Technical Appendix 1.6: Telecommunications Assessment

Telecommunications Impact Assessment

M74 West Renewable Energy Park

Ramboll UK Limited

July 2024

ADMINISTRATION PAGE

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EXECUTIVE SUMMARY

Report Overview

Pager Power has been commissioned to investigate the potential impact of a wind development, located near Abington, South Lanarkshire, Scotland, upon three wireless microwave point to point links, operated by Vodafone.

The wind development consists of 22 wind turbine locations with a maximum tip height of 200 metres above ground level (agl), hub height of 122.5 metres agl, and a rotor diameter of 155 metres. Wind turbine coordinates and elevations can be found in Appendix A.

Overall Conclusions

The most relevant results presented below are for the exclusion zones infringements based on Ofcom recommended methodology[1] with an additional 25m buffer applied[2].

Overall, the desk-based analysis indicates that mitigation is required for turbine locations 5 and 14. Turbines 5 and 14 infringe the exclusion zone in 2D by margins of 108m and 96.08m, respectively. Turbine locations 5 and 14 infringe the exclusion zones in 3D by margins of 32.43m and 80.92m, respectively. If the 25m buffer were not applied to the 3D exclusion zone, turbines 5 and 14 would still infringe by margins of 7.43m and 55.92m, respectively.

An overview of possible mitigation strategies has been provided for reference (see Section 4). It is important to coordinate any technical mitigation solutions with the relevant link operator. The potential solutions are:

- Micrositing / Layout Optimisation;
- Re-networking of the link via existing telecommunications sites;
- Use of a leased line.

If the locations or dimensions of the turbines are altered, it is recommended that the identified telecommunication link exclusion zones are accounted for when maintaining existing clearances.

[1] 2nd Fresnel zone for Microwave links.
[2] It is Pager Power's methodology to include a 25m buffer in the first instance due to the limitations of desk-based analysis e.g. potential coordinate inaccuracies.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 59 countries within Europe, Africa, America, Asia and Australasia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems. Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable, and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 BACKGROUND

1.1 Introduction

Pager Power has been commissioned to investigate the potential impact of a wind development, located near Abington, South Lanarkshire, Scotland, upon three wireless microwave point to point links, operated by Vodafone.

The wind development consists of 22 wind turbine locations with a maximum tip height of 200 metres above ground level (agl), hub height of 122.5 metres agl, and a rotor diameter of 155 metres.In detail, this report contains:

- Site description.
- Technical analysis including:
    - Exclusion zone calculations (Ofcom - recommended methodology).
    - Reflection calculations.
- High-level overview of common mitigation options.

2 WIND DEVELOPMENT DETAILS

2.1 Development Layout

Figure 1 below shows the layout of the wind development consisting of 22 wind turbine locations. Further details are shown in Appendix A.

Figure 1 *Wind development turbine layout*

3 TECHNICAL ASSESSMENT

3.1 Methodology

Microwave and UHF[3] wireless communication links are used to transmit information between two antennae via radio waves within a particular frequency band.

The exclusion zones associated with the identified link has been calculated based on the telecommunications data provided. Further 2-dimensional clearance calculations have then been undertaken to determine the extent of any clearance or infringement of the proposed development. The following subsections present an overview of the interference mechanisms and methodology.

3.1.1 Fresnel Zones

A Fresnel Zone takes the form of an ellipsoid surrounding a link path and represents the area in which obstructions should not be sited in order to avoid diffraction losses. The width of the zone at any point along the link path is determined by the Fresnel Zone number, the frequency of the link and the distance from each link end. The width of the zone is maximal at the midpoint of the link path.

3.1.2 Diffraction – Microwave and UHF Links

Obstructions such as wind developments which are sited in between two microwave link antennae can partially block the radio signal passing between them, thereby reducing the functionality of the link. This can occur even if the obstruction is not directly between the antennae but close to the link boresight[4]. This kind of blocking is called 'diffraction'.

There are various approaches to safeguarding microwave links against from obstruction via wind developments. The most common approaches are:

1. Implementation of a fixed stand-off distance around the link boresight.
2. Safeguarding the relevant Fresnel Zone (discussed below).

The first approach is used by many operators who request a set buffer distance. Set stand offs are occasionally conservative and produce a large exclusion zone distance. The second approach is to assess an obstruction on a case-by-case basis to calculate the most accurate exclusion zone. Pager Power considers the Second Fresnel zone when assessing the effect of a wind turbine upon microwave links and the 60% of the First Fresnel zone when assessing UHF links[1].

[3] Ultra-High Frequency
[4] This is the straight line between the two antennae.

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3.1.3 Reflections – UHF Links

Reflection effects occur when the transmitted signal from one link end is reflected by wind turbine or obstruction towards the other link end, causing interference. These reflected (unwanted) signals can interact with the direct (wanted) signal, thereby impairing the link's performance. Reflection issues need to be accounted for when assessing the potential impact of a wind development on telemetry links. UHF links can be affected by obstructions that reflect the signal between the transmitter and receiver. Reflection effects for microwave links are not a significant concern because they are highly directional.

3.2 Identified Telecommunication Links

Table 1 below presents the details of the relevant communications links.

Operator	Type	Link ID / Ref	Frequency	Mast A	Mast B
Vodafone	Microwave	0496701/1 / 'Vodafone Link 1'	18 GHz	292260E 623760N 60m agl	284070E 640870N 50m agl
		1332702/1 / 'Vodafone Link 2'	23 GHz	292276E 623789N 12m agl	286947E 629964N 19m agl
		1334216/1 / 'Vodafone Link 3'	18 GHz	289181E 626910N 11m agl	300392E 625963N 21m agl

Table 1 *Relevant telecommunications links - Vodafone*

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3.3 Exclusion Zone – Ofcom-Recommended Methodology

3.3.1 2D Exclusion Zone Chart Overview

The exclusion zone for each communications link is defined by the Fresnel zone radius [B], rotor radius [A/2], and additional 25-metre buffer zone [E]. This is shown in Figure 2 below. A 250-metre exclusion zone is applied to microwave link masts and a 500-metre exclusion zone is applied to UHF link masts.

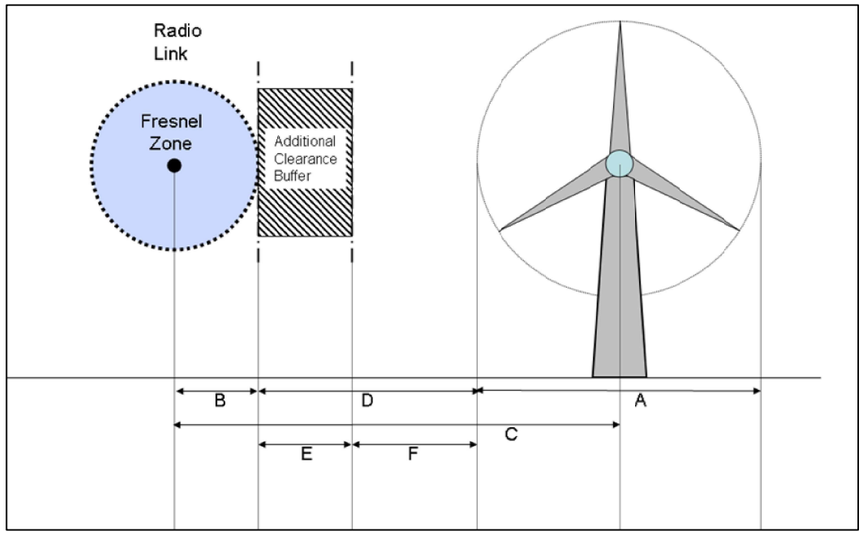

Figure 2 *Exclusion zone calculation*

3.3.2 3D Exclusion Zone Chart Overview

The 3D exclusion zone is determined by taking into account the height of the turbine hub [H + ground height] relative to the link boresight altitude [G + ground height] in addition to the calculations used to define the 2D exclusion zone for a communications link. This is shown in Figure 3 on the following page.

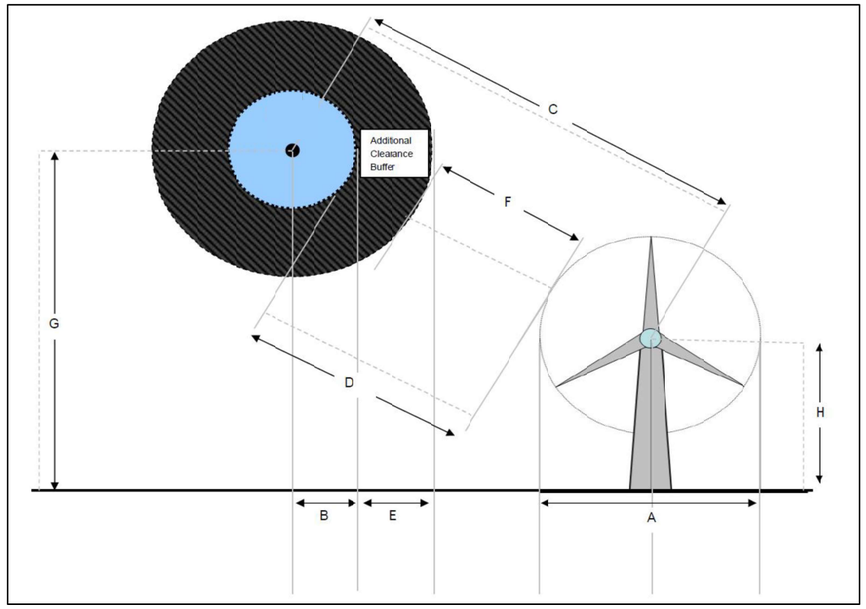

Figure 3 *3D exclusion zone calculation*

3.3.3 Exclusion Zone Charts

Figures 4 to 6 on the following pages show the identified link path exclusion zones associated with the identified Vodafone links. The exclusion zone is shown by two lines, marking the edges of the Fresnel zones. An additional 25 metre buffer is applied to allow for uncertainties in the coordinate data. The exclusion zones also include the maximum rotor radius. Any turbines located between the lines would infringe the zone in two dimensions.

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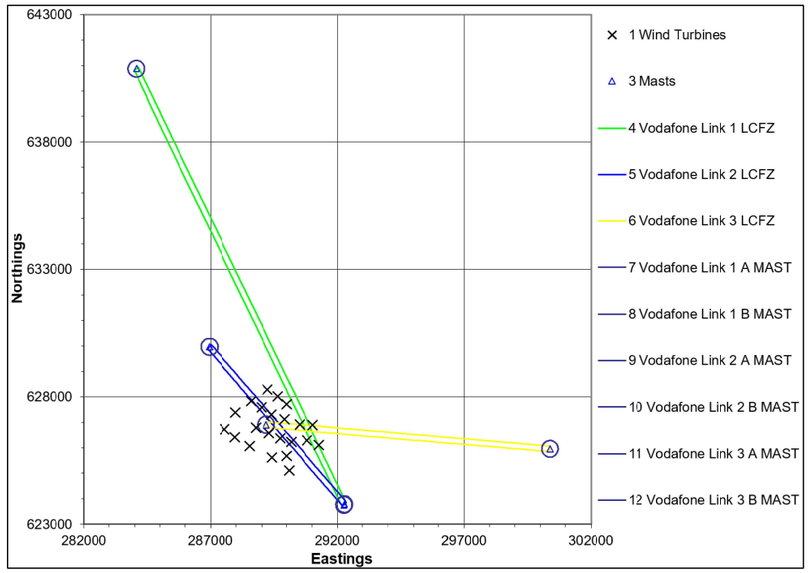

Figure 4 *Telecommunications link exclusion zone chart*

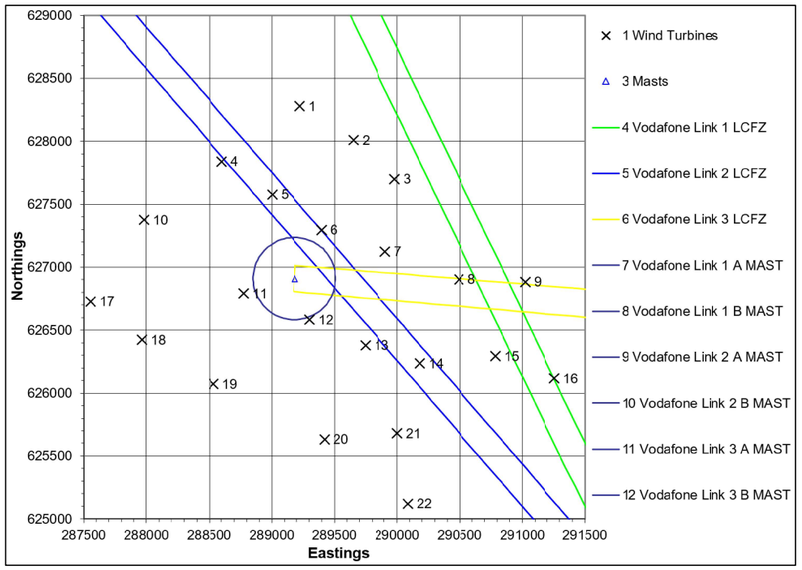

Figure 5 *Telecommunications link exclusion zone chart (zoomed in)*

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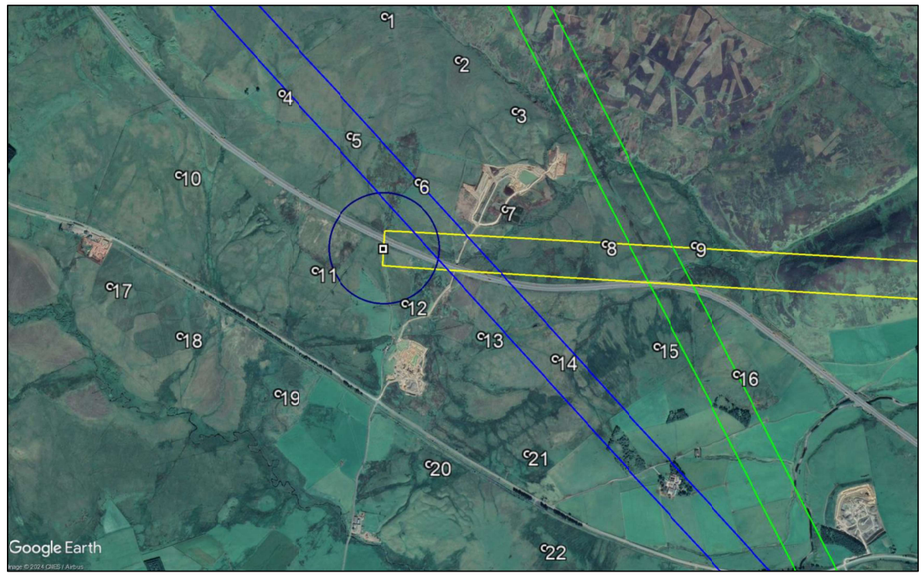

