4 MITIGATION

4.1 Overview

In the case of the proposed development, mitigation is expected to be a requirement. A high-level overview of the most common mitigation options is presented in the next sections.

4.2 Microwave Link Mitigation

4.2.1 Overview

The recommended solutions to consider for microwave communications links 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.

4.2.2 Micrositing / Layout Optimisation

This is potentially the simplest solution, depending on the available site area.

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

4.2.3 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.

4.2.4 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.

4.3 UHF Telemetry Links

4.3.1 Overview

Three of the most common and cost-effective mitigation options for UHF telemetry link that are affected by wind turbines are:

- Micrositing / Layout Optimisation;
- Use of an alternative scanner;
- Replacement of the UHF telemetry link with a microwave link.

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

- Use of a leased line or fibre optic connection;
- Construction of a new scanning station;
- 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.

4.3.2 Micrositing / Layout Optimisation

This is potentially the simplest solution, depending on the available site area. Relocation of any turbines that have the largest interference contribution could prevent any impacts on the link.

Relocating problem turbines away from the link paths may be sufficient to overcome the operator's concerns. Ensuring that replanted turbines remain more than 500 metres from a UHF link end is likely to remove any potential impact.

4.3.3 Use of an Alternative Scanner

In some cases, it is possible to direct the outstations to an alternative scanner. Discussions with the link operator would be required to establish the suitability of such a solution.

4.3.4 Replacement of the UHF Link with a Microwave Link

In cases where reflection issues are the only concern, replacement of the UHF link with a microwave link. This is because microwave links are not prone to reflection issues in the way that UHF telemetry links are. However, microwave links do require radio line of sight to operate, which UHF telemetry links do not. Therefore, detailed assessment of the technical feasibility of such a solution would be required. This would include assessment of radio line of sight between the link ends and establishment of whether the intervening terrain would obstruct the appropriate Fresnel zone.

4.4 Mitigation Analysis for Arqiva Link

4.4.1 Introduction

Mitigation may be required to avoid significant interference effects on the Black Hill to Leadhills RBL path. It is understood that the Leadhills telecommunications mast houses a relay TV transmitter, that will provide television and radio signals to the surrounding village of Leadhills. An investigation has been undertaken based on a first principles approach to present a mitigation solution.

4.4.2 Proposed Solution

It is proposed that the Leadhills mast is moved approximately 240 metres to the west, to allow it to sit in a gap between T1 and T5 relative to the Black Hill main transmitter. The solution has been proposed with the aim of avoiding causing any significant interference effects on the Black Hill to Leadhills RBL path. The proposed position of the mast, relative to the current position, is presented in Figure 11 below.

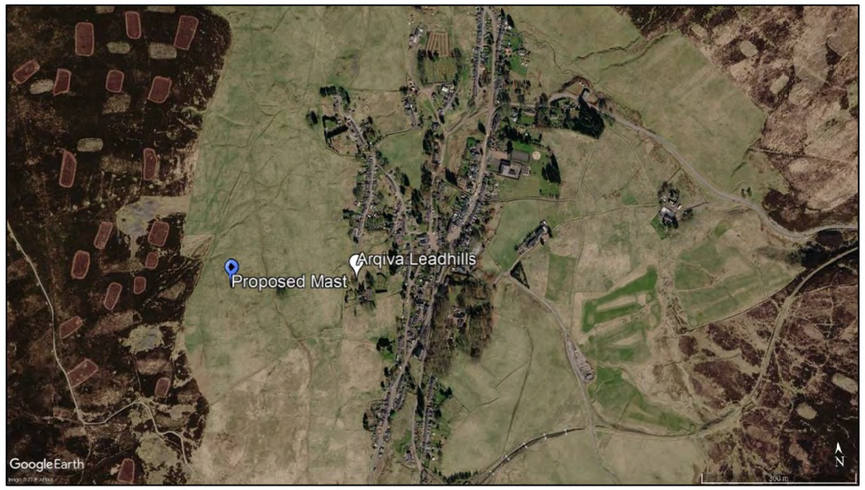

Figure 11 *Proposed new location for Arqiva Leadhills Mast*

The proposed coordinates and heights for the mast are presented in Table 4 below. The height above ground level has been modelled at the same height of the current transmitter.

Easting (British National Grid)	Northing (British National Grid)	Height agl	Height amsl
288165	614900	12.8	455.42

Table 4 *Proposed turbine coordinates*

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4.4.3 Line of Sight Analysis

Line of sight analysis has been undertaken to understand the visibility from the Black Hill Main Transmitter to the proposed new location for the Leadhills relay transmitter, in the context of the existing operational scenario. Figure 12 below shows the results of a line of sight calculation from the Black Hill Main Transmitter to the current Leadhills relay transmitter.

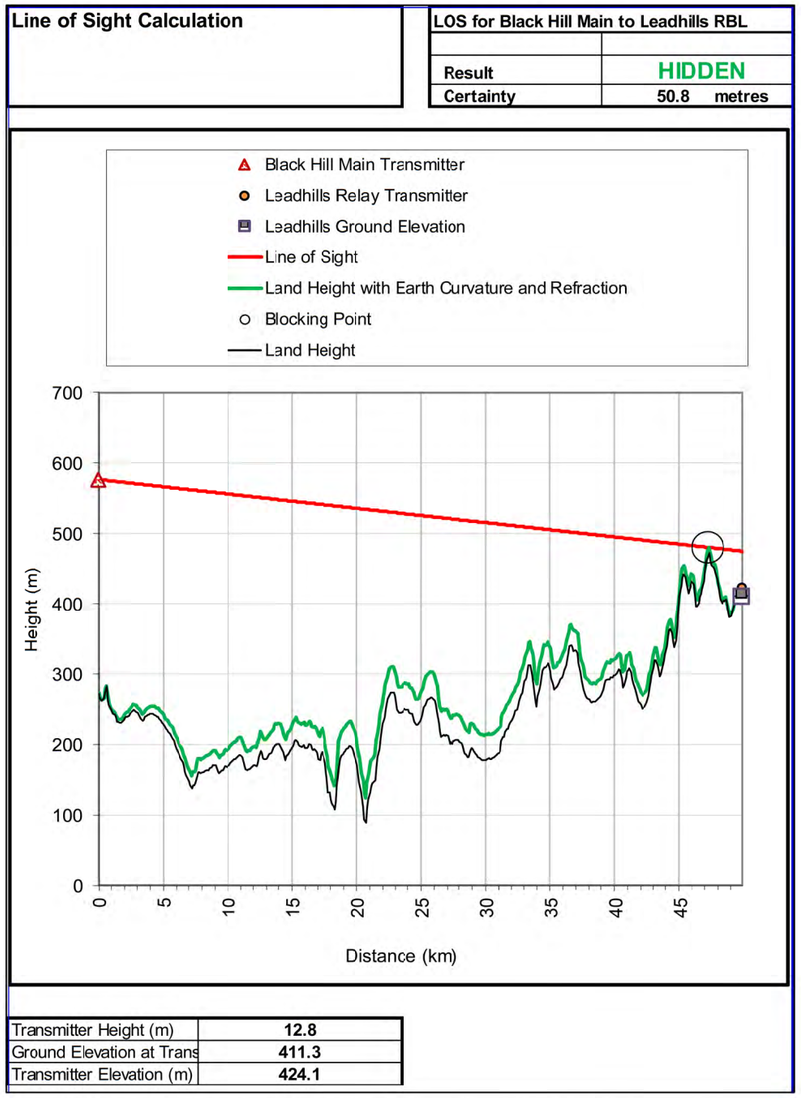

Figure 12 *Line of sight calculation for Black Hill Main Transmitter to Leadhills Relay Transmitter*

Figure 13 below shows the results of a line of sight calculation from the Black Hill Main Transmitter to the proposed Leadhills relay transmitter. It can be seen that the visibility of the new location is better, due to the higher terrain elevation at this location.

