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Site Suitability Assessment

Freightliner Rd	11 Nov 2016

Report issued by:

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Turbine(s) Assessed	EWT - DW54 - 900 kW
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CONTENTS

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REVISION HISTORY

Version No.	Details	Authorised by	Date
1.0	Initial assessment.	JP	11/11/2016

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1. EXECUTIVE SUMMARY

This report summarises the wind characteristics for the Freightliner Rd site as requested by Earthmill Ltd. A combination of wind, terrain, vegetation and man-made features has been used to create a three-dimensional model of the site. The wind statistics have been generated for the site at 100m using a Numerical Weather Prediction (NWP) method. A detailed three-dimensional CFD model of the terrain and ground features was then used to calculate the average wind speed across the site at hub height and accounts for all the effects of vegetation, buildings and other local wind breaks.

The W_{50} average wind speed is an estimate of the most likely 20 year long term average wind speed. This wind speed has a 50% probability of being exceeded.

The W_{90} average wind speed is a conservative estimate of the 20 year long term average wind speed. This wind speed has a 90% probability of being exceeded. The W_{90} result is calculated by subtracting 0.5 m/s from the W_{50} value. This reduction in wind speed is based on an average error determined by a validation exercise performed by Digital Engineering [1].

The input information is summarised in the table below:

Number of turbines	1
Turbine Type	EWT - DW54 - 900 kW
Wake Analysis	No
Hub height	40.0 m
Location (Lat Lon)	53.72774N 0.38342W

The results from the CFD analysis at **40.0 m** hub height can be summarised in the table below. These results are specific to the **EWT - DW54 - 900 kW** turbine. All quantities are 20 year averaged values and do not include any wake effects:

Long term average wind speed - W_{50}	5.6 m/s
Long term average wind speed - W_{90}	5.1 m/s
Average turbulence intensity - I_{ave}	24.8 %
Average turbulence intensity at 15 m/s - I_{15}	12.0 %
Wind shear exponent - α_{ave}	0.29
Weibull shape parameter - k	2.3
Weibull scale parameter - C	6.3
Reference wind speed - V_{ref}	34.3 m/s
Once in 50yr extreme wind speed - V_{e50}	44.6 m/s

Annual energy yield results, **including power loss estimates** are provided below:

Turbulence loss factor	1.00
Shear loss factor	0.98
Electrical loss factor	0.97
Availability factor	0.95
Wake loss factor	1.00
Energy yield (P_{50}) with losses and availability	1409 MWh
Energy yield (P_{90}) with losses and availability	1094 MWh

These losses are for guidance purposes only, the real losses may differ.

2. PROJECT

This report summarises the wind characteristics for the Freightliner Rd site as requested by Earthmill Ltd. A combination of wind, terrain, vegetation and man-made features has been used to create a three-dimensional model of the site. The wind statistics have been generated for the site at 100m using a Numerical Weather Prediction (NWP) method. A detailed three-dimensional CFD model of the terrain and ground features was then used to calculate the average wind speed across the site at hub height and accounts for all the effects of vegetation, buildings and other local wind breaks.

2.1. PROJECT DELIVERABLES

- Detailed wind parameters at turbine location, including: Wind speed, turbulence, shear, energy yield, extreme winds and other parameters.
- Results are presented as tabular data, micro-siting maps, roses and other diagrams.
- The methods employed to calculate this data are outlined alongside the results.

3. SITE DESCRIPTION

3.1. SITE LOCATION AND COORDINATES

Site name	Freightliner Rd
Site Centre (Lat Lon)	53.72774N 0.38342W
Coordinate System Datum	WGS 84
Hub Height Above Ground Level	40.0 m
Hub Height Above Sea Level at Turbine Location	44.9 m

Table 1. Site location

Figure 1. Site map (Ref.: Google Maps)

4. SITE SPECIFIC DATA

4.1. TERRAIN HEIGHT DATA

Terrain height data has been extracted from the following digital terrain model:

Source	OS Terrain 50
Resolution	50 m x 50 m
Height accuracy	±3 m

Table 2. Terrain data information

4.2. TERRAIN ROUGHNESS

Information regarding the type of terrain (e.g.: water or land), ground roughness and vegetation type. The terrain surface roughness information has been extracted from two separate sources with different levels of detail.

4.2.1. BACKGROUND ROUGHNESS

Source	CORINE Land Cover
Resolution	100 m x 100 m

Table 3. Terrain background roughness

4.2.2. LOCAL NATURAL FEATURES AND BUILDINGS

Centre	53.72774N 0.38342W
Area	1km radius
Number of features	Buildings: 1178 Vegetation: 88

Table 4. Natural features and buildings

4.3. MESO-SCALE WIND DATA

Resolution	3km x 3km
Reference Height	100 m
Time Period	20 years

Table 5. Wind rose information

5. TERRAIN MODEL, FORESTED AREAS AND BUILDING MODELS

This section contains a summary of the computational terrain, and the building and vegetation features included in the assessment. On the following plots, the site centre location is indicated with a black dot or red cross.

5.1. TERRAIN HEIGHT

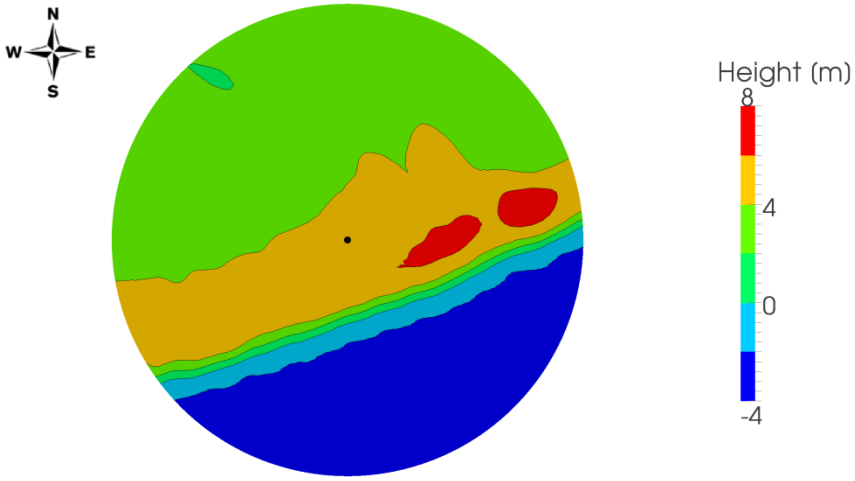

Figure 2. Terrain height map [m]. 1 km radius

5.2. THREE-DIMENSIONAL VEGETATION AND BUILDING FEATURES

In Figure 3 below, vegetation features are represented by green areas, and buildings are grey or black in colour.

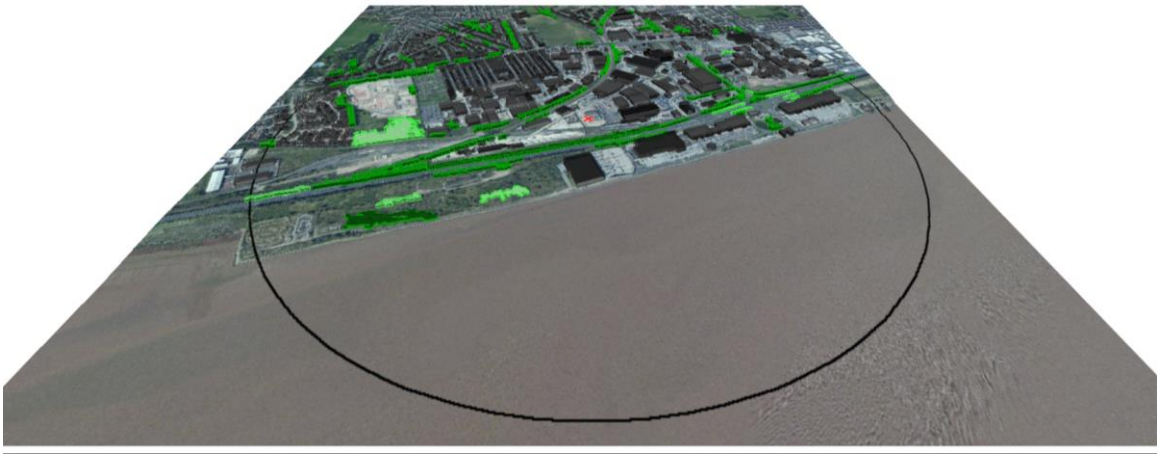

Figure 3. Three-dimensional vegetation and building map for domain, 1 km radius ring shown on picture

5.3. LOCAL VEGETATION AND BUILDINGS

Vegetation Features	OS StreetView and on-site imagery
Building Features	OS StreetView and on-site imagery

Table 6. Summary of local forestry and building feature sources

5.4. LOCAL VEGETATION FEATURES

The local vegetation features within a 1 km radius of the site centre location are summarised in Figure 4 below. Height above ground level for each area of vegetation has been confirmed by the customer [2], these confirmed heights are included as labels in the following figure. Digital Engineering has not performed a site visit for this location. Wind characteristics for the site have been generated based on the vegetation features summarised below. Any change from these values will affect the wind properties for the site.

Figure 4. Summary of vegetation features within 1 km, with height labels for each vegetation area.

5.5. LOCAL BUILDING FEATURES

The local building features within a 1 km radius of the site centre location are summarised in Figure 5 below. Height above ground level for each building has been confirmed by the customer [2], these confirmed heights are indicated by different area colours in the following figure. Digital Engineering has not performed a site visit for this location. Wind characteristics for the site have been generated based on the building features summarised below. Any change from these values will affect the wind properties for the site.

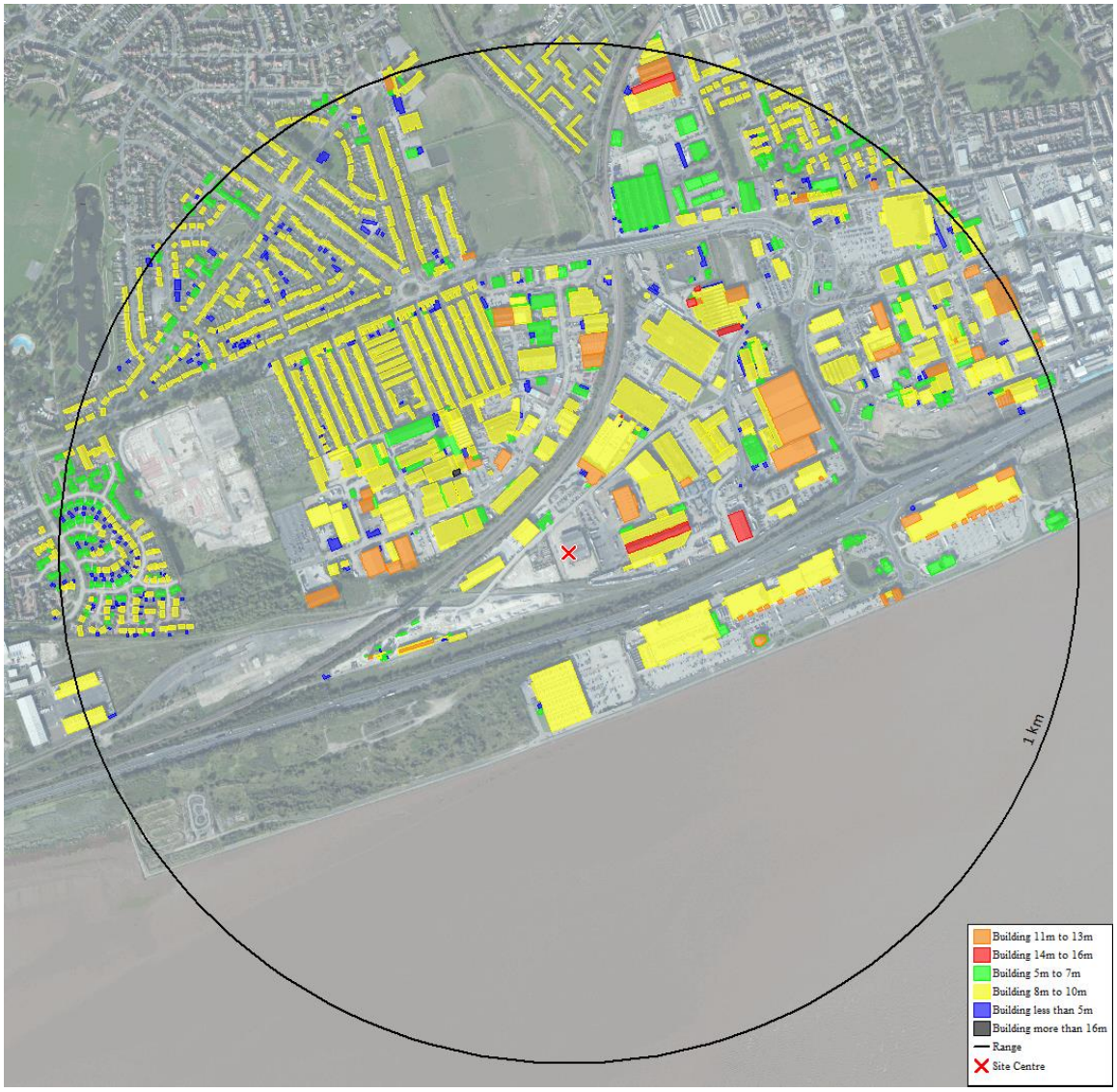

Figure 5. Summary of building features within 1 km, with height labels for each building.

