# Technical Appendix 9.4

# Derivation of Residual Noise Limits

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# 1 Daytime

### *Import Data*

Predictions made at each NSR for wind farms which are operational/consented/ahead in the planning process:

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | 37.9 | 42.3 | 43.9 | 44.2 | 44.2 | 44.3 | 44.3 | 44.3 |
| Templeland | 2 | 36.4 | 39.1 | 40.2 | 40.4 | 40.6 | 41.1 | 41.1 | 41.1 |
| Laigh Plewland | 3 | 38.6 | 40.4 | 41.1 | 41.5 | 41.7 | 42.6 | 42.6 | 42.6 |
| Glengavel - FI | 4 | 37.7 | 39.8 | 40.7 | 41.1 | 41.3 | 42 | 42 | 42 |
| High Plewlands Farm | 5 | 38.5 | 40.1 | 40.7 | 41 | 41.3 | 42.3 | 42.3 | 42.3 |
| Logan Farm | 6 | 37.5 | 40.7 | 41.1 | 41.1 | 41.1 | 41.1 | 41.1 | 41.1 |
| Dippal Lodge | 7 | 35 | 38.1 | 38.5 | 38.6 | 38.6 | 38.7 | 38.7 | 38.7 |

Overall noise limits (ONLs) determined for each NSR. These are obtained by undertaking a baseline noise survey, or from the planning consents/noise assessments of cumulative wind farms. These were determined by reference to measured baseline data collected for neighbouring wind farms.

*inputs_ONL =*

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | 40 | 40 | 40 | 40 | 41.7 | 43.3 | 44.4 | 44.8 |
| Templeland | 2 | 40 | 40 | 40 | 40 | 41.7 | 43.3 | 44.4 | 44.8 |
| Laigh Plewland | 3 | 40 | 40 | 40 | 40 | 41.7 | 43.3 | 44.4 | 44.8 |
| Glengavel - FI | 4 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| High Plewlands Farm | 5 | 40 | 40 | 40 | 40 | 41.7 | 43.3 | 44.4 | 44.8 |
| Logan Farm | 6 | 40 | 40 | 40 | 40 | 41.7 | 43.3 | 44.4 | 44.8 |
| Dippal Lodge | 7 | 40 | 40 | 40 | 40 | 41.7 | 43.3 | 44.4 | 44.8 |

### *Apply ETSU Limits*

If the predicted level from the cumulative wind farms exceeds the consented ETSU limit at a given NSR, then assessment assumes that the predicted level is equal to the consented noise limit.

*inputs_predictions_ETSU_corrected =*

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | 37.9 | 40 | 40 | 40 | 41.7 | 43.3 | 44.3 | 44.3 |
| Templeland | 2 | 36.4 | 39.1 | 40 | 40 | 40.6 | 41.1 | 41.1 | 41.1 |
| Laigh Plewland | 3 | 38.6 | 40 | 40 | 40 | 41.7 | 42.6 | 42.6 | 42.6 |
| Glengavel - FI | 4 | 37.7 | 39.8 | 40.7 | 41.1 | 41.3 | 42 | 42 | 42 |
| High Plewlands Farm | 5 | 38.5 | 40 | 40 | 40 | 41.3 | 42.3 | 42.3 | 42.3 |
| Logan Farm | 6 | 37.5 | 40 | 40 | 40 | 41.1 | 41.1 | 41.1 | 41.1 |
| Dippal Lodge | 7 | 35 | 38.1 | 38.5 | 38.6 | 38.6 | 38.7 | 38.7 | 38.7 |

### *Calculate Available Headroom*

The available headroom is given by arithmetically subtracting the predicted level at a given NSR from the ONL at that NSR. If the available headroom at an NSR is less than 5 dB, then the assessment considers there to be no headroom at the NSR:

*Available_headroom =*

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | 2.1 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.5 |
| Templeland | 2 | 3.6 | 0.9 | 0 | 0 | 1.1 | 2.2 | 3.3 | 3.7 |
| Laigh Plewland | 3 | 1.4 | 0 | 0 | 0 | 0 | 0.7 | 1.8 | 2.2 |
| Glengavel - FI | 4 | 7.3 | 5.2 | 4.3 | 3.9 | 3.7 | 3 | 3 | 3 |
| High Plewlands Farm | 5 | 1.5 | 0 | 0 | 0 | 0.4 | 1 | 2.1 | 2.5 |
| Logan Farm | 6 | 2.5 | 0 | 0 | 0 | 0.6 | 2.2 | 3.3 | 3.7 |
| Dippal Lodge | 7 | 5 | 1.9 | 1.5 | 1.4 | 3.1 | 4.6 | 5.7 | 6.1 |

