

HAILSTORM COLLIERY
SAND ROCK MINE
WORKED BY
MESS^{rs} BUTTERWORTH & BROOKS

Gravel Col. Laving Shale, R. 80 Limestone
 Average thickness of Coal 17 ft 6 in
 Roof of Coal Sand rock (Rough rock) shaly and
 round when not too near the surface
 Floor of Coal Siding or Common fine clay
 2 ft. to 4 ft. thick

EXPLANATION

Coal gotten from commencement to March 5 th 1870	coloured blue
Do March 5 th 1870 to March 6 th 1872	Do
Do March 6 th 1872 to August 2 nd 1874	Do
Do August 2 nd 1874 to June 8 th 1876	Do
Do June 8 th 1876 to March 16 th 1878	Do
Do March 16 th 1878 to March 6 th 1879	Do
Do March 6 th 1879 to March 16 th 1880	Do
Do March 16 th 1880 to August 4 th 1881	Do
Do August 4 th 1881 to July 15 th 1882	Do
Do July 15 th 1882 to May 24 th 1883	Do

1591

SCALE
 20 fms. to 1 inch

The position of this small Colliery
 may be seen on the Great Ordnance
 map Sheet 80, but being on a moor
 with but few landmarks the exact
 place may be found by the lines of
 latitude and longitude

Joseph Dickinson
 H.M. Inspector of Mines
 of the District.
 25th April 1884

SAND ROCK MINE BRANDWOOD MOOR COLLIERY WORKED BY MR DAVID LAW
AT INTAKE AND PART BLANK IN THE HAMLET OF BRANDWOOD LOWER END
TOWNSHIP OF SPOTLAND AND COUNTY OF LANCASTER

FEBRUARY 1886

Isabella Dickinson
W. & J. Dickinson & Sons of the District
12 & 14, Market, 1886

Coal which may be worked from the Breckings Brandwood Moor Colliery

The Breckings Brandwood Moor Colliery

COAL COTTEN BY MR E ASHWORTH

COAL COTTEN BY MR JOHN WOODHEAD

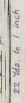
SUPPOSED OLD WORKINGS

OLD WORKINGS

Section of the Sand Rock Mine



Scale of Yards



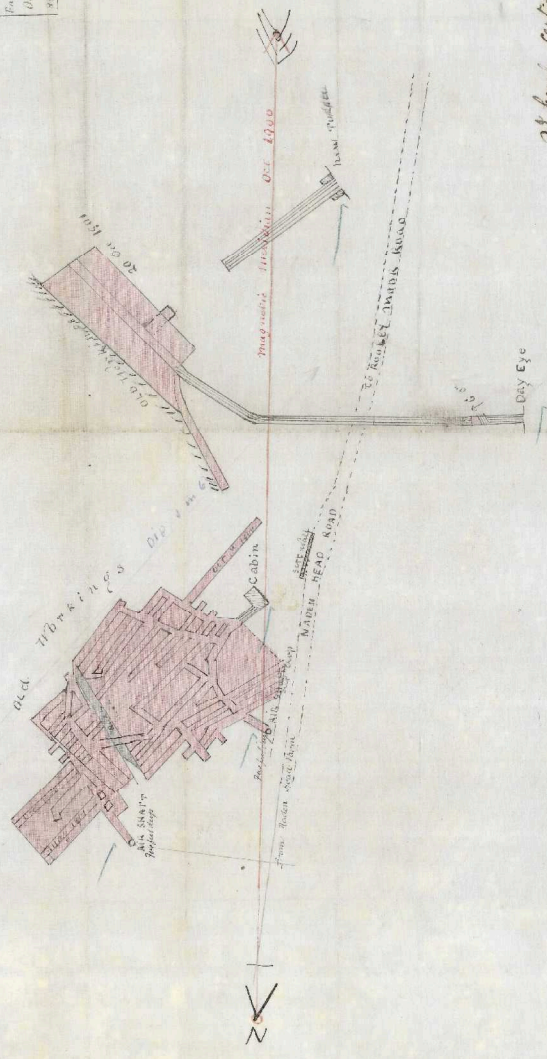
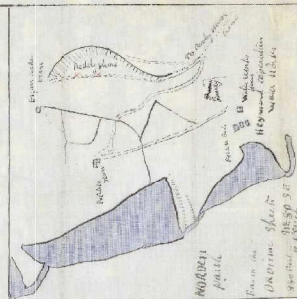
1843

THE COAL AUTHORITY

1843

WORKING BY

mess^{rs} J Lomax and C^o Lm^{td}



I hereby certify after thorough examination
and enquiry that to the best of my
knowledge and belief this plan is an
accurate plan of the mine.

Siôn Tho Andrews

4212

Scale 20 Yards to One Inch

4212

T. Address.



**The Coal
Authority**



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Catalogue No.: 4212 Sheet Info:

Date: 30/01/2012

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PLAN OF THE SAND ROCK MINE ROOLEY MOOR COLLIERIES WORKED BY MESS^{RS} JOHN LOMAX AND CO. LTD. 5454
TOWNSHIP OF NORDEN. PARISH OF ROCHDALE.
— COUNTY OF LANCASTER —



Scale 20 Yards to One Inch.

5454

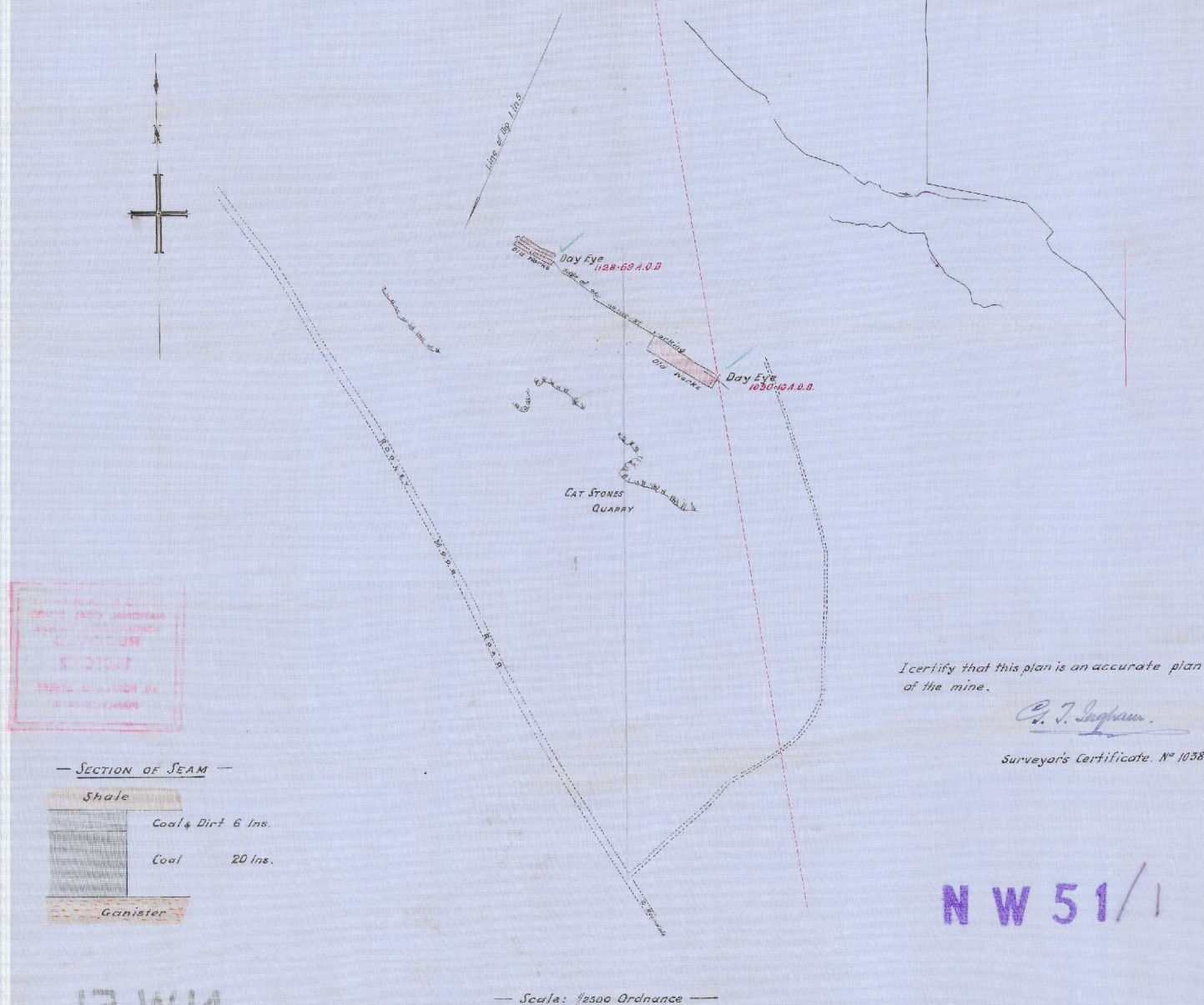
5454

LOWER MOUNTAIN MINE, ROOLEY MOOR COLLIERY.

— WORKED BY —

MESSRS COURTEN, REDMAN & DAVENPORT.

— KEY PLAN —



I certify that this plan is an accurate plan of the mine.

G. J. Ingham.

Surveyor's Certificate. No 1038.

NW 51/1

Scale: 1/2500 Ordnance

G. J. Ingham
Chartered Surveyor
Widened

The Coal Authority



Catalogue No.: NW51 Sheet Info: 1 OF 2

Date: 30/01/2012

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MESS^{RS} COURTEN, REDMAN & DAVENPORT.



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Scale: 1 TO 2500

Scout Moor Wind Farm Expansion - Mining Risk Assessment



February 2015

Client Name: Scout Moor Wind Farm Expansion
Limited

Site Address: Scout Moor Wind farm, Scout Moor
Quarry, Scout Road, Edenfield, Lancashire, BL9 6T

Author: Chris McCulla, Assistant Geotechnical Engineer

1000114

Planning & Development | Ecology & Hydrology | Technical
Construction & Geotechnical | Asset Management | Due Diligence



Document history

Author	Chris McCulla	08/12/2014
Checked	Gavin Germaine	09/12/2014
Approved	Gavin Germaine	24/02/2014

Client Details

Contact	Stephen Snowdon
Client Name	Scout Moor Wind Farm Expansion Limited
Address	Scout Moor Wind farm, Scout Moor Quarry, Scout Road, Edenfield, Lancashire, BL9 6T

Issue	Date	Revision Details
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B	January 2015	Draft Second Issue
C	February 2015	Draft Final Issue

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Local Office:

The Green House, Forrest Estate
Dalry, Castle Douglas, DG7 3XS
SCOTLAND, UK
Tel: +44 (0) 1644 430 008

Registered Office:

The Natural Power Consultants Limited
The Green House
Forrest Estate, Dalry,
Castle Douglas, Kirkcudbrightshire,
DG7 3XS

Reg No: SC177881
VAT No: GB 243 6926 48

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1. Introduction

1.1. Location

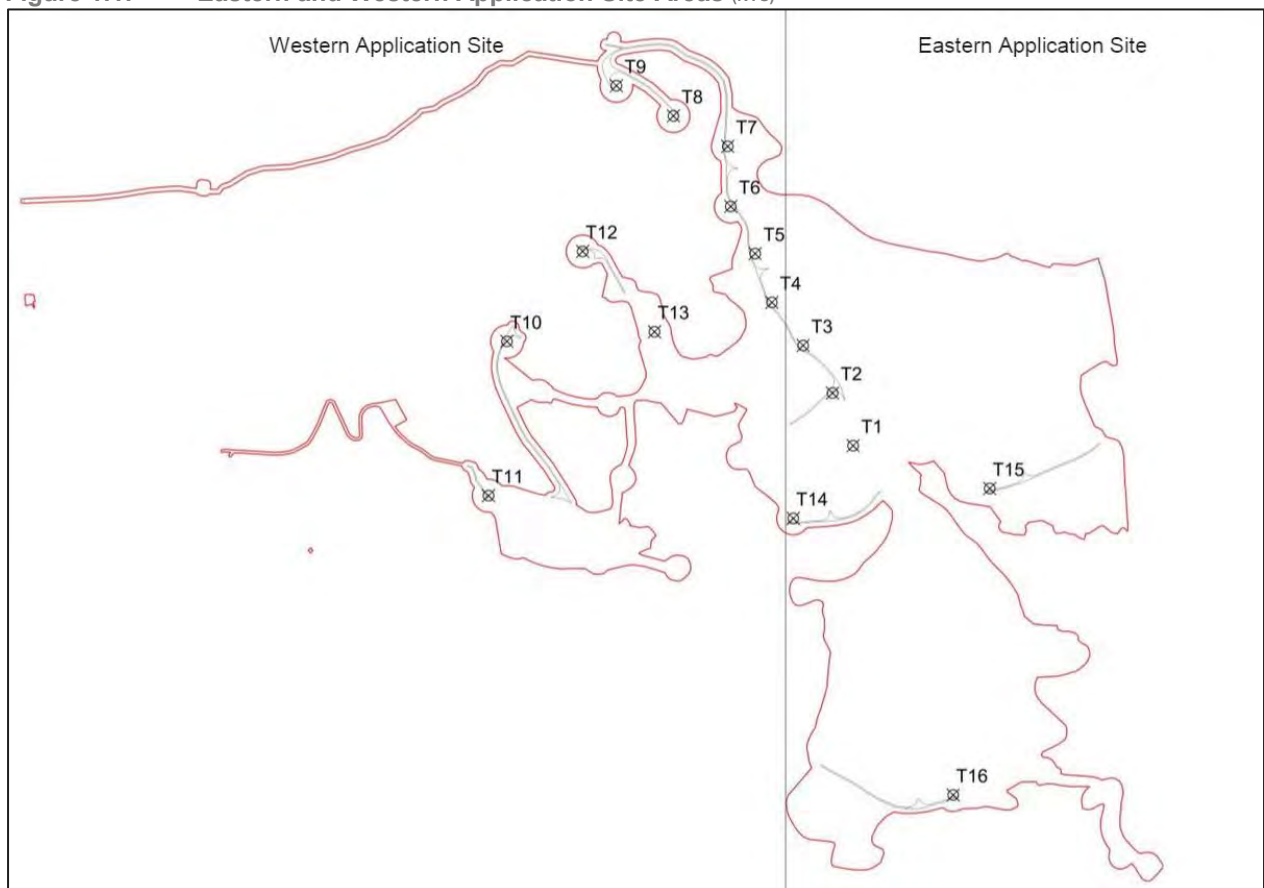
The Application Site is located within and adjacent to the existing Scout Moor Wind Farm, Lancashire. Currently there are 26 operational Nordex N80 wind turbines, set across upland moorland within the Southern Pennines. The expansion area for Scout Moor Wind Farm is situated between the village of Edenfield; 1km to the west and the town of Rochdale; approximately 5km southeast of the development boundary.

