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Fylingdales Moor, North Yorkshire: Photogrammetric Work

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SUMMARY

Wildfires on Fylingdales Moor occurring in September 2003 decimated the vegetation and peat soils across two areas of 243 and 11 hectares respectively. In response to these fires English Heritage collaborated with the North York Moors National Park, English Nature, DEFRA, the Strickland Estate, owner of the affected moor, and the Court Leet to formulate a conservation and rescue project.

A range of survey work has been undertaken to record the archaeological remains for both areas, but in particular the larger area which extends across Stony Marl Moor, Howdale Moor and Brow Moor. The timescale for the recording process was limited due to the need to quickly re-establish a protective layer of vegetative cover across the burnt area.

Detailed photography was commissioned and taken in November 2003. Using this photography and digital photogrammetric technology, plotting of the archaeological features to an accuracy of 4cm was achieved for the larger area. This report summarises the photogrammetric work undertaken, it is not intended to present a comprehensive analysis of the archaeological remains as this has largely been done in the field survey reports (Oswald 2005, Vyner 2005a). However, observations are made on the efficacy of the overall air photographic approach with reference to the other survey techniques.

1 INTRODUCTION

Fylingdales Moor is a tract of heather moorland lying between Whitby and Scarborough within the bounds of the North York Moors National Park Authority.

In September 2003 two separate fires occurred on the moor resulting in almost total destruction of the vegetation in two areas. The largest area (Area A, Figs. 1i and 2), measuring approximately 243 hectares, is centred at NZ 957 012 and covers much of Brow Moor, Howdale Moor and Stony Marl Moor. Four kilometres to the north-west of the first area the second much smaller area (Area B, Figs. 1ii and 2), measuring approximately 11 hectares, is centred at NZ 928 048 on Mossy Mere. Both areas form part of Fylingdales Moor. The severity of the burn and the sensitivity of the archaeology were much lower on this second area and therefore photogrammetric recording was not judged necessary. This report primarily discusses the larger area, so henceforth use of the term the moor relates to this area unless otherwise specified.

The Fylingdales project represents a partnership between English Heritage, English Nature, The North York Moors National Park Authority, DEFRA and the owners of the Moor, the Strickland Estate, also the Court Leet. The primary aim has been to re-establish vegetation on the moor as rapidly as possible to preserve both the ecology and the archaeological resource.

Figure 1 i: Burnt area A from west looking east. Figure 1 ii: Burnt area B from east looking west. (NMR 17922/30 NZ 9601/20 03-Oct-2003, NMR 17947/24 NZ 9204/9 03-Oct-2003.)

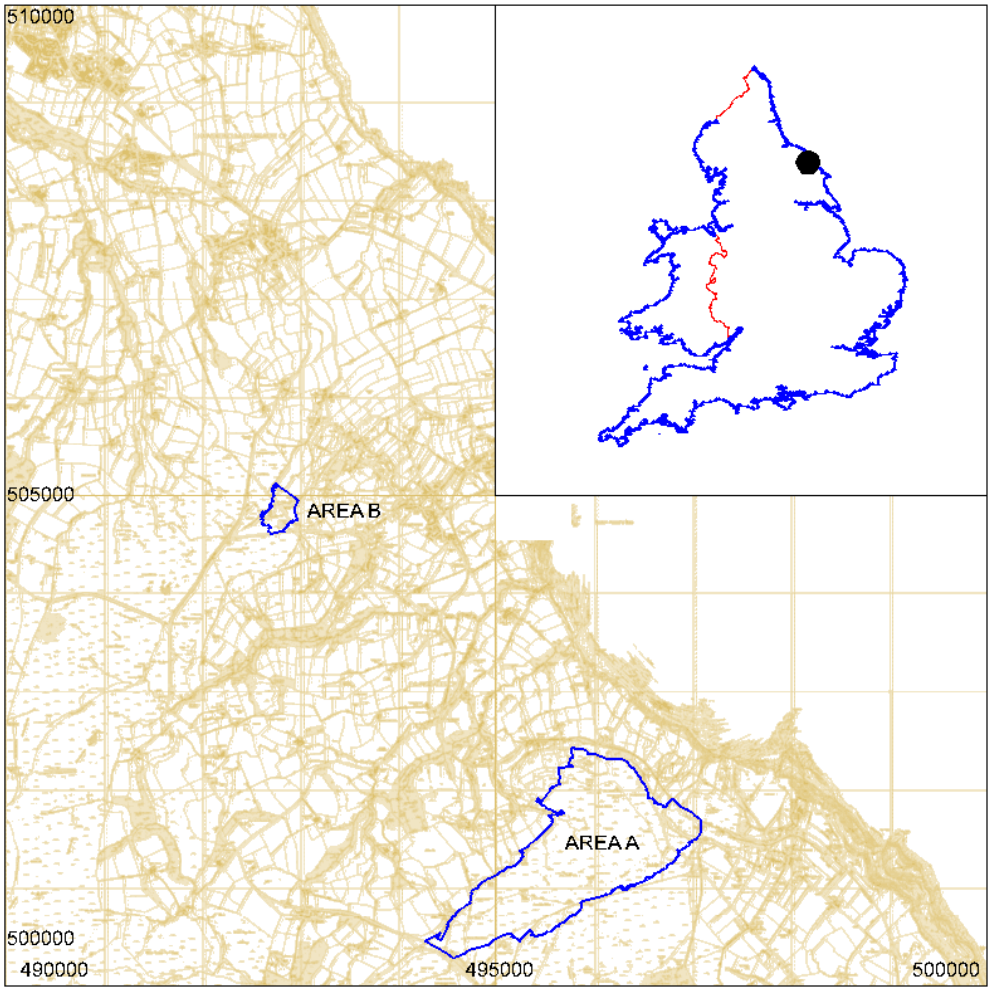


Figure 2: Location Map of burnt areas A and B.

The removal of the vegetation by the fires revealed a rich archaeological landscape with unprecedented clarity presenting a valuable opportunity for investigation and research. This area of Fylingdales Moor is significant in terms of its archaeological resource, with a wide variety of archaeological remains present ranging in date from the Bronze Age to World War II.

In addition to the photogrammetry a variety of other survey work has been undertaken to record the archaeology on the moor and has included an initial air photographic survey (Stone and Horne, 2003), a rapid walkover field survey of the entire burnt area (Vyner, 2005a) and a more detailed analytical field survey of the area of Stoupe Brow Moor (Oswald et al, 2005). The timescale for this work has been necessarily influenced by the re-seeding initiative.

More detailed site-specific research was undertaken in the following two cases:-

- The partial excavation of a Bronze Age ritual structure containing curb stones, one with unique carved decoration. (Vyner, 2005b)
- 3D laser scanning of a selection of decorated stones.

The results of the other survey work have been documented elsewhere (Stone and Horne 2003, Oswald et al 2005, Vyner 2005a and 2005b). This report presents an overview of the photogrammetric work undertaken as part of the further air photographic survey for this project.

2 PHOTOGRAMMETRY

2.1 Background

The primary aim of the wider Fylingdales Moor project was to re-establish vegetative cover on the burnt moor as rapidly as possible. The initial proposal of English Nature and the NYMNP was to spread heather seed. This is a difficult form of vegetation to establish and, in order for it to stand a chance of germination, it has to be sown in January. This gave just four months after the fire to record the archaeology of a significant area. This extremely short timescale was a major reason for choosing the photogrammetric approach for this project, together with the following considerations:-

- The specially commissioned large-scale photography would provide a detailed and accurate statement of condition for visible archaeology and ecology at a point in time immediately following the fire.
- The production of a terrain model and orthophotograph for the area through the photogrammetric software would provide valuable contextual information to underpin other survey work.
- Using the large scale photographs together with digital photogrammetric technology, detailed mapping of archaeological features to a high degree of metrical accuracy (4cm) could be undertaken at any time.

As the project progressed it became clear that heather seeding of the entire area of burnt moor was not practical. The chosen alternative was to use grass seed sown in April/May, therefore increasing slightly the timescales available for recording.

It was recognised from the outset that the photogrammetric recording would need to be tied in with some form of field survey to record additional detail, specifically the following:-

- Subtle earthwork detail
- Location of carved rocks
- Location of artefacts
- Stratigraphic and locational relationships between monuments

Ideally the photogrammetric mapping should have happened in advance of the field survey so that the drawing could have been taken out into the field and amended as necessary with the additional information. However, because of the short timescale available this did not happen. There was a delay in receiving the digital scans of the air photographs from Simmons Aerofilms which meant that the photogrammetric stereo models were only completed in January leaving only a few weeks for the plotting in advance of the field teams going out in March. An early estimate for the likely duration of one person doing the photogrammetric mapping was six months. This, in retrospect, was a considerable overestimate as it took 40 days or 8 weeks and this included not only

archaeology but other features such as heather-cutting boundaries. So, in reality, a considerable amount of plotting could have been achieved, even in the short amount of time available, for use by the field team.

