UPPER OGMORE WIND FARM
GROUND INVESTIGATION REPORT

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Date: March 2016

C O N T E N T S

1.0 INTRODUCTION

At the instruction of RES Ltd. a ground investigation has been undertaken at the site of a proposed wind farm near Nant-y-Moel, at the head of the Ogwr Fawr valley.

The area lies within the South Wales Coalfield and there is known to be extensive mining in the area. There are numerous old mine shafts and adits around the site as well as a legacy of the old mining in the form of reactivated fault scarps and large tension cracks.

A desk study was undertaken in 2014 (ref 1) which presented a hazard plan of the geological hazards. There are many large open fissures and fault scarps crossing the site but it is anticipated that there may be many smaller fissures and weaknesses in the rock which are not obvious at surface.

A non-intrusive geophysics investigation was undertaken in 2015 by Terradat Ltd (ref 2) at the proposed turbine locations, which confirmed the presence of discontinuities as well as a number of other anomalies which could have formed hazards to the proposed development. As a result of the geophysics the location of several proposed turbines were amended although not all could be moved into the low risk hazard areas. An additional location (Turbine 8) was also proposed.

An interpretative report on the geophysics investigation (ref 3) concluded that it would be prudent to carry out an intrusive ground investigation at the location of each of the turbine bases to try and rule out the possibility of encountering unforeseen hazards during construction. The investigation consisted of two parallel trial trenches extending across the full width of the turbine base at all of the turbine locations with the exception of Turbine 8. At three of the locations which were within the moderate risk hazard zone, three inclined boreholes were drilled and at the new turbine location a single vertical borehole sunk.

This report details the results of the ground investigation.

2.0 EXISTING SITE CONDITIONS

2.1 Site Location

The site lies approximately 1.5 kilometres to the north-west of Nant-y-Moel in the Ogwr valley and 1.5 kilometres to the north-east of Blaengarw in the Garw valley. The location of the site is shown on Figure 1.

The site is irregular in shape and measures a maximum of 2.8 kilometres from east to west and 3.4 kilometres from north to south.

The site is shown on the Ordnance Survey plans to consist of a moor-land plateau with steep sandstone scarp slopes. It is devoid of settlements and dwellings, although there are two large communications mast in the north central part of the site.

2.2 Site Topography

The topography of the site consists of a moorland plateau with steep slopes and deeply incised stream and river valleys, being the northern part of Mynydd Llangeinwyr, which runs roughly north to south. The topographic high point is Werfa in the northern part of the site at an elevation of 568 metres above Ordnance Datum (AOD) and the topographic low is in the southern part at around 440 metres AOD.

There are a number of streams which rise on the site, flowing to the south-west to the Garw valley, south-east to the Ogwr Fawr and north to the Afan valley.

2.3 Site Geology

The superficial geology is shown to consist of occasional areas of Glacial Till and peaty soil. Generally the topography suggests that superficial deposits are likely to be thin, particularly on the steeper sections of the site.

The solid geology beneath the site consist of Carboniferous Upper Coal Measures, Lower Pennant Measures, mainly sandstones with interbedded mudstones, siltstones and numerous coal seams at depth.

The geological structure consists of shallow, north-easterly dipping strata. There are few geological structures shown. A number of major geological faults are shown running north-west to south-east.

There are a number of coal seams interbedded within the strata beneath the site. Many of the seams are of economic importance and have been worked extensively in the past. Some of these seams lie at relatively shallow depth and outcrop close to the site boundary. These include the No. 1 Rhondda Rider, No. 1 Rhondda, No. 2 Rhondda and No. 3 Rhondda, seams.

There are a number of landslips on the steep slopes around the site. Many of the landslides occur below the main sandstone strata outcrop, close to the crop of the No. 2 Rhondda, probably as a result of water issues at the base of the sandstone unit. The landslides appear to be shallow debris slides with toppling failure from the steep rock face at the head of the slide. The extent of the landslips closest to the site boundary appear to have changed since the geological sheet was produced.