Application Site has been defined as all land within the red line planning boundary as defined in the main Environmental Statement.

Figure 1.1 provides a context for the Application Site description references used in this assessment and defines the Eastern and Western Application Site areas:

Study Area has been defined as encompassing the site and wider environs including local surroundings and localities which may extend or exist beyond the application site but may relate either directly or indirectly to this assessment.

Figure 1.1: Eastern and Western Application Site Areas (NTS)



1.2. Development

Natural Power understands Scout Moor Wind Farm Expansion Limited is exploring the possibility of expanding Scout Moor Wind Farm with 16 wind turbine generators and associated infrastructure. The detailed description of the development study area is provided within the main chapters of the Environmental Statement. The following is an outline of the proposed key infrastructure elements:

- 16 wind turbine generators founded on reinforced concrete gravity or piled foundations where ground conditions dictate.
- 16 crane hardstand areas adjacent to each wind turbine foundation. These areas will comprise a main crane pad and possible outlying trestle pads utilised in the erection and installation of wind turbine components. The final design of these elements will be subject to confirmation by the appointed turbine supplier;
- New access track infrastructure with the method of construction dictated by the peat depth and ground conditions with excavated tracks across shallower areas of peat and 'floated' track over consistently deep areas of peat. All tracks will be constructed so as to provide a minimum running width of approximately 5m with local widening at junctions, bends, passing places and turning heads;
- Underground power and control cables shall be routed between the wind turbines, running adjacent to the track routes.

Water crossings and drainage infrastructure shall be required as part of the development and shall be designed to mitigate impact on surface hydrology and peatland habitats. A comprehensive discussion of these elements is covered within Chapters 13 & 14 of the Environmental Statement.

The following temporary structures are usually a requirement of the construction phase of development:

- Construction compound;
- Temporary lay-down area

Access to the proposed expansion area is understood to be from the local highway network using existing wind farm access tracks. The main site entrance is proposed off the A680 at Scout Moor Quarry.

1.3. Site Characterisation

The site description has been compiled from a variety of sources, including Ordnance Survey mapping and GIS mapping software. A detailed site walkover survey was conducted by an experienced geotechnical / mining engineer during November 2014. This walkover covered areas within the Application Site.

1.3.1. Topography

The landforms covering the Application Site and wider locality are of broad upland moorland, rising steeply from the surrounding valleys to a maximum elevation of approximately 477mAOD (above Ordnance Datum) at the summit of 'Hail Storm Hill'. The majority of the Application Site is across the higher elevations between 330 and 472mAOD. The Scout Moor moorland plateau is typified by upland glaciated terrain which has been impacted by the advance and final retreat of ice sheets at the end of the late Devensian Glaciation (last ice age). The proceeding peri-glacial environmental conditions further eroded the steepened valleys, escarpments and rock outcrops. All these elements are now integral to the makeup of different terrain units across the Application Site. The wider post glaciated landscape including land outside of the Application Site is also mantled by a variety of superficial deposits which include, peat, glacial till and mass movement deposits which have formed since the retreat of ice sheets.

1.3.2. Application Site Description

In order to simplify description of this large scale area two zones; **East** and **West** have been defined (Figure 1.1). Table 1.3.2 below provides an overview description of each part of the expansion area and includes a 3D terrain view to establish the wider setting.

Table 1.3.2 Description of Application Site**Western Application Site**

The image below depicts the western part of Application Site and combines a digital terrain model and aerial photographic imagery dating from 2005 (Google Earth Professional). The view aspect is looking towards the east. The outer red line boundary delineates the planning application boundary.



From the A680, the pre-existing access track climbs through Scout Moor Quarry towards currently existing wind turbines and the internal access track network. The Western Application Site is predominantly set across southerly and westerly aspect sloping moorland. The land surface is of modified peat land, grass and heather cover. The flat lying high plateau contains historic artificial trellised drainage networks. The steeper valley sides and escarpments are affected by a natural dendritic drainage comprising ephemeral streams minor tributaries and tertiary rivers. A dominant land form is the steep sided valley containing Dearden Brook & Scout Moor Brook which is headed by the Scout Moor High Level Reservoir. The reservoir is understood to be supplied by the upland catchment of Scout Moor. The reservoir is retained by a multi-tiered rock fill and earth embankment dam, set into a steep sided 'v-shaped' valley. Down-stream the east-west orientated valley system turns south with Dearden Brook out-flowing towards the village of Edenfield.

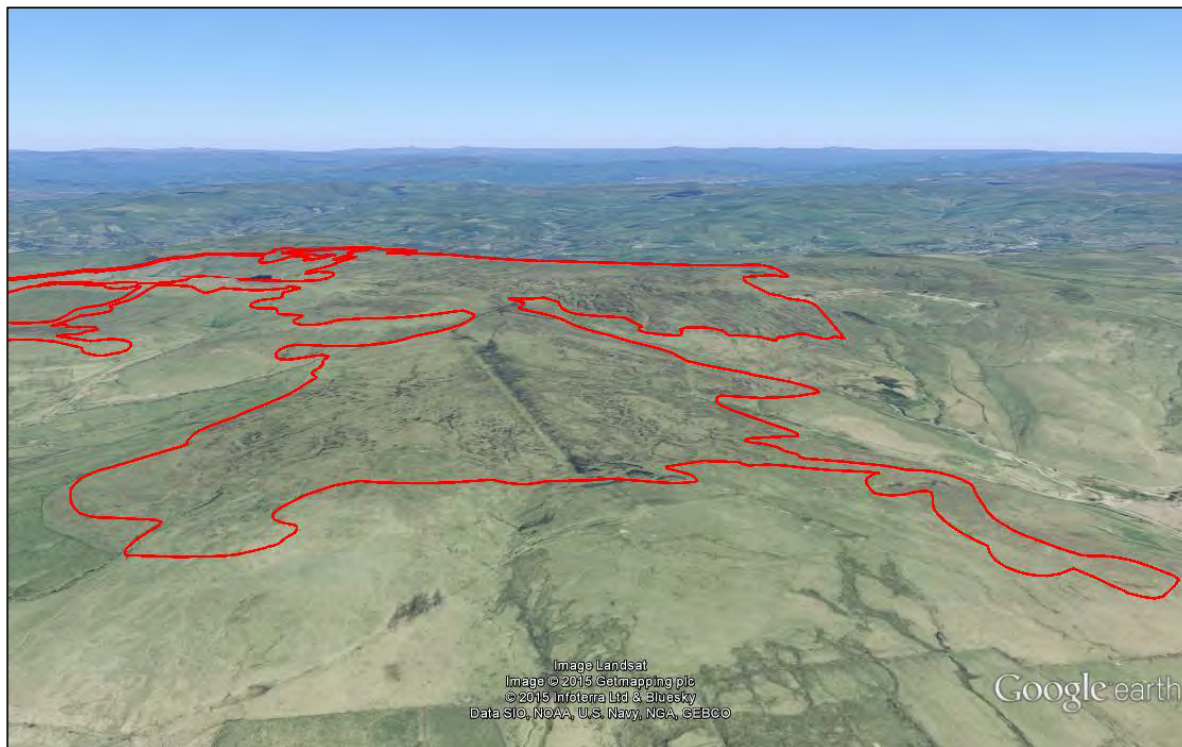
Across the Western Application Site there is a limited network of minor farm tracks to the north of the 'Dearden Valley' with pre-existing wind farm access tracks permitting access across the centre of this part of the development. There were determined to be no residential dwellings within the Application Site. However there are a number of residential properties surrounding this part of the development and out-with The Application Site (this list is not exhaustive):

- **Higher & Lower Mount Pleasant Farms**, approximately 450m west of the nearest planning application boundary;
- **Stone Acre Farm at 'Turn'**, approximately 700m south west of the nearest planning application boundary;
- **Fecit Farm**, approximately 470m south west of the nearest planning application boundary;
- **Cowpe Hall Farm**, approximately 710m northeast of the nearest planning application boundary;

Currently the sensitive structures in terms of stability are concluded to be the operational Scout Moor Wind Farm turbines, infrastructure and the Scout Moor High Level Reservoir Dam which is out-with the Application Site.

Table 1.3.2 Description of Application Site**Eastern Application Site**

The image below depicts the Eastern Application Site and combines a digital terrain model and aerial photographic imagery dating from 2005 (GEP). The view aspect is looking towards the north. The outer red line boundary delineates the approximate limit of the planning application boundary with the large areas encompassing the proposed moorland restoration areas.



Generally across this part of the Application Site, terrain slopes from the central plateau towards the south and east and into the steep sided valley which contains the Naden Higher, Middle and Lower Reservoirs (Out-with the Site). These eventually head the larger Greenbooth Reservoir (not shown) which is retained just 600m north of the village of Norden all these elements are south-east and out-with the Eastern Application Site.

T16 is proposed across the upland moorland plateau with T15 positioned around the upper reaches of the Naden valley terrain unit. The surface geomorphology of the peat land is of generally naturally and artificially drained peat with discrete areas of surface modification, a result of historical quarrying and mining activity. The pre-existing Scout Moor wind farm infrastructure stretches across the southerly limb of the upland moorland plateau with existing turbines E2, E4, E9 & E18 situated approximately on the upper rim of the Naden Valley.

There is a prolific dendritic drainage pattern which is present across the upper areas of peat land and extends down into sharply incised tributaries which flow into the Naden valley to the south. Across the flatter terrain of the upper moorland there is a multitude of minor surface ponds which may be natural or mark the sites of former quarries or mine entries. This may also be an indication that there is shallow retention of groundwater reserves across this part of the Application Site. There is drainage towards the north and down the main escarpment above the village of Cowpe to the north. Within the Eastern Application Site there is a prominent linear artificial drainage ditch which has been termed 'Man Road Ditch' by the Ordnance Survey map. This feature runs approximately north-south and is easterly adjacent to the proposed expansion turbine T16. There were determined to be no residential dwellings in this part of the study area. However there are a number of residential properties surrounding the Eastern Application Site but all out-with the red line planning boundary:

- **Higher Knowl Farm**, [SD 84665, 161020];
- **Higher Red Lumb Farm**, [SD 84095, 16132];
- Semi-detached properties on A680, [SD 82712, 16419];
- **Willowfield Farm**, [SD 83933, 20076];

Currently the sensitive structures in terms of stability within the Eastern Application Site are concluded to be the existing Scout Moor Wind Farm turbines and infrastructure.

1.3.3. Surrounding Area

The Application Site is surrounded by a semi-rural landscape with the villages Edenfield, Cowpe, Bacup, Millgate, Whitworth, Broadley Bagslate Moor and Turn situated clockwise around the Application Site. These small settlements occupy lower ground below the elevated moorland with Rochdale town centre situated approximately 5km south from the Application Site boundary.

The history and development of the local area has been strongly influenced by the industrial revolution and therefore the expansion of population centres across in the region at the start of the 19th Century. It is understood that the industrial revolution and expansion of Rochdale and Greater Manchester was strongly driven by the wool and cotton trade with a local requirement for building stone and coal to construct and power industrial development. As a consequence; the coal measures geology which forms the landscape, has been extensively quarried and mined. Open cast quarry sites were opened in order to win high quality sandstone for building material, with many mining sites implemented to win coal from underground coal seams.

Within the Application Site is an extensive area of former opencast quarry sites. These are understood to be the location of former sandstone quarrying which are now ceased. These features now remain as large open-excavations which have been allowed to flood and become partially re-vegetated. Similarly to the northwest of the Application Site, there is a large area of former sandstone quarries interspersed across the landscape however all activity across this area appears to have now ceased. Scout Moor Quarry which occupies land out-with the Application Site is understood to be still operational and producing clay, shale and sandstone.

The moorland which exists at relatively high elevations adjacent to steep sided valley systems has created ideal conditions for impounding reservoirs. The high moorland plateau creates a large upland catchment area for rainfall and as a result there are seven reservoir systems surrounding the Application Site as described in Section 1.3.2. All are out-with the Application Site.

1.4. Access

It is understood that access to the Scout Moor Wind farm Expansion will utilise the pre-existing Scout Moor Wind Farm infrastructure. Access from the public road network can be from the M66 motorway and then onto the A56, B6527 to Edenfield. From Edenfield the A680 is followed southbound to the entrance to Scout Moor Quarry. The pre-existing wind farm access track traverses the edge of Scout Moor Quarry and climbs the open moorland towards the internal wind farm access track network and the high ground of Whittle Hill.

Access when surveying the expansion area is gained from the pre-existing wind farm access track network across the western and central development areas. Access for Scout Moor High Level Reservoir also provides a quicker access to expansion areas in the north west of the study area.

2. Geological Setting

2.1. Superficial Deposits

As part of this study the British Geological Survey (BGS) England and Wales, Sheet 76, Rochdale bedrock and superficial deposits map has been reviewed in detail. Both 1:50,000 and 1:10,000 scale geological maps have been reviewed. Further BGS digital map datasets are presented within the GroundSure GeolInsight Report, Appendix B. Drawing GB200361_M_039, Appendix A depicts the superficial geology across the Application Site.

2.1.1. Peat

The primary map data indicates the predominant superficial deposit to be of blanket peat which mantles the upper area of the moorland and has accumulated in greatest extent on the upper moorland plateau across relatively level and gently sloping terrain.

NPC initially completed a 'first pass' peat depth survey which is reported in the Scout Moor Wind Farm Expansion Peat Survey Report (118_R_NPC_PEEL_4), February 2011. During this survey, peat depth probes have been implemented on a 100m spaced grid set across the relevant Application Site areas (Drawing GB200361_M_041, Appendix A). This survey has identified the deepest areas of peat (1.5 – 3.0m) to be focussed in the north east and south east parts of the Application Site. There is a broad open plateau immediately to the east of the high point of Hail Storm Hill which represents the greatest expanse of deep peat. However this has been largely avoided by the footprint of the proposed infrastructure. From this phase of study, the second most significant area of deep peat is present across the southern limb of the moorland plateau which extends south from the middle of the Eastern Application Site area. Similarly deep peat exists as discrete pockets which have been identified across the Western Application Site.

The interceding areas between blanket peat deposits are likely to be a variety of mineral soils at surface. Information has been gathered from the Soils Site Report, provided by the National Soil Resources Institute at Cranfield University. This indicated that the mineral soils across the Application Site are likely to consist of well drained, coarse loamy soil over bedrock. Across the southeast and south west of the Study Area there is also indicated to be a prevalence of coarse loamy, very acid upland soils over rock. Such soils may have a wet peaty surface horizon and thin iron pan (hard layer of precipitated iron salts). There also may be more slowly permeable and seasonally waterlogged fine loamy, clayey soils throughout the site.