When photogrammetric plotting did start in April it was targeted at recording access routes onto the moor in support of the re-seeding process. Despite the fact that the rapid walkover field survey and a higher level field survey had already been completed, a decision was made to plot the archaeology in its entirety to enable the different survey techniques to be compared to help inform future projects, see section 7.2.

2.2 Vertical photography: Specifications and set up

The vertical photography was flown by Simmons Aerofilms Limited on 23/11/03 at a scale of 1:2,500, according to a specification defined by English Heritage's Metric Survey Team (Metric Survey, 2003). A total of 52 frames were taken for the larger of the two burnt areas (NMR AF/03c/469/5720-26; 5728-39; 5741-5756; 5758-5774) and 6 frames for the smaller area (NMR AF/03c/469/5714-5719). Because a few weeks had elapsed since the fires, the layer of post-fire ash which had settled across the moor had largely been blown and washed away, revealing features to better advantage. The diapositives were scanned by Simmons Aerofilms at a resolution of 20 microns enabling a GSD (ground sample distance) of approximately 4cm per pixel. The quality of the digital scans was variable, some were particulary dark and were more difficult to work with. This was due to the automatic settings of the scanner which did not compensate for the dark tones of the burnt ground.

In order to rectify the photographs to correspond with the National Grid, 47 control points were observed across the burnt areas by members of the Metric and Field Investigation Survey teams. Features recognisable on the photographs (mostly stones) were located on the ground and surveyed using differential GPS to an accuracy of at least 25mm. The coordinates of the base receiver were calibrated to the National Grid (OSTN02) using Trimble Geomatics software, based on the position of the receiver relative to the five nearest Ordnance Survey active GPS stations, following an occupation of 18 hours. The position computed, using precise ephemeredes and passing the standard chi-squared test after one iteration of the adjustment routine, using an alternative scalar weighting strategy, was 496636.91E, 501408.327N, 256.570AOD. The survey station was permanently marked by a brass rivet set into a large boulder.

The photogrammetric work was undertaken using a Leica Digital Photogrammetric Workstation with Socet Set software. For the larger of the burnt areas, the triangulation of the four strips of photography was carried out manually using the Multi-Sensor Triangulation module. Following the bundle adjustment the XYZ rms errors for the control points were 0.021, 0.018 and 0.019 respectively, giving a total RMS of 0.033cms. The maximum error at any control point, that is, the level of maximum locational error inherent in the stereo models, was 4cm in any direction.

All photogrammetric set up and production of the terrain models and orthophotographs as detailed below was undertaken by Mick Clowes of the Metric Survey Team.

2.3 Products: Digital Terrain Model

A DTM (digital terrain model) based on a grid of 5m spacing was automatically produced through the software for the larger of the burnt areas and consisted a total of 545,000 points. For the smaller area the DTM was of 10m spacing and totalled 11,792 points.

In order to generate the terrain model, the software matches groups of pixels on one image with the same group on the consecutive image, a 3D co-ordinate is then computed for that point. The software can have difficulties with this process of pixel correlation if there are areas on the images which are very similar in colour and contrast. Because of the homogenous appearance of the burnt soils at Fylingdales, manual editing of the grid posts was necessary to increase the accuracy of the computer generated DTM.

2.4 Products: Orthophotographs

The photogrammetric software can produce orthophotographs. These are images, generated from the stereo photographs, which have had the scaling errors caused by tilt and height variation inherent in a photograph removed. Orthophotographs with a ground sample distance of approximately 4cm have been produced for both burnt areas (Appendices 1 and 2 and CD). In essence these images are very accurate photo maps of the landscape.

2.5 Products: Interpretation and mapping

Once set up, the stereo imagery was viewed and interpreted on the workstation monitor in 3D using polarising glasses. Features were plotted using vectorised line detail recorded in Microsoft Microstation as a .dgn file. Different layers were used to record specific categories of feature. The plotting was undertaken by Jane Stone of the Aerial Survey and Investigation team. See Section 3 for further detail.

2.6 Costs of photography

Simmons Aerofilms specially commissioned verticals including production of digital scans = £5710.00 + VAT.

2.7 Timescale and staff resource

Breakdown of tasks in days:

	Marcus Jecock	Mick Clowes	Jane Stone
Collection of field control	10.5	10	3
Set up of stereo models		8	
Production of DTMs		12	
Production of orthophotos		5	
Production of flyrounds		1.5	
Plotting to help access for re-seeding			12
Plotting burnt extent, both areas			0.5
Detailed plot, Stoupe Brow			10
Detailed plot, rest of area			18
Person totals (days)	10.5	36.5	43.5
Grand total (days)	90.5		

3 SUMMARY OF MAPPING RESULTS

3.1 Phases of plotting

The photogrammetric plotting has been undertaken in three separate stages, although not ideal, this was necessary due to other work schedules.

- April 2004: The first stage of plotting was done to help provide English Nature with information on route ways onto and across the moor to facilitate the re-seeding process. Tracks were depicted along with boundaries cut through the heather which act as firebreaks as it was thought that these might serve as useful additional routes. Selected archaeological features were also drawn where they lay close to, or were impacted by, tracks. Eventually the decision to use low pressure-bearing vehicles for the re-seeding negated the need for this plotting.
- April/May 2004: The aim of the second phase of plotting was to record the archaeology of Stoupe Brow in as much detail as practical. This was done to act as a comparison with the results of detailed field survey being undertaken by the English Heritage Archaeological Investigation team in this area, also the results of the walkover field survey. Section 7.2 summarises some initial observations on the comparison between the surveys.
- March/April 2006: The aim of the third phase was to complete the plotting of the whole of the burnt area to a consistent standard.

3.2 Timescale for plotting

The time taken for each of the stages of plotting is shown in a table, section 3.7 above.

3.3 Scope of plotting

Photogrammetric plotting was only undertaken for the larger of the two burnt areas. All visible archaeology was drawn with the following exceptions – these were made to speed up the plotting process:-

- At the eastern extent of the burnt area where the moorland descends steeply towards the coast, only features on the higher ground were systematically plotted. For example, the network of hollow ways leading up onto the high ground were only depicted in part where they approach the higher ground.

- For areas with the densest concentration of hollow ways and cart tracks, just the extent of the area was recorded, rather than individual tracks. No attempt was made to

systematically plot later vehicle tracks such as those made by World War II military vehicles, although a selected few were recorded.

- An ‘extent of area’ polygon was used for those areas of densest stone extraction, although some individual stone pits within these areas may have been drawn as well.

- Earth-fast stones were only drawn in the following cases:-
    - For one area centred at NZ 958 015, known to have both cairns and several examples of cup and ring marked stones, all significant earth-fast stones were recorded, although, of course, no carved decoration is visible on the photographs.
    - Certain larger stones were plotted where they coincided closely to, and potentially had a relationship with, other features of interest eg: prehistoric cairns, ring cairns and boundaries.
    - In cases of stone extraction where part of the stone has been removed leaving a pit, the remaining fragment of stone was plotted.

3.4 Interpretative drawing

The interpretative digital drawing (Appendix 6 and CD) is the main product of the photogrammetric mapping. Detailed analysis of the data has not been undertaken as this has been done in the reports resulting from the field surveys (Oswald et al 2005, Vyner 2005a and 2005b). Further desired research should be identified in the next stages of the project design. However, recording of the drawn monuments into English Heritage’s National Monuments Database (AMIE) has been undertaken (see section 4.6) and an overview of the archaeology is given in section 5.

Drawn features were allocated to different layers according to interpretation; see Appendix 3 for full list of layers used.

The majority of features drawn from the stereo models have been captured as polygons or for the linear features, such as tracks and leats, recorded as lines. For those features which have significant height, such as barrows or some of the earthworks associated with the alum reservoir and leat network, the tops and bottoms were recorded.

The Microsoft ‘dgn.’ file was opened in AutoCAD 2004 and saved as a ‘.dwg’ file. The drawn features were recorded as 3D polylines, but it was necessary to convert them to 2D polylines in order to vary the linetypes. It is the 2D version of the drawing which has been deposited in the NMR archive.

The following should be noted with respect to the drawing:-

- Hollow ways (drawn in green on interpretative plan) represent incised tracks. Most are thought to form part of the extensive network of cart tracks.
- Similarly those tracks recorded on the 'Main track' layer (depicted in orange) represent the major tracks still in use.These main tracks were drawn early in the plotting process to act as route ways across the moor which could be used by vehicles in the re-seeding process.
- Tracks were drawn on the cart track layer (drawn in sand/yellow on the interpretative plan) if there was evidence of wheel ruts of the correct spacing (approximately 1m 30 cm). Additionally, for some tracks, the central horse track is also visible although has not been drawn individually.
- It is possible that some of the stone cairns or spreads which are recorded on prehistoric layers in areas of stone extraction may be related to the latter activity instead. Where it is thought probable that stone spreads relate to stone extraction they have been drawn onto the 'Stone pile or spread' layer.

3.5 Limitations

Mapping from the vertical aerial photographs is subject to the following limitations:-

- It has not been possible to observe those features obscured by cover of trees, heavy vegetation or dense shadow.
- Some subtler earthwork features, identified through ground survey, are not visible on the photography, such as lynchets and areas of prehistoric cultivation.
- Relationships of monuments to the landscape in which they sit and also to other monuments are often more appreciable from ground survey.
- Although carved decoration on stones is not visible on the photographs, many of the decorated stones recorded through ground survey are visible.
- Although stones as small as 5cm diameter are visible scatters of artefacts are not.

3.6 Monument recording

Summary recording of the monuments drawn has been undertaken into English Heritage's National Monuments Record database (AMIE); 49 new records were created and 21 existing records amended. Appendix 4 lists these records and also lists the relevant RSM (Register of Scheduled Monument) numbers. The AMIE monument numbers have been attached to the relevant drawn objects in the digital drawing.

For certain categories of feature a single record was created for the whole of the burnt area, such as World War II features, stone extraction, peat extraction and the cart track/hollow way network.

Recording for already known monuments was dictated by existing records, for example the scheduled sites.

As part of the monument recording process a rapid concordance of the photogrammetric mapping with the results of the walkover field survey and the higher level analytical field survey was undertaken. The monument recording therefore takes into account, at a basic level, the results of the other surveys. Full concordance and analysis of the data has not been done and may form part of a future project.

4 DISCUSSION OF THE ARCHAEOLOGY

4.1 Later prehistoric archaeology of the moor

In terms of late Neolithic and Bronze Age archaeology the overall picture of activities and site types on the moor has not drastically changed, although new sites and more detail for known sites have been revealed by the fire. Many of the Bronze Age barrows were already recorded and scheduled, as were the field systems and cairnfields, but their real extent and location is now more accurately recorded. Additional data mapped includes old excavation trenches in the mounds of some barrows and details such as ditches surrounding the mounds where they exist.

New potenitial Bronze Age sites identified through the photogrammetric mapping and field surveys (Oswald 2005, Vyner 2005a) include the following:-

- at least one field system, Stoupe Brow (monument 1450144) (Oswald 2005,18-20).
- large enclosures, Stoupe Brow (monument 1449990), possibly representing livestock corrals (Oswald 2005, 14-17).
- a series of enclosures (monument 1449953) again possibly for stock (Oswald 2005, 20) around one of the Robin Hood's Butts barrows (monument 1397312).
- at least one hut circle site, Stoupe Brow (monument 1449926), with other potential sites identified through the field surveys (Oswald 2005, 21; Vyner 2005a, 27).
- field survey (Vyner 16-17; Oswald 2005, 19-20) identified several areas of ridges and grooves which may represent possible Bronze Age ploughing. The space between ridges varies from 15 to 30 centimetres. Three of these areas were also identified through the photogrammetric mapping.
- additionally the field surveys recorded almost 200 examples of late Neolithic/early Bronze Age rocks bearing carved decoration, including an intricately carved rock panel. Flint tools were also identified. (Oswald 2005, 11-13; Vyner 2005a, 17-18).

Furthermore, distinction can now be more clearly made between the following monument types:-

- round barrows varying in diameter between 8 to 21 metres.
- potential burial mounds visible as regularly-shaped cairns with diameters from 4 to 7 metres. Some of these appear to have old excavation trenches dug into their tops (monuments: 29669, 29788).
- smaller, often more irregularly-shaped, clearance cairns forming part of field systems.
- ring cairns (monuments: 29601,1449925, 1449927, 1450020, 1450021, 1450023, 1450040): circular monuments defined by a low, external bank encircling an area presumably containing burials of which only one example had been recorded for this area prior to the fire. Interpretation of these is subjective and, on closer examination, it is possible that some may prove to be round barrows.

The majority of sites occur on the higher ground as could be expected, with some areas appearing to be a particular focus for certain monument types for example the high, eastern crest of Stoupe Brow along which numerous large round barrows have been sited. Another focus appears to be a ridge of higher ground (centred NZ 958 015) sandwiched between, and overlooking, tributaries of Slape Stone Beck upon which a group of cairns (the larger of which may be burial cairns) and decorated rocks are situated (group monument 29604).

There is some difference of suggested interpretation between the three surveys for some of the features discussed above, in particular the series of enclosures around the Robin Hood Butts barrow (1449953), some banked boundaries (monument 29607) and one of the 'corral' enclosures (1449990) which all appear on Vyner's plot of features as post medieval, rather than of Prehistoric date.

4.2 Post medieval archaeology

There is evidence of a few activities of post medieval date occurring across the moor. These include alum mining, stone extraction, peat extraction and sheep farming. The evidence for these is discussed in more detail below.

The eastern extent of the burnt area encompasses two old alum quarries – Stow Brow Alum Works and the Peak Alum Works operating from the seventeenth to the nineteenth centuries. An extensive network of reservoirs and leats relating to the Stow Brow Works (1449901) was mapped on Howdale and Brow moors. These are partly depicted on nineteenth century OS mapping (1853-4), but the full extent of the system was only revealed by the fire. The earthwork remains of the quarry and its water management system have been recorded in detail and examined together with documentary sources by Oswald (2005, 23-39).

Many pits have been mapped across the burnt area. The majority of these are thought to result from the extraction of outcropping sandstone slabs (see also Oswald 2005, 43-44). In some cases parts of the split stone remain in situ in the stone pit and have been recorded when identified. Stone spreads or piles have also been recorded and presumably relate to this activity. The date of the extraction is thought likely to be post medieval (monument UID: 1449890).

Larger scale stone quarrying has been recorded at the southern extent of the burnt area (monument: 1449872). The Ordnance Survey map of 1853-4 records this in part and depicts a track, also evident on the photographs, approaching the quarry from the north-west.

An extensive network of incised hollow ways and tracks crosses the moor. The majority of these are presumed to have their origins in the post medieval period. Some of the tracks are clearly two-wheeled cart tracks as the wheel ruts and a central hollow worn by the horses' hooves are visible. The average width between the cart wheel ruts is approximately 1.3 metres. Many of the incised

hollow ways recorded are also thought to relate to the passage of carts but are perhaps just more heavily eroded. Also, clearly some tracks have remained in use to current times (these are recorded on the 'main track' layer on the photogrammetric mapping). Most of the tracks are variants of those depicted on nineteenth century Ordnance Survey mapping (1853-4). This network of tracks presumably in part relates to stone extraction which occurred extensively across the moor, also some of those crossing Stoupe Brow will be undoubtedly related to the Stow Brow Alum Quarry.

Evidence for peat-cutting on the moor takes two forms, the first being areas of peat extraction (monument 150678). Two of the areas of extraction are quite large-scale and may be twentieth century in date. The second form of evidence is a number of presumed peat-stacking platforms for the purposes of storing the slabs of cut peat. These are defined by ditches approximately 0.5 metres in width enclosing a sub-rectangular or ovular area on average measuring 4 by 3 metres. The majority of the peat stacks occur on Brow Moor. Vyner (2005a, 21-2) has proposed an alternative interpretation for these features as later prehistoric gullied structures with upright posts being set into the gullies.

Nineteenth century OS mapping (1853-4) records two sheepfolds within the burnt area. One of these is a squarish embanked enclosure, measuring 17 by 17 metres, which is still clearly evident (1449779). However, as Vyner (2005a, 19) points out, the enclosure curiously has no entrance and he draws parallel between the form of this enclosure and the Roman signal station on Bowes moor. The second 'sheepfold' label appears to correspond to a circular enclosure defined by a low bank and with a diameter of 15 metres (1450020). Vyner (2005a, 26) has suggested this feature may represent a Bronze Age ring cairn. The poor condition of the earthen banks may verify a prehistoric origin and the enclosure could have been re-used at a later date. A third potential sheepfold has been recorded on the bank of Slape Stone Beck (1449755). It is an oval embanked enclosure, measuring 23 by 18 metres with an entrance to the south-east. The OS mapping records a sheep wash on the banks of the beck close to the enclosure corroborating this interpretation. A second sheepwash is recorded on Brow Moor which re-uses a reservoir relating to the Stow Brow Alum Works.

4.3 20th century archaeology

Some 230 slit trenches and weapons pits of World War II date have been mapped across the extent of the burnt area (monument 1449886). No distinction has been made between the features in the drawing file, both being recorded onto the same layers. The slit trenches vary in size and shape, but the majority are linear trenches for 1 or 2 men, measuring approximately 2 by 0.7 metres. There are also numerous examples of 'right-angled' slit trenches. A few possible ordnance craters surrounded by upcast spoil were recorded at the northern extent of the burnt area of Howdale Moor. The largest crater has an approximate diameter of 9 metres. Other pits occurring close by may represent more craters, however, given the stone extraction activity on the moor,

interpretation of these features is subjective. No attempt was made to systematically plot later vehicle tracks including those made by World War II military vehicles, although this was done by the two field surveys.

Two lines of circular grouse shooting butts have been mapped. One is orientated north-north-west/south-south-east and the other lies roughly at a right angle to the first with a west-south-west/east-north-east orientation. Areas of turf extraction are visible around most of the butts.

A vestigial network of heather-cutting boundaries was mapped from the photographs at the request of English Nature and the NYMNP. The original objective was to use these as trackways onto the moor to help with the re-seeding initiative. Eventually the use of low pressure bearing vehicles negated the need for this. Photographs taken of Brow Moor in 2001 by English Heritage, just two years before the fire, illustrate the pattern of heather-cutting then extant (see section 6.1).

4.4 Scheduled monuments

Thirty scheduled monuments fall within the bounds of the larger of the two burnt areas, these comprise examples of late Neolithic rock art and the Bronze Age round barrows, cairns and field systems. It is clear from a rapid comparison of monuments drawn through the photogrammetric survey with a map showing the extent of the scheduled sites that the prehistoric archaeology on the moor is more extensive than previously thought, especially in terms of Bronze Age field systems and cairnfields. Also it is clear that, in many cases, the locational accuracy of the scheduled areas could be improved. Interpretation of some scheduled monuments, similarly, may need re-evaluation in light of the new evidence.

The Fylingdales study also highlights the fact that recording moorland monuments, usually covered by heather, will commonly be subject to inaccuracies in extent and location.

5 CONDITION MONITORING

5.1 Further photography

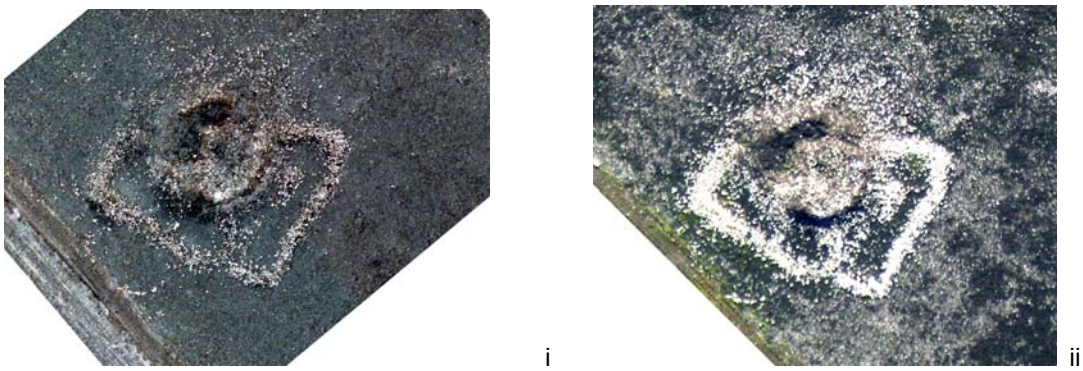
Seven sets of photographs (details of which are tabulated in appendix 4) have been taken of the burnt moor since the fire, five of these were taken by the English Heritage Reconnaissance team, one was the specially commissioned set taken by Simmons Aerofilms Ltd, and another set was taken by Anthony Crawshaw, an independent photographer. Crawshaw's photographs were taken under a light covering of snow which highlights many of the earthwork features particularly well. These sets of photographs are valuable for monitoring the state of the regeneration of the vegetation and also the condition of the archaeology.

Additionally, some photographs (NMR 17530/16-21 and NMR 17537/37-42, 26-Jan-2001) were taken of Fylingdales by English Heritage in January 2001 which show the moorland a couple of years before the fire occurred. The system of heather cutting boundaries is clearly visible across the area of Stoupe Brow, see Figure 3 below.

Figure 3: Stoupe Brow from north looking south, tow years before the fire. (NMR 17530/17 NZ 9601/6 26-Jan-2001)

5.2 Erosion

A comparison of the two images (Figure 4i and ii) below indicates the level of erosion of soils following the fire. The first image, dated 23rd November 2003, was taken just a couple of months after the fire, whereas the second was taken approximately one year later. Clearly far more stone is revealed on the second image, without the bonding properties of the soil the stone banks are liable to tumble, and the loose soils have further washed away.



i ii

Figure 4i: Robin Hood's Butts round barrow 2003. Figure 4ii: Robin Hood's Butts round barrow 2004. (af_03c_469/5731 23-Nov-2003; NMR 20175/15 NZ 9601/43 04-Nov-2004).

5.3 Regeneration of Vegetation

The composite image (Figure 5) shows the success of the re-seeding process which has been one of the key objectives of the project. The main photograph was taken in 2004 with the inset photograph taken a year beforehand just after the fire. Figure 6 illustrates the same bit of moorland approximately two years before the fire.

Figure 5: Slape Stone Beck from north looking south, showing vegetation growth. (NMR 20178/20 NZ 9501/57 4-Nov-2004, with inset photograph NMR 17947/4 NZ 9501/18 03-Oct-2003)

Figure 6:. Slape Stone Beck before the fire, from north looking south. (NMR 17530/19 NZ 9501/6 26-Jan-2001)

The main episode of grass-seeding the burnt moor occurred in May 2004, however, the area of Stoupe Brow, at the north-eastern extremity, was not re-seeded at this time, it was heather seeded some five months later in October 2004. This area, still dark and unvegetated, is clearly visible on

the overview photograph below (Figure 7) taken in November 2004. The photograph shown in Figure 8 also illustrates the stages of re-seeding. The trackway which bisects a likely prehistoric enclosure was clearly used as the northern boundary for the area of grass-seeding in May 2004. Heather-brashing of specific areas, including monuments on Stoupe Brow and Stony Marl Moor, followed in December 2004 and then further brashing of mossy areas occurred in December 2005.

Figure 7: Area A from north-west looking south-east. The success of germination of grass seed, laid in May 2004, across the majority of the burnt area is evident. (NMR 20175/1 NZ 9501/43 04-Nov-2004)

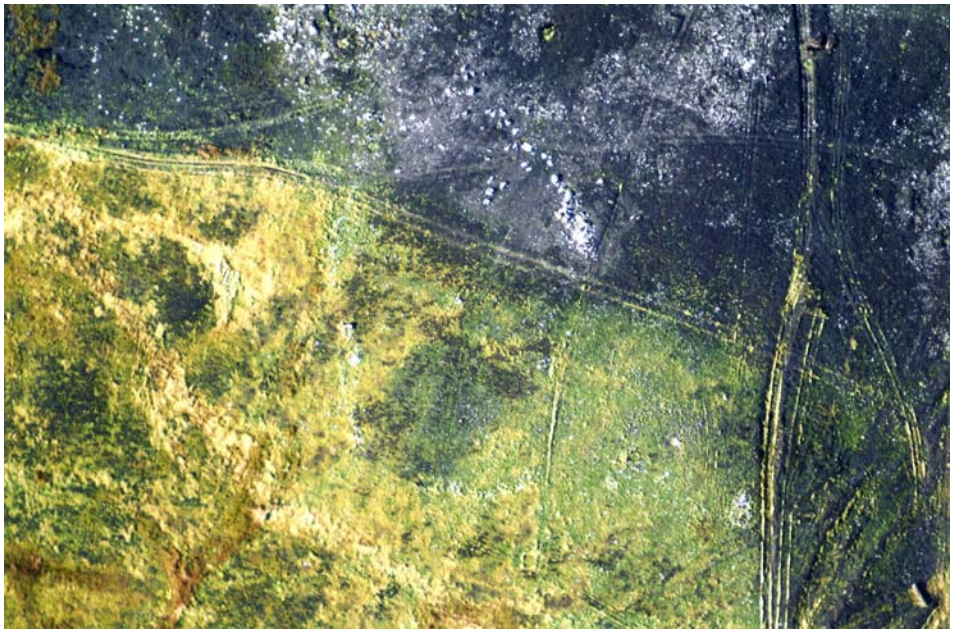


Figure 8: Prehistoric enclosure from south looking north. (NMR 20175/18 NZ9601/46 04-Nov-2004)

The moor was photographed again in May 2006 (Figure 9), the regenerating grass shows as a pale colour across the majority of the treated area.

Figure 9: Regenerating moor from west looking east. (NMR 20546/42 21-May-2006)

Figure 10 illustrates the situation two and a half years after the fire with germinating heather seed on Stoupe Brow, and the Robin Hood's Butts barrows covered in heather brash. Many of the more significant monuments on Stoupe Brow and Stony Marl Moor were treated in this way.

Figure 10: Stoupe Brow from east looking west. (NMR 20546/55 21-May-2006)

6 DISCUSSION AND CONCLUSIONS

6.1 Archaeology

For later Neolithic and Bronze Age archaeology the general picture of monument types and land use recorded on the moor has not changed to any great extent, although the sites are now recorded more accurately in terms of extent and location. Classes of monuments comprise:-

- Late Neolithic/early Bronze Age rock art (not identified through the photogrammetry although the individual stones are often visible).
- Bronze Age field systems comprising banked boundaries and clearance cairns.
- Bronze Age burial monuments in the form of cairns and round barrows.

However, there is now also evidence for the following sites of Bronze Age date:-

- Enclosures, possibly for stock management.
- House sites.
- Ring cairns, of which only one example was previously recorded for this area.
- Cultivation in the form of areas of ridges and furrows thought to represent plough marks.

The survey data recorded has implications for scheduling, as many of the scheduled records require re-evaluating in terms of one or all of the following counts - location, extent and interpretation.

Evidence has been recorded for post medieval activities including stone extraction, peat extraction and a water management system, in the form of reservoirs and leats, related to Stow Brow Alum Works. Also there is extensive earthwork evidence for World War II military training in the form of slit trenches, weapons pits, ordnance craters and vehicle tracks, although the latter were not recorded systematically by the photogrammetric mapping.

The surveys undertaken have interpreted features differently in some cases, potentially flagging the need for further research.

The archaeology recorded for Fylingdales will undoubtedly be paralleled on uplands elsewhere, but rarely is there an opportunity to record it in detail without the covering of vegetation which masks so much. Perhaps more consideration should be given to the recording of areas which have had the vegetation removed through the regular moorland activity of localised burning undertaken to regenerate the heather.

6.2 Comparison of survey techniques

The Fylingdales project has presented a useful opportunity to compare and contrast the results of three different types/levels of survey - digital photogrammetry, rapid walkover field survey and high level analytical field survey. To do this comprehensively, a detailed concordance of data from the surveys is required and may happen as part of the further project. However, because of the requirement to record the results of the photogrammetric mapping into the National Monuments Record, a basic concordance of the data was undertaken from which the following general observations are made:-

- **Locational accuracy:** Comparison of the photogrammetric mapping with each of the two field surveys is favourable in terms of locational accuracy. Some features match exactly but there is a discrepancy of approximately 3.5 metres in some places between the photogrammetric survey and both field surveys. There is a similar discrepancy between the two field surveys. For the photogrammetric and level 3 analytical field surveys AutoCAD drawing files overlaid onto each other were used, this should give a very accurate basis for comparison. However, for the walkover field survey scans of paper maps were used which were then aligned in AutoCAD using grid cuts which may account for some inaccuracies. Clearly, in this case, comparison would be more accurately made if the digital data for the walkover field survey had been used.
- **Identification of features:** The surveys can be ranked as follows in terms of identification of features from the highest level down: analytical field survey, walkover field survey, photogrammetric survey. The photogrammetric survey did record the majority of the earthworks but the field surveys identified more subtle details like additional examples of the turf cutting stack stands and areas of prehistoric cultivation, which were difficult to see with confidence on the photography. Additionally they identified artefacts and decorated rocks which, from the outset, it was known that the photogrammetry could not.

  The analytical field survey, as expected, recorded the highest level of data, identifying an additional dimension of subtle earthwork detail such as slight scarps interpreted as field boundaries. However, it is interesting to note that one particular earth and stone boundary on the crest of Stoupe Brow, clearly visible on the photography, proved difficult to identify on the ground. Also, the rapid walkover field survey appears to have recorded some features that the analytical field survey did not, such as carved rocks and cairns. Obviously weather conditions play a considerable part in ground survey, and conditions on the moor in March and April when the surveys occurred were often very difficult.

  It is also worth noting that the quality of the digital scans used in the photogrammetry were variable with some images being very dark despite contrast/brightness adjustments available in the photogrammetric software. This was due to the automatic settings of the scanner used to produce the digital copies of the photographic diapositives which did not compensate for the dark tones of the burnt ground.

Another factor to consider is the photography was taken a good three months before the field surveys occurred, so this may have had some bearing on the visibilility of certain features, such as the patches of cultivation.

- **Interpretation of features:** In terms of broad interpretation the three surveys compare well, although there are some differences, discussed in Section 5. This is often the nature of archaeology and hopefully further research will help clarify any such anomalies. The highest level of understanding of the archaeology came unsurprisingly from the analytical field survey.
- **Product type:** Both the photogrammetric and analytical field surveys produced a 3D drawing depicting the archaeology on separate interpretative layers. The rapid walkover field survey produced a dot distribution along with linears and extents of areas. In terms of ease of use and understanding, the drawn products must be considered more desirable.
- **Timescales/Staff resource:** For comparative purposes with the other survey techniques a breakdown of the person hours for the photogrammetric work is detailed in Section 3.7. It should be noted that the plotting was undertaken in three distinct phases with months imbetween each phase, this was not ideal and undoubtedly the process would have been done more quickly and efficiently if it had been done as a single phase.
- **Lidar:** One form of survey with great potential for this type of project which was not tested in this case is light detection and ranging (lidar) which is currently providing very successful results (Bewley et al 2005, Crutchley 2006).

6.3 Summary of contribution of air photographic work to this project

- At the beginning of the project the initial set of oblique photographs taken by the English Heritage reconnaissance team gave an immediate and rapid overview of the project area. These photographs contain much information on the archaeology and could have formed the basis for interpretation and mapping to an accuracy of approximately 5 metres or better.
- The commissioned large scale verticals provide a very accurate and detailed record of the condition of both the ecology and archaeology of the moor just a few weeks after the fires. The level of detail visible on this photography is considerable with stones as little as 5cm in diameter visible.
- The photogrammetric work has provided a detailed and metrically accurate digital terrain model and orthophotograph for both areas to underpin the rest of the project work.
- Photogrammetric mapping is the highest level of air photographic mapping. Interpretation and plotting from the stereo models has identified and recorded the majority of the visible archaeology of the moor. Accuracy of the mapping is approximately 4cm.

- Further photography taken of the site by the English Heritage reconnaissance team documents the regeneration process and contributes to the process of condition monitoring.
- It was not felt necessary to consult the historical photography for the area, including previous vertical photography, as the new photography revealed the landscape and archaeological features with such clarity.

6.4 Other factors to consider with respect to photogrammetry

With respect to other projects the following aspects of photogrammetric survey should be considered along with the observations made above:-

- It is not reliant on prolonged decent weather conditions – all that is needed is a few hours of good weather enabling the photography to be obtained. The success of the mapping is dependant on the quality of images taken.
- It is a non-intrusive form of survey causing no damage to archaeology or ecology.
- Currently English Heritage is the only practitioner of photogrammetric mapping for archaeological purposes in England. Clearly, therefore, ability of English Heritage to support suitable projects is dependant on both availability of specialist staff and photogrammetric equipment.
- Features masked by dense vegetation or shade may not be identified.
- The timing of any photography is important. The first English Heritage photography was taken two weeks after the fire and some features were still masked by ash. The Simmons vertical photography was taken two months after the fire when light rain and wind had dispersed some of the ash revealing more detail.
- Photogrammetry will not identify as much detail as field survey. So, ideally it needs to be supported by some level of field survey to identify additional features, relationships and help resolve anomalies. At the very least, field visits during plotting will help promote more accurate interpretation.
- Once the photography and control information have been captured mapping can be undertaken at any time. This is obviously particularly useful if a site is under imminent threat of damage or destruction.
- If a site or area is dangerous or difficult for ground survey, photogrammetry, or indeed lidar, can provide an effective alternative.

7 DATA ARCHIVE AND DISSEMINATION

7.1 Copyright

The copyright of the majority of photographs (including all those used in this report), air photo mapping, report and CD produced by this project lies with English Heritage. Permission to reproduce and publish any of this material must be sought from NMR Enquiry and Research Services, NMRC, Kemble Drive, Swindon SN2 2GZ. The photographs taken by Anthony Crawshaw on 02/03/04 (see Appendix 4) were taken independently of this project and he retains copyright

7.2 Project Archive

The main product of this project is an Autodesk Map 2004 drawing file. Digital and hard copy versions of this drawing have been deposited with the NMR archive and can be accessed by contacting NMR Enquiry and Research Services in Swindon address as above.

In addition a CD containing .pdf versions of the interpretative plan and orthophotographs for both burnt areas is included with this report (Appendix 7).

7.3 Project Dissemination

A digital copy of the photogrammetric mapping has been supplied to the North York Moors National Park Authority.

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8 REFERENCES

Bewley, RH, Crutchley, SP and Shell, CA 2005 New light on an ancient landscape lidar survey in the Stonehenge World Heritage site. *Antiquity* **79** (305), 636-647.

Crutchley, SP 2006 Light detection and ranging (lidar) in the Witham Valley, Lincolnshire: an assessment of new remote sensing techniques. *Archaeological Prospection* **13** (4), 251-257.

Metric Survey 2003 *Vertical Aerial Photography and Derived Digital Imagery. Client Specification Guidelines. Fylingdales Moor.*

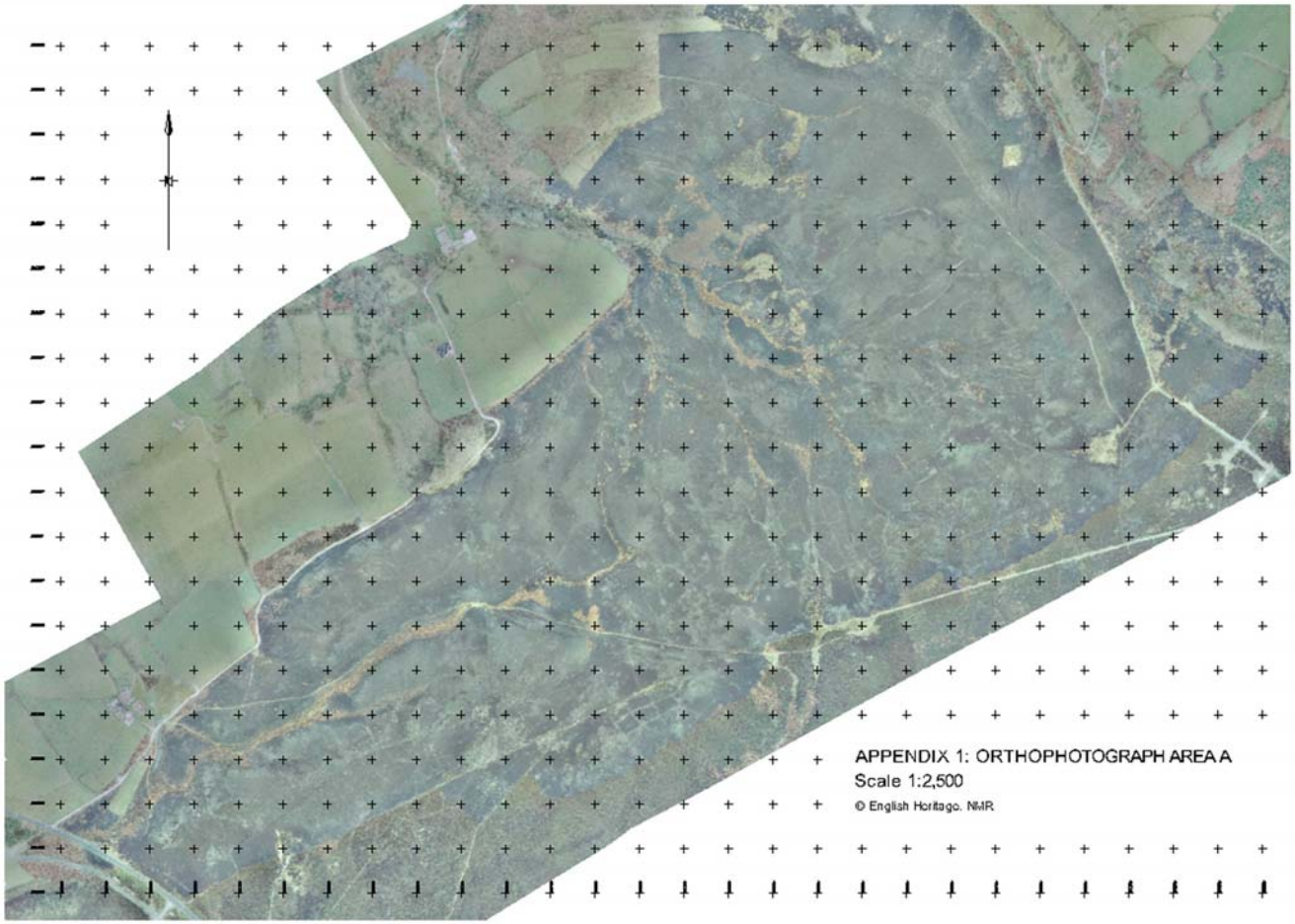
Oswald, A et al 2005 *Analytical field survey of prehistoric and post-medieval remains on Fylingdales Moor, North Yorkshire*. Archaeological Investigation Report Series AI/12/2005.

Stone, JL and Horne, PD 2003 *Fylingdales Moor, North Yorkshire.* English Heritage Aerial Survey Report Series AER/07/2003

Vyner, B 2005a *Stony Marl, Howdale, Stoupe Brow Moors, Mossey Moor Fylingdales, North Yorkshire: Report on walk-over survey of the fire sites.*

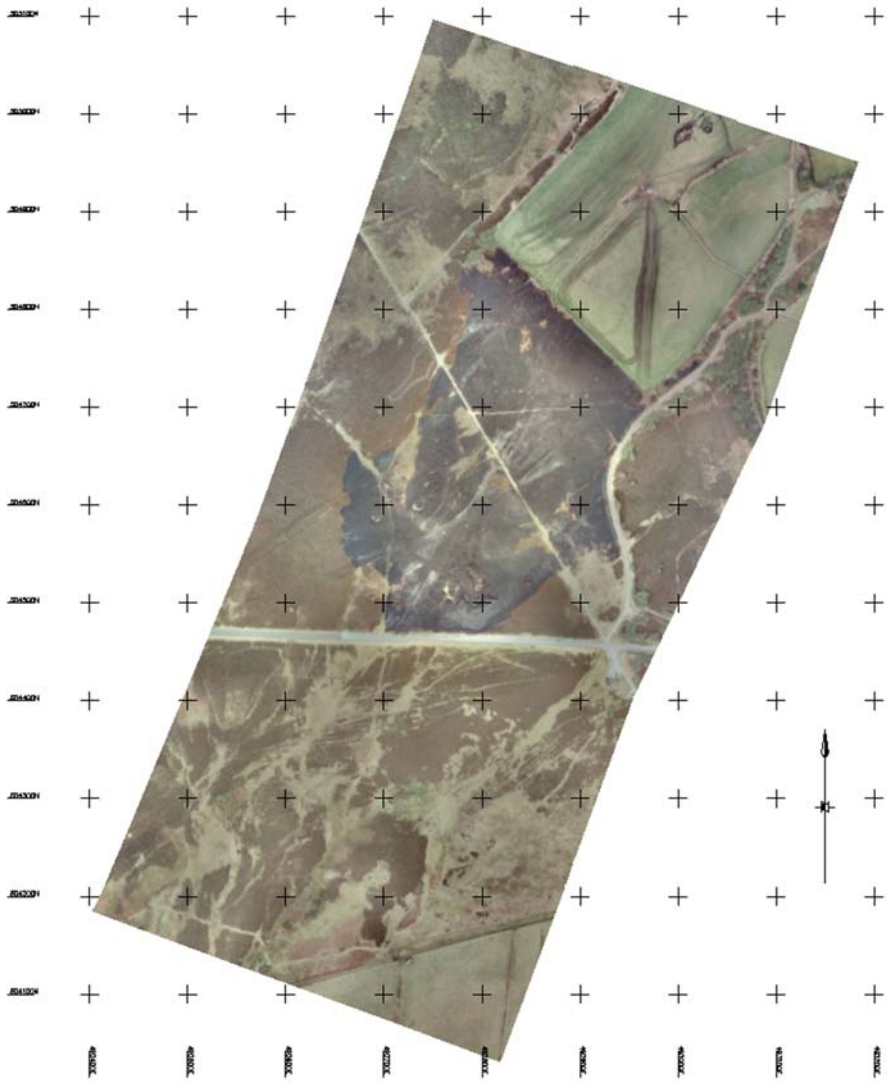
Vyner, B 2005b *The Stoupe Brow Monument, Fylingdales, North Yorkshire: Report on the Archaeological Evaluation of an Early Bronze Age Ritual Structure.*

APPENDIX 1: ORTHOPHOTOGRAPH AREA A



An illustration of the orthophotograph of the burnt area on Stony Marl, Howdale and Brow Moors. A .pdf version is also included on the CD supplied with this report.

APPENDIX 2: ORTHOPHOTOGRAPH AREA B



An illustration of the orthophotograph of the burnt area on Mossy Mere. A .pdf version is also included on the CD supplied with this report.

APPENDIX 3: AUTODESK MAP INTERPRETATIVE LAYERS

Layer name	Color	Linetype
Alum earthwork bottom	5 (blue)	DASHED
Alum Leat or reservoir spoil	5 (blue)	DOT
Alum Leat or resevoir top	5 (blue)	Continuous
Alum Quarry edge	11	Continuous
Alum earthwork top	5 (blue)	Continuous
Burnt boundary	252	Continuous
Cart track	52	Continuous
Cart track extent	52	DASHDOT
Excavation earthwork bottom	4 (cyan)	DASHED
Excavation spoil	4 (cyan)	DOT
Excavation earthwork top	4 (cyan)	Continuous
Unknown earthwork bottom	252	DASHED
Unknown earthwork top	252	Continuous
Grouse butt	250	Continuous
Heather cutting boundaries	204	Continuous
Hollow way	3 (green)	Continuous
Main track	37	Continuous
Modern cairn	7 (white)	Continuous
Modern drain spoil	31	DOT
Modern drain top	31	Continuous

Modern vehicle track	51	Continuous
Multiple hollow ways extent	3 (green)	DASHDOT
Natural knoll top	43	Continuous
Natural knoll bottom	43	DASHED
Natural watercourse hatch	4 (cyan)	Continuous
Natural watercourse top	4 (cyan)	Continuous
Peat extraction or cutting	253	Continuous
Peat stack enclosure spoil	47	DOT
Peat turf stack enclosure top	47	Continuous
Prehistoric feature bottom	1 (red)	DASHED
Prehistoric cairn	1 (red)	Continuous
Prehistoric cultivation	1(red)	DOT
Prehistoric feature subjective bottom	1 (red)	DASHED
Prehistoric feature subjective top	1 (red)	Continuous
Prehistoric feature top	1 (red)	Continuous
Quarry hatch	7 (white)	DOT
Quarry spoil	7 (white)	DOT
Quarry top	7 (white)	Continuous
Road modern	2 (yellow)	Continuous
Sheepfold bottom	43	DASHED
Sheepfold top	43	Continuous
Stone	134	Continuous
Stone pile or spread	134	DASHED

Stone pit	40	Continuous
Stone pit area extent	40	DASHDOT
Stone pit spoil	40	DOT
Unknown earthwork top	252	Continuous
Unknown earthwork bottom	252	DASHED
Vegetation	103	Continuous
Vegetation hatch	103	Continuous
Water erosion	132	Continuous
Water hatch	5 (blue)	Continuous
Water line	5 (blue)	Continuous
World War crater spoil	191	DOT
World War crater top	191	Continuous
World War spoil extent	6 (magenta)	DOT
World War trench bottom	6 (magenta)	DASHED
World War trench top	6 (magenta)	Continuous

APPENDIX 4: LIST OF NMR RECORDS

HOB UID	PERIOD	MONUMENT TYPE	NGR	RSM number
29598	BRONZE AGE	ROUND BARROWS	NZ 95631 02116, NZ 95724 02099	34385 34386
29601	BRONZE AGE	ROUND BARROWS/RING CAIRN	NZ 9587 0205, NZ 9593 0204, NZ 9594 0205, NZ 9596 0203	34387
29604	LATE NEOLITHIC/BRONZE AGE	BURIAL CAIRNS/ROUND BARROWS/CUP AND RING MARKED ROCKS	NZ 9586 0152	34380
29607	BRONZE AGE	FIELD SYSTEM/BOUNDARY/CLEARANCE CAIRN/BURIAL CAIRN	NZ 957 012	34381
29610	BRONZE AGE	CAIRNFIELD/CLEARANCE CAIRN/BURIAL CAIRN	NZ 952 008	34374
29613	BRONZE AGE	ROUND BARROWS	NZ 95521 00603 NZ 95621 00675 NZ 95695 00725 NZ 95775 00723 NZ 95790 00704	31371 31372 31373 31374
29616	BRONZE AGE	ROUND BARROW	NZ 9594 0106	
29645	BRONZE AGE	ROUND BARROW	NZ 96039 01985	34388
29651	BRONZE AGE	ROUND BARROW/CLEARANCE CAIRN	NZ 96545 01606	34392
29654	BRONZE AGE	ROUND BARROW	NZ 96095 01614	34391
29657	BRONZE AGE	ROUND BARROW	NZ 9606 0103	34384
29660	BRONZE AGE	CAIRNFIELD/CLEARANCE CAIRN	NZ 9570 0093	34382
29669	BRONZE AGE	BURIAL CAIRN	NZ 96218 01743	34390
29704	BRONZE AGE	RING CAIRN/ROUND BARROW	NZ 94723 00709	31380
29788	BRONZE AGE	CAIRNFIELD/CLEARANCE CAIRN/BURIAL CAIRN/BOUNDARY	NZ 948 005	34372
584426	BRONZE AGE	ROUND BARROW	NZ 95289 01290	34379
1339950	BRONZE AGE	ROUND BARROW	NZ 9647 0170	34404
1342777	BRONZE AGE	ROUND BARROW	NZ 9594 0100	34383
1364714	BRONZE AGE	ROUND BARROW/CLEARANCE CAIRN/BURIAL CAIRN	NZ 9647 0134	34394
1365663	BRONZE AGE	ROUND BARROW/CLEARANCE CAIRN/BURIAL CAIRN	NZ 967 014	34393
1397312	BRONZE AGE	ROUND BARROW	NZ 96265 01978 NZ 96293 01916 NZ 96296 01898	34389

1449755	POST MEDIEVAL	SHEEP FOLD	NZ 9573 0173	
1449770	POST MEDIEVAL	SHEEP FOLD	NZ 9642 0127	
1449773	POST MEDIEVAL	PEAT STACK STAND	NZ 96052 01812	
1449778	POST MEDIEVAL	PEAT STACK STAND	NZ 96067 01830	
1449781	POST MEDIEVAL	PEAT STACK STAND	NZ 96080 01841	
1449782	POST MEDIEVAL	PEAT STACK STAND	NZ 96095 01853	
1449790	POST MEDIEVAL	PEAT STACK STAND	NZ 96125 01859	
1449801	POST MEDIEVAL	PEAT STACK STAND	NZ 96108 01788	
1449803	POST MEDIEVAL	PEAT STACK STAND	NZ 96191 01785	
1449818	POST MEDIEVAL	PEAT STACK STAND	NZ 96085 01705	
1449819	POST MEDIEVAL	PEAT STACK STAND	NZ 96088 01690	
1449831	POST MEDIEVAL	PEAT STACK STAND	NZ 96001 01903	
1449839	POST MEDIEVAL	PEAT STACK STAND	NZ 96352 01858	
1449842	POST MEDIEVAL	PEAT STACK STAND	NZ 96193 02122	
1449860	POST MEDIEVAL	ENCLOSURE/SHELTER/HEARTH	NZ 96081 01808	
1449861	POST MEDIEVAL/MODERN/WORLD WAR II	RECTANGULAR ENCLOSURE/GUN EMPLACEMENT	NZ 95666 02158	
1449862	POST MEDIEVAL/20TH CENTURY	MOUND	NZ 95779 02213	
1449872	POST MEDIEVAL	SANDSTONE QUARRY	NZ 9497 0042	
1449886	WORLD WAR II	WEAPONS PIT/SLIT TRENCH/BOMB CRATER	NZ 95 01	
1449890	POST MEDIEVAL	STONE EXTRACTION SITE/SANDSTONE QUARRY	NZ 95 01	
1449900	POST MEDIEVAL	HOLLOW WAY/CART TRACK	NZ 95 01	
1449901	POST MEDIEVAL	ALUM WORKS/RESERVOIR/QUARRY/LEAT	NZ 959 022	
1449918	BRONZE AGE	ROUND BARROW	NZ 95735 02113	
1449923	BRONZE AGE	ROUND BARROW	NZ 95733 02136	
1449924	BRONZE AGE	ROUND BARROW	NZ 95846 02114	
1449925	BRONZE AGE	RING CAIRN	NZ 96160 02075	
1449926	BRONZE AGE	HUT CIRCLE	NZ 96188 02064	
1449927	BRONZE AGE	RING CAIRN	NZ 96125 02084	
1449953	BRONZE AGE	ENCLOSURE	NZ 96265 01988	
1449976	BRONZE AGE	CLEARANCE CAIRN/BURIAL CAIRN	NZ 96191 01733	