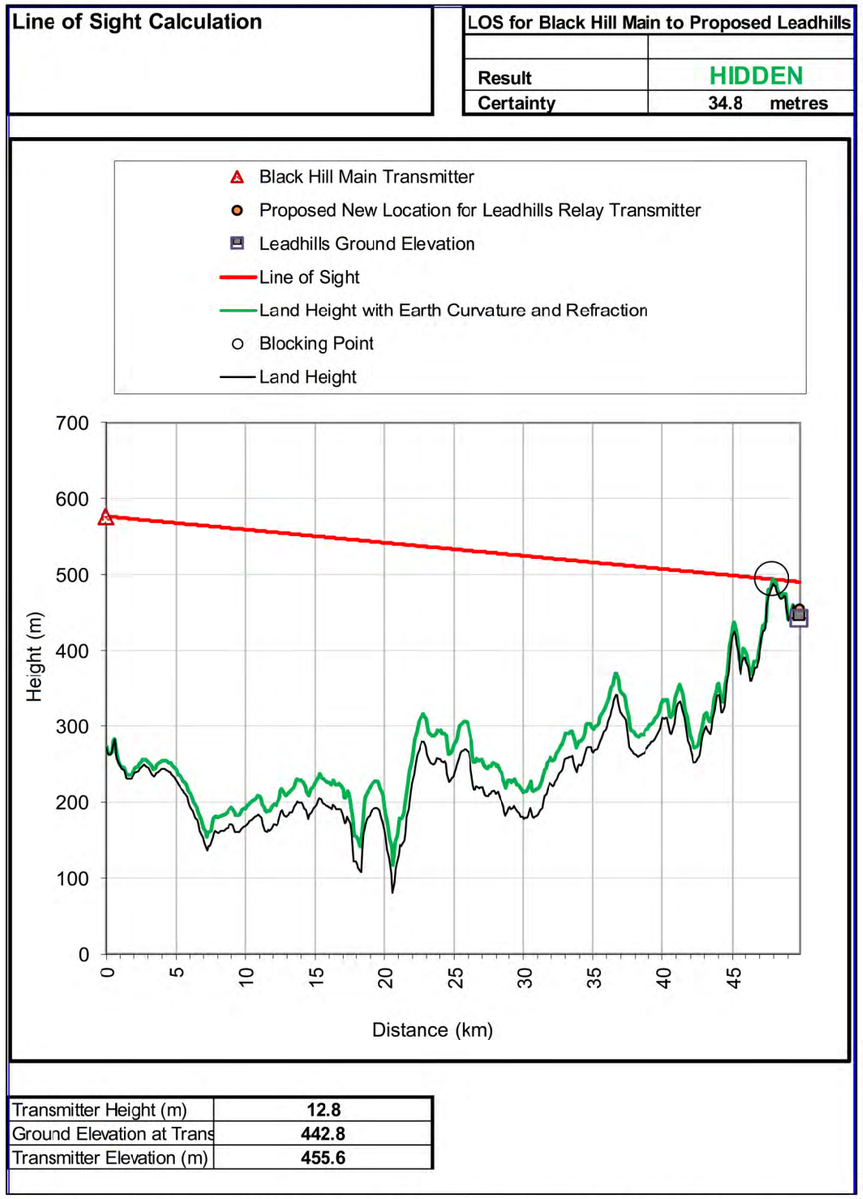

Figure 13 *Line of sight calculation for Black Hill Main Transmitter to Proposed Leadhills Relay Transmitter*

4.4.4 Updated Arqiva Constraint Map

Figure 14 to Figure 16 on the following pages show the map of the exclusion zone for the proposed new RBL path. The exclusion zone has been constructed following the 100m clearance criteria that Arqiva typically requires plus the rotor radius (green polygon). The centre line of the Arqiva microwave communications link is represented by the red line.

Turbines placed outside of the green polygon would satisfy the 100m Arqiva clearance criteria.

The 100m clearance criteria that Arqiva typically requires is more conservative than the exclusion zones based on diffraction effects, however, it is likely that Arqiva will require any turbine layout to follow this.

Based on the turbine layout, all turbines meet the criteria and no significant interference effects would be possible.

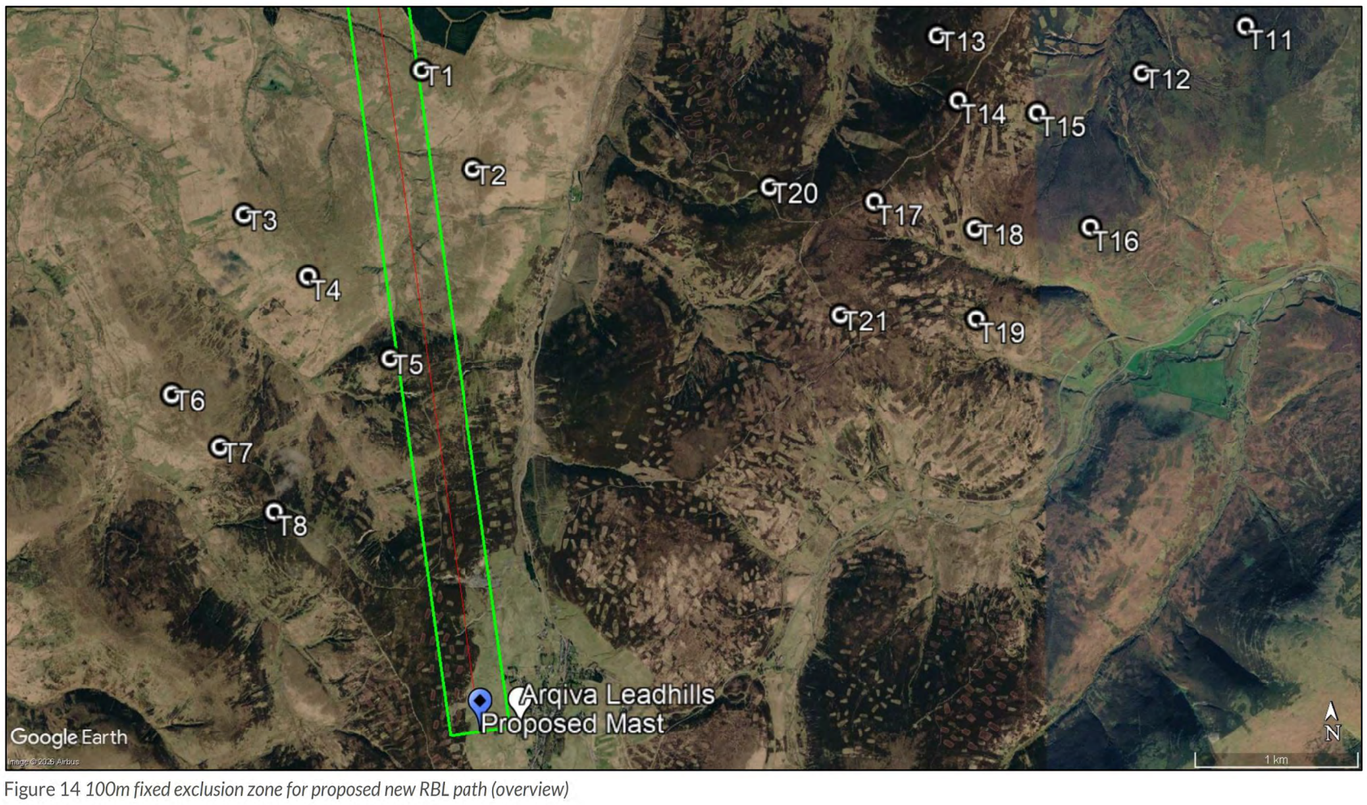

Figure 14 *100m fixed exclusion zone for proposed new RBL path (overview)*

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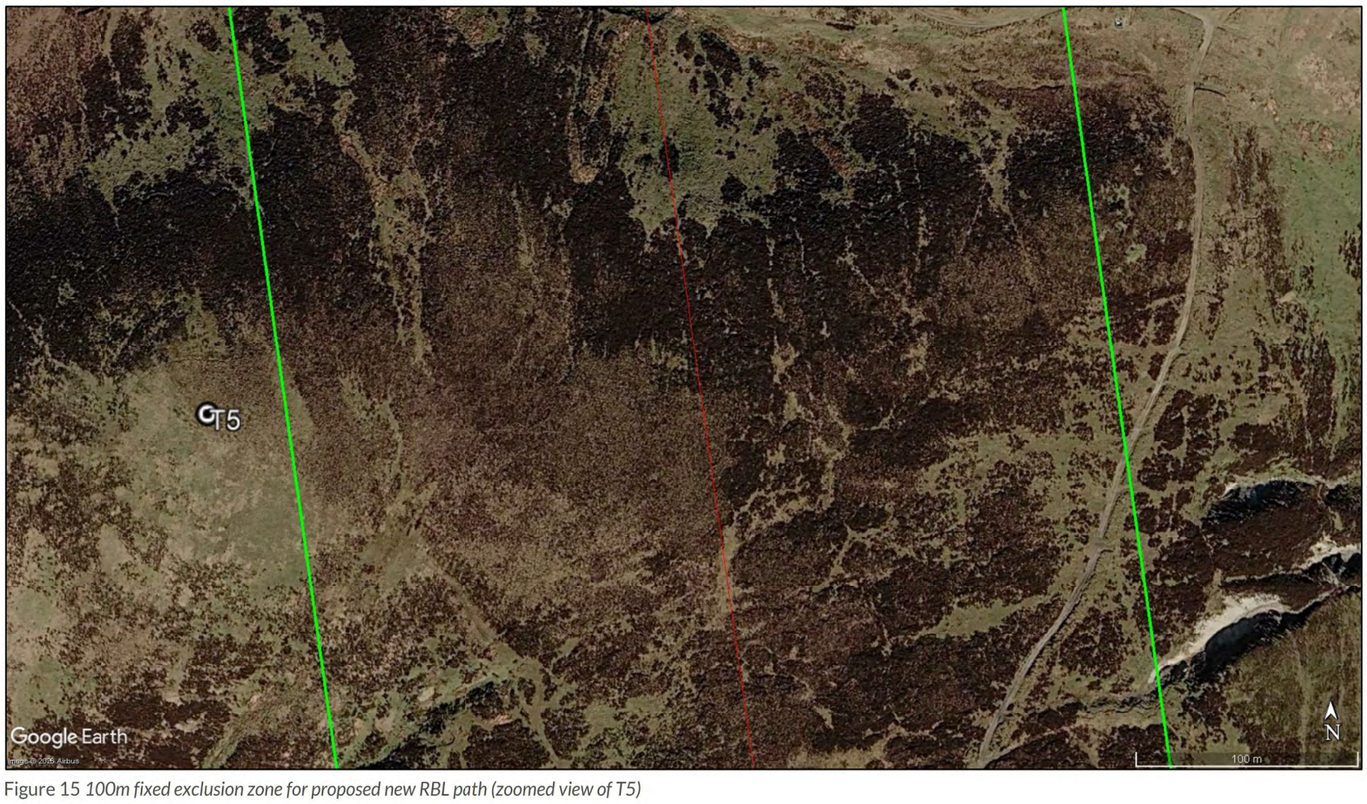

Figure 15 *100m fixed exclusion zone for proposed new RBL path (zoomed view of T5)*