Detailed peat probing surveys were completed by the end of November 2014. Field surveys were undertaken by a third party at a grid resolution of up to 25m. This covers the Proposed Wind Farm Expansion layout design as depicted in the main Environmental Statement. The peat depth contour map provided in Appendix A; provides an interpolation of the peat depth using this detailed data-set. 'Kriging' was the method of mathematical interpolation used to achieve the indicative spatial depth distribution. This was deemed to provide the most accurate representation of the dataset. As can be demonstrated by the peat depth contour map the proposed expansion turbine locations have been designed away from the deepest areas of peat with T1, T2, T4 & T16 on the periphery of deeper peat areas.

2.1.2. Glacial Till

BGS 1:50,000 scale Digital Map Data reveals limited areas of glacial till mapped within the Application Site. Mapped units of glacial till are confined to the lower Dearden Valley within the north-western part of the study area. The BGS describes the glacial till to comprise clay to sandy clay, unsorted with common, gravels, cobbles and some boulders. The composition of granular material will be strongly linked to provenance from the local bedrock geology (i.e. sandstone, mudstone, siltstone and coal). The depth of glacial till deposits across the Application Site is currently not defined and is likely to be highly variable. Only through intrusive site investigation would it be possible to determine the depth of glacial till across the proposed infrastructure locations.

2.1.3. Head Deposits

Head deposits although shown to only be present across one small area are closely related to mass movement deposits. Formed on sub-aerial slope systems from material accumulated by down slope movements including landslide, debris flow, solifluction, soil creep and hill wash processes. The BGS indicate the extent of a head deposits on the valley slopes to the east of pre-existing Scout Moor wind turbine E8. This is not thought to influence any part of the Application Site. However only through intrusive site investigation would it be possible to determine the presence of head deposits at the proposed infrastructure locations.

2.2. Artificial Deposits

Information derived from the 1:50,000 scale BGS map data highlights the mapped extent of artificial ground within the Application Site. Drawing GB200361_M_039, Appendix A depicts areas of artificial ground. The principal types of artificial ground are set out below:

- **Made Ground** – man-made deposits on the original ground surface, mainly comprising colliery spoil quarry waste and possibly with some industrial and domestic waste;
- **Infilled Ground** – man-made deposits, areas where the ground has been cut away and then had artificial ground deposited, e.g. backfilled quarry, landfill site.
- **Disturbed Ground** – sites of former workings where worked ground, infilled and made ground deposits cannot be distinguished.

The GroundSure GeolInsight Report, Appendix B for the Study Area depicts the detailed distribution of artificial deposits on Map 1.1 – Artificial Ground Map.

Over the western part of the Study Area there is a large area of in-filled ground and undifferentiated made ground which covers the area of Scout Moor Quarry at the site entrance and extends north contouring along the side of Dearden Valley. These deposits are thought to mark the site of former quarrying operations now backfilled up to the operational limits of Scout Moor Quarry.

Within the northwest and north east parts of the Study Area is an area of in-filled and made ground, this extends out-with the Application Site along the prominent escarpment overlooking the Cowpe Valley and Reservoir. However the area of in-filled ground widens into the western study area and is shown to extend beneath the area of three of the proposed extension turbines (T5, T6 & T7). These artificial deposits are also understood to be sites of former sandstone quarrying which have exploited the shallow bedrock profile along the escarpment. Site walkover observations have confirmed the presence of these mapped units.

The third main area of artificial ground is situated approximately 180m east from pre-existing Scout Moor Turbine E19. Covering a circular area of approximately 500m in diameter this area of in-filled ground marks the location of a former sandstone quarrying site. There are understood to be some open quarry voids and rough tracks still remaining across this area. It is noted that these features are not in the area of the proposed expansion and out-with the Application Site.

2.3. Mass Movement Deposits

The BGS 1:50,000 scale digital geological map data highlights several areas which are mapped as landslide deposits. These are described by the BGS to comprise areas of debris slide of rock and superficial soil materials and may include mud flows. These deposits commonly lie un-conformably onto the bedrock units. The composition and internal structure of these deposits will greatly depend on the upslope provenance of material and the type of mass movement or slip failure.

At the head of the Naden Valley, there is an area of extensive sloping ground between the pre-existing Scout Moor Turbines E10 and E18. This feature has been defined as a landslip system. The mode of failure is not discernible from the primary data sources however Natural Power's local geotechnical knowledge across the Southern Pennine region points to a post glacial landslip system controlled by large and deep seated rotational slips which penetrate into the coal measures geology. These larger systems generally influence smaller multiple rotational slips down-slope which then evolve and become heavily modified by contemporaneous or later debris flow events, (Burgess, 1976). The debris flows are likely to entrain glacial till, head and peat materials. It should be noted that proposed expansion turbine T15 is

upslope from this system. A site walkover survey revealed no signs of active instability at the proposed turbine location however the risk of deep seated landslide risk remains elevated at this location.

The second main area of mass movement deposits are mapped across large areas of the mid and lower Dearden Valley below and to the west from the Scout Moor High Level Reservoir. The highest of these mass movement deposits situated approximately 275m northwest from the pre-existing E26 covering the locations of two proposed turbines (T10 and T12.) These two locations are in the upslope section of the mass movement deposits and remain at elevated risk from deep seated geological instability.

There are additional mapped areas of mass movement deposits on the periphery of the Application Site and generally on steepened ground on escarpments and valley flanks.

Mass movement deposits can often be meta-stable and present a significant geo-hazard to construction development. Mass-movement may be re-activated naturally as a consequence of changing climate or can be influenced by significant rainfall events. Modification of the mass-movement deposits through excavation or surcharge loading can also lead to re-activation or further slope failure. It should be highlighted that the geotechnical properties of mass movement complexes can present a contrast in material strength to surrounding ground conditions. Re-moulding of cohesive deposits and sliding along shear planes can cause failures to be controlled by re-moulded and residual shear strengths. Map 1.2 within the GroundSure GeoInsight Report (Appendix B) depicts the distribution of these deposits across the study area. Post consent detailed site investigation should be utilised to further investigate any possible deep seated land slip systems at the proposed expansion turbines at elevated risk (T10, T12 & T15).

2.4. Solid Geology

The solid bedrock geology beneath the Application Site is formed of the Millstone Grit Group and Pennine Coal Measures Group Rocks. Table 2.4.1 and 2.4.2 set out the simplified stratigraphic column indicating the rock formations and individual rock units which are present beneath the Application Site and wider study area. The stratigraphy beneath the Application Site has been compiled from the BGS Lexicon of Named Rock Units with the colours presented on the table coordinated with the BGS map dataset. A complete bedrock and faults map is depicted as Map 1.3 within the GroundSure GeoInsight Report, (Appendix B). A detailed solid geology map (Drawing GB200361_M_040, Appendix A) has also been provided.

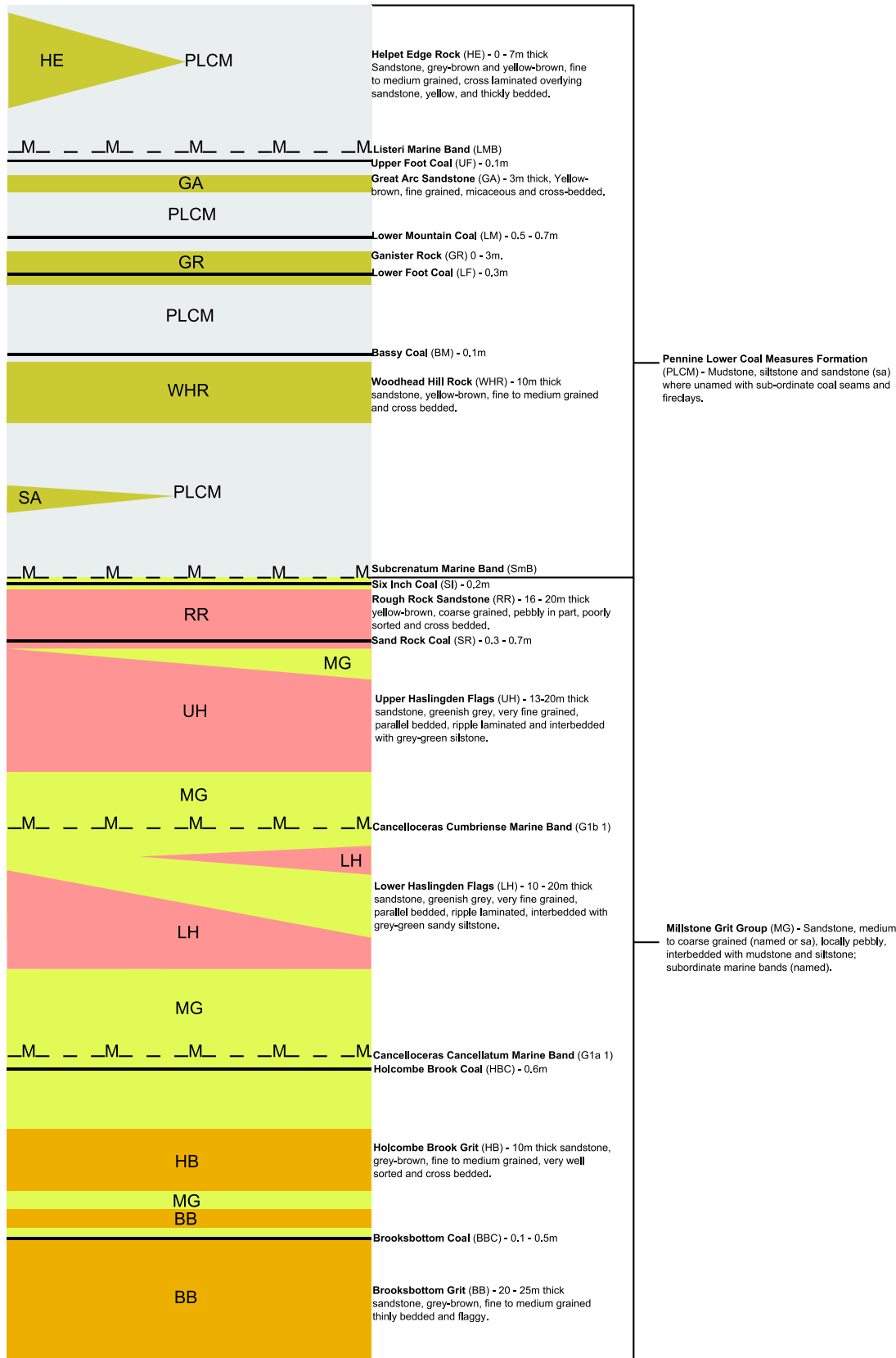
This data has been collated from the BGS 1:10,000 scale solid geology map sheets SD81NW Cheeden & SD81NE Whitworth. The stratigraphic relationships seen beneath the Application Site are a direct result of the development and evolution of the Pennine area during the Carboniferous period. The Pennine range was part of a series of structurally controlled basins which were major sites of deposition derived from erosion of a growing chain of mountains (The Variscan Front). From the end of the Carboniferous to early Permian times, during further mountain building to the north of the Pennine basins, inversion of the basins occurred with tectonic movement generating deep seated faulting through the basin structures. As part of this movement the Carboniferous rocks were uplifted. Subsequent substantial erosion and planation of these formations then took place. It is assumed that no significant tectonic activity has occurred since the Tertiary period. It is postulated that contemporary tectonic movements may be associated with mining subsidence and stress relief and are likely to be focussed along pre-existing fault lines. This movement can be complexed hill cambering and interconnection with shallow mining features. Evidence of this action may be fissuring of bedrock units. Such sub-surface features should be investigated through a pre-construction phase of detailed site investigation.

Table 2.4.1 Bedrock Geology Units & Stratigraphic Relationships		
	Rock Formation	Rock Units
Pennine Coal Measure Group	Pennine Lower Coal Measures Formation (undifferentiated mudstone – siltstone - sandstone) – Interbedded grey mudstone, siltstone and pale grey sandstone, commonly with mudstones containing marine fossils in the lower part, and more numerous and thicker coal seams in the upper part. 720m maximum thickness in Lancashire – parent unit is the Pennine Coal Measures Group.	Great Arc Sandstone Buff grey, fine to medium grained, micaceous, thickly bedded, cross bedded and ripple laminated sandstone. 20m maximum thickness – parent unit is the Pennine Lower Coal Measures Formation.
		Gannister Rock Sandstone – Not Defined
		Helpet Edge Rock Sandstone Massive and coarse grained sandstone often evenly bedded and flaggy. Parent unit is the Pennine Lower Coal Measures Formation.
		Woodhead Hill Rock Sandstone Coarse grained and massive fine grained and flaggy sandstone. Parent unit is the Pennine Lower Coal Measures Formation.
Millstone Grit Group	Rossendale Formation A fine to very coarse grained and pebbly, feldspathic sandstone, interbedded with grey siltstone and mudstone and sub-ordinate marine black shales, thin coals and seat-earths. Typically, the formation comprises a lower mudstone – dominated succession including two prominent marine shales, the <i>Cancelloceras cancellatum</i> and <i>Cancelloceras cumbriense</i> marine bands, and an upper sandstone dominated succession, including the Rough Rock and Rough Rock Flags. 130m maximum thickness in Rochdale – parent unit is the Millstone Grit Group.	Upper Haslingden Flags Pale buff to pale grey fine grained sandstones often micaceous. Parent unit is the Rossendale Formation.
		Rough Rock Sandstone Coarse grained feldspathic and cross bedded sandstone. Maximum thickness of approximately 30m throughout the central Pennines and the parent unit is the Rossendale Formation.
		Lower Haslingden Flags Pale buff to pale grey fine grained sandstones often micaceous. Parent unit is the Rossendale Formation.
	Marsden Formation Fine to very coarse grained and pebbly feldspathic sandstone which is interbedded with grey siltstone and mudstone, and subordinate marine black shales, thin coals and seat-earths. 600m maximum thickness and the parent unit is the Millstone Grit Group.	Holcombe Brook Grit Quartz-feldspathic sandstone.

Description of rock formations and units taken from the British Geological Survey Lexicon of Named Rock Units & English Heritage, (2011).

Fireclay

Sedimentary mudstones which occur as 'seatearths' beneath the majority of coal seams. A 'seatearth' represents the palaeosoil horizon on which the coal forming vegetation once grew. These are distinguished from other sedimentary units by the presence of fossil rootlets and an absence of bedding structure. The term 'fireclay' was derived from their ability to resist heat and from their original use in the manufacture of refractory bricks for lining furnaces. Fireclays are typically thin (<1m) and composed of clay minerals including kaolinite and illite together with fine grained quartz in varying proportions. This material therefore may have been extracted at the same time as the overlying coal deposits.

