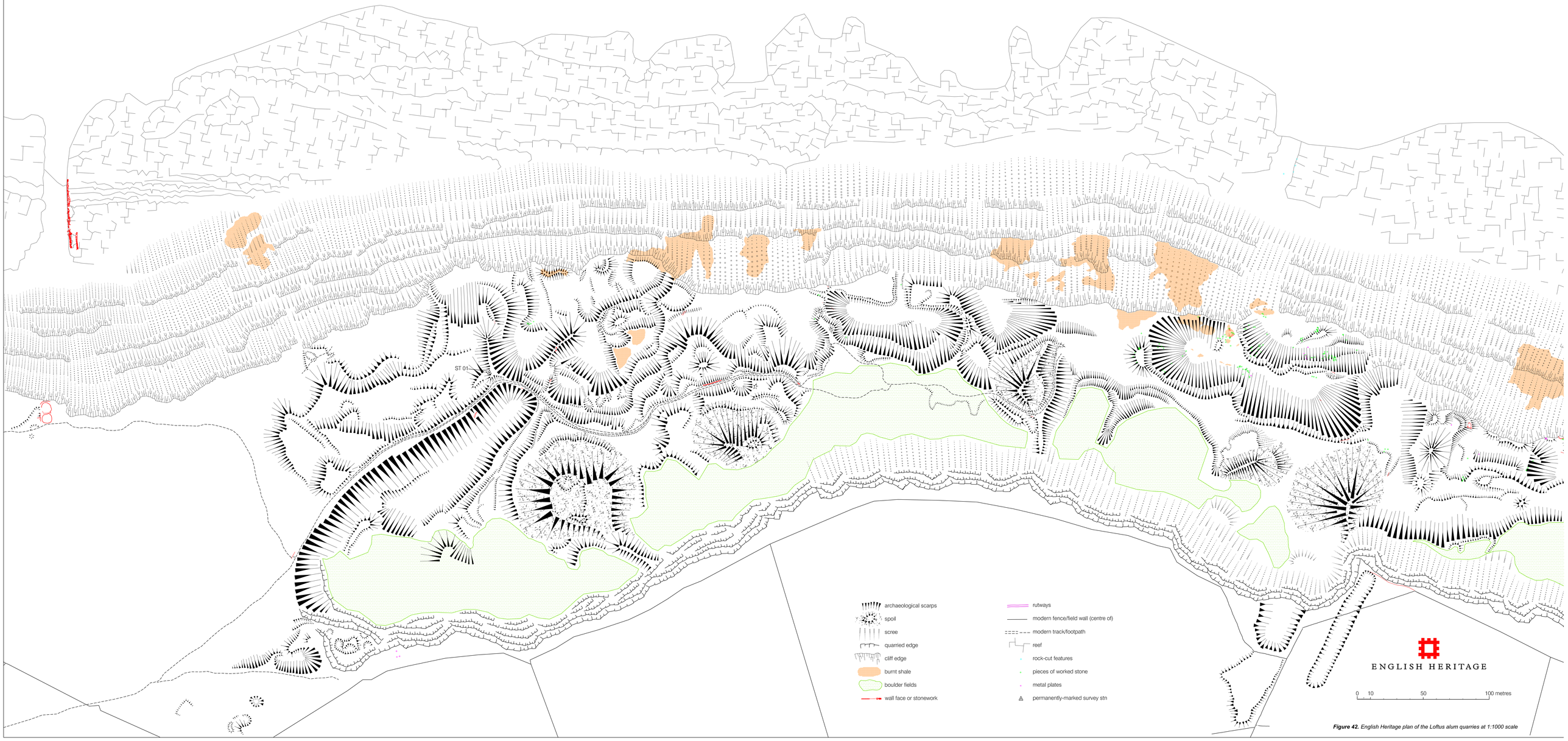

Figure 42. *English Heritage plan of the Loftus alum quarries at 1:1000 scale*