2.4 Proposed Turbine Layout

The proposed turbine layout is shown in Figure 2. The current proposals are for eight turbines, layout PWALuog013, as shown on RES drawing 02959D0001-04.

The locations of several turbines had been previously amended, following recommendations given in the Geophysical Investigation Report, to place them in a 'low' risk hazard zone. Two of the turbines, T4 and T5 remained in the 'moderate' risk hazard zone. T8 was a new location and was not in the area covered by the geophysics ground investigation.

During the early stages of the current investigation is was decided to amend the locations of T5 and T6 due to local topographic and drainage constraints.

2.5 Ground Investigation Requirements

The requirements of the ground investigation were as follows: -

- Confirm the sequence of the superficial deposits, depth to rock-head and groundwater level (all turbines);
- Confirm whether shallow features associated with fissures or reactivated faults were present for turbines in low and moderate risk zones (T1 to T7 inclusive);
- Confirm whether deeper anomalies found by the geophysics investigation could be associated with fissures or reactivated faults, for the turbines in the moderate risk zone (T4, T5 and T6); and
- Confirm the local ground conditions, the depth of any coal seams and the presence of any shallow mining (T8).

3.0 FIELDWORK

The fieldwork commenced on 15th February 2016. It was carried out by Ruddlesden Geotechnics with sub-contractors Evans Plant Hire, Apex Drilling and European Geophysical and consisted of 14 machine excavated trial trenches and 10 rotary boreholes. Full details of the investigation and result**s** are given in the Ruddlesden report on the investigation of March 2016 (ref 4). The locations of the exploratory holes are shown in Figure 3

3.1 Trial Trenches

The trial trenches were excavated using a tracked excavator supplied by Evans Plant Hire. The work was completed over the period 15th to 19th February 2016 and was carried out at the location of seven of the proposed turbine locations (T1 to T7 inclusive).

Two parallel trenches were excavated at each proposed turbine base. The orientation of the trenches was aligned to be perpendicular to the orientation of any fissures and the trenches were extended across the full width of the proposed turbine foundation. The aim of the trenches was to expose bedrock to check for any indication of fissuring and also to provide data on superficial deposits, bedrock and groundwater level for foundation design. The trenches were logged by an Engineer from Ruddlesden.

3.2 Rotary Open-Hole Drilling

The rotary open-hole drilling was carried out by Apex Drilling Services over the period 23rd to 29th February 2016. The aim of the drilling operation was to check for sub-surface broken rock or voids beneath the proposed turbine locations, which could be indicative of fissuring.

A total of 9 inclined holes and one vertical hole were drilled, three at each proposed turbine location at T4, T5 and T6. The inclined holes were drilled at an angle of 45 degrees and were inclined either to the NE of SW, perpendicular to the general orientation of the fissures. The holes were drilled using rotary open-hole techniques with air-flush to a depth of 40m.

A vertical borehole was drilled at T8 and was to check for the presence of shallow coal seams or old workings. It was drilled to a depth of 28m.

On completion of the drilling a temporary plastic casing was installed to the base of each hole to facilitate the down-hole geophysical logging.

3.3 Down-hole Geophysical Logging

The down-hole logging was carried out by European Geophysical Services (EGS) on 26th and 29th February 2016. The aim of the geophysics was to provide a detailed strata log and a check for the presence of coal seams, voids or broken ground.

The geophysical techniques used were natural gamma and dual density logging. The logging was carried out by lowering a sonde down the hole at a controlled rate.

4.0 RESULTS OF THE INVESTIGATION

4.1 Trial Trenching

The trenching did not find any features which could be considered to be related to fissures or re-activated faults.

In most trenches there was a relatively thin layer of peat overlying thin superficial deposits of glacial origin, in turn overlying weathered rock strata.

The peat was typically 0.2 to 0.3m thick and described as 'silty, black amorphous peat with frequent roots and rootlets'.

The superficial deposits were found in all but 2 trenches and was described as 'head' or 'fluvio-glacial' deposits. The 'head' was found underlying the peat and extended to depths of between 0.3 and 0.8m. It was found in 7 of the trenches. It was laterally persistent across the length of the trenches and was described as 'silty sand' or 'silty, sandy clay'.

The fluvio-glacial deposits were found in 6 of the trenches and extended to depths of 1.2m. The deposits were typically described as 'loose, sub-rounded to sub-angular, sandy, fine to coarse gravel'. These deposits were found in distinct channels which had been cut into the weathered rock.

Weathered rock strata was encountered at depths of between 0.5 to 1.7m. The deposits were described as 'loose to medium dense gravel' or occasionally 'stiff, gravelly clay' where the original rock strata was more argillaceous. These strata frequently showed traces of the original rock structure such as bedding and jointing. The strata consisted of sandstone with some mudstone and siltstone layers. 'Dense' strata were encountered below the weathered layers and was generally excavated as angular gravel and cobbles.

The trenches were excavated to 'hard' strata which could not be further excavated without the use of a breaker. The rock strata were encountered at depths of 0.9 to 2.2m depth and consisted of mainly strong sandstone with some weaker interbedded siltstone and occasional mudstone.

The dip and dip direction of the rock strata varied across the site but was generally shallow with the bedding measured from 10 to 20 degrees.

The trenches were logged by an Engineer from Ruddlesden. On completion of the logging the trenches were backfilled with arisings, replaced in the reverse order of excavation.

4.2 Rotary Open-Hole Drilling

The rotary open-hole drilling did not find any features which could be considered to be related to fissures or re-activated faults.

In general, the strata appeared solid with very few broken zones. Full flush was obtained throughout drilling. There were several small water inflows but no significant water strikes.

Drilling rates were measured for every 0.5m advance and strata logged from the cuttings. The main rock type encountered was sandstone but there were some thin siltstone and mudstone beds noted.

Several thin coal bands were encountered in a number of the boreholes. In the three boreholes at T5, coal in a number of thin bands was encountered at depths in the boreholes of between 23.6 and 29.2m (16.7 and 20.6m below ground level). In two of the boreholes at T6 coal bands were encountered at depths of 15 to 20.1m (10.6 and 14.2m below ground level). In the single vertical borehole at T8 coal bands were encountered at 7.8 to 8.3m and a distinct seam at 17.8 to 18.4m below ground level. There were no indications of any coal mining.

It is possible that the coal encountered in T5, T6 and at 17.8 in T8 is the No1 Rhondda Rider seam, which is shown to crop close to the boundary of the site at these locations. This seam is of little economic importance and has not been mined extensively. There are some indications of crop working of this seam on the slopes around the site. Around 30m below this seam is the No1 Rhondda and a further 90m below is the No2 Rhondda which has been mined more extensively in the locality.

4.3 Down-hole Geophysical Logging

The down-hole geophysical logging did not find any features which could be considered to be related to fissures or re-activated faults.

The geophysics interpretation shows superficial deposits overlying mainly sandstone rock strata with some interbedded mudstone and occasional low density strata which is thought to be coal seams. Rock strata was encountered at depths of between 1.3 and 4m in the holes (0.9 and 2.8m below ground level) which conforms well with the depth of the ‘hard’ strata in the trenches.

5.0 DISCUSSION

The ground investigation did not find any features which could be related to re-activated faults, fissures or shallow coal mining.

The anticipated geological sequence was broadly confirmed with strong sandstone at shallow depth interbedded with some weaker siltstone and mudstone horizons. There were several thin coal seams encountered. In the eastern part of the site the coal seams were slightly thicker and could be tentatively correlated with named seams identified on the British Geological Survey plan of the site. No mine workings were encountered.

The superficial deposits consisted of a relatively thin peaty topsoil overlying weathered bedrock material. In some trenches thin gravel layers were seen which appeared to have been fluvio-glacial in origin.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The ground investigation did not find any features which could be related to re-activated faults of fissures. This means that the risk categorisation for Turbines 1 to 3 and 6 to 8 is confirmed as low. For Turbines 4,5 and 6 which were originally within the moderate risk zone the categorisation is now low.

There remains a low risk to the development as a result of potential ongoing ground movements which could be triggered by: -

- Further collapse of old coal workings deep below the site which could result in subsidence or trigger fault-reactivation and fissuring.
- Ground movements such as landslides on the steep slopes surrounding the site which could reduce lateral restraint and trigger further fissuring.
- Changes to surface water flow patterns and ground water levels as a result of global warming or groundwater rebound following cessation of mining operations.

The likely depth of the turbine foundations is unlikely to exceed 3m to achieve the required bearing capacity, given the ground conditions encountered during the ground investigation.

The ground investigation has proven an area with a radius of 17m from the centre of Turbine locations 1 to 7 inclusive, that can be assumed to be clear of any hazards associated with fissures or faults.

Turbine 8 was outside of the area covered by the mining desk study and geophysics investigation but appears to be outside of the hazard zones associated with fissures and faults. It has been shown to be clear of hazards from shallow coal mining.

6.2 Recommendations

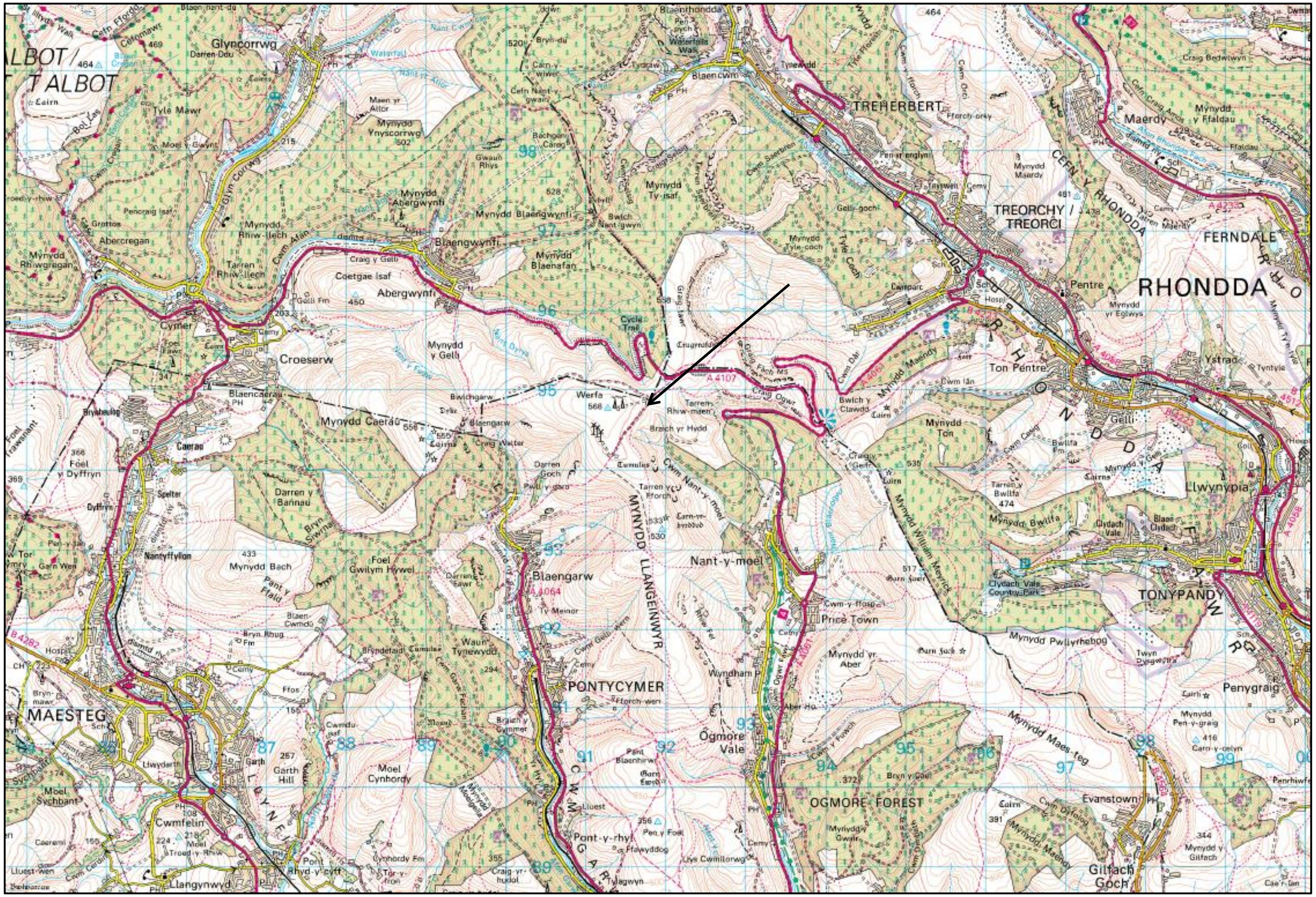
During any excavations on site it would be prudent to have a suitably qualified engineer present to inspect the excavations for any features which may be related to fissures, reactivated faults or shallow mining.

The location of the site access roads and other infrastructure is not known at this stage and therefore has not been part of this investigation. It is possible that further investigation work may be required, depending on how close to the known zones of fissures and reactivated faults the development is proposed.

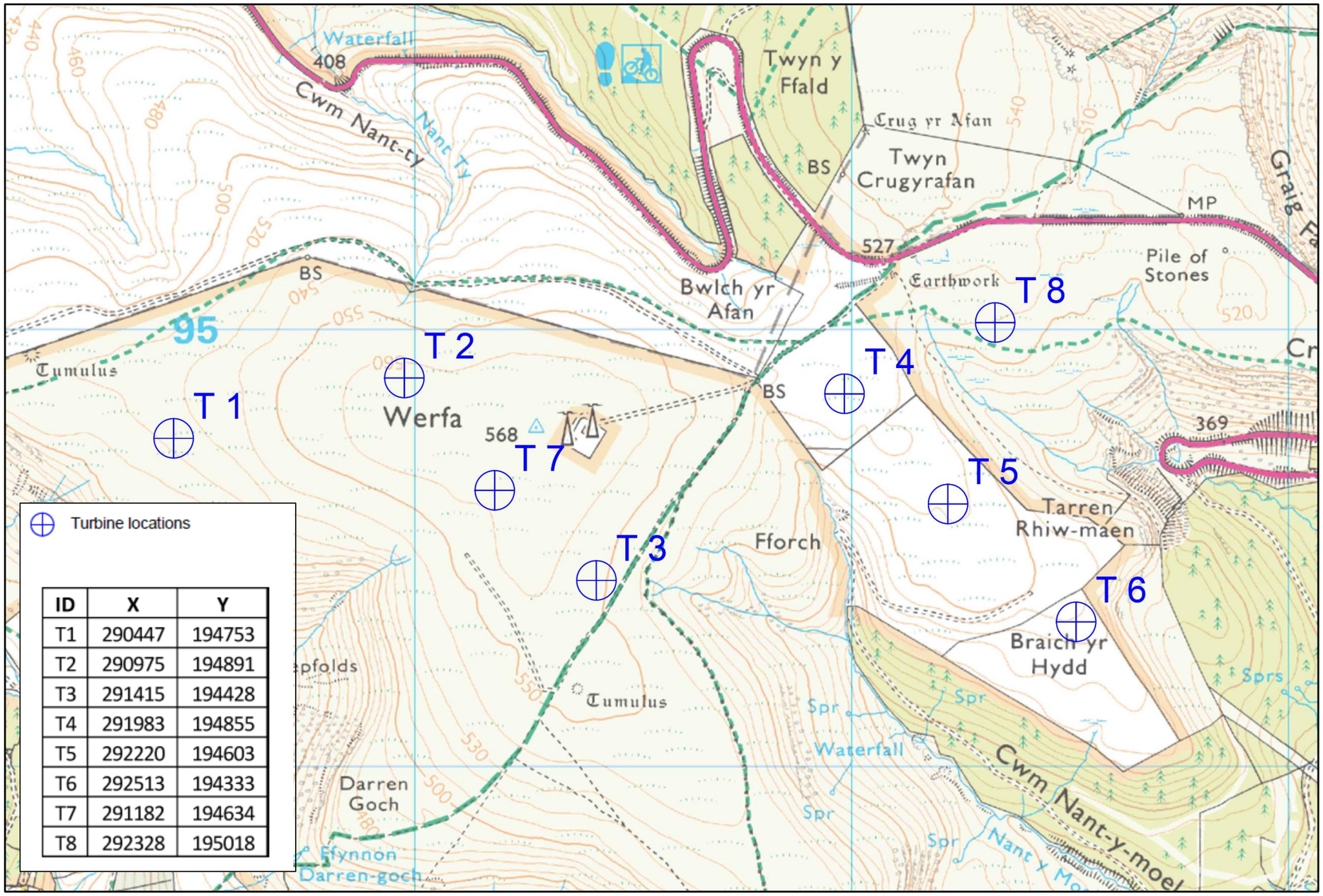
7.0 REFERENCES

1. N.A.Brown, Engineering Geologist – Upper Ogmore Mining Desk Study Report, Oct 2014.
2. Terradat Ltd – Geophysical Survey Report, 4565, Oct 2015.
3. N.A.Brown, Engineering Geologist – Upper Ogmore Geophysics Investigation Report, Oct 2015.
4. Ruddlesden Geotechnical – Ground Investigation Report, March 2016.

FIGURES

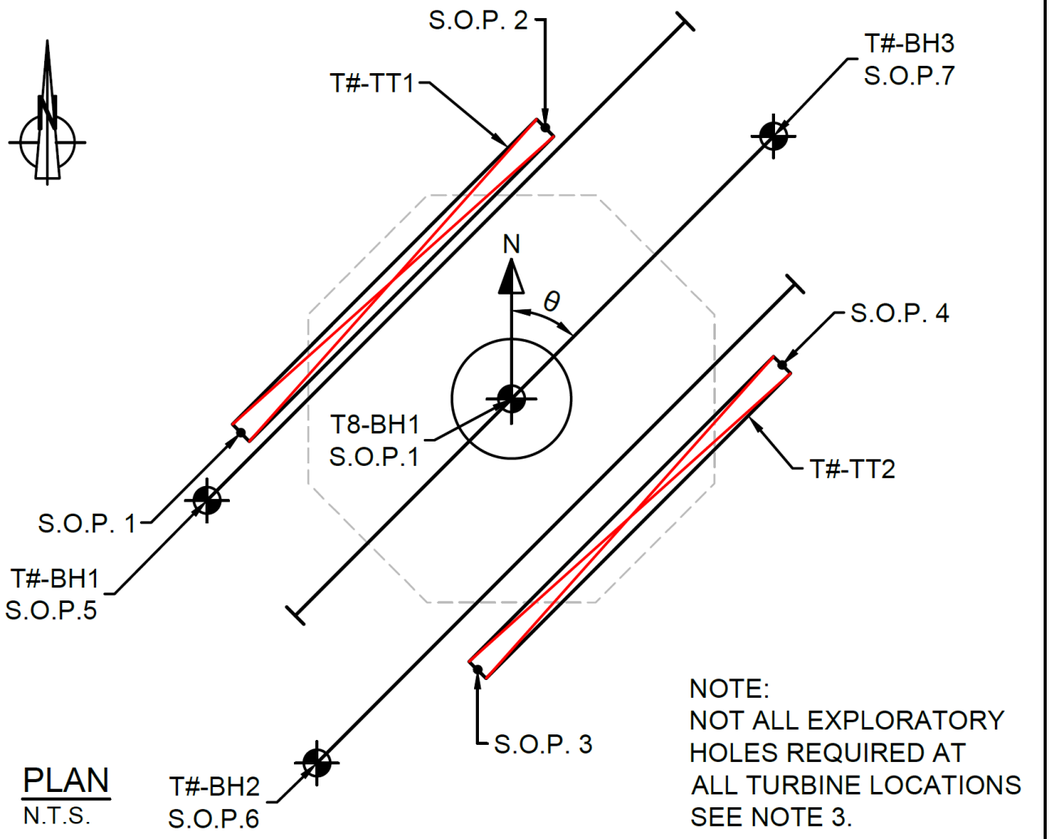


UPPER OGMORE WIND FARM
FIGURE 1
SITE LOCATION
NOT TO SCALE

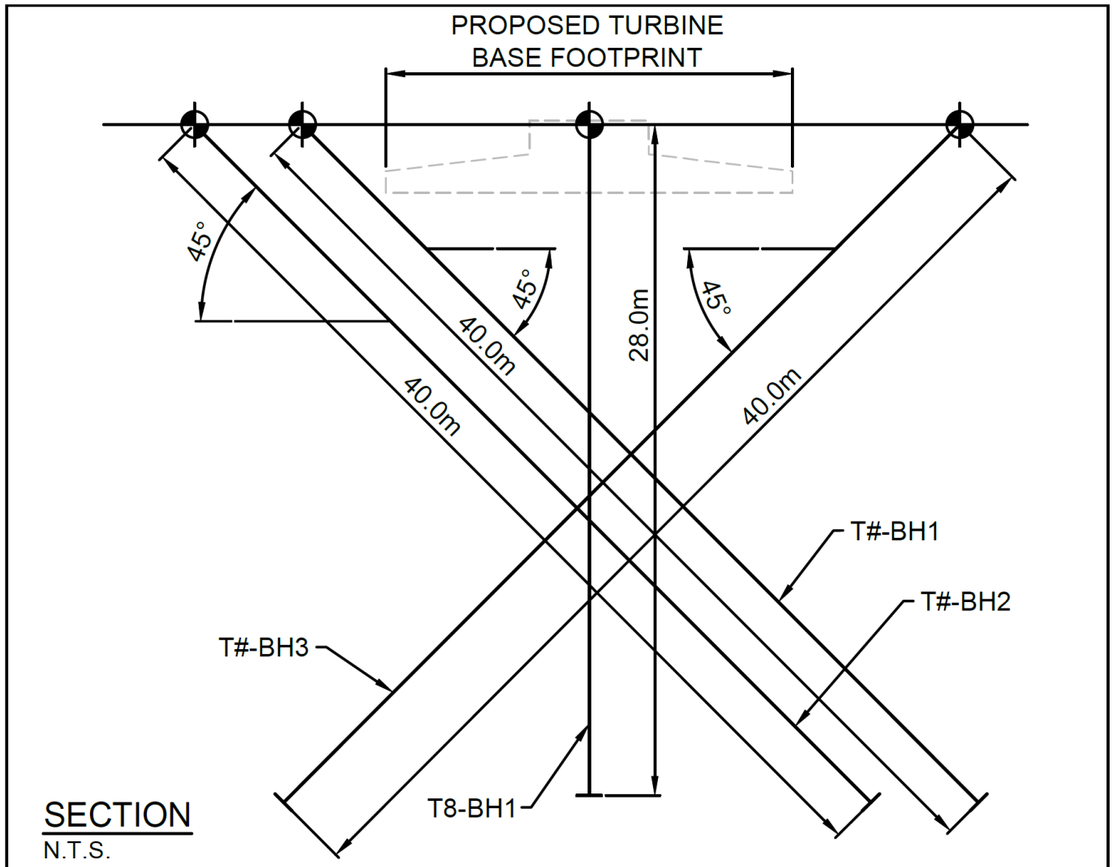


ID	X	Y
T1	290447	194753
T2	290975	194891
T3	291415	194428
T4	291983	194855
T5	292220	194603
T6	292513	194333
T7	291182	194634
T8	292328	195018

UPPER OGMORE WIND FARM
FIGURE 2
PROPOSED TURBINE LAYOUT
(BASED ON PWALuog013)
SCALE 1:10,000



PLAN
N.T.S.



SECTION
N.T.S.

UPPER OGMORE WIND FARM
FIGURE 3
EXPLORATORY HOLE LOCATIONS (RELATIVE TO THE CENTRE OF THE TURBINE LOCATION)
NOT TO SCALE