Table 2.4.2: Detailed stratigraphic column (thickness in metres)

2.5. BGS Borehole Records

Following the review of geological mapping data the BGS onshore geo-index was searched for all relevant exploratory borehole records. Table 2.5; below details the available borehole records in closest proximity to the Application Site. Copies of the original borehole records have been included within Appendix C. Where relevant all values have been converted to metric equivalent.

Table 2.5: Details of relevant BGS borehole records

Borehole ID	Description	NGR	Depth	Year
SD81NW1	Scout Moor Irwell Valley Water Board	380723, 419586	306m	1959
SD81NW9	Scout Moor Quarry	381610, 418810	23m	1975
SD81NW22	Higher Red Lumb Farm - Rochdale	384100, 416100	49m	1990

Source: British Geological Survey

A brief summary of each borehole record is presented below and highlights key stratigraphic horizons which may have been targeted by past shallow sub-surface mining activity. It is highlighted that unfortunately all historical borehole data pertains to point locations out-with the Application Site.

2.5.1. BGS Borehole Record SD81NW1

Table 2.5.1: Summary of key stratigraphic horizons: Borehole SD81NW1

Unit	Thickness (m)	Depth (mbgl)
Shattered Strata	2.4	81.7m
Grit with coal	1.8	203.9m
Grit with coal joints	3.6	215.5m
Coal and fireclay	0.3	221.5m

Source: British Geological Survey

This borehole was implemented in 1959 by the Irwell Valley Water Board. The position is indicated to be approximately 82m east of a water aqueduct at a point approximately 460m north of Dearden Clough and approximately 90m south-southwest of New Hall. The borehole location is approximately 125m south from the Application Site boundary in the lower reaches of the Dearden Valley.

Superficial deposits described as 'Drift and broken shale' are recorded to 6mbgl (metres below ground level). This is underlain by a 'Rock and Shale' sequence to 79mbgl. A zone of 'shattered strata' extends to 82m and perhaps represents a fault zone or zone of consolidated mine workings. Beneath a sequence of 'shale' and 'gritstone' with occasional coal persists to 306mbgl at which point the borehole was terminated. The resting water level targeted by the water-well is indicated at 28mbgl.

2.5.2. BGS Borehole Record SD81NW9

Table 2.5.2: Summary of key stratigraphic horizons: Borehole SD81NW9

Unit	Thickness (m)	Depth (mbgl)
Sandstone Coal Mine	0.9m	3.65mbgl
Further shallow coal workings	1.15	4.55mbgl

Source: British Geological Survey

Borehole record SD81NW9 was implemented as what is thought to be a programme of prospecting for Scout Moor Quarry. The borehole dates from 1975 and is located within the area still operational as Scout Moor Quarry. This borehole is not coincident with any of the proposed expansion areas and is confirmed as out-with the Application Site.

A core log with a low level of detail records a bedrock interface at 2.0mbgl. From 2.00 to 3.65mbgl is a sandstone unit presumed on the log to represent the Upper Rough Rock Sandstone. From 3.65 to 4.55mbgl a core loss event is reported with coal traces. This has been interpreted as the 'Sand Rock' coal horizon which may have been mined out across this location. Further core loss was reported to 5.70mbgl. From 5.70 to 20.44mbgl is recorded a sequence of sandstone interpreted as the Lower Rough Rock Sandstone. From 20.44 to 20.70mbgl is reported to be a sandstone sequence reported as the 'Haslingden Flags'.

2.5.3. BGS Borehole Record SD81NW22

Table 2.5.3: Summary of key stratigraphic horizons: Borehole SD81NW22

Unit	Thickness (m)	Depth (mbgl)
Coal Seam	1.6	3.0

Source: British Geological Survey

This borehole was implemented during 1990 as part of a water well installation at Red Lumb Farm. The borehole was commissioned in order to supply water to a domestic property. The location of this borehole is approximately 900m south from the Application Site Boundary.

The borehole records 0.6m of backfill or made ground material which overlies a sequence of 'brown shale' to a depth of 3.0mbgl. A coal seam is recorded to 4.6mbgl beneath which is recorded to be a sequence of sandstone interpreted as the Rough Rock Sandstone and Haslingden Flags sandstone. The borehole was terminated at 48.7mbgl. On completion the standing groundwater level was recorded to be 1.5mbgl within the water well installation.

2.6. Previous Site Investigation Data

As part of the preparatory works for the construction of the operational Scout Moor Wind Farm a programme of ground stabilisation was implemented in order to address the issue of shallow mine workings and potential influence on wind turbine foundations and crane hard stand areas. A report on the Treatment of Shallow Abandoned Mine Workings, produced by Scott Wilson Ltd in 2008 has been reviewed (Report No.D110643/GEO/1232). The salient treatment measures are detailed in Table 2.6 below.

Table 2.6 Scout Moor Pre-existing Infrastructure Information – Treatment of Mine Workings

Turbine ID	Treatment Details (High – Moderate - Low Impact)
T1	Proof drilling was carried out to a maximum depth of 16mbgl. A coal seam was identified at 3.5 to 4.0mbgl of 0.8 to 1.2m in thickness. There was no evidence of the coal seam of being worked. A grout take test was conducted owing to the presence of a nearby abandoned mine entry. There were no significant grout takes recorded and therefore no further treatment was considered necessary.
T2	Proof drilling was undertaken to 15mbgl. Voids were reported between 6 and 7mbgl with broken ground prevalent throughout the rock sequence. Intact coal seams also detected in probe holes suggested the possible presence of intact pillars supporting mined out areas. A full drilling and grouting pattern utilising a grout curtain wall and primary infill holes was scheduled for both the turbine foundation and crane pad area. Grouting of the turbine foundation was undertaken at reducing 3m...1.5m...and 0.75m spacing in order to complete a grout curtain wall. A total of 44tonnes of pea gravel was used with the primary infill holes backfilled with P200 foamed concrete (HA Class). A total of 427tonnes of P200 foamed concrete was used in the treatment of the void beneath the turbine foundation covering a plan area of 20x20m. Voiding was recorded as uniform across the crane pad area each outrigger taking similar amounts of grout. A total of 60tonnes of pea gravel and 65tonnes of P200 foamed concrete were utilised in the stabilisation works.
T3	Proof drilling has been undertaken to 12mbgl with only one probe hole recording a loss of flush and broken ground. Further proof drilling revealed a linear trend of broken ground across the south east corner of the turbine foundation area. This was orientated towards a nearby mine entry. Proof grouting was undertaken across the turbine foundations however no grout take was recorded. The zone of broken ground was considered sufficiently consolidated and no further treatment measures were taken.
T4	Proof drilling has been undertaken to 18mbgl with an intact coal seam located. No voids, flush loss, broken or soft ground was recorded across the majority of proof drill holes. Two drill holes implemented to the northeast of the turbine foundation indicated broken ground and voiding between 5.5 and 6.0mbgl. No groundwater was encountered during the drilling operations. Additional proof drilling to 10mbgl was undertaken to check the potential extent of voiding beneath the foundation all holes recorded intact coal between 5 and 7m. Proof grouting was undertaken with no significant grout take at just 0.25tonnes of grout injected. No further treatment measures were considered necessary.
T5	Proof drilling has been undertaken to 9mbgl. A large percentage of proof holes recorded an intact coal seam between 8 and 6mbgl. A single proof drill hole implemented out-with the foundation footprint recorded a void between 6.1 and 7.1mbgl. Groundwater was encountered during drilling operations in two proof drill holes at 7.5 and 8.5mbgl. Grout curtain wall holes confirmed the presence of a void along the edge the curtain wall, with all further drill holes reporting no evidence of workings however intact coal was also not confirmed. Additional proof drilling carried out beneath the turbine foundation indicated any loss of flush, voiding, broken or soft ground. With all additional holes confirming an intact coal seam. Grouting of holes where voiding was reported utilised a total of 76tonnes of grout. No further stabilisation works were undertaken at this location.
T6	Proof drilling reported coal at depths ranging from 9 to 11mbgl with no evidence of shallow mine workings. No groundwater was encountered during the drilling and no further treatment works were considered necessary.
T7, T8, T9	No information provided

Table 2.6 Scout Moor Pre-existing Infrastructure Information – Treatment of Mine Workings

T10	Proof drilling reported coal at depths ranging from 2.2 to 5.0mbgl with no evidence of shallow mine workings. No groundwater was encountered during the drilling and no further treatment works were considered necessary.
T11	Proof drilling carried out across this location encountered extensive voiding between 5.0 and 7.5mbgl with broken ground recorded between 6.0 and 6.5mbgl. In three of the proof drill holes, an intact coal seam was reported between 7.5 and 7.7mbgl. A grout curtain wall was implemented to 9.5mbgl around the foundation area with voids again encountered between 5 and 6mbgl. Grout take across these holes varied from 0.25tonnes to 12tonnes. Secondary infill holes were implemented in order to reinforce the grout curtain wall prior to infill of the main body beneath the foundation areas. The total grout take including primary infill holes was 455tonnes with an estimated plan area of 21x21m. A total of 461tonnes of grout was utilised to treat voids beneath the crane pad outrigger positions.
T12	Proof drilling reported intact coal seams beneath the turbine foundation. No evidence of workings was identified and no further treatment works were considered necessary.
T13	Initial proof drilling was implemented to 16mbgl encountering extensive voiding between 8 and 9mbgl. Two proof drill holes recorded an intact 'Sand Rock Mine Coal Seam' between 8.0 and 8.4mbgl. Owing to the extent of voids across the foundation area, a full drill and grout programme was implemented: Drilling and grouting of a perimeter curtain wall was initially undertaken with the majority of drill holes recording voiding. The perimeter grout curtain wall required approximately 280tonnes of grout mix. The total final grout take across the turbine foundation was 329tonnes with an approximate plan area of 18x18m stabilised. At the crane pad location five of the outrigger pads only took nominal quantities of grout enough to back fill the drill holes. The remaining three outrigger areas took approximately 140tonnes of grout.
T14	Proof drilling was implemented to 15mbgl with no coal or shallow mine workings reported and no further treatment works were considered necessary.
T15	Proof drilling undertaken at this location reported no loss of flush or voiding.
T16	No information provided
T17	Initial proof drilling was conducted to depths ranging between 12 and 20mbgl. Drill flush loss was reported between 6 and 9mbgl in a single drill hole. With no further drill holes recorded flush loss above 12mbgl. It is highlighted that the drilling rate indicated a softer material across this location. Flush loss was also reported between 12 and 15mbgl in two thirds of the drill holes. The flush loss was accompanied by spouting water from previously drilled holes indicating linkages between holes at depths between 12 and 15mbgl. It was also noted that flush loss was recorded in a lower seam and air pressure was reported to be escaping from a nearby mine shaft entry. Conclusions were that shallow mine workings existed at two levels with strong evidence for open workings at the lower level. Further conclusions that broken ground above the lower seam of working is likely to be associated with the localised collapse of lower mine workings. Therefore drilling and grouting should proceed on the assumption that only the lower seams required full drilling and grouting operations, with localised collapse and broken ground above being consolidated during this process. A perimeter grout curtain was considered unnecessary at this location. There was no requirement to drill and grout the crane pad foundation positions due to the temporary nature of the loading, the cover of intact rock between foundation formation and the workings (>10m) and the reduced presence of voids due to the drilling and grouting operations carried out beneath the turbine foundation.

Table 2.6 Scout Moor Pre-existing Infrastructure Information – Treatment of Mine Workings	
T18, T19	No Information Provided
T20	Proof drilling reported no evidence of shallow mine workings. However soft ground was reported within three drill holes implemented across the crane pad area. These holes were grouted with 10:1 cement to PFA mix with a flowability of >700mm. No further treatment works were considered necessary at this location.
T21	Proof drilling undertaken at this location reported no evidence for shallow mine workings. Coal was identified in one of the proof drill holes at 9.5 to 10.0mbgl. No further treatment works were considered necessary.
T22	Proof drilling confirmed a coal seam present close to rock head level. As this seam was removed during the foundation excavation no further treatment works were undertaken.
T23	Proof drilling was carried out beneath the turbine foundation and crane pad area with no evidence of shallow mine workings was identified. No further treatment works were considered necessary at this location.
T24	Initial proof drilling was carried out to 16mbgl with coal identified at 5 to 7mbgl in six of the proof drill locations with no evidence of workings. No further treatment works were considered necessary.
T25	Initial proof drilling was implemented to 13mbgl. Three of the holes encountered voids and flush loss between 2.5 and 3.0mbgl with the remaining drill holes across the turbine foundation reporting an intact coal seam between 2.5 and 3.0mbgl. The entire crane pad area underwent proof drilling with voiding reported in seven drill holes. The final recommendation was for over-excavation of the foundation to remove the area of shallow voiding.
Met Mast	Initial proof drill holes were conducted to 15mbgl with voids reported in all drill holes between 6 and 7mbgl. No groundwater was encountered during the drilling operations. A full drilling and grouting pattern was undertaken. Approximately 140tonnes of P200 foamed concrete was used in the consolidation of the void beneath the turbine foundations covering an approximate plan area of 12x12m.

Source: Scott Wilson, 2008

3. Mining Setting

Historical Ordnance Survey (OS) Map data has been reviewed across the proposed expansion areas. Due to the large scale, the study area was split into four quadrants (A1, A2, B1, B2). The description of the historical maps is based on these areas depicted in Figure 3 below and described Table 3. All OS map data is presented within Appendix E of this report.

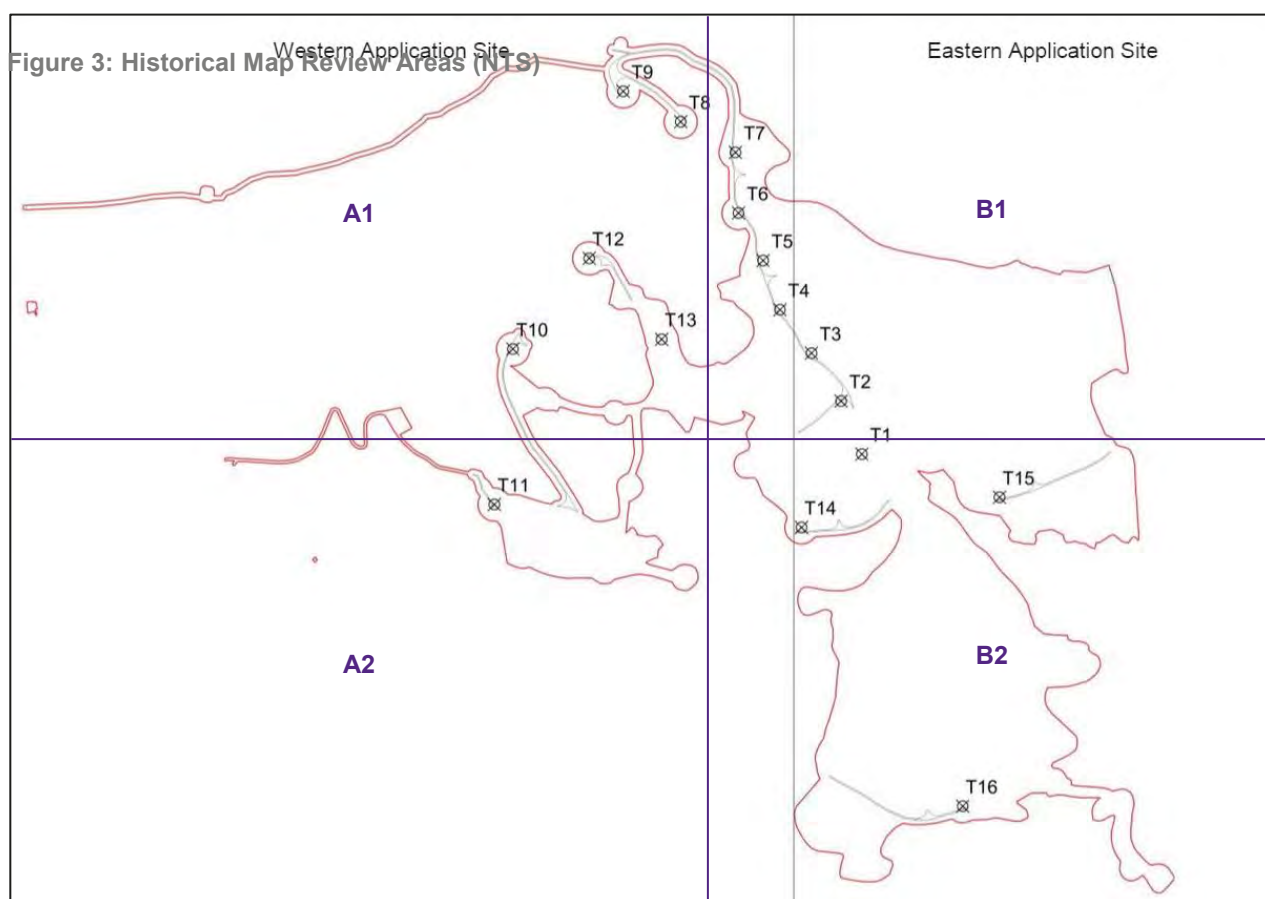


Table 3: Review of Historical Ordnance Survey Map Data

Date	Scale	Description of Application Site and Surrounding Area
1890 - 1891	1:10,560	(North) Grid A1-A2 The higher elevations of the moorland plateau including the summit of Whittle Hill are devoid of any mapped features or indications of industrial development. However there is shown to be a geometric arrangement of drainage channels which may indicate the moorland and particularly the peat land was being managed and drained at this time. Drainage generally is shown to flow west and north down into the Dearden Valley or 'Dearden Clough' as it is termed on the map and eventually joining 'Scout Moor Brook' at the base of the valley. On the northern facing slopes of Dearden Valley is a network of farm tracks and quarry access tracks which interconnect a number of sheep folds and a small quarry termed 'Back o'th' Lowe Quarry'. On the western limit of the Scout Moor plateau begins an extensive area of quarrying which is serviced by a tramway. The large elongate quarry site is nestled into the westerly facing escarpment of Scout Moor, and extends from

Table 3: Review of Historical Ordnance Survey Map Data

Date	Scale	Description of Application Site and Surrounding Area
		the present day location of the operational Scout Moor Quarry north and east into Dearden Valley. There are numerous small buildings and barns on the periphery of the quarry area. A tramway linking to a minor road and further on to local Haslingden and Rochdale tram network at an interconnector close to the present day wind farm entrance is shown. From this location the tramway runs northeast up into the Dearden Valley contouring up to the quarry sites. It is presumed that this area was wholly concerned with the extraction of sandstone. Sand Beds Lane intersects the extreme north western part of the study area on the edge of Dearden Moor which begins just north of the study area. Further east and situated on the northern and eastern head of the Dearden Valley is another extensive area shown as quarried ground. This is termed 'Foe Edge Quarry'. Again the quarry sites are serviced by a separate tramway which enters the Application Site from a larger quarry site to the north and on the top of Dearden Moor. Generally the topography within the Application Site is shown to be comparable to the present day however there is a greater proliferation of quarrying shown in the outlying areas from the development. (South) Grid A2 The south western corner of the Application Site contains a network of artificial drains depicted across the southerly slopes of Scout Moor although this area of the development is termed 'Turf Moor' on the 1891 map edition. There is a small reservoir which is impounded by a linear earthen embankment and covers an area approximately in between the present day Scout Moor Turbines E11 and E13. A tramway is shown to traverse the south western corner of the Application Site. The alignment of this feature climbs the westerly moorland escarpment from the village of Turn and stops at a Colliery site which would be located at the eastern end of the present day Scout Moor Quarry. From the unnamed colliery the tramway runs southeast to the small aforementioned reservoir and then south and east to a termination....
1890 - 1891	1:10,560	...point close to the southern Application Site boundary. An old shaft is depicted as approximately 60m southwest from pre-existing turbine E17. This suggests mining activity has occurred across this area pre-dating the 1890's. A moderately sized quarry site termed 'Fecit End Delf' is depicted approximately 500m southwest from the proposed expansion turbine T11. The map key indicated this feature to comprise a sandstone quarry or ground working. A small track termed 'Coal Road' traversed the southern facing escarpment to 'Turf Moor' and Scout Moor. This track runs approximately east to west from the village of Turn and climbs onto the moorland contouring the steep ground and terminating approximately 100m south of pre-existing turbine WTG 14. Grid B1 The moorland is defined as 'moss' indicating blanket peat deposits across much of this area. A small reservoir impounded by an earth embankment is depicted on the higher moorland plateau in an area which is now immediately to the north of pre-existing turbine E23. There are several small tributary streams which drain into this feature from the head slopes of the Dearden Valley and 'Whittle Hill'. There is a large quarry site named 'Ding Quarry' which existed across an area north east of proposed turbine T2. A tramway is shown to service the quarry and traverses the north central moorland in a northwest – southeast

Table 3: Review of Historical Ordnance Survey Map Data

Date	Scale	Description of Application Site and Surrounding Area
		orientation and then descends the northern Scout Moor escarpment into an extensive quarry site named 'Cragg Quarry'. This extends east-west along the northern Application Site Boundary. Further small quarry sites are present to the north across the Cowpe valley and are interspersed amongst small farmsteads. Grid B2 The majority of the upper moorland across this area is shown to be without any major industrial development. There is the artificial 'Man Road Ditch' which is shown as a sharp linear surface water course which drains the southern limb of the moorland plateau and carrying surface water towards the south and into 'Red Lumb Brook' to the south of the Application Site. The Naden Higher, Middle & Lower reservoir system is shown to be present to the east within the Naden Valley. The land to the south of the Application Site boundary is occupied by parcels of land indicated as pasture. There are several air shafts situated approximately 550m south-southeast from the location of pre-existing turbine E2.
1908 -1909	1:10,560	Grid A1 Scout Moor High Level Reservoir is now shown in its present day location; No further major changes are shown within this part of the Application Site. Grid A2 'Fecit End Delf' sandstone quarry shows a moderate expansion in the quarry void east along the Scout Moor escarpment. The area is still out-with from the southern Application Site boundary; No further major changes are shown within this part of the study area. Grid B1 'Cowpe Reservoir' is now shown to the north of the Application Site and is set within the Cowpe Valley at its present day location and form; 'Cragg High Level Tank' a small reservoir is shown to be situated approximately 600m north of the existing turbine E25. No further major changes are shown within this part of the Application Site. Grid B2 The moderately sized 'Ding Quarry' shows it has been expanded both laterally and towards the south; No further major changes are shown within this part of the Application Site.
1927 - 1928	1:10,560	Grid A1 No further major changes are shown within this part of the Application Site. Grid A2 'Scout Moor Colliery' is now designated as disused; The small reservoir situated centrally on 'Turf Moor' has halved in size perhaps suggesting that by this time the reservoir was no longer being used or maintained; No further major changes are shown within this part of the Application Site. Grid B1 Cragg Quarry on the northern Application Site boundary is described as disused; The tramway previously running through Cragg Quarry and crossing from the north into the site to 'Ding Quarry' is no longer shown with just a footpath / track in place of the tramway; No further major changes are shown within this part of the Application Site.

Table 3: Review of Historical Ordnance Survey Map Data

Date	Scale	Description of Application Site and Surrounding Area
		Grid B2 'Lower East Knowl Colliery' is depicted approximately 250m south from pre-existing Scout Moor Turbine E2. The feature is indicated to be a drift mine, understood to be in the form of a series of inclined horizontal adits which advanced northwards beneath the Application Site; No further major changes are shown within this part of the Application Site.
1927 - 1928	1:10,560	Grid A1 No further major changes are shown within this part of the Application Site. Grid A2 'Scout Moor Colliery' is now designated as disused; The small reservoir situated centrally on 'Turf Moor' has halved in size perhaps suggesting that by this time the reservoir was no longer being used or maintained; No further major changes are shown within this part of the Application Site. Grid B1 Cragg Quarry on the northern Application Site boundary is described as disused; The tramway previously running through Cragg Quarry and crossing from the north into 'Ding Quarry' is no longer shown with just a footpath / track in place of the tramway; No further major changes are shown within this part of the Application Site. Grid B2 'Lower East Knowl Colliery' is depicted approximately 250m south from pre-existing Scout Moor Turbine E2. The feature is indicated to be a drift mine, understood to be in the form of a series of inclined horizontal adits which advanced northwards beneath the southern study area; No further major changes are shown within this part of the Application Site.
1938	1:10,560	No significant changes are depicted within the Application Site. Throughout the surrounding areas to the expansion areas there is interpreted to be a minor decline in the number of active quarry sites.
1949 - 1950	1:10,560	Grid A1 Many of the sheepfolds which dotted the northern flanks of the Dearden Valley are no longer shown. No further major changes are shown within this part of the Application Site. Grid A2 The tramway which serviced the now disused 'Scout Moor Colliery' is no longer shown. The small reservoir on top of 'Turf Moor' is no longer designated as such. No further major changes are shown within this part of the Application Site. Grid B1 No further major changes are shown within this part of the Application Site. Grid B2 No further major changes are shown within this part of the Application Site.
1967 - 1968	1:10,560	Grid A1 Scout Moor Quarries which extended up into the middle Dearden valley are designated as disused; The tramway which entered the Application Site from the north and serviced 'Foe Edge Quarry' is described as dismantled;

Table 3: Review of Historical Ordnance Survey Map Data

Date	Scale	Description of Application Site and Surrounding Area
		No further major changes are shown within this part of the Application Site. Grid A2 Scout Moor Colliery is no longer designated as such; No further major changes are shown within this part of the Application Site.
1967 - 1968	1:10,560	Grid B1 'Ding Quarry' is designated as disused; The small 'Great Lodge' Reservoir situated at the head of the Dearden Valley is shown as halved in size. This may be an indication that at this time this reservoir was no longer used or maintained; No further major changes are shown within this part of the Application Site. Grid B2 No further major changes are shown within this part of the Application Site.
1978 - 1979	1:10,000	Grid A1 Partial coverage with no further major changes detected within this part of the Application Site. Grid A2 No coverage Grid B1 Limited coverage with no further major changes detected within this part of the Application Site. Grid B2 No coverage
1987 - 1992	1:10,000	Grid A1 No further major changes are shown within this part of the Application Site. Grid A2 No further major changes are shown within this part of the Application Site.
1987 - 1992	1:10,000	Grid B1 No further major changes are shown within this part of the Application Site. Grid B2 No further major changes are shown within this part of the Application Site.
2002	1:10,000	No significant changes are depicted within the Application Site.
2011	1:10,000	Scout Moor Operational Wind Farm is now depicted

The Coal Authority provided a variety of geospatial data relevant to the Study Area. Table 3.1.1 below provides list of attributes linked to each dataset.

Table 3.1.1: Coal Authority Supplied Digital Data

Dataset ID	Description
'In Seam Level'	Point data indicating coal seam and depth below Ordnance Datum
Mine Entries	Point data indicating type of entry (shaft or adit) and the adit angle of entry where applicable
Areas of Probable Workings	Polygon data with depth indication: (Shallow, Moderate, Considerable) Shallow = 0 – 30mbgl Moderate = 30 – 100mbgl Considerable = >100mbgl

Dataset ID	Description
Spine Roadways	Polygon data indicating known underground roadways within mine workings with depth indication: (Shallow, Moderate, Considerable) Shallow = 0 – 30mbgl Moderate = 30 – 100mbgl Considerable = >100mbgl
Areas of Underground Working	Polygon data indicating the name of worked coal seam and the extraction thickness in cm.
Areas of Unlicensed Opencast	Polygon data which indicates the sites of worked opencast sites, as worked by the National Coal Board (NCB) and/or British Coal
Coal Working Dates	Point data indicating mine entries and / or coal workings with the name of the worked coal seam and the last known date of working.

Source: The Coal Authority

The Coal Authority datasets have been collated within GIS software in order to analyse the distribution of coal workings beneath the Application Site. The primary findings are discussed in detail below. Drawings GB200361_M_021 & 022 provided within Appendix A collate mine features data and depict the location of these surface and sub-surface mining features in relation to the proposed infrastructure.

3.1. Past Coal Mining

3.1.1. Underground Coal Workings in the Sand Rock Coal Seam

Western Application Site

An area of historic underground coal workings is indicated beneath the eastern part of the pre-existing Scout Moor Wind Farm. The workings are at moderate depth and indicated to be between 50 to 70mbgl. Workings are shown to extend beneath the pre-existing turbines E20 and E23 and associated wind farm access tracks. The proposed extension turbine T13 is also situated over the top of this area of workings with approximately 60m of overburden, predicted above the mine working. The Sand Rock Coal Seam targeted by these workings is indicated to be 0.5m in thickness. This overburden thickness would generally be thought of as sufficient cover to dissipate the effects of consolidation of these workings. There is however the possibility of void migration through the overburden where the geological strata is of insufficient mass strength to prevent crown hole formation. The last known year of working is reported to be 1940. From The Coal Authority data it was not possible to verify the mode of coal extraction from these workings. Although extraction is most likely to have been in the form of 'pillar and stall' mining inferred from the rectangular geometry at the indicated extents of the workings.

An isolated shallow underground working has been identified beneath pre-existing Scout Moor Turbine E11. The coal working is indicated to exist at approximately 10mbgl with the last known year of working reported as 1940. A further isolated small coal working is shown to be coincident beneath the pre-existing wind farm access track spur running south to existing turbine E11. The workings are predicted to exist at 10mbgl and are also understood to date from 1940.

Eastern Application Site

A second extensive area of the underground coal workings in the Sand Rock Coal Seam has been identified. The workings are indicated to extend from beneath pre-existing wind turbine E5 and cover an area to the east beneath pre-existing turbine E2. The workings then extend south and begin at the area of 'Red Lumb' (out-with the Application Site). The workings are indicated to be at shallow depth 13 to 21mbgl with the depth of working understood to decrease south with reducing elevation of the moorland. This working depth geometry indicates this was a drift mine implemented south of the development near 'Red Lumb' and worked north beneath the Scout Moor escarpment. The workings are predicted to be ~50m west from proposed expansion turbine T16. The date of working is indicated from 1900 with the last known year of working reported as 1938.

A moderately sized area of shallow coal workings is present within the north east Application Site. Extending from an area 90m east from existing turbine E25 and then northeast for approximately 370m. These are shallow coal workings reported to be between 8 and 15mbgl with the last year of working given at 1883. This area of former underground workings is not understood to be within the footprint of proposed infrastructure.

3.1.2. Underground Coal Workings in the Lower Mountain Coal Seam

Western Application Site

An approximately circular area measuring 250m in diameter at its widest extent is indicated beneath the summit of Whittle Hill. These workings begin immediately to the north of existing turbine E22. The depth of working is indicated to be approximately 40mbgl with a seam thickness reported at 0.7m. The last date of working is given as 1884. The nearest proposed expansion turbine is T13 approximately 110m NE from the edge of the workings.

3.1.3. Probable Areas of Shallow Coal Mine Workings

The Coal Authority has provided an indication as to the probable areas of historic coal mine workings (extraction now ceased). This is based on the outcrop and sub-crop areas of coal bearing strata. The known location of surface mine entries has also been considered. Table 3.1.3 below highlights the proposed expansion turbine locations which are situated above areas of shallow (<30mbgl) coal workings.

Table 3.1.3: Proposed Expansion Turbines Affected by Probable Areas of Shallow Coal Workings

Proposed Extension Turbine	Comments
T1	Directly above probable shallow coal workings affecting sub-surface at depth of <30mbgl.
T11	
T13	

Source: The Coal Authority

3.1.4. Mine Entries

The Coal Authority have provided no record of what steps, if any have been taken to treat the mine entries identified across the Application Site. It should also be highlighted that Coal Authority records may be incomplete and consequently, there may exist across the development and local area, mine entries of which the Coal Authority has no knowledge.

The Coal Authority has provided location data on 119 separate mine entries within the study area. The distribution of each mine entry in relation to the Application Site is shown on drawing GB200361_M_022, Appendix A. There are a total of 45 mine entries indicated to be adits and the remaining 74 mine entries indicated to be vertical shafts.

CIRIA SP32 describes shafts and adits to have been used for any number of the following operations:

- Winding and haulage of the mined coal resource;
- Access of miners;
- Pumping and removal of groundwater;
- Ventilation;
- Connection of seams at different stratigraphic levels (in such cases the shaft may be contained underground and not emerge at the ground surface)

Shafts

Shafts can be circular, oval, or rectangular, however the circular form is understood to have been most widely use throughout England. CIRIA SP32 indicates between 1800 & 1900 shaft diameters were in the range of 1 – 8m. Shafts were sunk vertically into the coal measures strata and are commonly lined where

passing through superficial deposits or weak strata. It is probable that shafts across the Study Area are lined with the local sandstone as it was readily available at surrounding quarry sites.

Adits

Adits are mine entries which enter the coal bearing strata in a sub-horizontal orientation from the ground surface. Adits are generally sited where coal outcrops at the surface with the adit forming the 'mouth' of the mine. The underground working would progress sub-horizontally along the coal seam and get progressively deeper. Across Scout Moor the adits have been sited to exploit the steep topography on the surrounding escarpments, with adits opened where coal outcrops along the escarpments and workings then progressing beneath the moorland plateau. Adits are often obscured at the surface and may have been backfilled or sealed on abandonment.

3.2. Present and Future Coal Mining

The Application Site is not indicated to be in the likely zone of influence of any operational underground coal workings. However it should be highlighted that coal reserves exist in the local area which could be worked at some point in the future.

3.3. Quarrying and Opencast Coal Mining

A total of 530 individual surface ground workings have been identified within the study area. The distribution and type of ground works has been indicated on Drawing GB200361_M_021, Appendix A. The source of this data comes from the GroundSure GeolInsight Report, Appendix B and the British Pits (BRITPITS) database, administered by the BGS.

There are two quarry sites indicated by the BGS to be currently active. Both quarries are out-with of the proposed Application Site boundary:

- Scout Moor Quarry, Edenfield [381400, 419000] is an active quarry extracting clay, shale and sandstone.
- Whitworth Quarry, Whitworth [387500, 420280] is north east of the Application Site and is actively extracting sandstone

3.4. Mining Hazards

Due to the confirmed presence of multiple shallow mine workings beneath the Application Site it is important to highlight the differing conditions and hazards, associated with different modes of coal extraction. The following discussion draws on information and guidance provided within CIRIA SP32 and includes further outline guidance from Waltham (2009).

Outlined in CIRIA SP32; the 1872 Coal Mines Regulation Act, there was a mandatory requirement to deposit accurate plans of mines with the Secretary of State following their abandonment. The prospect of unrecorded coal mining features within the site therefore cannot be discounted and it should be highlighted that the earliest mine plans were completed using rudimentary surveying methods and as such may not provide a high degree of accuracy. A report by the Mines Department Waters Dangers Committee in 1927 concluded that plans, certainly prior to 1887, may not indicate the actual position of workings and may only be evidence that old workings exist. The committee also concluded that from 1887 the standard of accuracy improved and the mine plans become more reliable.

3.4.1. Adits and Bell Pit Workings

Early mine workings represented on the late 19th Century historical maps may indicate small scale extraction of coal through adits and bell pits. In forming a bell pit, an unsupported shaft approximately 1m diameter was sunk to the coal seam. The depth is dependent on the extent of overburden and the thickness and quality of the seam. Mining would then proceed radially from the base of the shaft until the area became too large to be naturally or artificially supported, when ventilation became restricted, or when the inflow of groundwater exceeded the rate of bailing. Bell pits were then abandoned and a new one sunk nearby. CIRIA SP32 advises that early shafts and bell pits can be up to 12m deep and may comprise of a

single shaft which serviced a number of seams. However it is highlighted that the collapse of bell pits is likely to have a relatively small scale impact on the ground.

3.4.2. Pillar and Stall

Waltham, (2009) describes pillar and stall type extraction as: sub-surface mining of coal seams through the partial extraction which was utilised for most coal workings before 1940. Between 10% and 40% of the coal is left in-situ to form pillars that support the roof of the mine. The geometry of this natural support is often random but may become more systematic and geometrical. Where coal seams have been over-worked there may be a long term subsidence threat.

Mine pillars may fail where they are left too small to support the overburden and subsequently become overloaded by surface construction activities or are affected by erosion by fluctuating groundwater flow. Pillars may puncture into underlying soft clay deposits ('seat earth' / 'fireclay') and create an issue of long term subsidence. The collapse of such features may be delayed and unpredictable. Waltham, (2009) comments that ground failure is minimal in mines greater than 50m depth, where any surface imposed loads are minimal compared to the overburden load.

3.4.3. Shafts and Mine Entries

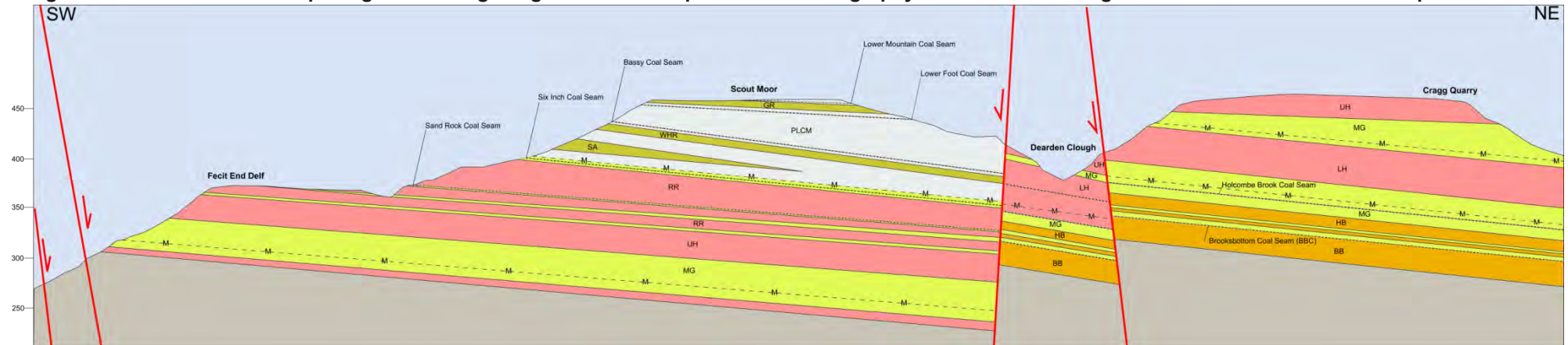
The risk of unrecorded mine shafts is considered high across the site area. Shafts and adits may be typically 1 – 8m in diameter and may extend to deeper workings in the local area which are predicted to be up to 90m below the surface. The condition of mine shafts can vary widely and may be brick or concrete lined, but likely to be dry-stone supported due to local abundance of sandstone. In worst cases shafts may be un-supported and unlined and can have loose fill or may be empty. It was common for shafts to be backfilled with colliery spoil and mine waste after the mine was abandoned however capping of these features may be absent.

4. Conclusion

4.1. Ground Model Analysis

The following geological cross section has been constructed from the BGS 1:10,000 scale composite maps represented on drawing GB200361_M_040, within Appendix A. The lines of cross section have been projected onto the geological map presented within Appendix A. The cross sections examine the relationship between the topography of the site, the superficial deposits and the underlying solid geology of the Pennine Lower Coal Measures and Millstone Grit Group. It should be highlighted that the superficial deposits may vary in thickness across the development. It should be noted that the geological cross sections have been vertically exaggerated to ensure key stratigraphic relationships are visible. The approximate scale is indicated on the section.

Figure 4.1 – ‘Section AB’ depicting the main geological relationships and the stratigraphy of the coal bearing strata beneath the western expansion area.



Approximate Scales at A3: Horizontal Scale - 1:8,350, Vertical Scale 1:4,170. Vertical elevations are indicated as mAO.

4.1. MRA Conclusions

The Application Site is impacted by over one hundred years of coal extraction, predominantly from the Sand Rock Coal Seam and Lower Mountain Coal Seams which sub-crop beneath the site. Shallow abandoned mine workings (<30mbgl) have been identified across the eastern and western parts of the proposed Application Site. There are numerous surface ground workings which are relicts of sandstone quarries and open coal pits across the development. These may now exist as backfilled voids containing artificial ground or may exist as open voids at the surface.

It is highlighted that shallow mine workings present beneath the proposed Study Area may have primarily adopted a 'pillar and stall' method of coal extraction associated with 18th and early 19th Century periods. Coal seams are reached through a series of shafts and adits and the mine then opened up along the worked seam by mining out 'stalls' leaving 'pillars' of mineral supporting the roof of the mine. This method of mining is less efficient than 'long wall' as a large percentage of coal is left in-situ. Hence when such mines were abandoned it was common for 'pillars' to be 'robbed' whereby the majority of pillars were removed leaving minimum support providing short term stability. Mines abandoned in such circumstances represent an increased risk. The overlying strata are marginally stable and collapse may occur unpredictably. Mine voids may remain in the sub-surface indefinitely until disturbed from surface construction or changes in the groundwater regime.

The assessment of risk to surface development has adopted a guideline figure for 30m as a safe cover depth above shallow mine workings. This has been reinforced by CIRIA SP32 guidance. Local ground conditions can vary over short distances due to the presence of local faulting. Poor ground conditions or a 'stacking' effect from multiple shallow workings at different levels within the sub-surface may require an increased safe cover depth.

No details exist as to the nature of any treatment of abandoned mine entries and adits present in the proposed Application Site. Therefore all shaft locations should be regarded as a potential hazard. It is usual for such features to be backfilled with mine waste and spoil which would be considered artificial ground and potentially contaminated. Drawings GB200361_M_021 & GB200361_M_022 (Appendix A) depicts all known shafts, adits and colliery workings within the Application Site.

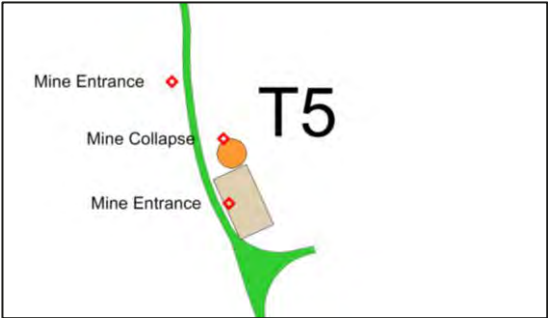
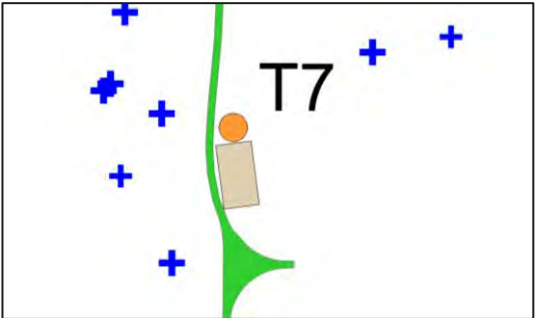
The likelihood is that any subsidence caused by any mining activity has likely ceased however there is the possibility that shallow underground workings may remain in a state of marginal stability and exist at a shallow level where any disturbance could lead to the migration of voids to the surface.