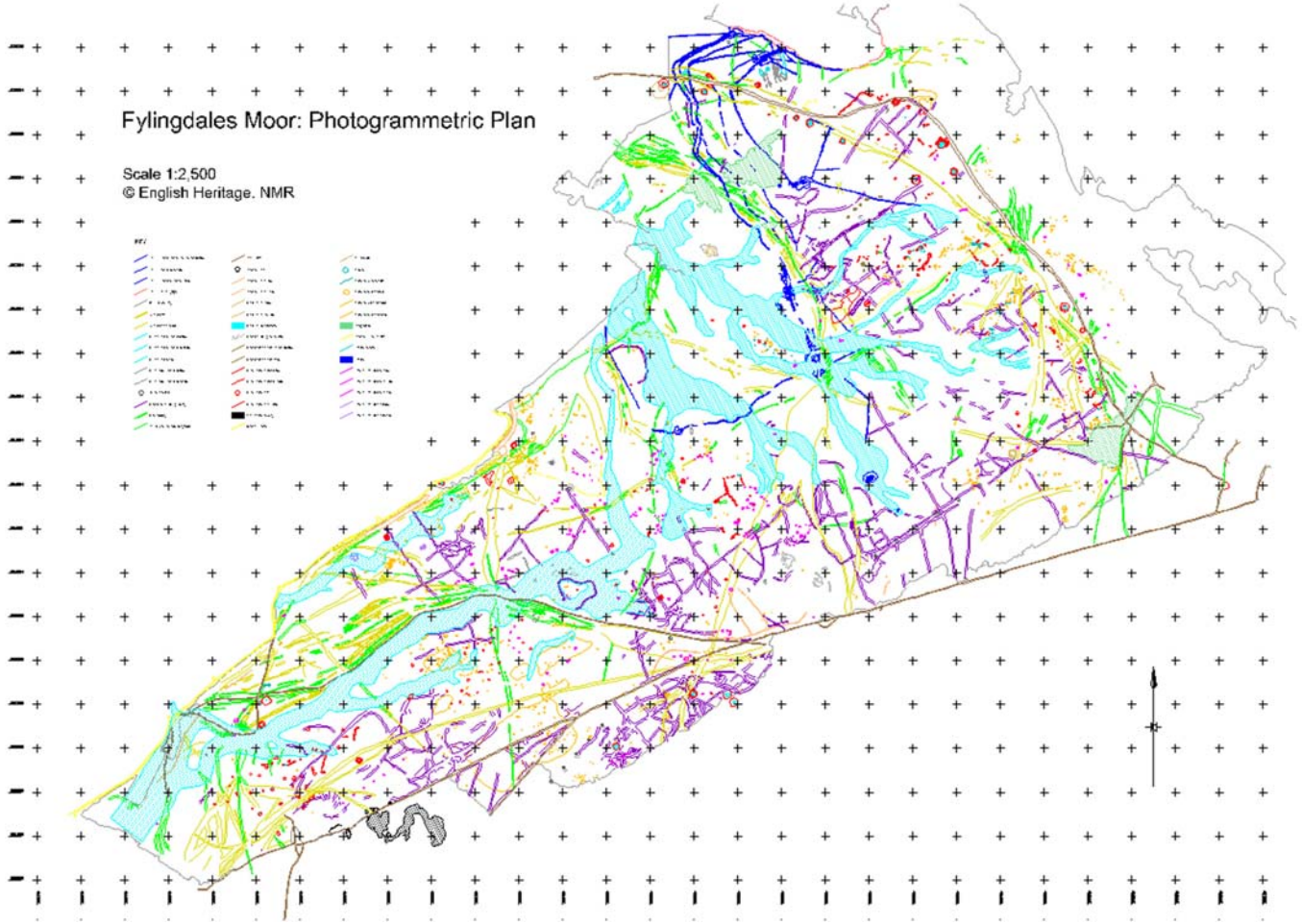
1449978	BRONZE AGE	CLEARANCE CAIRN/BURIAL CAIRN	NZ 96014 01699	
1449987	BRONZE AGE	CLEARANCE CAIRN/BURIAL CAIRN	NZ 9623 0186	
1449990	BRONZE AGE	ENCLOSURE	NZ 962 017	
1450020	BRONZE AGE	CIRCULAR ENCLOSURE/SHEEP FOLD/RING CAIRN	NZ 94713 00653	
1450021	BRONZE AGE	RING CAIRN/ROUND BARROW	NZ 94934 00573	
1450023	BRONZE AGE	RING CAIRN/ROUND BARROW	NZ 94998 01082	
1450026	BRONZE AGE	ROUND BARROW	NZ 95124 01206	
1450030	BRONZE AGE	ROUND BARROW/RING CAIRN	NZ 95675 01210	
1450040	BRONZE AGE	RING CAIRN/ROUND BARROW	NZ 95624 00944	
1450127	BRONZE AGE	CLEARANCE CAIRN	NZ 955 011	
1450131	BRONZE AGE	FIELD SYSTEM/FIELD BOUNDARY/CLEARANCE CAIRN/BURIAL CAIRN	NZ 953 011	
1450144	BRONZE AGE	FIELD SYSTEM/FIELD BOUNDARY/LYNCHET/CLEARANCE CAIRN	NZ 961 019	
1450675	POST MEDIEVAL	FIELD SYSTEM/BOUNDARY BANK	NZ 952 010	
1450678	POST MEDIEVAL/20TH CENTURY	PEAT CUTTING	NZ 95 01	
1451292	POST MEDIEVAL	CIRCULAR ENCLOSURE	NZ 95337 00898	
1451295	POST MEDIEVAL	PEAT STACK STAND	NZ 96129 01849	
1451300	POST MEDIEVAL	PEAT STACK STAND	NZ 96184 01834	
1451302	POST MEDIEVAL	PEAT STACK STAND	NZ 96404 01708	
1451329	BRONZE AGE	PLOUGH MARKS	NZ 9522 0121 NZ 9528 0121 NZ 9605 0162	

APPENDIX 5: PHOTOGRAPHY UNDERTAKEN SINCE THE FIRES

Copyright & Repository	Film and Frames	Oblique/ Vertical	Date flown	Area A and or Area B	Additional Comments
NMR	17922/8-10, 13-35 17923/0-35 17947/1-11, 24	O	03/10/03	A and B	Photography taken just a few weeks after the fires and which was used as basis for intial assessment of archaeology
NMR	Area A AF/03c/469/5720-26; 5728-39; 5741-5756; 5758-5774 Area B AF/03c/469/5714-5719	V	23-4/11/03	A and B	Simmons Aerofilms verticals, scale 1:2500 used for the photogrammetric work
NMR	17975/10-15 17981/5-10	O	22/12/03	A	Photography taken under heavyish snow cover

AJC	480/1-30	O	02/03/04	A	Taken in covering of light snow accentuating some of the earthworks
NMR	20174/5-6; 16-17 20175/1-18 20176/1-10 20178/5-24 20179/1-20 20180/1-24 20181/1-19	O	04/11/04	A and B	Photography taken approximately one year after the fire and useful for showing erosion of sites and regeneration of vegetation.
NMR	EHV/05001/1-24 EHV/05002/1-15 EHV/05003/1-24 EHV/05004/1-23	V	25/06/05	A and B	Scale varies from 1:2700 to 1:3000. Photography taken approaching two years after the fires – useful for showing regeneration of vegetation.
NMR	20546/40-56 20547/1-23	O	31/05/06	A	Photography taken in 2006 approximately two and a half years after the fires – useful for further condition monitoring

APPENDIX 6: INTERPRETATIVE PLAN OF PHOTOGRAMMETRIC MAPPING



An illustration of the interpretative plan of the photogrammetric mapping of the burnt area on Stony Marl, Howdale and Brow Moors. A .pdf version is also included on the CD supplied with this report.