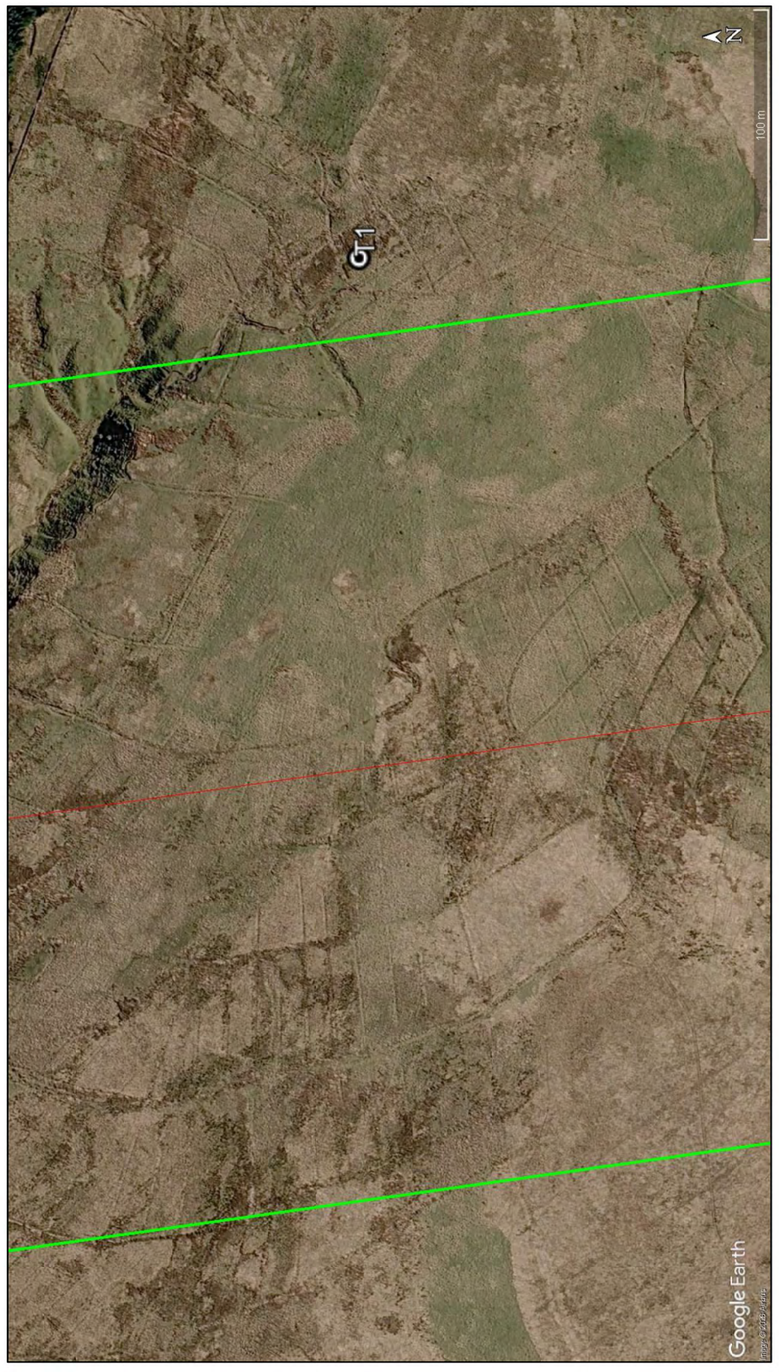

Figure 16 *100m fixed exclusion zone for proposed new RBL path (zoomed view of T1)*

4.4.5 Conclusions

This solution involves moving the mast approximately 240m to the west uphill (approximately 16 metres higher terrain elevation). There are no significant obstructions introduced between the proposed mast location and the dwellings by moving the mast, in fact, visibility and line of sight from the new transmitter location and TV aerials on dwellings in the village should improve in many cases. Moving the mast to the proposed location would mean that all turbines would be sited outside of the 100 metres 2D exclusion zone required by Arqiva.

This has been evaluated on a first principles basis, however, Arqiva will need to be consulted to understand whether this mitigation option is feasible. Alternatively, further consultation with Arqiva may reveal if other mitigation options are available.

5 OVERALL CONCLUSIONS

5.1 Results

Arqiva, Atkins, British Telecoms (BT), Mobile Broadband Network Limited (MBNL), MLL Telecom, the Joint Radio Company (JRC), Virgin Media/O2, and Vodafone were consulted as per the process explained in Section 2.

Atkins, BT, MLL Telecom, Virgin Media/O2, and Vodafone have confirmed that they have no objections to the proposed development based on the previous turbine layout. No nearby links were identified, therefore it is assumed that there would be no objection to the latest turbine layout given the minor changes.

MBNL confirmed that there are potential interference issues with nearby links based on the previous turbine layout. They have since confirmed that there are no issues with the latest turbine layout due to changes to turbine positions moving them outside of the relevant exclusion zones.

Arqiva and the JRC have confirmed that there are potential interference issues with nearby links based on the current turbine layout. T1 infringes the exclusion zone for the Arqiva link by 180.8m. This means that the turbine would need to move a minimum of 180.8 metres for it to be sited outside of the exclusion zone. T1, T2, and T5 infringe the exclusion zones of two JRC links.

Therefore, based on the currently proposed turbine layout, potential impacts upon wireless communications infrastructure (point-to-point links) are predicted. Mitigation is likely to be required for the proposed development to proceed as currently designed.

5.2 Recommendations and Mitigation

An overview of typical mitigation strategies has been provided for reference (see Sections 4.2 and 4.3).

Further consultation with the JRC is currently ongoing to understand the mitigation options available for the potential interference issues with their links.

A mitigation investigation has been undertaken for the Arqiva RBL link from the Black Hill main transmitter to the Leadhills relay transmitter. A solution is presented in Section 4.4, where the Leadhills mast would be moved approximately 240 metres to the west. This has been evaluated on a first principles basis, however, Arqiva will need to be consulted to understand whether this mitigation option is feasible. Consultation is currently ongoing with Arqiva to understand the available mitigation options.

If any significant changes are made to the proposed development layout, then the consultees should be contacted again with the updated layout.

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APPENDIX A – FRESNEL ZONES EXPLANATION

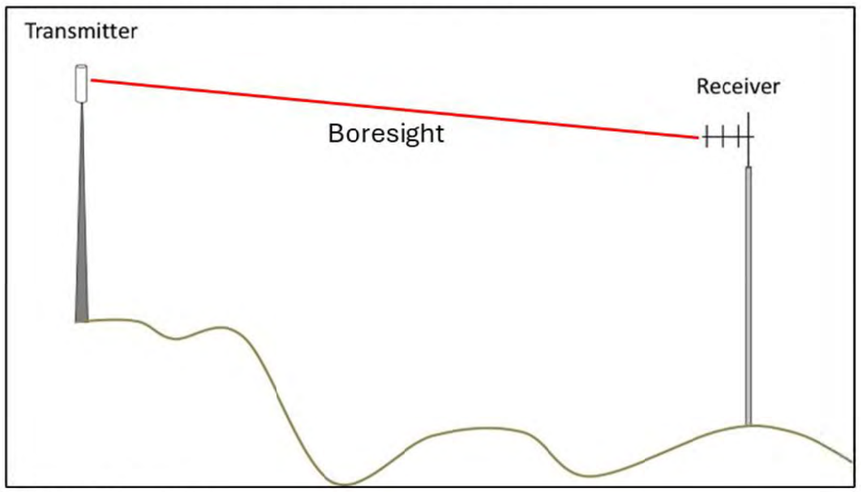
Wireless Links

Links between two antennae function best with a clear, unobstructed path between each end. For microwave links, this is usually considered a requirement. Links at lower frequencies sometimes function without radio line-of-sight. Structures located between transmitters and receivers have the potential to corrupt or block the transmitted signal.

Potential interference from terrain, vegetation, buildings, wind farms and a host of other obstructions must be considered when designing and maintaining wireless communication systems.

Link Boresight

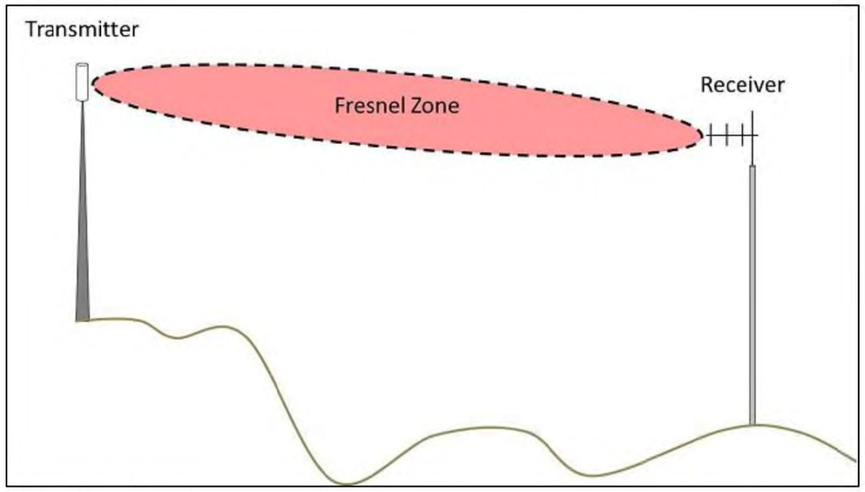
The term 'boresight' in the context of a wireless link means the straight line between the transmitter and the receiver. The figure below illustrates this.



Link boresight illustration

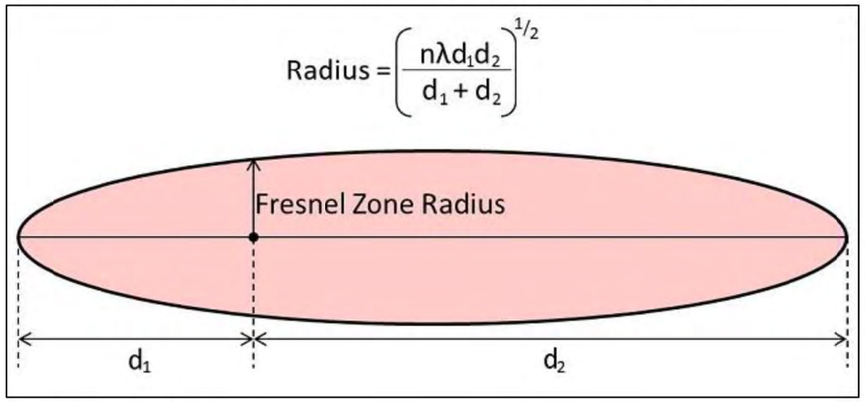
Fresnel Zones

A Fresnel Zone is a cigar-shaped area, in three dimensions, centred on a link boresight. The figure below illustrates this.



Fresnel zone illustration

It can be seen that the Fresnel Zone is widest in the middle and narrowest at the ends. The Fresnel Zone radius, along with the formula for calculating it, are shown in the figure below.



Fresnel zone radius illustration

The radius is dependent on:

- The length of the link;
- The distance along the link path;
- The frequency of the link;
- The Fresnel Zone number 'n' – which is a number greater than zero.

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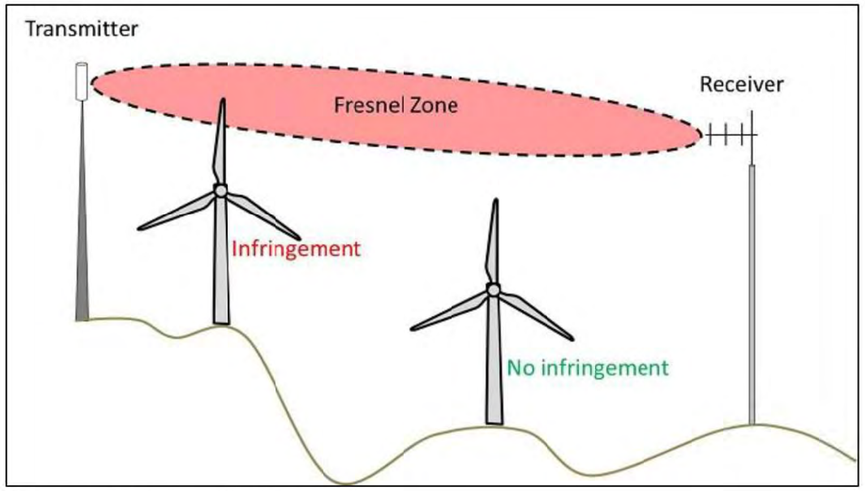
Link Infringement

Structures that infringe Fresnel Zones can adversely affect the link's performance. This can lead to objections in the pre-planning stage of a development and mitigation requirements. The figure below illustrates this concept using two wind turbines, with identical dimensions, beneath the link path illustrated in the figure on page 20. This principle applies to other constructions, such as buildings, as well.



Fresnel zone infringement illustration

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Pager Power Limited
Stour Valley Business Centre
Sudbury
Suffolk
CO10 7GB

Tel: +44 1787 319001 **Email:** info@pagerpower.com **Web:** www.pagerpower.com