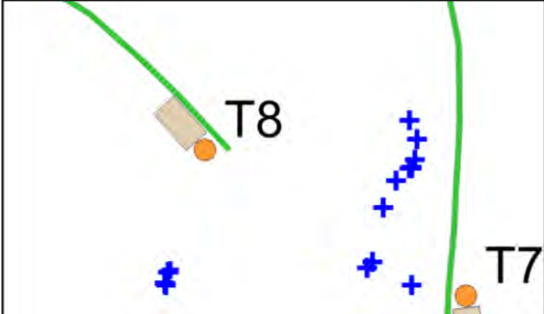
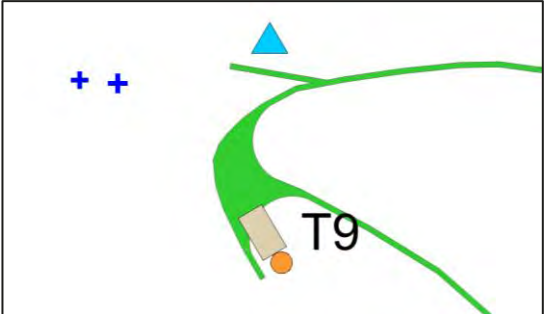
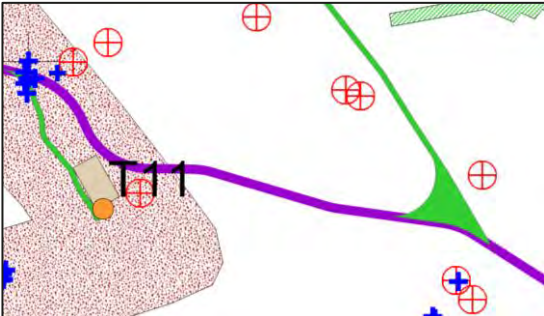
It has been concluded that subject to planning approval and as part of the pre-construction development there should be a comprehensive geotechnical investigation carried out at each proposed wind turbine and critical infrastructure sites to verify the absence / presence of shallow underground workings and refine the geotechnical ground model for the site.

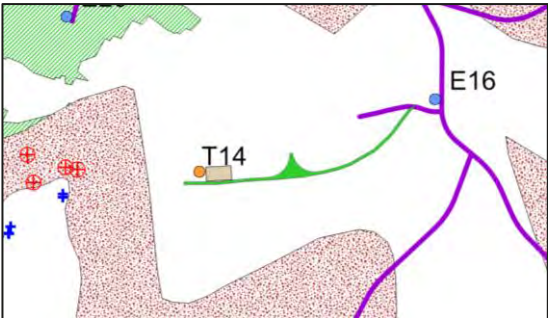
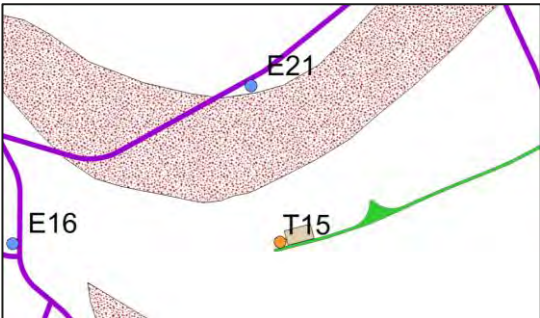
Table 4.1 below provides an indication of the likely shallow mine workings and conditions to be encountered beneath each proposed expansion turbine location.

Table 4.1: Mining Risk Assessment of Expansion Turbine Locations

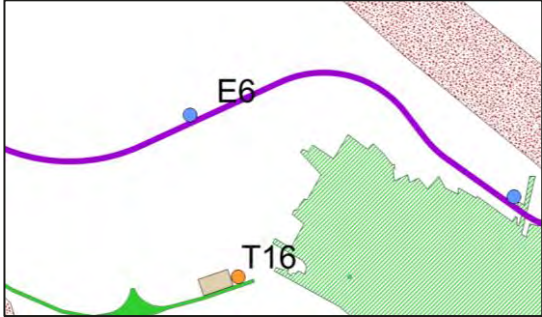
Turbine ID	Proximity to Historical Ground Working or Mine Entry	Recorded Shallow Mine Workings	Depth of Working (mbgl)	Risk
T1	Derelict Reservoir (449BR) – 150m west north west	Sited over probable shallow underground coal workings	<30mbgl	High
		GIS analysis of turbine position T1 in relation to area of probable shallow underground mine workings directly beneath the location and clustering of surface groundwork and derelict reservoir features 150m further to the north-west.		
T2	None Indicated	Edge of probable shallow underground coal workings 60m southwest	-	Moderate
		GIS analysis of turbine position T2 in relation to area of probable shallow underground mine workings approximately 60m to the south.		
T3	None Indicated	None Indicated	-	Low
		GIS analysis of turbine position T3, highlights no data for recorded mine or surface workings near to the proposed location.		
T4	Pond (429) – 220m northeast	None indicated	-	Low
		GIS analysis of turbine position T4, highlights no data for recorded mine or surface workings near to the proposed location. A surface ground working (now recorded as a pond) is 220m distant to the northeast. No further data was found for this location.		

Turbine ID	Proximity to Historical Ground Working or Mine Entry	Recorded Shallow Mine Workings	Depth of Working (mbgl)	Risk
T5	Probable mine entries located 30m south & 65m northwest of turbine centre	Crown collapse observed nearby from site visit 12m north west of turbine centre indicating possible meta-stable sub-surface conditions	<30mbgl	High
		GIS analysis with site walkover observations indicating. These display the location of a potential crown hole (mine collapse) feature evident at the surface. This is extremely close to the turbine and only 12m away which would equate to the approximate edge of the foundation base. Two further features indicative of mine entrances are also indicated at greater proximity.		
T6	Within Upper Haslingden Flags quarry recorded surface working 50m southwest.	None Indicated	-	Moderate
		GIS analysis of turbine position T6 showing the singular surface ground working feature approximately 50m to the southwest. This is noted as a former quarry working in the Upper Haslingden Flag Sandstone. During the site walkover there was abundant surface evidence for past quarrying activity recorded at this location.		
T7	Unspecified Heaps (46K) ~ 50m distant from turbine centre associated with surface quarry workings	None Indicated	-	Moderate
		GIS analysis of turbine position T7 with multiple surface ground working data points depicted around the periphery of the infrastructure. These are likely to represent historic sandstone quarrying sites. During the site walkover there was abundant surface evidence for past quarrying activity recorded at this location.		

Turbine ID	Proximity to Historical Ground Working or Mine Entry	Recorded Shallow Mine Workings	Depth of Working (mbgl)	Risk
T8	Unspecified Pit (290AD) – 115m south west	None Indicated	-	Low
		GIS analysis of turbine position T8. Unspecified surface ground working pits are depicted approximately 115m to the south west.		
T9	Sandstone brown hill close (1084EA) – 220m north west	None Indicated	-	Low
		GIS analysis of turbine position T9. Two prominent surface ground workings (former quarry sites) are depicted approximately 220m north west of the location.		
T10	None indicated	Unspecified mine entry (117296) – 125m west	<30mbgl	Moderate
		GIS analysis of turbine position T10, indicating relative close proximity of mine entries to the west. These are down-slope from the turbine position and therefore potential adits and shallow underground workings may extend east below the proposed position.		
T11	Unspecified mine entry (116396) – 35m north east Mineral washing (26) – 33m south west	Sited over probable shallow underground coal workings	<30m	High
		GIS analysis of turbine position T11, indicating high risk location with area of probably underground shallow mine workings directly beneath the location. A recorded mine entry approximately 35m to the north east.		

Turbine ID	Proximity to Historical Ground Working or Mine Entry	Recorded Shallow Mine Workings	Depth of Working (mbgl)	Risk
T12	None Indicated	Ferric Hydroxide deposits indicating coal mine drainage located ~190m south east from turbine centre	-	Low
		GIS analysis of turbine position T12. Limited archival data was available with no recorded underground or surface ground workings in close proximity to the position. During the site walkover a deposit of ferric hydroxide was noted in a spring, approximately 190m south east from the turbine centre. This may be a signal of subsurface coal mine workings draining groundwater which is affected by acidification. No ground information details of the operational turbine T26 were available at the time of reporting.		
T13	Unspecified mine entry (114226) – 120m south west	Sited over recorded workings in sand rock coal seam	<20mbgl	High
		GIS analysis of turbine position T13 showing the high risk from shallow underground mine workings. The turbine is directly above recorded underground workings within the 'Sand rock' coal seam. Coal Authority data indicates these workings to influence ground at shallow depths of <20mbgl. The area of workings extends south and west of the turbine with several mine entries recorded to the south west.		
T14	None Indicated	Edge of Probable shallow underground workings ~90m west from turbine position	-	Moderate
		GIS analysis of turbine position T14. This location is now shown to be directly impacted by any recorded surface or underground mining features. However the zone of probable shallow underground workings is identified approximately 90m west of the location.		
T15	None Indicated	Edge of Probable shallow underground workings ~100m north from turbine position	-	Moderate
		GIS analysis of turbine position T15. A zone of probable underground shallow workings is recorded approximately 100m north from the position.		

Turbine ID	Proximity to Historical Ground Working or Mine Entry	Recorded Shallow Mine Workings	Depth of Working (mbgl)	Risk
T16	None Indicated	Edge of recorded workings in sand rock coal seam ~55m east	<20mbgl	Moderate



GIS analysis of turbine position T16. The location is not directly impacted by any recorded surface or underground mine workings. It is clear that a zone of shallow underground coal workings exists approximately 55m east of the location. Archival data indicates the underground workings to be at <20mbgl.

Source: Natural Power; Diagrams NTS.

The mining risk assignment is based on the proximity of the proposed wind turbine location to mine entries, former quarry sites and probable and recorded areas of shallow underground mine workings. Table 4.1.1 below details criteria have been adopted for the risk assessment:

Table 4.1.1: Mining Risk Assessment Criteria		
Risk Level	Criteria	Development Implication
High	Turbine position is within 50m of shallow mining feature	Turbine locations considered to be at high risk will likely require ground improvement and/or stabilisation of shallow workings beneath turbine foundations and crane hard stand areas to mitigate the risk of instability. This may consist of a programme of targeted drilling and grouting of mine workings and sub-surface voids.
Moderate	Turbine position is within 150m of shallow mining or quarry feature	Turbine locations considered to be at moderate risk have a possible requirement for ground improvement and/or stabilisation. Proof grouting may be required to confirm that workings and voids are not present within the depth of influence beneath critical infrastructure sites.
Low	Turbine position is greater than 150m from a shallow mining or quarry feature	Turbine locations considered to be at low risk are unlikely to require ground improvement and/or stabilisation prior to construction. This condition should be confirmed through targeted intrusive ground investigation.

Source: Natural Power

5. Recommendations

Subject to planning approval Natural Power recommends that a geotechnical ground investigation is undertaken in accordance with current British and European Standards (BS EN 1997: 2:2007) and should comprise the following elements:

- A Site investigation should be designed for Geotechnical Category 3 Structures with sufficient data gathered concerning the ground and groundwater conditions at and around the proposed wind turbine locations. A minimum of 2 – 6 investigation points is suggested per foundation. The final depth of investigation should be determined by the encountered ground conditions however for shallow foundations it is recommended that the investigation depth is greater than 2 times the anticipated foundation width below formation level. In specific cases, deeper intrusive ground investigation may be required to target coal seams to prove ground model predictions.
- The depth of superficial overburden deposits should be determined at all proposed temporary and permanent construction locations. There is considerable uncertainty regarding the depth superficial deposits beneath the proposed study area. A sampling regime should be adopted whereby soil, rock and groundwater samples are obtained according the geological conditions, hydro-geological conditions and the likely imposed construction loads.
- Trial pit investigation should be undertaken at each wind turbine location and along key sections of proposed infrastructure. Superficial deposits should be logged in detail with representative samples obtained and scheduled for geotechnical laboratory testing. Where appropriate in situ strength testing should be undertaken and details of any groundwater recorded. Where areas of artificial ground are identified these should be delineated and sampled against relevant geochemical suites. Where solid geology is encountered a rock mass assessment should be undertaken with details of compressive strength and discontinuity spacing recorded.
- The rock mass should be characterised to sufficient depths beneath the proposed wind turbine generators and key infrastructure sites. Site investigation for construction purposes should allow for rotary core drilling and recovery of high quality core samples necessary for establishing a geological ground model and shall be used to assess the likely design requirements of foundation structures.
- Detailed logging of all exploratory holes should be undertaken in accordance with BS EN 14688 / 14689 to define the rock mass characteristics and identify any salient shallow mining features.
- The drilling methodology should be agreed with The Coal Authority and Environment Agency prior to being undertaken and should account for the hazardous ground gas, mine water discharge and poor rock mass ground conditions. A detailed assessment of any impact upon mine water drainage should be undertaken prior to drilling with suitable contingencies plans in place.
- The prior written permission of the Coal Authority will be required to investigate and/or treat any coal seam horizons, coal mine workings or mine entries.
- Prior written permission of the Coal Authority will be required to extract and remove any incidental coal as part of construction operations.
- Geophysical investigation of targeted areas across the site should be considered prior to intrusive ground investigation. Resistivity profiling, ground probing radar (GPR), electromagnetic and gravity imaging are potential methods of identifying shafts and sub-surface voids prior to undertaking intrusive investigations. Geophysical investigation may be a cost effective non-intrusive technique of determining

the risk to construction during the pre-construction planning phase of development and to ensure efficient targeting of the intrusive ground investigation boreholes.

5.1. Hazard Mitigation and Ground Improvement Options

Following completion of a sufficiently detailed, combined mining and geotechnical ground investigation there will likely be a requirement to consider the available ground improvement and stabilisation options. This should be undertaken as part of a detailed review of the design requirements for wind turbine foundations at the Application Site. Turbine foundations and crane hard standing areas should be assessed for the requirement for drill and grout stabilisation which was required as part of the original construction design of the operational Scout Moor Wind Farm. Across areas where shallow mine risk is uncertain, proof grouting is recommended to verify any requirement for further grouting stabilisation. The following hierarchical discussion of the best practice methods for construction over shallow abandoned mine workings details the primary approaches. These methods should be considered as part of the wider concept of the wind farm layout design and the use of available micro-siting options for the wind farm infrastructure.

5.1.1. Raft Foundations

Construction of low-rise and relatively lightly loaded structures on rafts or reinforced strip footings may be a suitable solution over shallow mine workings at a marginal depth. Any subsidence would generally be accommodated across the large area of the raft foundation and therefore would only be suitable for non-sensitive structures. This may rule out the wind turbine generators but may be a viable option for control building foundations and other similar lightly loaded structures.

5.1.2. Excavation and Backfilling

This approach is only viable at depths typically of less than 5m-7m. This is due to the large volume and complex earthworks required for deeper excavation and backfill operations. Generally where voids and backfilled / collapse zones are encountered at shallow depths, these would be identified and delineated as part of the ground investigation. During site preparatory works, these areas would be excavated and backfilled with engineering grade material where appropriate. This approach effectively removes the risk from collapse of shallow and near surface mining features.

Where shallow or near surface workings are encountered the most economical approach to ground stabilisation would be excavation and backfilling. Should such features be proven to extend to deeper levels beyond 10m below ground, and of an interconnecting nature, excavation and back filling may not be a viable option.

5.1.3. Piling

A deeper foundation design may be adopted where encountered shallow mine workings are between approximately 5 and 30m below ground level. Piled foundations would transfer design loads imposed by the wind turbine generator to deeper stratigraphic levels and below the influence of shallow mine workings. Consideration should be made for the prevailing ground conditions, where deeper boring through sandstone and limestone may become un-economic. The rock mass characteristics determined during a ground investigation may also rule out a piled option as issues such as steeply dipping strata liable to sliding failure can be problematic for piled foundations. Critical to such foundation designs would be the effect of groundwater on both the stability of the foundation and on the surrounding ground. Where pathways are created during installation of deeper foundations, there may be an increased risk of destabilisation of the ground due to an increased influx of groundwater.

Furthermore the effects from unforeseeable deep mining may lead to deformation at the base of piles and is difficult to predict these effects. The final design of the wind turbine foundations should be considered by suitably qualified designers after a comprehensive ground investigation has been completed.

5.1.4. Grouting

Where a predictable distribution of shallow abandoned mine workings has been identified during a ground investigation the option of drill and grouting methods to stabilise sub-surface voids and collapse zones may be a consideration.

In accordance with guidance set out in CIRIA SP32 (Construction Over Abandoned Mine Workings); typically 100mm drill holes are advanced to the level of workings within the influence of the proposed turbine foundations. The drill holes would be arranged on a grid of between 3 – 6m across the area of the foundation. The area of grouting would generally extend beyond the footprint of a shallow gravity foundation to encompass the zone of influence from loading. Perimeter grouting is initially undertaken, whereby a seal surrounds the mined area beneath the foundation. Perimeter grout is stiffened by adding coarse gravel. The perimeter grouting operation produces cones around drill holes bored on a 1.5m centre which then coalesces to create a wall within the mine. The volume inside the grout perimeter is then injected with lower strength foamed concrete or lean rock paste to prevent the roof collapse between sound pillars of rock within the shallow workings.

Load tests should be undertaken following curing of the grouted mine workings as parts of a system of quality control and the effectiveness of the ground stabilisation tested in relation to the proposed design loads.

6. References

British Geological Survey. 2008. Rochdale. England and Wales Sheet 76. Superficial Deposits and Simplified Bedrock 1:50 000. (Keyworth, Nottingham: British Geological Survey).

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Healy, P.R., and Head, J.M., 1984, CIRIA Special Publication SP32, Construction Over Abandoned Mine Workings.

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Appendix - A – Drawings

GB200361_M_039 – Superficial Geology Map

GB200361_M_040 – Solid Geology Map

GB200361_M_041 – Peat Depth Contour Map

GB200361_M_021 – Surface Ground Workings

GB200361_M_022 – Underground Workings

Appendix - B – Groundsure Geoinsight Report

This is available to download at
<http://www.scoutmoorwindfarm.co.uk/> and also on
the DVD.

If hard copies are required these are available on
request.

Appendix - C – British Geological Survey Boreholes

NGR. 8073 1959

RECORD OF WELL (SHAFT OR BORE)

(now Irwell Valley Water Board)

At Scout Moor Borehole. Bury & District Joint Water Board

1" N.S. 76

1" O.S.

Grid

Ref. 3

Town or Village _____ County Lancs Six-inch quarter sheet 80 NW
Exact site 90 yds. E. of Aqueduct at a point 500 yds. N. of (A rough sketch-map
Dearden Clough; and about 100 yds. SSW of New Hall. or a tracing from a
map is very desirable)
Level of ground surface above sea-level (O.D.) 2850 ft. If well starts below ground surface, state how far _____ ft.
Shaft _____ ft., diameter _____ ft. Bore _____ ft. Diameter of bore: at top _____ ins.; at bottom _____ ins.
Details of permanent lining tubes (internal diameters preferred) _____

Water struck at depths of (feet) _____
Rest-level of water below top of well _____ feet. Suction at _____ feet. Yield on _____ hours' test
_____ gallons per _____ (with pump of capacity _____ g.p.h.); depressing water level to _____ feet
below top. Time of recovery _____ hrs. Amount normally pumped daily _____ g.p.h. for _____ hours.
Quality (attach copy of analysis if available) _____
Sunk by _____ for Mr. _____ Date of well _____
Information from _____

(For Survey use only).
GEOLOGICAL
CLASSIFICATION.

NATURE OF STRATA
(and any additional remarks).

THICKNESS

DEPTH

Feet. Inches.

Feet. Inches.

Drift and Broken Shale

21 -

21 -

Rock

108 -

129 -

Shale

17 -

146 -

Rock

8 -

154 -

Shale

38 6

192 6

Rock

11 -

203 6

Black Shale

41 -

244 6

Rock

15 6

260 -

Shattered Strata

8 -

268 -

Shale

35 -

303 -

Gritstone

36 -

339 -

Black Shale

265 -

604 -

Grey sandy shale

9 -

613 -

Gritstone

50 -

663 -

Grit with coal

6 -

669 -

Black Shale

6 -

675 -

Grit & Shale

20 -

695 -

Grit with coal joints

12 -

707 -

Grey Shale

4 -

711 -

Grey Grit

15 -

726 -

Coal & Clay

1 -

727 -

Gritstone

43 -

770 -

Dark Shale

51 -

821 -

Shaly Grit

34 -

855 -

Dark Shale

150 -

1005 -

Visited & sited on Lane 80 N.W.W. Bury

Well for C + B50. 10/25/50.

Bore well used. S. H. on 1st July 1941 was 125' below surface
For use is intended, but the opinion which is to be used in that the
bottom is light, so that the S.H. appears to be about 10'
further to the west the borehole is intended to be used.

For Survey use only

Date received

G.S.M. File No.

Site marked
on 1" map
(use symbol)(*11815) W1.29051/0.369 10,000 9/39
A.& E.W. Ltd. Gp. 686

SD 81 NW/1
County _____
6" Quarter Sheet _____

THICKNESS		DEPTH	
Feet.	Inches.	Feet.	Inches.
6	40	6	40
32	92	39	32
5	18	44	50
2	44	46	94
11	73	58	67
3	36	62	03
12	49	74	52
4	73	79	25
2	43	81	68
10	67	92	35
10	98	103	33
80	67	184	10
2	74	186	84
15	24	202	08
1	83	203	91
1	83	205	74
6	10	211	84
3	65	215	49
1	22	216	71
4	58	221	29
0	30	221	59
13	11	234	70
15	54	250	24
10	36	260	60
45	72	306	32

SD 8075 1957

76/SD 81/2
76
SD 81 NW/1
1957

RECORD OF WELL (SHAFT OR BORE)

NEW HALL (near Irwell Valley Water Board)

At Scout Moor Firehole, Lyrri & District Joint Water Board

Town or Village _____ County Lancs Six-inch quarter sheet 80 NWExact site 90 yds. E. of Aqueduct at a point 500 yds. N. of } (A rough sketch-map
Dearden Clough; and about 100 yds. S.S. of New Hall. } or a tracing from a
in parish of _____ map is very desirable)Level of ground surface above sea-level (O.D.) 2850 ft. If well starts below ground surface, state how far _____ ft.

Shaft _____ ft., diameter _____ ft. Bore _____ ft. Diameter of bore: at top _____ ins.; at bottom _____ ins.

Details of permanent lining tubes (internal diameters preferred) _____

Water struck at depths of (feet) _____

Rest-level of water below top of well _____ feet. Suction at _____ feet. Yield on _____ hours' test
above _____ days

_____ gallons per _____ (with pump of capacity _____ g.p.h.); depressing water level to _____ feet

below top. Time of recovery _____ hrs. Amount normally pumped daily _____ g.p.h. for _____ hours.

Quality (attach copy of analysis if available) _____

Sunk by _____ for Mr. _____ Date of well _____

Information from _____

(For Survey use only).
GEOLOGICAL
CLASSIFICATION.NATURE OF STRATA
(and any additional remarks).

THICKNESS

Feet. Inches

DEPTH

Feet. Inches.

Drift and Broken Shale

21 -

21 -

Rock

108 -

129 -

Shale

17 -

146 -

Rock

8 -

154 -

Shale

38 6

192 6

Rock

11 -

203 6

Black Shale

41 -

244 6

Rock

15 6

260 -

Shattered Strata

8 -

268 -

Shale

35 -

303 -

Gritstone

36 -

339 -

Black Shale

265 -

604 -

Grey sandy shale

9 -

613 -

Gritstone

50 -

663 -

Grit with coal

6 -

669 -

Black Shale

6 -

675 -

Grit & Shale

20 -

695 -

Grit with coal joints

12 -

707 -

Grey Shale

4 -

711 -

Gray Grit

15 -

726 -

Coal & Clay

1 -

727 -

Gritstone

43 -

770 -

Dark Shale

51 -

821 -

Shaly Grit

34 -

855 -

Dark Shale

150 -

1005 -

Visited & sited on lower 80 NW/4.

Lumpen - with 1000 + 500 ft. 25.4.56.

Bore not used. S.W.L. on 1st July 1941 was 125' unknown surface.

The bore is timbered, but the engineer thinks it unlikely that the
tapping is tight, so that the S.W.L. appears to be about the
position of the base of the Lower Old Red Sandstone. 1.1.56.GEOLOGICAL SURVEY AND MUSEUM.
SOUTH KENSINGTON.
LONDON, S.W. 7.

For Survey use only

Date
receivedG.S.M. Office
File No.Site marked
on 1" map
(use symbol)*111151 W.129151/1.359 10,000 9/20
A. & K.W. Ltd. Op. 666

British Geological Survey

SD 81 NW/1
County _____

8" Quarter Sheet

THICKNESS		DEPTH	
Feet. Inches.		Feet. Inches.	
6	40	6	40
32	92	39	32
5	18	44	50
2	44	46	94
11	73	58	67
3	36	62	03
12	49	74	52
4	73	79	25
2	43	81	68
10	67	92	35
10	98	103	33
80	67	184	10
2	74	186	84
15	24	202	08
1	83	203	91
1	83	205	74
6	10	211	84
3	65	215	49
1	22	216	71
4	58	221	29
0	30	221	59
13	11	234	70
15	54	250	24
10	36	260	60
45	72	306	32

British Geological Survey

British Geological Survey

British Geological Survey

SD 81/3

50

540

600

615

660

[Fletcher
Grit
Barra]

720

780

770

Shale

840

835

Shale

900

Shale

960

1005.0

1020

SD81/3
550' (N)

Scout Moor

Shale

LOWER
HASLINGDEN
FLAGS

cont.

W.L.

21

60

92

176

139

186

Shale

cont.

Shale

cont.

210

255

300

308

Helmrishore
Grit

339

360

420

SD 81 NW/9

SD 81 NW.

British Geological Survey

British Geological Survey

British Geological Survey



READY MIXED CONCRETE (UNITED KINGDOM) LIMITED

Long Lane
Attenborough Nottingham
NG9 6BL

Telephone 0602-221221

RJH/BC
British Geological Survey

British Geological Survey

22nd July, 1975

British Geological Survey

Mrs L. C. Jones
Institute of Geological Sciences
Ring Road
Halton
LEEDS
LS15 8TQ

British Geological Survey

British Geological Survey

British Geological Survey

CONFIDENTIAL

Dear Mrs Jones,

BOREHOLES, SCOUT MOOR

Thank you for your recent letter requesting information on the above boreholes.

For a number of reasons we never completed this drilling programme. In fact only one hole was commenced and this was stopped prematurely at approximately 23.00m. The core from this borehole was logged, but not in great detail owing to our lack of interest in the site at that time for commercial reasons.

British Geological Survey

British Geological Survey

British Geological Survey

The approximate position of this hole was at SD 8161 1881, the surface altitude is unknown. Briefly I recorded :

2.0m to 3.65m	Sandstone, probably Upper Rough Rock
3.65m to 4.55m	Core lost but coal traces, presumed to be the Sandrock Mine coal horizon.
4.55m to 5.70m	Core lost.
5.70 to 20.44m	Sandstone, probably Lower Rough Rock
20.44 to 22.76m	Sandstone, probably Haslingden Flags.

British Geological Survey

British Geological Survey

British Geological Survey

I am sorry the above is not very detailed, if you have any specific questions I may be able to help if you will let me know.

British Geological Survey

British Geological Survey

British Geological Survey

Yours sincerely,

R. J. HAWKINS
Senior Geologist

British Geological Survey

British Geological Survey

British Geological Survey

Registered in London No. 885018

Registered Office:
RMC House, High Street,
Feltham, Middlesex, TW13 4HA.

DIRECTORS: P. J. Owen P. E. Bennett N. T. Grant J. S. Ornsby G. R. C. Smith F. C. S. Spinks G. S. Tyler P. L. Young

Mr. W.B. Evans, Leeds.

READY MIXED CONCRETE (UNITED KINGDOM) LIMITED

~~RMC House High Street~~
~~Feltham Middlesex~~
~~TW13 4HA~~

Nottingham 253542/3

~~TELEPHONE 0533 601371~~
Cables Readymix Hounslow

Please reply to our office at :

Long Lane
Attenborough
Nottingham NG9 6BL

Commercial
In Confidence

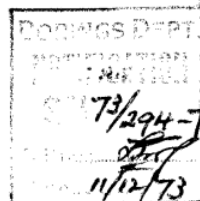
RJH/BC

6th December, 1973

The Director
Institute of Geological Sciences
Exhibition Road
South Kensington
LONDON SW7 2DE

Dear Sir,

BOREHOLE NOTIFICATION



Under the requirements of the Mining Industry Act 1926 I am writing to inform you that my company is at present engaged in a drilling programme which is likely to involve holes in excess of 30m (100 feet).

It is hoped that a total of four holes will be completed on Scout Moor, near Edenfield and 8 km north of Bury. The purpose of these holes is to prove the thickness of the Rough Rock and Haslingden Flags. A copy of part of the O.S. 1" Sheet No. 95 showing the approximate area of drilling is enclosed.

The holes will, at least in part, be cored and the cores which will be logged by myself are to be retained at our offices in Nottingham. As our interest lies in the suitability of these rocks as a potential source of aggregate material it is intended to subject these cores to laboratory tests as soon as possible.

If there is a possibility that you will require access to the cores would you please inform me as soon as possible so that arrangements can be made.

May I take this opportunity of asking you to treat this information, and any further information which you may receive from us on this subject as confidential.

Yours faithfully,

R. J. Hawkins

R. J. HAWKINS
Aggregate Land Search Department