6. DETAILED SITE SPECIFIC RESULTS

All results provided in this section **do not include the effect of wakes**, unless explicitly stated.

6.1. WIND SPEED AND DISTRIBUTION

6.1.1. ANNUAL AVERAGE WIND SPEED

The W_{50} average wind speed is an estimate of the most likely 20 year long term average wind speed. This wind speed has a 50% probability of being exceeded.

The W_{90} average wind speed is a conservative estimate of the 20 year long term average wind speed. This wind speed has a 90% probability of being exceeded. The W_{90} result is calculated by subtracting 0.5 m/s from the W_{50} value. This reduction in wind speed is based on an average error determined by a validation exercise performed by Digital Engineering [1].

The long term average wind speed was obtained from the CFD model of the site, using 20 years of Meso-scale wind data. The following equation was used to adjust wind speed for air density, for the purposes of loading calculations:

$$V_{ave} = V_{lt}\sqrt{\frac{\rho_{site}}{\rho_{standard}}}$$

Equation 1. Calculation for long term and density adjusted wind speed

The local air density, and the wind speeds before and after the adjustment for density are provided below:

Local air density - ρ_{site}	1.22 kg/m^3
Long term average wind speed – W_{50}	5.6 m/s
Long term average wind speed – W_{90}	5.1 m/s
Long term and air density adjusted wind speed - V_{ave}	5.6 m/s

Table 7. Annual average wind speed results

6.1.2. LONG TERM AVERAGE WIND SPEED MAP

A long term average wind speed map for the area of interest at **40.0 m** above ground level is shown below. This shows a 500 m x 500 m area divided into 50 m squares.

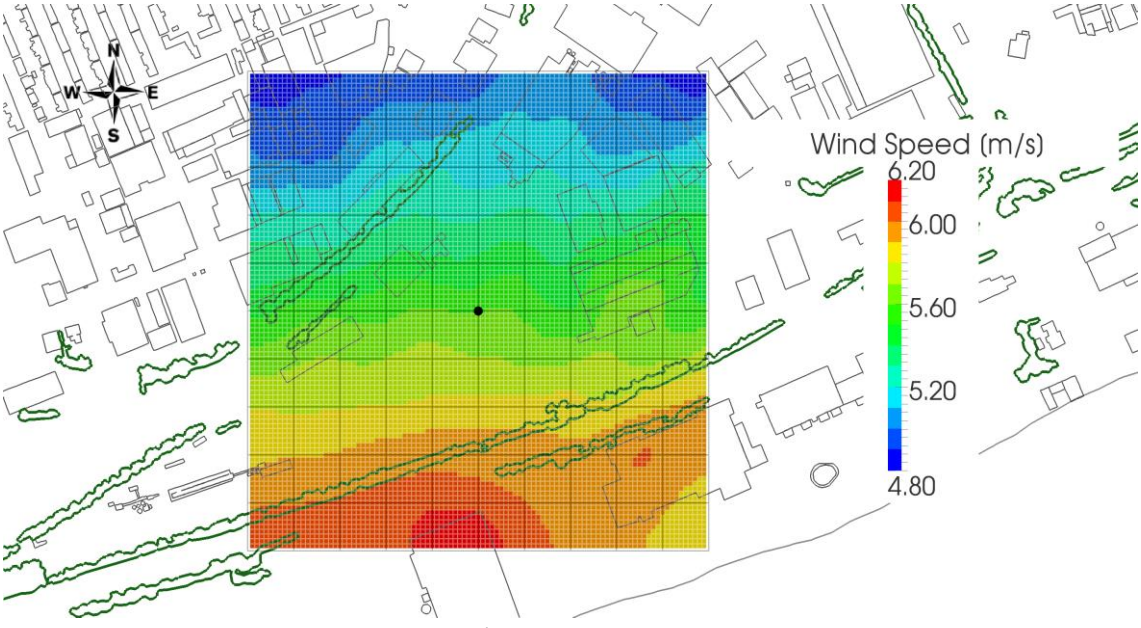

Figure 6. Long term average wind speed map [m/s], 40.0 m AGL

6.1.3. WIND DIRECTION DISTRIBUTION

The wind direction distribution is summarised as a wind rose below:

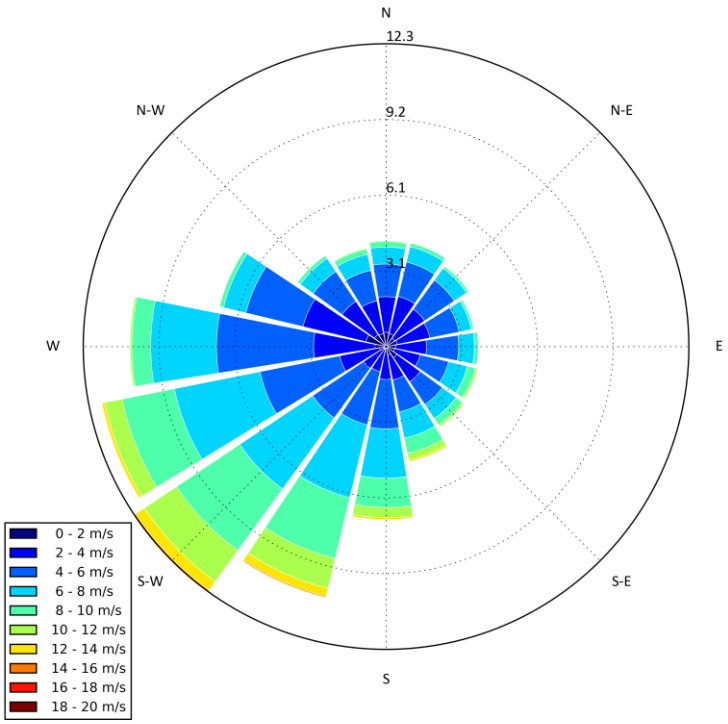

Figure 7. Wind rose at 40.0 m AGL

The same wind direction distribution is summarised in the table below:

Wind Direction Distribution	
Direction (°)	Frequency (%)
0.0	4.3
22.5	4.3
45.0	4.0
67.5	3.6
90.0	3.8
112.5	3.8
135.0	3.9
157.5	4.8
180.0	7.0
202.5	10.5
225.0	12.3
247.5	11.8
270.0	10.4
292.5	7.0
315.0	4.5
337.5	4.1

Table 8. Wind direction distribution

6.1.4. WEIBULL PARAMETERS

A Weibull distribution can be used to describe the wind conditions at the turbine position at **40.0 m** hub height. The parameters that make up this distribution were calculated using an optimisation process to fit wind frequency data at the turbine. The resulting Weibull parameters for all directions are provided below:

Weibull shape parameter - k	2.3
Weibull scale parameter - C	6.3

Table 9. Weibull parameter results

6.1.5. WIND SPEED DISTRIBUTION PER DIRECTION SECTOR

The wind speed distribution per direction sector, described by Weibull parameters are provided below:

Wind Speed Distribution		
Direction *(°)*	Shape Parameter *(k)*	Scale Parameter *(C)*
0.0	2.1	5.0
22.5	2.3	4.8
45.0	2.5	4.8
67.5	2.3	4.7
90.0	2.4	5.0
112.5	2.2	5.6
135.0	2.0	5.3
157.5	2.2	6.5
180.0	2.8	7.0
202.5	3.1	8.2
225.0	3.2	8.4
247.5	2.9	7.2
270.0	2.9	5.8
292.5	2.4	4.7
315.0	2.3	4.7
337.5	2.1	5.0

Table 10. Wind speed distribution per direction sector

6.2. EXTREME WIND SPEEDS

The extreme wind speed for the site, and the calculation methods are explained below.

6.2.1. REFERENCE WIND SPEED

The reference wind speed V_{ref} is the maximal 10 min average of the wind speed over 50 years. The value at **40.0 m** hub height is provided below:

Reference wind speed - V_{ref}	34.3 m/s

Table 11. Reference wind speed result

6.2.2. EXTREME WIND SPEED

As gust maxima were not measured for the site, gust factors were calculated for each wind speed bin and direction using Equation 2 below. The averaging time (T) was 10 mins, the sampling time (t) was 3 secs and the mean turbulence intensity (I) for each wind speed bin was produced by the CFD model.

$$G_{10\,min} = 1 + 0.42 \cdot \ln\left(\frac{T}{t}\right) \cdot I$$

Equation 2. Calculation of gust factor for each ten minute interval

From these gust factors, characteristic gust factors were calculated for each wind bin, based on directional standard deviation. The gust factor for high wind speeds G_{high} was calculated by averaging the characteristic gust factors for wind speed bins higher than 15 m/s.

The extreme wind speed V_{e50} represents the maximal 3 sec wind gust over 50 years. In order to calculate V_{e50} the following equation was used:

$$V_{e50} = G_{high} \cdot V_{ref}$$

Equation 3. Calculation for extreme wind speed

The calculated gust factor and extreme wind speed are given in the table below:

Gust factor for high wind speeds - G_{high}	1.3
Extreme wind speed - V_{e50}	44.6 m/s

Table 12. Extreme wind speed result

6.3. TURBULENCE

The average turbulence intensity (I_{ave}) was calculated based on the measured turbulence kinetic energy k and wind speed V from the CFD model of the site. In addition to the base calculation for turbulence intensity, a meandering component m was also included in the calculation of I_{ave}. The equation used to calculate turbulence intensity is given below:

$$I_{ave} = \frac{\sqrt{2/3\,k}}{V} + \frac{m}{V}$$

Equation 4. Calculation for turbulence intensity, based on turbulence kinetic energy and velocity

A table summarising average turbulence intensity for each wind speed and direction sector bin is provided in Section 9.2 in the Appendix.

The average turbulence intensity at 15 m/s, as required by IEC 61400-1 [3], is given in the table below:

Average turbulence intensity - I_{ave}	24.8 %
Average turbulence intensity at 15 m/s - I_{15}	12.0 %

Table 13. Turbulence intensity results

6.3.1. TURBULENCE DIAGRAM

A turbulence intensity diagram including average turbulence per wind speed bin and frequency per bin is provided below. The cut in speed for the **EWT - DW54 - 900 kW** turbine is highlighted with a red dashed line.

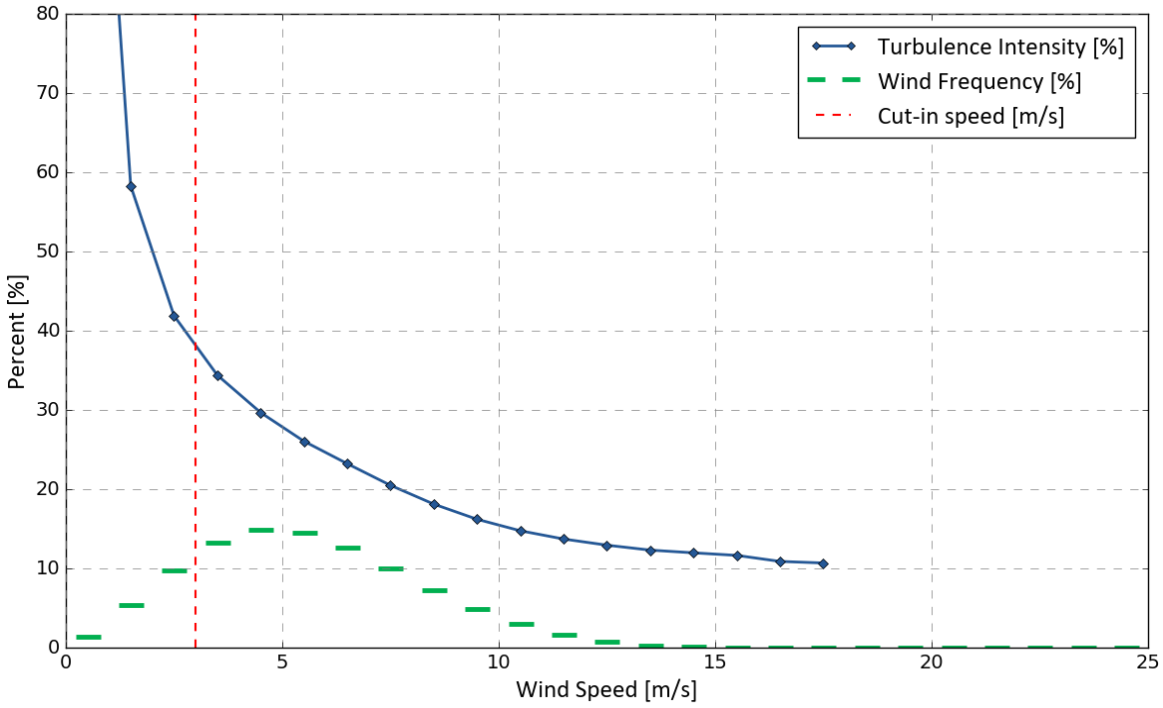

Figure 8. Turbulence intensity diagram including average turbulence intensity and frequency per wind speed bin

6.3.2. TURBULENCE ROSE

The plot below shows the turbulence rose at 15 m/s at **40.0 m** AGL.

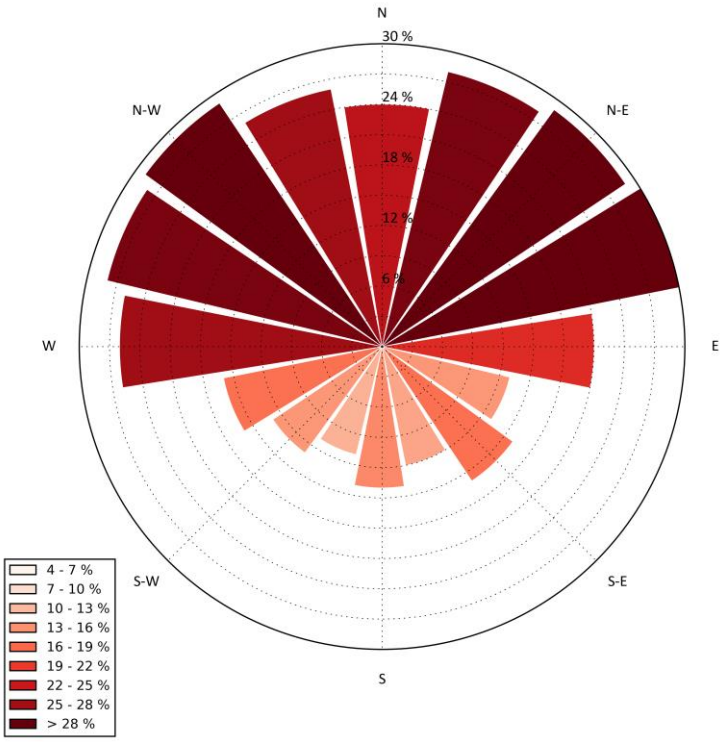

Figure 9. Turbulence rose at 15 m/s at 40.0 m AGL

6.3.3. AVERAGE TURBULENCE INTENSITY (AT 15 M/S) MAP

An average turbulence intensity (at 15 m/s) map for the area of interest at **40.0 m** above ground level is shown below. This shows a 500 m x 500 m area divided into 50 m squares.

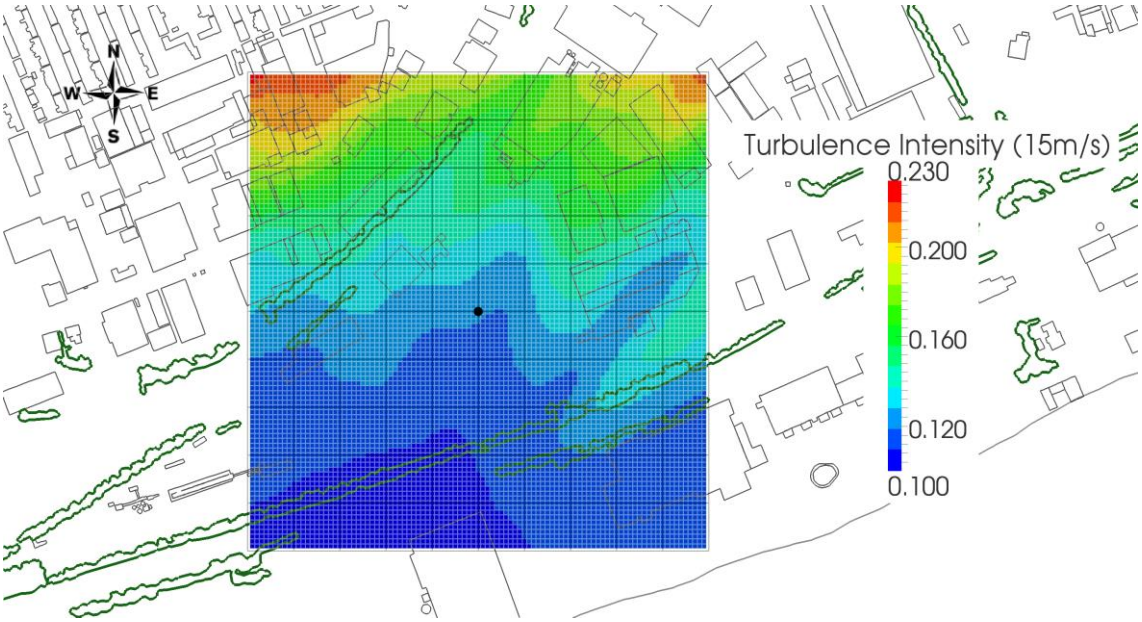

Figure 10. Average turbulence intensity (at 15 m/s) map [%], 40.0 m AGL

6.4. WIND SHEAR EXPONENT

The wind shear exponent (α) at the turbine location was calculated over the turbine swept area, using the following equation:

$$\alpha = \frac{\ln\left(V_1/V_2\right)}{\ln\left(Z_1/Z_2\right)}$$

Equation 5. Calculation for wind shear exponent

The frequency averaged wind shear exponent (α_{ave}) for the **EWT - DW54 - 900 kW** turbine at **40.0 m** hub height is provided in the table below:

Average wind shear exponent - α_{ave}	0.29

Table 14. Wind shear exponent

6.4.1. DIRECTIONAL WIND SHEAR EXPONENT

The average wind shear exponent per wind speed sector is provided below:

Wind Shear Exponent	
Direction (°)	Wind Shear Exponent
0.0	0.25
22.5	0.30
45.0	0.32
67.5	0.37
90.0	0.49
112.5	0.38
135.0	0.53
157.5	0.16
180.0	0.39
202.5	0.18
225.0	0.23
247.5	0.21
270.0	0.31
292.5	0.39
315.0	0.37
337.5	0.29

Table 15. Wind shear exponent for each direction sector

6.4.2. AVERAGE WIND SHEAR MAP

An average wind shear exponent map for the **EWT - DW54 - 900 kW** turbine at **40.0 m** above ground level is shown below. This shows a 500 m x 500 m area divided into 50 m squares. For the purposes of displaying this data the maximum wind shear exponent has been capped at 0.3 and as such may be higher. If you require further information please contact Digital Engineering Ltd.