Figure 6 *Telecommunications link exclusion zones (zoomed in) – aerial image*

3.3.4 Exclusion Zone Results – Ofcom-Recommended Methodology

The results of the exclusion zone calculations in 2D and 3D are shown within Table 2 below and on the following pages.

Turbine	Link ID/Reference	2D Clearance/Infringement Distance	2D Clearance/Infringement Considering 25m Buffer	3D Clearance/Infringement Distance	3D Clearance/Infringement Considering 25m Buffer
1	Vodafone Link 1	**Clear** by 696.71m	**Clear** by 671.71m	**Clear** by 696.79m	**Clear** by 671.79m
	Vodafone Link 2	**Clear** by 540.06m	**Clear** by 515.06m	**Clear** by 544.64m	**Clear** by 519.64m
	Vodafone Link 3	**Clear** by 1292.24m	**Clear** by 1267.24m	**Clear** by 1298.65m	**Clear** by 1273.65m
2	Vodafone Link 1	**Clear** by 427.99m	**Clear** by 402.99m	**Clear** by 428.03m	**Clear** by 403.03m
	Vodafone Link 2	**Clear** by 687.34m	**Clear** by 662.34m	**Clear** by 689.37m	**Clear** by 664.37m
	Vodafone Link 3	**Clear** by 1054.84m	**Clear** by 1029.84m	**Clear** by 1060.07m	**Clear** by 1035.07m
3	Vodafone Link 1	**Clear** by 264.5m	**Clear** by 239.5m	**Clear** by 265.21m	**Clear** by 240.21m
	Vodafone Link 2	**Clear** by 734.52m	**Clear** by 709.52m	**Clear** by 735.41m	**Clear** by 710.41m
	Vodafone Link 3	**Clear** by 772.42m	**Clear** by 747.42m	**Clear** by 776.94m	**Clear** by 751.94m
4	Vodafone Link 1	**Clear** by 1449.18m	**Clear** by 1424.18m	**Clear** by 1449.57m	**Clear** by 1424.57m
	Vodafone Link 2	**Clear** by 50.4m	**Clear** by 25.4m	**Clear** by 84.25m	**Clear** by 59.25m
	Vodafone Link 3	**Clear** by 1018.01m	**Clear** by 993.01m	**Clear** by 1029.27m	**Clear** by 1004.27m
5	Vodafone Link 1	**Clear** by 1199.98m	**Clear** by 1174.98m	**Clear** by 1200.05m	**Clear** by 1175.05m

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Turbine	Link ID/Reference	2D Clearance/Infringement Distance	2D Clearance/Infringement Considering 25m Buffer	3D Clearance/Infringement Distance	3D Clearance/Infringement Considering 25m Buffer
5	Vodafone Link 2	**Infringes** by 83m	**Infringes** by 108m	**Infringes** by 7.43m	**Infringes** by 32.43m
	Vodafone Link 3	**Clear** by 613.55m	**Clear** by 588.55m	**Clear** by 627.28m	**Clear** by 602.28m
6	Vodafone Link 1	**Clear** by 966.69m	**Clear** by 941.69m	**Clear** by 966.69m	**Clear** by 941.69m
	Vodafone Link 2	**Clear** by 27.7m	**Clear** by 2.7m	**Clear** by 42.01m	**Clear** by 17.01m
	Vodafone Link 3	**Clear** by 322.94m	**Clear** by 297.94m	**Clear** by 340.6m	**Clear** by 315.6m
7	Vodafone Link 1	**Clear** by 582.16m	**Clear** by 557.16m	**Clear** by 583.55m	**Clear** by 558.55m
	Vodafone Link 2	**Clear** by 300.62m	**Clear** by 275.62m	**Clear** by 301m	**Clear** by 276m
	Vodafone Link 3	**Clear** by 192.16m	**Clear** by 167.16m	**Clear** by 201.37m	**Clear** by 176.37m
8	Vodafone Link 1	**Clear** by 146.32m	**Clear** by 121.32m	**Clear** by 150.8m	**Clear** by 125.8m
	Vodafone Link 2	**Clear** by 602.87m	**Clear** by 577.87m	**Clear** by 602.96m	**Clear** by 577.96m
	Vodafone Link 3	**Clear** by 20.99m	**Infringes** by 4.01m	**Clear** by 35.85m	**Clear** by 10.85m
9	Vodafone Link 1	**Clear** by 146.42m	**Clear** by 121.42m	**Clear** by 156.2m	**Clear** by 131.2m
	Vodafone Link 2	**Clear** by 988.99m	**Clear** by 963.99m	**Clear** by 989.07m	**Clear** by 964.07m
	Vodafone Link 3	**Clear** by 43.56m	**Clear** by 18.56m	**Clear** by 45.88m	**Clear** by 20.88m
10	Vodafone Link 1	**Clear** by 2210.18m	**Clear** by 2185.18m	**Clear** by 2210.26m	**Clear** by 2185.26m

Turbine	Link ID/Reference	2D Clearance/Infringement Distance	2D Clearance/Infringement Considering 25m Buffer	3D Clearance/Infringement Distance	3D Clearance/Infringement Considering 25m Buffer
10	Vodafone Link 2	**Clear** by 824.38m	**Clear** by 799.38m	**Clear** by 825.73m	**Clear** by 800.73m
	Vodafone Link 3	**Clear** by 1209.44m	**Clear** by 1184.44m	**Clear** by 1213.72m	**Clear** by 1188.72m
11	Vodafone Link 1	**Clear** by 1745.92m	**Clear** by 1720.92m	**Clear** by 1746.11m	**Clear** by 1721.11m
	Vodafone Link 2	**Clear** by 603.65m	**Clear** by 578.65m	**Clear** by 604.68m	**Clear** by 579.68m
	Vodafone Link 3	**Clear** by 344.62m	**Clear** by 319.62m	**Clear** by 357.23m	**Clear** by 332.23m
12	Vodafone Link 1	**Clear** by 1360.76m	**Clear** by 1335.76m	**Clear** by 1361.27m	**Clear** by 1336.27m
	Vodafone Link 2	**Clear** by 340.52m	**Clear** by 315.52m	**Clear** by 341.16m	**Clear** by 316.16m
	Vodafone Link 3	**Clear** by 235.86m	**Clear** by 210.86m	**Clear** by 248.88m	**Clear** by 223.88m
13	Vodafone Link 1	**Clear** by 1048.31m	**Clear** by 1023.31m	**Clear** by 1048.82m	**Clear** by 1023.82m
	Vodafone Link 2	**Clear** by 137.06m	**Clear** by 112.06m	**Clear** by 138.56m	**Clear** by 113.56m
	Vodafone Link 3	**Clear** by 398.6m	**Clear** by 373.6m	**Clear** by 406.6m	**Clear** by 381.6m
14	Vodafone Link 1	**Clear** by 718.02m	**Clear** by 693.02m	**Clear** by 718.67m	**Clear** by 693.67m
	Vodafone Link 2	**Infringes** by 71.08m	**Infringes** by 96.08m	**Infringes** by 55.92m	**Infringes** by 80.92m
	Vodafone Link 3	**Clear** by 505.12m	**Clear** by 480.12m	**Clear** by 510.7m	**Clear** by 485.7m

Turbine	Link ID/Reference	2D Clearance/Infringement Distance	2D Clearance/Infringement Considering 25m Buffer	3D Clearance/Infringement Distance	3D Clearance/Infringement Considering 25m Buffer
15	Vodafone Link 1	**Clear** by 148.86m	**Clear** by 123.86m	**Clear** by 149.98m	**Clear** by 124.98m
	Vodafone Link 2	**Clear** by 423.59m	**Clear** by 398.59m	**Clear** by 424.62m	**Clear** by 399.62m
	Vodafone Link 3	**Clear** by 396.28m	**Clear** by 371.28m	**Clear** by 402.52m	**Clear** by 377.52m
16	Vodafone Link 1	**Clear** by 25.96m	**Clear** by 0.96m	**Clear** by 38.71m	**Clear** by 13.71m
	Vodafone Link 2	**Clear** by 664.61m	**Clear** by 639.61m	**Clear** by 664.61m	**Clear** by 639.61m
	Vodafone Link 3	**Clear** by 530.44m	**Clear** by 505.44m	**Clear** by 531.55m	**Clear** by 506.55m
17	Vodafone Link 1	**Clear** by 2872.26m	**Clear** by 2847.26m	**Clear** by 2872.67m	**Clear** by 2847.67m
	Vodafone Link 2	**Clear** by 1567.96m	**Clear** by 1542.96m	**Clear** by 1568.07m	**Clear** by 1543.07m
	Vodafone Link 3	**Clear** by 1556.67m	**Clear** by 1531.67m	**Clear** by 1558.51m	**Clear** by 1533.51m
18	Vodafone Link 1	**Clear** by 2635.87m	**Clear** by 2610.87m	**Clear** by 2636.47m	**Clear** by 2611.47m
	Vodafone Link 2	**Clear** by 1457.47m	**Clear** by 1432.47m	**Clear** by 1457.5m	**Clear** by 1432.5m
	Vodafone Link 3	**Clear** by 1232.02m	**Clear** by 1207.02m	**Clear** by 1234.07m	**Clear** by 1209.07m
19	Vodafone Link 1	**Clear** by 2274.68m	**Clear** by 2249.68m	**Clear** by 2275.53m	**Clear** by 2250.53m
	Vodafone Link 2	**Clear** by 1256.46m	**Clear** by 1231.46m	**Clear** by 1256.46m	**Clear** by 1231.46m
	Vodafone Link 3	**Clear** by 981.38m	**Clear** by 956.38m	**Clear** by 983.8m	**Clear** by 958.8m

Turbine	Link ID/Reference	2D Clearance/Infringement Distance	2D Clearance/Infringement Considering 25m Buffer	3D Clearance/Infringement Distance	3D Clearance/Infringement Considering 25m Buffer
20	Vodafone Link 1	**Clear** by 1665.95m	**Clear** by 1640.95m	**Clear** by 1666.67m	**Clear** by 1641.67m
	Vodafone Link 2	**Clear** by 872.66m	**Clear** by 847.66m	**Clear** by 872.71m	**Clear** by 847.71m
	Vodafone Link 3	**Clear** by 1172.42m	**Clear** by 1147.42m	**Clear** by 1175.1m	**Clear** by 1150.1m
21	Vodafone Link 1	**Clear** by 1122.3m	**Clear** by 1097.3m	**Clear** by 1123.02m	**Clear** by 1098.02m
	Vodafone Link 2	**Clear** by 402.91m	**Clear** by 377.91m	**Clear** by 403.18m	**Clear** by 378.18m
	Vodafone Link 3	**Clear** by 1075.71m	**Clear** by 1050.71m	**Clear** by 1078.39m	**Clear** by 1053.39m
22	Vodafone Link 1	**Clear** by 1285.11m	**Clear** by 1260.11m	**Clear** by 1285.58m	**Clear** by 1260.58m
	Vodafone Link 2	**Clear** by 701.27m	**Clear** by 676.27m	**Clear** by 701.54m	**Clear** by 676.54m
	Vodafone Link 3	**Clear** by 1623.08m	**Clear** by 1598.08m	**Clear** by 1625.22m	**Clear** by 1600.22m

Table 2 *Results summary - Ofcom-Recommended Methodology*

3.3.5 3D Exclusion Zone Charts – Ofcom-Recommended Methodology

Relevant 3D exclusion charts are shown in Figures 7 to 12 below and on the following pages. The y-axis begins at the terrain height of the turbine. Figure 7 below shows the 3D exclusion chart for turbine 16 and Vodafone Link 1.

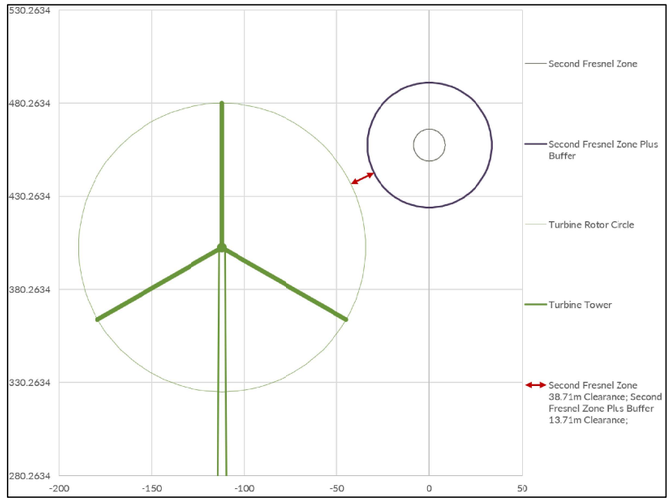

Figure 7 *3D chart for turbine 16 - Vodafone Link 1*

Figure 8 to 10 below and on the following pages show the 3D exclusion charts for turbines 5, 6, and 14 and Vodafone Link 2.

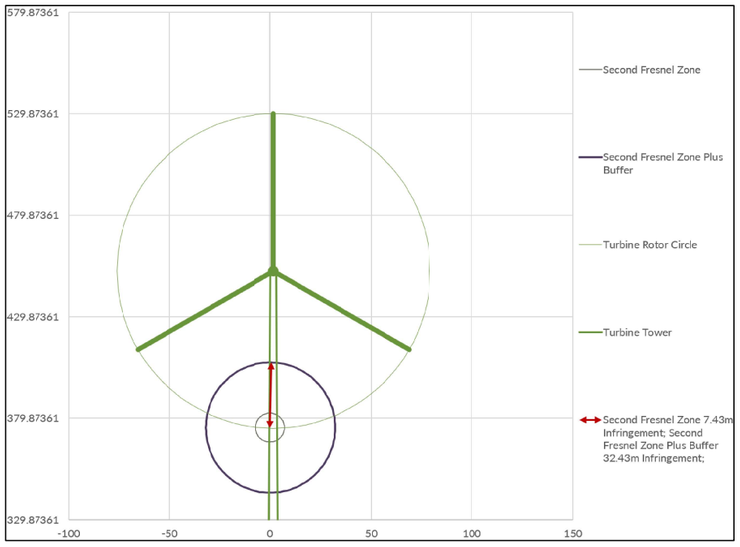

Figure 8 *3D chart for turbine 5 - Vodafone Link 2*

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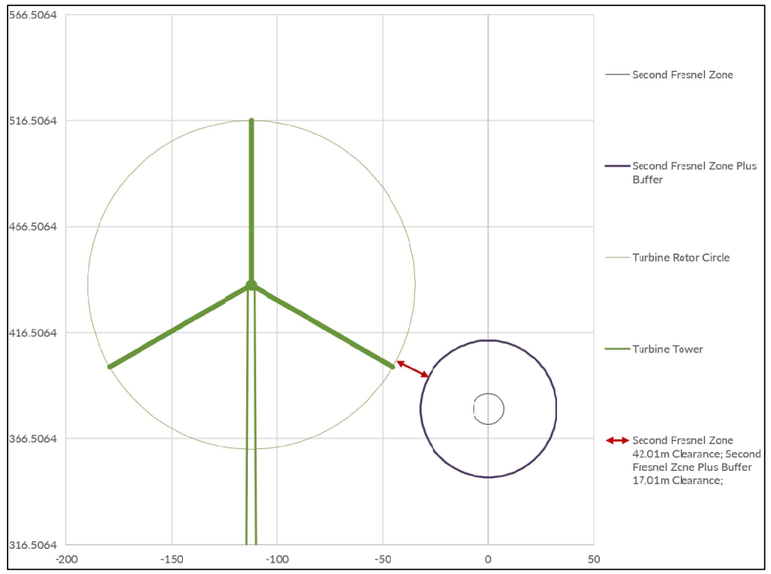

Figure 9 *3D chart for turbine 6 - Vodafone Link 2*

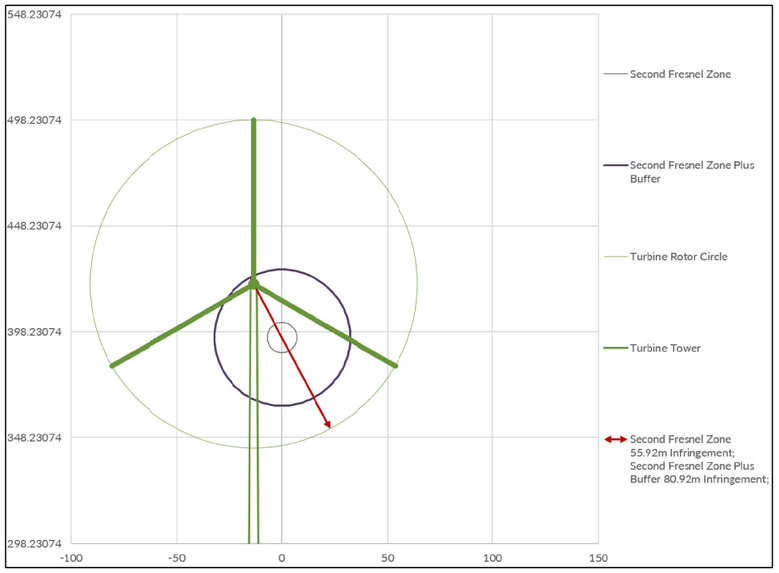

Figure 10 *3D chart for turbine 14 - Vodafone Link 2*

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Figure 11 and 12 below and on the following page show the 3D exclusion chart for turbines 8 and 9 and Vodafone Link 3.

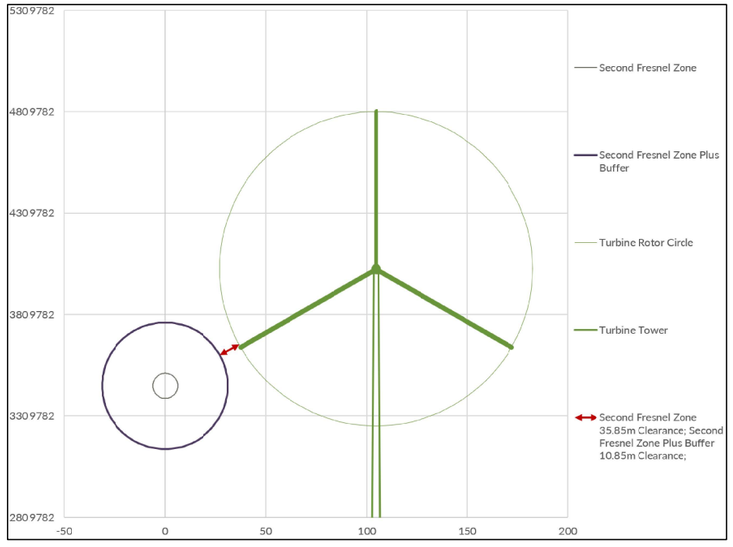

Figure 11 *3D chart for turbine 8 - Vodafone Link 3*

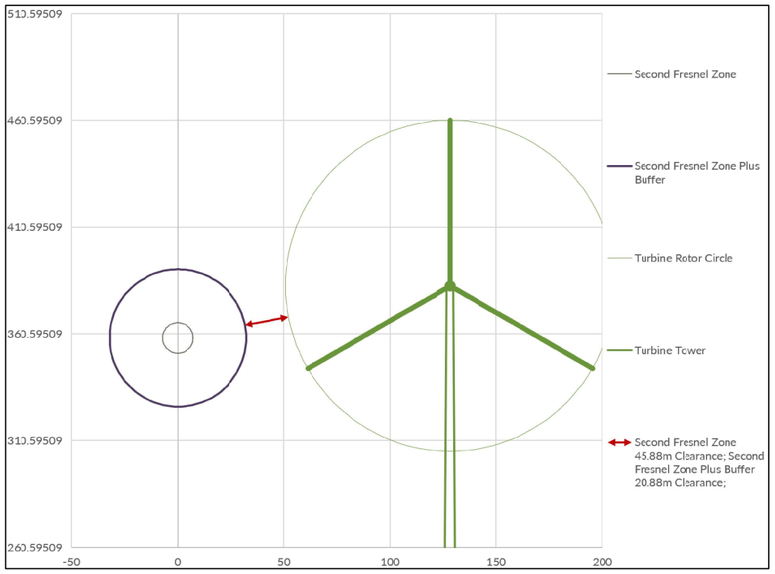

Figure 12 *3D chart for turbine 9 - Vodafone Link 3*

3.3.5.1 250-metre exclusion zone for Mast A of Vodafone Link 3

A 250-metre exclusion zone is applied to microwave link mast ends. Figures 5 and 6 in Section 3.3.3 show the 250-metre exclusion zone for Mast A of Vodafone Link 3 as indicated by the blue circle. The clearance values for turbines 6, 11, and 12 (the closest turbines) with respect to the mast exclusion zone are shown in Table 3 below. The turbines are clear of this zone and the other exclusion zones associated with the other mast link ends.