*is_there_available_headroom =*

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | No | No | No | No | No | No | No | No |
| Templeland | 2 | No | No | No | No | No | No | No | No |
| Laigh Plewland | 3 | No | No | No | No | No | No | No | No |
| Glengavel - FI | 4 | Yes | Yes | No | No | No | No | No | No |
| High Plewlands Farm | 5 | No | No | No | No | No | No | No | No |
| Logan Farm | 6 | No | No | No | No | No | No | No | No |
| Dippal Lodge | 7 | Yes | No | No | No | No | No | Yes | Yes |

## *Calculate Residual Noise Limits (RNLs)*

If there is available headroom (the headroom value is more than 5 dB), then the RNL is calculated by first arithmetically adding 2 dB to the predicted level, and then logarithmically subtracting the resultant value from the ONL:

$$\boldsymbol{RNL = 10 \cdot \log\left(10^{\frac{ONL}{10}} - 10^{\frac{Predicted\ Level + 2\ dB}{10}}\right)}$$

Where there is no available headroom and the receptor is not financially involved, then the RNL is calculated by arithmetically subtracting 10 dB from the ONL.

Where there is no available headroom and the receptor is financially involved, then the RNL is calculated by either:

a) logarithmically subtracting the non-financially involved ONL from the financially involved ONL (45 dB), i.e.

$$\boldsymbol{RNL = 10 \cdot \log\left(10^{\frac{45\ dB}{10}} - 10^{\frac{non-FI\ ONL}{10}}\right)}$$; or

b) arithmetically subtracting 10 dB from the financially involved ONL

The chosen method is the one which gives the higher result.

*Residual_noise_limits =*

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | 30 | 30 | 30 | 30 | 31.7 | 33.3 | 34.4 | 34.8 |
| Templeland | 2 | 30 | 30 | 30 | 30 | 31.7 | 33.3 | 34.4 | 34.8 |
| Laigh Plewland | 3 | 30 | 30 | 30 | 30 | 31.7 | 33.3 | 34.4 | 34.8 |
| Glengavel - FI | 4 | 43.5 | 43.3 | 43.3 | 43.3 | 42.3 | 40.1 | 36.1 | 35 |
| High Plewlands Farm | 5 | 30 | 30 | 30 | 30 | 31.7 | 33.3 | 34.4 | 34.8 |
| Logan Farm | 6 | 30 | 30 | 30 | 30 | 31.7 | 33.3 | 34.4 | 34.8 |
| Dippal Lodge | 7 | 37.0 | 30 | 30 | 30 | 31.7 | 33.3 | 42.0 | 42.7 |

# 2 Night-time

### *Import Data*

Predictions made at each NSR for wind farms which are operational/consented/ahead in the planning process:

*inputs_predictions =*

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | 37.9 | 42.3 | 43.9 | 44.2 | 44.2 | 44.3 | 44.3 | 44.3 |
| Templeland | 2 | 36.4 | 39.1 | 40.2 | 40.4 | 40.6 | 41.1 | 41.1 | 41.1 |
| Laigh Plewland | 3 | 38.6 | 40.4 | 41.1 | 41.5 | 41.7 | 42.6 | 42.6 | 42.6 |
| Glengavel - FI | 4 | 37.7 | 39.8 | 40.7 | 41.1 | 41.3 | 42 | 42 | 42 |
| High Plewlands Farm | 5 | 38.5 | 40.1 | 40.7 | 41 | 41.3 | 42.3 | 42.3 | 42.3 |
| Logan Farm | 6 | 37.5 | 40.7 | 41.1 | 41.1 | 41.1 | 41.1 | 41.1 | 41.1 |
| Dippal Lodge | 7 | 35 | 38.1 | 38.5 | 38.6 | 38.6 | 38.7 | 38.7 | 38.7 |

Determine the overall noise limits at each NSR (as described above):

*inputs_ONL =*

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| Templeland | 2 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| Laigh Plewland | 3 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| Glengavel - FI | 4 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| High Plewlands Farm | 5 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| Logan Farm | 6 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| Dippal Lodge | 7 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |

## *Apply ETSU Limits*

If the predicted level from the cumulative wind farms exceeds the consented ETSU limit at a given NSR, then assessment assumes that the predicted level is equal to the consented noise limit.