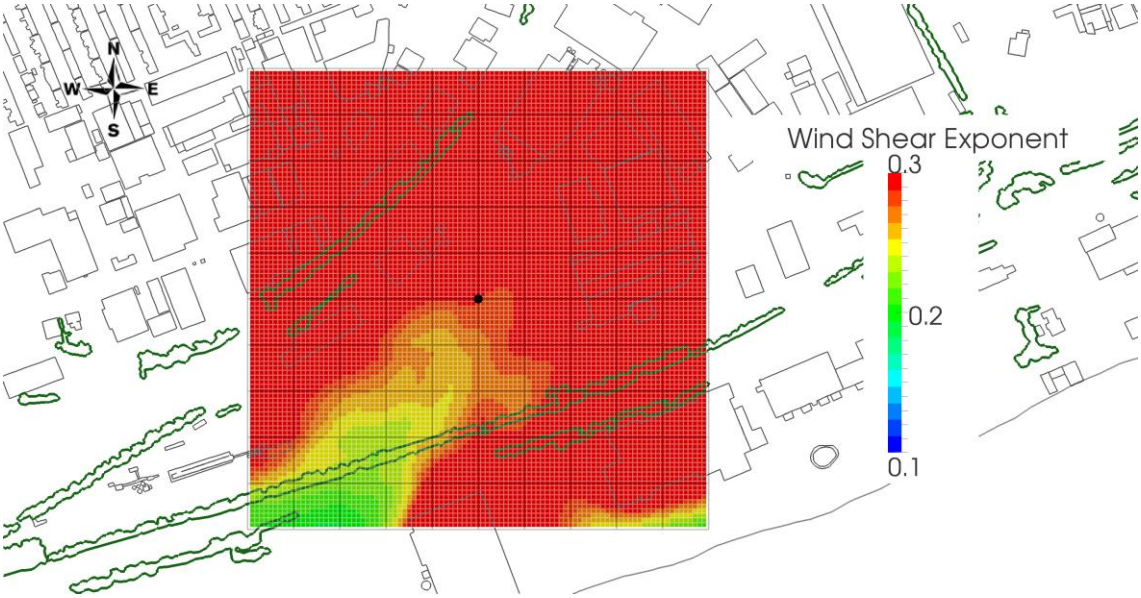

Figure 11. Average wind shear exponent map, 40.0 m AGL

6.5. ENERGY YIELD

All energy yield results provided in this section include adjustments for air density (the value of which is provided in Section 6.1.1). The equation used to adjust wind speed when calculating energy yield results is provided below:

$$V_{corr} = V \cdot \sqrt[3]{\frac{\rho_{site}}{\rho_{standard}}}$$

Equation 6. Air density corrected wind speed for energy yield calculations

6.5.1. TURBINE POWER CURVE

The turbine power curve is used to predict annual energy yield as part of this assessment. All energy yield values assume that the turbine is performing at 100 % of the power curve outlined below. Any deviation in performance from this power curve will affect the energy yield estimates provided in this report.

EWT - DW54 - 900 kW	
Speed (m/s)	Power (kW)
0.0	0.0
2.0	0.0
3.0	12.0
4.0	39.0
5.0	78.0
6.0	138.0
7.0	222.0
8.0	337.0
9.0	477.0
10.0	605.0
11.0	733.0
12.0	827.0
13.0	884.0
14.0	900.0
15.0	900.0
20.0	900.0
25.0	900.0

Table 16. Power curve data

6.5.2. AVERAGE ANNUAL ENERGY YIELD

P_{50} is the annual energy yield based on the measured wind conditions at the turbine location. P_{90} is calculated using the following equation:

$$P_{90} = P_{50}\left(1 - F_{PS}\left(1 - {}^{W_{90}}/_{W_{50}}\right)\right)$$

Equation 7. Calculation for P_{90} annual energy yield

In the above equation F_{PS} is the power sensitivity factor calculated for the turbine. This factor describes the sensitivity of the annual energy yield to a change in wind speed equal to the W_{90} reduction value. Power sensitivity factor is turbine and site specific.

The P_{50} and P_{90} results, **assuming 100% availability and no technical losses**, are provided below, along with the calculated power sensitivity factor:

Power sensitivity factor - F_{PS}	2.5
Average annual energy yield - P_{50}*	1560 MWh
Average annual energy yield - P_{90}*	1211 MWh

** Assumes 100% availability and no technical losses. Estimates for the losses at the site are provided in Section 7.*

Table 17. Average annual energy yield and sensitivity factor

6.5.3. ANNUAL ENERGY YIELD MAP

An annual energy yield map for the **EWT - DW54 - 900 kW** turbine at **40.0 m** above ground level is shown below. This shows a 500 m x 500 m area divided into 50 m squares. **Assumes 100% availability and no technical losses.**

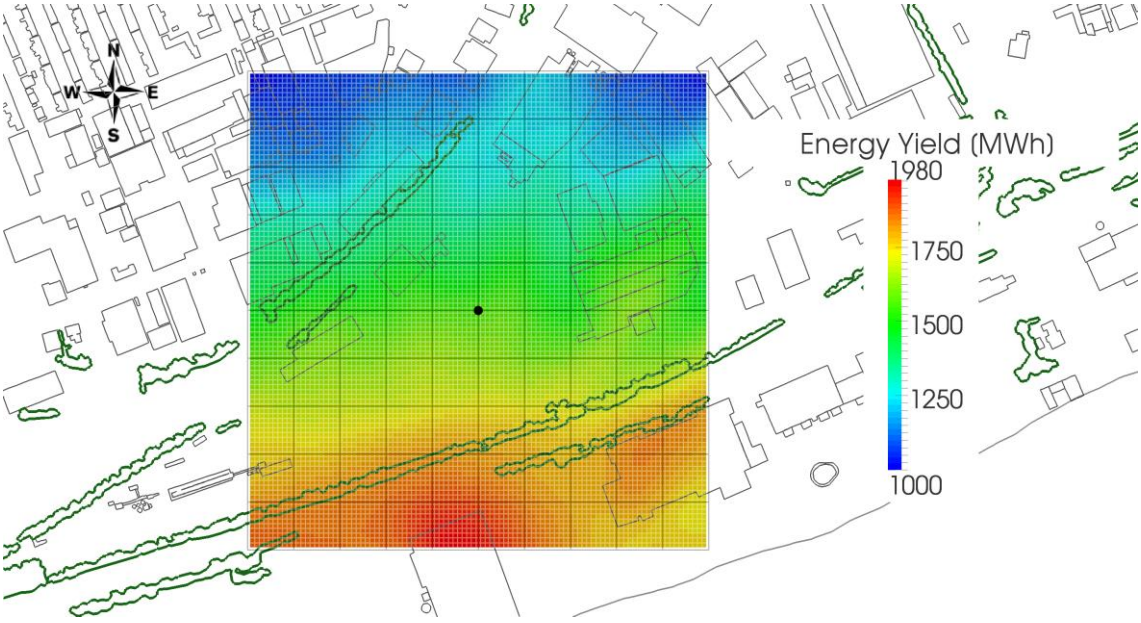

Figure 12. Annual energy yield map [MWh], 40.0 m AGL

6.6. ADDITIONAL SITE CONDITIONS

6.6.1. FLOW INCLINATION

Flow inclination has been measured at the turbine location and hub height. The maximum deviation of flow inclination from 0 degrees, positive or negative, for each calculated direction is provided in the table below:

Flow Inclination	
Direction (°)	Maximum Inclination (°)
0.0	-1.2
22.5	-1.4
45.0	-1.6
67.5	-1.5
90.0	-1.1
112.5	-0.3
135.0	0.6
157.5	0.6
180.0	0.6
202.5	0.8
225.0	0.7
247.5	-0.1
270.0	-0.8
292.5	-1.3
315.0	-1.4
337.5	-1.4

Table 18. Maximum flow inclination for each sector

6.6.2. DIRECTION GRADIENT

The direction gradient was measured as the difference in wind direction between the bottom and top tip height of the turbine. The maximum value of direction gradient for each wind direction sector is provided below:

Direction Gradient	
Direction (°)	Direction Gradient (°)
0.0	0.6
22.5	1.5
45.0	2.6
67.5	1.5
90.0	0.2
112.5	0.5
135.0	0.9
157.5	0.9
180.0	0.1
202.5	0.1
225.0	0.2
247.5	1.1
270.0	1.6
292.5	0.1
315.0	2.4
337.5	2.2

Table 19. Maximum direction gradient for each sector

7. LOSSES

An estimation of the losses at the site are provided in this section. These losses are for guidance purposes and real losses may differ.

A brief description of how each loss was calculated is provided below. For further information on how these losses were calculated please contact Digital Engineering.

Turbulence loss factor

The turbulence loss factor is calculated based on the second derivative of the power curve combined with turbulence for each direction sector and wind speed bin [4].

Shear loss factor

The shear loss factor is calculated based on a combination of the average wind speed for the site and the wind shear exponent over the turbine swept area [4].

Electrical loss factor

The electrical loss factor is fixed and an industry standard value. This may differ based on turbine model.

Availability loss factor

The availability factor used is based on an industry standard value, the actual availability may be higher or lower than this value. Availability is dependent on a large range of conditions and will vary on a site by site basis.

Wake loss factor

Any wake effects or losses have not been modelled in this report. If a wake loss analysis is required for the site, please contact Digital Engineering.

Site losses:

Turbulence loss factor	1.00
Shear loss factor	0.98
Electrical loss factor	0.97
Availability factor	0.95
Wake loss factor	1.00

Table 20. Estimates for the availability and technical losses for the turbine

The above site specific losses were applied to the average annual energy yield values outlined in Section 6.5.2. The energy yield results **including losses** are provided below.

Energy yield (P_{50}) with losses and availability	1409 MWh
Energy yield (P_{90}) with losses and availability	1094 MWh

Table 21. Average annual energy yield including estimates of the site losses

8. REFERENCES

[1] “Wind-Validation-Summary-DE.pdf”, Digital Engineering Ltd, Mar 2013

[2] Matthew Dowley, Matthew.Dowley@earthmill.co.uk, RE: ACTION REQUIRED: Building and Vegetation Heights - Freightliner Road, 4th Nov 2016

[3] “Wind turbines – Part 1: Design Requirements”, IEC 61400-1, Jan 2005

[4] “Simulation of shear and turbulence impact on wind turbine performance”, Rozenn W., Michael C. S., Torben L. J., Risø DTU, Jan 2010

9. APPENDIX

9.1. WIND FREQUENCY TABLE

The wind frequency table for the turbine location at **40.0 m** hub height is provided below:

	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.5	0.14	0.12	0.08	0.10	0.07	0.08	0.15	0.08	0.03	0.01	0.01	0.04	0.06	0.17	0.13	0.13
1.5	0.44	0.43	0.34	0.37	0.31	0.28	0.39	0.27	0.18	0.11	0.11	0.23	0.39	0.68	0.46	0.41
2.5	0.67	0.71	0.64	0.61	0.55	0.47	0.56	0.45	0.42	0.31	0.32	0.59	0.94	1.18	0.75	0.63
3.5	0.77	0.85	0.83	0.73	0.71	0.59	0.62	0.59	0.70	0.61	0.65	1.05	1.55	1.44	0.88	0.72
4.5	0.73	0.80	0.82	0.69	0.71	0.62	0.60	0.66	0.93	0.95	1.05	1.50	1.96	1.36	0.82	0.69
5.5	0.59	0.63	0.64	0.53	0.59	0.57	0.51	0.66	1.07	1.27	1.44	1.80	1.98	1.02	0.63	0.57
6.5	0.42	0.41	0.40	0.33	0.41	0.46	0.40	0.59	1.07	1.49	1.73	1.87	1.61	0.63	0.41	0.41
7.5	0.27	0.23	0.20	0.17	0.23	0.33	0.29	0.49	0.93	1.54	1.83	1.67	1.05	0.31	0.22	0.26
8.5	0.15	0.11	0.08	0.07	0.11	0.21	0.19	0.37	0.71	1.41	1.70	1.30	0.54	0.12	0.10	0.14
9.5	0.07	0.04	0.02	0.03	0.04	0.12	0.11	0.26	0.48	1.12	1.38	0.86	0.22	0.04	0.04	0.07
10.5	0.03	0.01	0.01	0.01	0.01	0.06	0.06	0.16	0.28	0.78	0.98	0.49	0.07	0.01	0.01	0.03
11.5	0.01	0.00	0.00	0.00	0.00	0.03	0.03	0.10	0.14	0.47	0.59	0.23	0.02	0.00	0.00	0.01
12.5	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.06	0.24	0.30	0.09	0.00	0.00	0.00	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.10	0.13	0.03	0.00	0.00	0.00	0.00
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.05	0.01	0.00	0.00	0.00	0.00
15.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
16.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

9.2. AVERAGE TURBULENCE INTENSITY TABLE

The average turbulence intensity table for the turbine location at **40.0 m** hub height is provided below:

	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
0.5	138.9	142.8	144.4	145.1	136.1	128.3	130.9	126.9	129.4	126.0	127.2	130.9	141.2	143.5	144.4	141.4
1.5	58.9	62.8	64.4	65.1	56.1	48.3	50.9	46.9	49.4	46.0	47.2	50.9	61.2	63.6	64.4	61.4
2.5	42.9	46.8	48.4	49.1	40.1	32.3	34.9	30.9	33.4	30.0	31.2	34.9	45.2	47.6	48.4	45.5
3.5	36.1	40.0	41.5	42.2	33.2	25.4	28.0	24.0	26.6	23.2	24.4	28.0	38.4	40.7	41.5	38.6
4.5	32.3	36.2	37.7	38.4	29.4	21.6	24.2	20.2	22.7	19.4	20.6	24.2	34.6	36.9	37.7	34.8
5.5	29.8	33.7	35.3	36.0	27.0	19.2	21.8	17.8	20.3	16.9	18.1	21.8	32.2	34.5	35.3	32.4
6.5	28.3	32.2	33.7	34.5	25.7	17.9	20.2	16.4	18.9	15.7	16.9	20.4	30.6	32.9	33.7	30.8
7.5	27.1	31.0	32.5	33.2	24.4	16.7	19.0	15.2	17.7	14.5	15.7	19.2	29.4	31.7	32.5	29.6
8.5	26.1	30.0	31.6	32.3	23.5	15.7	18.1	14.3	16.8	13.5	14.8	18.2	28.4	30.7	31.6	28.6
9.5	25.4	29.3	30.8	31.6	22.7	15.0	17.3	13.5	16.0	12.8	14.0	17.5	27.7	30.0	30.8	27.9
10.5	24.8	28.7	30.2	31.0	22.1	14.4	16.7	12.9	15.4	12.2	13.4	16.9	27.1	29.4	30.2	27.3
11.5	24.3	28.2	29.7	30.5	21.6	13.9	16.2	12.4	14.9	11.7	12.9	16.4	26.6	28.9	29.7	26.8
12.5	23.9	27.8	29.3	30.0	21.2	13.5	15.8	12.0	14.5	11.3	12.5	16.0	26.2	28.5	29.3	26.4
13.5	23.5	27.4	29.0	29.7	20.9	13.1	15.5	11.7	14.1	10.9	12.2	15.6	25.8	28.1	28.9	26.0
14.5	23.3	27.1	28.7	29.4	20.6	12.9	15.2	11.5	13.9	10.8	12.0	15.4	25.6	27.8	28.7	25.8
15.5	23.0	26.9	28.4	29.2	20.4	12.6	14.9	11.2	13.7	10.5	11.8	15.1	25.3	27.6	28.4	25.5
16.5	22.8	26.6	28.2	28.9	20.1	12.4	14.7	11.0	13.4	10.3	11.5	14.9	25.1	27.3	28.2	25.3
17.5	22.6	26.4	28.0	28.7	19.9	12.2	14.5	10.8	13.2	10.1	11.3	14.7	24.9	27.1	28.0	25.1
18.5	22.4	26.3	27.8	28.5	19.7	12.0	14.3	10.6	13.0	9.9	11.1	14.5	24.7	27.0	27.8	24.9
19.5	22.2	26.1	27.6	28.4	19.6	11.8	14.1	10.4	12.9	9.7	11.0	14.3	24.5	26.8	27.6	24.7
20.5	22.1	25.9	27.5	28.2	19.4	11.7	14.0	10.3	12.7	9.6	10.8	14.2	24.4	26.6	27.5	24.6
21.5	21.9	25.8	27.4	28.1	19.3	11.6	13.8	10.1	12.6	9.4	10.7	14.0	24.2	26.5	27.3	24.4
22.5	21.8	25.7	27.2	28.0	19.2	11.4	13.7	10.0	12.5	9.3	10.6	13.9	24.1	26.4	27.2	24.3
23.5	21.7	25.6	27.1	27.9	19.0	11.3	13.6	9.9	12.4	9.2	10.4	13.8	24.0	26.3	27.1	24.2
24.5	21.6	25.5	27.0	27.8	18.9	11.2	13.5	9.8	12.3	9.1	10.3	13.7	23.9	26.2	27.0	24.1
25.5	21.5	25.4	26.9	27.7	18.8	11.1	13.4	9.7	12.2	9.0	10.2	13.6	23.8	26.1	26.9	24.0
26.5	21.4	25.3	26.8	27.6	18.8	11.0	13.3	9.6	12.1	8.9	10.2	13.5	23.7	26.0	26.8	23.9
27.5	21.3	25.2	26.7	27.5	18.7	10.9	13.2	9.5	12.0	8.8	10.1	13.4	23.6	25.9	26.7	23.8
28.5	21.3	25.1	26.7	27.4	18.6	10.9	13.2	9.5	11.9	8.7	10.0	13.4	23.5	25.8	26.7	23.7
29.5	21.2	25.0	26.6	27.3	18.5	10.8	13.1	9.4	11.8	8.7	9.9	13.3	23.5	25.7	26.6	23.7
30.5	21.1	25.0	26.5	27.3	18.5	10.7	13.0	9.3	11.8	8.6	9.9	13.2	23.4	25.7	26.5	23.6
31.5	21.1	24.9	26.5	27.2	18.4	10.7	13.0	9.2	11.7	8.5	9.8	13.2	23.3	25.6	26.5	23.5
32.5	21.0	24.9	26.4	27.2	18.3	10.6	12.9	9.2	11.6	8.5	9.7	13.1	23.3	25.6	26.4	23.5
33.5	20.9	24.8	26.4	27.1	18.3	10.6	12.8	9.1	11.6	8.4	9.7	13.1	23.2	25.5	26.3	23.4
34.5	20.9	24.7	26.3	27.0	18.2	10.5	12.8	9.1	11.5	8.4	9.6	13.0	23.2	25.5	26.3	23.4
35.5	20.8	24.7	26.3	27.0	18.2	10.5	12.7	9.0	11.5	8.3	9.6	12.9	23.1	25.4	26.2	23.3

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