Turbine	Mast A Vodafone Link 3 Link End Exclusion Zone Results
6	Clear by 115.31m
11	Clear by 94.62m
12	Clear by 21.52m

Table 3 *Results summary – Mast end exclusion zones - Vodafone Link 3 – Turbines 6, 11, & 12*

3.4 Exclusion Zone Chart – Vodafone 100m Exclusion Zone

Vodafone initially request a 100-metre clearance to the centre of the link from the blade tip[5]. Where there are infringements, Vodafone advise that Fresnel Zone calculations, adhering to the recommended Ofcom methodology are progressed. The results of the Fresnel Zone calculations have been presented in Section 3.3.5. This section of the report presents the 100-metre Vodafone 100m Exclusion Zone for completeness.

3.4.1 Exclusion Zone Charts – Vodafone 100m Exclusion Zone

The 100m exclusion zones are shown in Figure 13 on the following page.

[5] *Vodafone require 100m clearance from the tip of any turbine blade to fixed link radio path. ** In the event of any conflict, we advise performing Fresnel Zone calculations, adhering to the recommended Ofcom methodology. This may indicate that reduced clearance margins at location point are possible.*

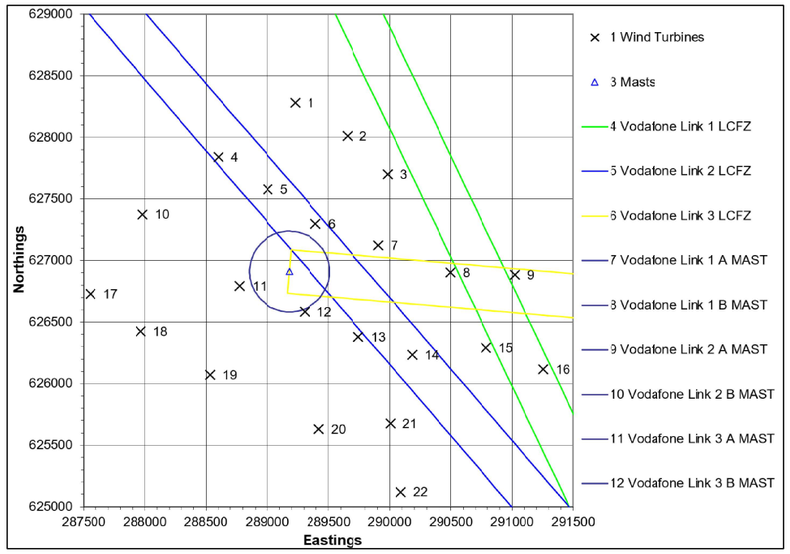

Figure 13 *Telecommunications link exclusion zone chart (zoomed in)*

3.4.2 Exclusion Zone Results – Vodafone 100m Exclusion Zone

The results of the 100m exclusion zone calculations in 2D and 3D are shown within Table 3 below and on the following pages.

Turbine	Link ID/Reference	2D Clearance/Infringement Distance	2D Clearance/Infringement Considering 25m Buffer	3D Clearance/Infringement Distance	3D Clearance/Infringement Considering 25m Buffer
1	Vodafone Link 1	**Clear** by 708.05m	**Clear** by 608.05m	**Clear** by 708.12m	**Clear** by 608.12m
	Vodafone Link 2	**Clear** by 546.96m	**Clear** by 446.96m	**Clear** by 551.54m	**Clear** by 451.54m
	Vodafone Link 3	**Clear** by 1292.24m	**Clear** by 1192.24m	**Clear** by 1298.65m	**Clear** by 1198.65m
2	Vodafone Link 1	**Clear** by 439.04m	**Clear** by 339.04m	**Clear** by 439.08m	**Clear** by 339.08m
	Vodafone Link 2	**Clear** by 694.48m	**Clear** by 594.48m	**Clear** by 696.51m	**Clear** by 596.51m
	Vodafone Link 3	**Clear** by 1058.33m	**Clear** by 958.33m	**Clear** by 1063.56m	**Clear** by 963.56m
3	Vodafone Link 1	**Clear** by 275.22m	**Clear** by 175.22m	**Clear** by 275.93m	**Clear** by 175.93m
	Vodafone Link 2	**Clear** by 741.78m	**Clear** by 641.78m	**Clear** by 742.67m	**Clear** by 642.67m
	Vodafone Link 3	**Clear** by 777.2m	**Clear** by 677.2m	**Clear** by 781.72m	**Clear** by 681.72m
4	Vodafone Link 1	**Clear** by 1460.43m	**Clear** by 1360.43m	**Clear** by 1460.83m	**Clear** by 1360.83m
	Vodafone Link 2	**Clear** by 57.26m	**Infringes** by 42.74m	**Clear** by 91.1m	**Infringes** by 8.9m
	Vodafone Link 3	**Clear** by 1018.01m	**Clear** by 918.01m	**Clear** by 1029.27m	**Clear** by 929.27m
5	Vodafone Link 1	**Clear** by 1210.95m	**Clear** by 1110.95m	**Clear** by 1211.01m	**Clear** by 1111.01m

Turbine	Link ID/Reference	2D Clearance/Infringement Distance	2D Clearance/Infringement Considering 25m Buffer	3D Clearance/Infringement Distance	3D Clearance/Infringement Considering 25m Buffer
5	Vodafone Link 2	**Infringes** by 75.9m	**Infringes** by 175.9m	**Infringes** by 0.33m	**Infringes** by 100.33m
	Vodafone Link 3	**Clear** by 613.55m	**Clear** by 513.55m	**Clear** by 627.28m	**Clear** by 527.28m
6	Vodafone Link 1	**Clear** by 977.32m	**Clear** by 877.32m	**Clear** by 977.32m	**Clear** by 877.32m
	Vodafone Link 2	**Clear** by 34.94m	**Infringes** by 65.06m	**Clear** by 49.26m	**Infringes** by 50.74m
	Vodafone Link 3	**Clear** by 325.4m	**Clear** by 225.4m	**Clear** by 343.06m	**Clear** by 243.06m
7	Vodafone Link 1	**Clear** by 592.47m	**Clear** by 492.47m	**Clear** by 593.85m	**Clear** by 493.85m
	Vodafone Link 2	**Clear** by 307.91m	**Clear** by 207.91m	**Clear** by 308.29m	**Clear** by 208.29m
	Vodafone Link 3	**Clear** by 196.85m	**Clear** by 96.85m	**Clear** by 206.07m	**Clear** by 106.07m
8	Vodafone Link 1	**Clear** by 156.18m	**Clear** by 56.18m	**Clear** by 160.65m	**Clear** by 60.65m
	Vodafone Link 2	**Clear** by 610.09m	**Clear** by 510.09m	**Clear** by 610.19m	**Clear** by 510.19m
	Vodafone Link 3	**Clear** by 27.21m	**Infringes** by 72.79m	**Clear** by 42.06m	**Infringes** by 57.94m
9	Vodafone Link 1	**Clear** by 156.01m	**Clear** by 56.01m	**Clear** by 165.79m	**Clear** by 65.79m
	Vodafone Link 2	**Clear** by 996.1m	**Clear** by 896.1m	**Clear** by 996.18m	**Clear** by 896.18m
	Vodafone Link 3	**Clear** by 50.72m	**Infringes** by 49.28m	**Clear** by 53.03m	**Infringes** by 46.97m

Turbine	Link ID/Reference	2D Clearance/Infringement Distance	2D Clearance/Infringement Considering 25m Buffer	3D Clearance/Infringement Distance	3D Clearance/Infringement Considering 25m Buffer
10	Vodafone Link 1	**Clear** by 2221.33m	**Clear** by 2121.33m	**Clear** by 2221.41m	**Clear** by 2121.41m
	Vodafone Link 2	**Clear** by 831.2m	**Clear** by 731.2m	**Clear** by 832.55m	**Clear** by 732.55m
	Vodafone Link 3	**Clear** by 1209.44m	**Clear** by 1109.44m	**Clear** by 1213.72m	**Clear** by 1113.72m
11	Vodafone Link 1	**Clear** by 1756.39m	**Clear** by 1656.39m	**Clear** by 1756.58m	**Clear** by 1656.58m
	Vodafone Link 2	**Clear** by 610.89m	**Clear** by 510.89m	**Clear** by 611.92m	**Clear** by 511.92m
	Vodafone Link 3	**Clear** by 344.62m	**Clear** by 244.62m	**Clear** by 357.23m	**Clear** by 257.23m
12	Vodafone Link 1	**Clear** by 1370.85m	**Clear** by 1270.85m	**Clear** by 1371.36m	**Clear** by 1271.36m
	Vodafone Link 2	**Clear** by 347.81m	**Clear** by 247.81m	**Clear** by 348.45m	**Clear** by 248.45m
	Vodafone Link 3	**Clear** by 238.07m	**Clear** by 138.07m	**Clear** by 251.1m	**Clear** by 151.1m
13	Vodafone Link 1	**Clear** by 1058.01m	**Clear** by 958.01m	**Clear** by 1058.51m	**Clear** by 958.51m
	Vodafone Link 2	**Clear** by 144.3m	**Clear** by 44.3m	**Clear** by 145.8m	**Clear** by 45.8m
	Vodafone Link 3	**Clear** by 402.98m	**Clear** by 302.98m	**Clear** by 410.98m	**Clear** by 310.98m
14	Vodafone Link 1	**Clear** by 727.35m	**Clear** by 627.35m	**Clear** by 728m	**Clear** by 628m
	Vodafone Link 2	**Infringes** by 63.96m	**Infringes** by 163.96m	**Infringes** by 48.79m	**Infringes** by 148.79m

Turbine	Link ID/Reference	2D Clearance/Infringement Distance	2D Clearance/Infringement Considering 25m Buffer	3D Clearance/Infringement Distance	3D Clearance/Infringement Considering 25m Buffer
14	Vodafone Link 3	**Clear** by 510.77m	**Clear** by 410.77m	**Clear** by 516.34m	**Clear** by 416.34m
15	Vodafone Link 1	**Clear** by 157.93m	**Clear** by 57.93m	**Clear** by 159.05m	**Clear** by 59.05m
	Vodafone Link 2	**Clear** by 430.55m	**Clear** by 330.55m	**Clear** by 431.58m	**Clear** by 331.58m
	Vodafone Link 3	**Clear** by 403.13m	**Clear** by 303.13m	**Clear** by 409.37m	**Clear** by 309.37m
16	Vodafone Link 1	**Clear** by 34.54m	**Infringes** by 65.46m	**Clear** by 47.3m	**Infringes** by 52.7m
	Vodafone Link 2	**Clear** by 671.28m	**Clear** by 571.28m	**Clear** by 671.28m	**Clear** by 571.28m
	Vodafone Link 3	**Clear** by 538.03m	**Clear** by 438.03m	**Clear** by 539.14m	**Clear** by 439.14m
17	Vodafone Link 1	**Clear** by 2883.12m	**Clear** by 2783.12m	**Clear** by 2883.53m	**Clear** by 2783.53m
	Vodafone Link 2	**Clear** by 1574.91m	**Clear** by 1474.91m	**Clear** by 1575.02m	**Clear** by 1475.02m
	Vodafone Link 3	**Clear** by 1556.67m	**Clear** by 1456.67m	**Clear** by 1558.51m	**Clear** by 1458.51m
18	Vodafone Link 1	**Clear** by 2646.36m	**Clear** by 2546.36m	**Clear** by 2646.96m	**Clear** by 2546.96m
	Vodafone Link 2	**Clear** by 1464.64m	**Clear** by 1364.64m	**Clear** by 1464.67m	**Clear** by 1364.67m
	Vodafone Link 3	**Clear** by 1232.02m	**Clear** by 1132.02m	**Clear** by 1234.07m	**Clear** by 1134.07m
19	Vodafone Link 1	**Clear** by 2284.63m	**Clear** by 2184.63m	**Clear** by 2285.48m	**Clear** by 2185.48m

Turbine	Link ID/Reference	2D Clearance/Infringement Distance	2D Clearance/Infringement Considering 25m Buffer	3D Clearance/Infringement Distance	3D Clearance/Infringement Considering 25m Buffer
19	Vodafone Link 2	**Clear** by 1263.75m	**Clear** by 1163.75m	**Clear** by 1263.75m	**Clear** by 1163.75m
	Vodafone Link 3	**Clear** by 981.38m	**Clear** by 881.38m	**Clear** by 983.8m	**Clear** by 883.8m
20	Vodafone Link 1	**Clear** by 1675.01m	**Clear** by 1575.01m	**Clear** by 1675.74m	**Clear** by 1575.74m
	Vodafone Link 2	**Clear** by 879.8m	**Clear** by 779.8m	**Clear** by 879.85m	**Clear** by 779.85m
	Vodafone Link 3	**Clear** by 1175.76m	**Clear** by 1075.76m	**Clear** by 1178.45m	**Clear** by 1078.45m
21	Vodafone Link 1	**Clear** by 1131.09m	**Clear** by 1031.09m	**Clear** by 1131.81m	**Clear** by 1031.81m
	Vodafone Link 2	**Clear** by 409.9m	**Clear** by 309.9m	**Clear** by 410.16m	**Clear** by 310.16m
	Vodafone Link 3	**Clear** by 1081.02m	**Clear** by 981.02m	**Clear** by 1083.69m	**Clear** by 983.69m
22	Vodafone Link 1	**Clear** by 1293.11m	**Clear** by 1193.11m	**Clear** by 1293.58m	**Clear** by 1193.58m
	Vodafone Link 2	**Clear** by 707.94m	**Clear** by 607.94m	**Clear** by 708.22m	**Clear** by 608.22m
	Vodafone Link 3	**Clear** by 1628.72m	**Clear** by 1528.72m	**Clear** by 1630.87m	**Clear** by 1530.87m

Table 4 *Results summary – Vodafone 100m exclusion zones*

3.5 Discussion

The most relevant results presented below are for the exclusion zones infringements based on Ofcom recommended methodology[6] with an additional 25m buffer applied[7].

For Vodafone Link 1, turbine 16 is clear the exclusion zone in 2D by a margin of 0.96m. In 3D, turbine 16 is clear of the exclusion zone by a margin of 13.71m.

For Vodafone Link 2, turbines 5 and 14 infringe the exclusion zone in 2D by margins of 108m and 96.08m, respectively. In 3D, turbines 5 and 14 infringe the exclusion zone by margins of 32.43m and 80.92m, respectively. If the 25m buffer were not applied to the 3D exclusion zone, turbines 5 and 14 would still infringe by margins of 7.43m and 55.92m, respectively.

For Vodafone Link 3, turbine 8 infringes the exclusion zone in 2D, by a margin of 4.01m. In 3D, turbine 8 is clear of the exclusion zone by a margin of 10.85m.

A 250-metre exclusion zone is also applied to microwave link mast ends. Mast A of Vodafone Link 3 is the closest mast end, of which the clearance values for turbines 6, 11, and 12 (the closest turbines) are 115.31m, 94.62m, and 21.52m, respectively. All turbines are clear of the exclusion zones applied to mast ends.

Overall, mitigation is expected to be required for turbine locations 5 and 14. An overview of mitigation options is shown in the following section. It is important to coordinate any technical mitigation solutions with the relevant link operator.

If the locations or dimensions of the turbines are altered, it is recommended that the identified telecommunication link exclusion zones are accounted for when maintaining existing clearances.

[6] 2nd Fresnel zone for Microwave links.
[7] It is Pager Power's methodology to include a 25m buffer in the first instance due to the limitations of desk-based analysis e.g. potential coordinate inaccuracies.

4 MITIGATION FOR MICROWAVE LINKS

4.1 Microwave Link Mitigation

4.1.1 Overview

When an impact on a microwave link has been identified, the recommended solutions to consider could include:

- Micrositing / Layout Optimisation;
- Re-networking of the link via existing telecommunications sites;
- Use of a leased line.

Further information regarding these options is given below. Other options that can be considered are:

- Construction of a new telecommunications site for the purpose of re-networking solution;
- Use of an alternative technology such as a satellite link.

These options are less likely to be feasible and are not discussed in detail. They could be explored if an impact could not be mitigated by other means.

4.1.2 Micrositing / Layout Optimisation

This is potentially the simplest solution, depending on the available site area depending on the viability of developing the wind farm around the telecommunication link exclusion zones.

Ensuring that turbines remain outside the exclusion zones associated with the microwave links and remain more than 250 metres from a microwave link ends is likely to remove any potential impact.

4.1.3 Re-networking Solution

In some cases, it is possible to re-network a microwave link via an existing telecommunications site that lies away from the wind farm.

This involves adding an extra node on the link path, so that instead of the signal being sent from End A to End B, it is sent from End A to a re-networking site, and from the re-networking site to End B.

Implementation of such a solution requires identification of a suitable re-networking site, and assessment of the intervening terrain to ensure the appropriate Fresnel zone would not be infringed by terrain for the re-networked link.

The costs and timescales associated with such a solution are variable, however it is likely to be more cost-effective and have a shorter timescale than construction of a new telecommunications site.

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4.1.4 Use of a Leased Line

In some cases, it is possible to replace the wireless link with a leased line between the link ends, thereby avoiding potential interference due to the wind development.

The feasibility of such a solution is dependent on the accessibility of each link end with regard to installation of a leased line.

The costs and timescales of the solution are variable and dependent on the individual site locations and the distance between them.

5 CONCLUSIONS

5.1 Overall Conclusions

The most relevant results presented below are for the exclusion zones infringements based on Ofcom recommended methodology[8] with an additional 25m buffer applied[9].

Overall, the desk-based analysis indicates that mitigation is required for turbine locations 5 and 14. Turbines 5 and 14 infringe the exclusion zone in 2D by margins of 108m and 96.08m, respectively. Turbine locations 5 and 14 infringe the exclusion zones in 3D by margins of 32.43m and 80.92m, respectively. If the 25m buffer were not applied to the 3D exclusion zone, turbines 5 and 14 would still infringe by margins of 7.43m and 55.92m, respectively.

An overview of possible mitigation strategies has been provided for reference (see Section 4). It is important to coordinate any technical mitigation solutions with the relevant link operator. The potential solutions are:

- Micrositing / Layout Optimisation;
- Re-networking of the link via existing telecommunications sites;
- Use of a leased line.

If the locations or dimensions of the turbines are altered, it is recommended that the identified telecommunication link exclusion zones are accounted for when maintaining existing clearances.

[8] 2nd Fresnel zone for Microwave links.
[9] It is Pager Power's methodology to include a 25m buffer in the first instance due to the limitations of desk-based analysis e.g. potential coordinate inaccuracies.

APPENDIX A – COORDINATE DATA

Coordinate Data

The proposed wind development coordinates are shown in the table below. The wind development consists of 22 wind turbine locations with a maximum tip height of 200 metres above ground level (agl), hub height of 122.5 metres agl, and a rotor diameter of 155 metres.

Turbine	Easting (British National Grid)	Northing (British National Grid)	Longitude	Latitude
1	289226	628279	-3.75676	55.53562
2	289653	628010	-3.74989	55.53330
3	289983	627700	-3.74454	55.53060
4	288602	627840	-3.76646	55.53154
5	289004	627578	-3.75999	55.52928
6	289398	627296	-3.75364	55.52683
7	289907	627124	-3.74551	55.52540
8	290496	626904	-3.73610	55.52356
9	291024	626883	-3.72773	55.52349
10	287981	627375	-3.77611	55.52722
11	288776	626791	-3.76329	55.52216
12	289303	626583	-3.75486	55.52041
13	289747	626380	-3.74775	55.51869
14	290183	626235	-3.74079	55.51748
15	290787	626292	-3.73125	55.51813
16	291256	626117	-3.72376	55.51666
17	287557	626728	-3.78256	55.52131
18	287965	626424	-3.77598	55.51868

Turbine	Easting (British National Grid)	Northing (British National Grid)	Longitude	Latitude
19	288535	626071	-3.76681	55.51564
20	289421	625632	-3.75261	55.51189
21	290002	625678	-3.74343	55.51244
22	290089	625121	-3.74184	55.50746

Proposed wind development turbine coordinates

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