*inputs_predictions_ETSU_corrected =*

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | 37.9 | 42.3 | 43 | 43 | 43 | 43 | 43 | 43 |
| Templeland | 2 | 36.4 | 39.1 | 40.2 | 40.4 | 40.6 | 41.1 | 41.1 | 41.1 |
| Laigh Plewland | 3 | 38.6 | 40.4 | 41.1 | 41.5 | 41.7 | 42.6 | 42.6 | 42.6 |
| Glengavel - FI | 4 | 37.7 | 39.8 | 40.7 | 41.1 | 41.3 | 42 | 42 | 42 |
| High Plewlands Farm | 5 | 38.5 | 40.1 | 40.7 | 41 | 41.3 | 42.3 | 42.3 | 42.3 |
| Logan Farm | 6 | 37.5 | 40.7 | 41.1 | 41.1 | 41.1 | 41.1 | 41.1 | 41.1 |
| Dippal Lodge | 7 | 35 | 38.1 | 38.5 | 38.6 | 38.6 | 38.7 | 38.7 | 38.7 |

## *Calculate Available Headroom*

The available headroom is given by arithmetically subtracting the predicted level at a given NSR from the ONL at that NSR. If the available headroom at an NSR is less than 5 dB, then the assessment considers there to be no headroom at the NSR:

*Available_headroom =*

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | 5.1 | 0.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| Templeland | 2 | 6.6 | 3.9 | 2.8 | 2.6 | 2.4 | 1.9 | 1.9 | 1.9 |
| Laigh Plewland | 3 | 4.4 | 2.6 | 1.9 | 1.5 | 1.3 | 0.4 | 0.4 | 0.4 |
| Glengavel - FI | 4 | 5.3 | 3.2 | 2.3 | 1.9 | 1.7 | 1 | 1 | 1 |
| High Plewlands Farm | 5 | 4.5 | 2.9 | 2.3 | 2 | 1.7 | 0.7 | 0.7 | 0.7 |
| Logan Farm | 6 | 5.5 | 2.3 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 |
| Dippal Lodge | 7 | 8 | 4.9 | 4.5 | 4.4 | 4.4 | 4.3 | 4.3 | 4.3 |

*is_there_available_headroom =*

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | Yes | No | No | No | No | No | No | No |
| Templeland | 2 | Yes | No | No | No | No | No | No | No |
| Laigh Plewland | 3 | No | No | No | No | No | No | No | No |
| Glengavel - FI | 4 | Yes | No | No | No | No | No | No | No |
| High Plewlands Farm | 5 | No | No | No | No | No | No | No | No |
| Logan Farm | 6 | Yes | No | No | No | No | No | No | No |
| Dippal Lodge | 7 | Yes | No | No | No | No | No | No | No |

## *Calculate Residual Noise Limits*

If there is available headroom (the headroom value is more than 5 dB), then the RNL is calculated by first arithmetically adding 2 dB to the predicted level, and then logarithmically subtracting this number from the ONL:

$$\boldsymbol{RNL = 10 \cdot \log\left(10^{\frac{ONL}{10}} - 10^{\frac{Predicted\ Level + 2\ dB}{10}}\right)}$$

Where there is no available headroom and the receptor is not financially involved, then the RNL is calculated by arithmetically subtracting 10 dB from the ONL.

Where there is no available headroom and the receptor is financially involved, then the RNL is calculated by either:

c) logarithmically subtracting the non-financially involved ONL from the financially involved ONL (45 dB), i.e. $\boldsymbol{RNL = 10 \cdot \log\left(10^{\frac{45\ dB}{10}} - 10^{\frac{non-FI\ ONL}{10}}\right)}$; or

d) arithmetically subtracting 10 dB from the financially involved ONL

The chosen method is the one which gives the higher result.

*Residual_noise_limits =*

| Location Name | Location ID | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | 11 m/s | 12 m/s |
|---|---|---|---|---|---|---|---|---|---|
| Dungavel Immigration Removal Centre | 1 | 40.1 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |
| Templeland | 2 | 41.2 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |
| Laigh Plewland | 3 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |
| Glengavel - FI | 4 | 40.3 | 40.7 | 40.7 | 40.7 | 40.7 | 40.7 | 40.7 | 40.7 |
| High Plewlands Farm | 5 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |
| Logan Farm | 6 | 40.4 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |
| Dippal Lodge | 7 | 41.7 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |