# Theodore Wind Farm

## Noise Impact Assessment

24 July 2024
Reference ID: 232-6

echo
Acoustic Consulting

# Contents



## Figures



## Tables

## Abbreviations

| | |
|---|---|
| **AO** | Acceptable Outcome of the State code 23 |
| **BESS** | Battery Energy Storage System |
| **EPA** | Environment Protection Authority |
| **Good Practice Guide** | *Institute of Acoustics (UK) "A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise"* |
| **ISO 9613-2** | *ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* |
| **MVA** | Megavolt Amperes |
| **MW** | Mega Watt |
| **MWh** | Mega Watt hour |
| **OEM** | Original Equipment Manufacturer |
| **PO** | Performance Outcome of the State code 23 |
| **Policy** | *Environmental Protection (Noise) Policy 2019* |
| **Project** | Theodore Wind Farm |
| **SARA** | State Assessment and Referral Agency |
| **Scheme** | *Banana Shire Council Planning Scheme 2021* |
| **State code 23** | *State code 23: Wind farm development of the State Development Assessment Provisions*, Version 3.0 |
| **State code 23 guidance** | *Planning guidance - State code 23: Wind farm development,* February 2022 |
| **TED** | Theodore Energy Development Pty Ltd |
| **WTG** | Wind Turbine Generator |

## Glossary

| | |
|---|---|
| **A-weighting** | A mathematical adjustment to the measured noise levels to represent the human response to sound. An *A-weighted noise level* is presented as dB(A) |
| **Background creep** | An increase in the total amount of background noise in the area from the introduction of new noise sources |
| **Background noise level** | Minimum ambient noise level, evaluated as the level exceeded for 90 per cent of 10-minute sample periods. Nomenclature for the background noise level is $L_{A90}$ |
| **Candidate WTG** | A candidate WTG is used as an example to indicate the ability of the wind farm to comply with legislative requirements. Candidate WTGs are indicative of WTGs which might be procured at a future design and tender stage |
| **Day** | 6.00 am to 10.00 pm |

| | |
|---|---|
| **Decibels** | The logarithmic unit of measurement to define the magnitude of a fluctuating air pressure wave. Presented as dB and used as the unit for *sound* or *noise level* |
| **Deed of Release** | Written agreement from non-host lot owners within 1500m of the nearest WTG |
| **Equivalent noise level** | The A-weighted noise level which is equivalent to a noise level which varies over time. Nomenclature for the *A-weighted equivalent noise level* is $L_{Aeq}$ |
| **Frequency** | Frequency is the number of pressure fluctuation cycles per second of a sound wave. Measured in units of Hertz (Hz) |
| **Host lot** | A host lot is a sensitive land use which accommodates any part of a wind farm |
| **Noise** | An interchangeable term with sound but which is most often described as *unwanted sound*. |
| **Non-host lot** | A non-host lot is a sensitive land use no part of which is used for a wind farm |
| **Night** | 10.00 pm to 6.00 am |
| **Octave Band** | The segregation of sound into discrete frequency components. For example, the 63 Hz *octave band* is a low frequency component of sound/noise, and the 2000 Hz *octave band* is a high frequency component of sound/noise. The one-third (or 1/3) octave is more finite segregation (1/3$^{rd}$) of each octave band |
| **Sensitive land uses** | Existing or approved sensitive land uses as identified in State code 23. This includes, amongst other things, dwellings, community and childcare facilities, health care facilities, schools and tourist parks |
| **Sound** | An activity or operation which generates a fluctuating air pressure wave. The ear drum can perceive both the frequency (pitch) and the magnitude (loudness) of the fluctuations to convert those waves to sound |
| **Sound pressure level** | The magnitude of sound (or noise) at a location. The sound pressure level can vary according to distance to the noise source, and operational, meteorological and topographical influences. The terms *Sound Pressure Level* and *Noise Level* are used interchangeably in this Noise Impact Assessment |
| **Sound power level** | The amount of sound energy an activity produces for a given operation. The sound power level is a constant value for a given activity. The sound power level is analogous to the power rating on a light globe (which remains constant), whereas the lighting level in a space (sound pressure level in this analogy) will be influenced by the distance from the globe, shielding and different locations within the space |
| **Tonality** | Noise containing a perceptible pitch component as objectively identified using a one-third octave band test as per State code 23 guidance |
| **Warranted sound power level** | The sound power level which the WTG supplier guarantees can be achieved inclusive of uncertainties |

# Introduction

Theodore Energy Development Pty Ltd (**TED**) is proposing to develop the Theodore Wind Farm (the **project**) in the Banana Shire Council local government area.

The project will be located approximately 30km east of the Theodore township and has the potential for up to 170 wind turbine generators (**WTG**s) each with a generating capacity in the order of 7.2 MW, four Battery Energy Storage Systems (**BESS**s) each with a capacity of 250 MW / 500 MWh, and associated transformers.

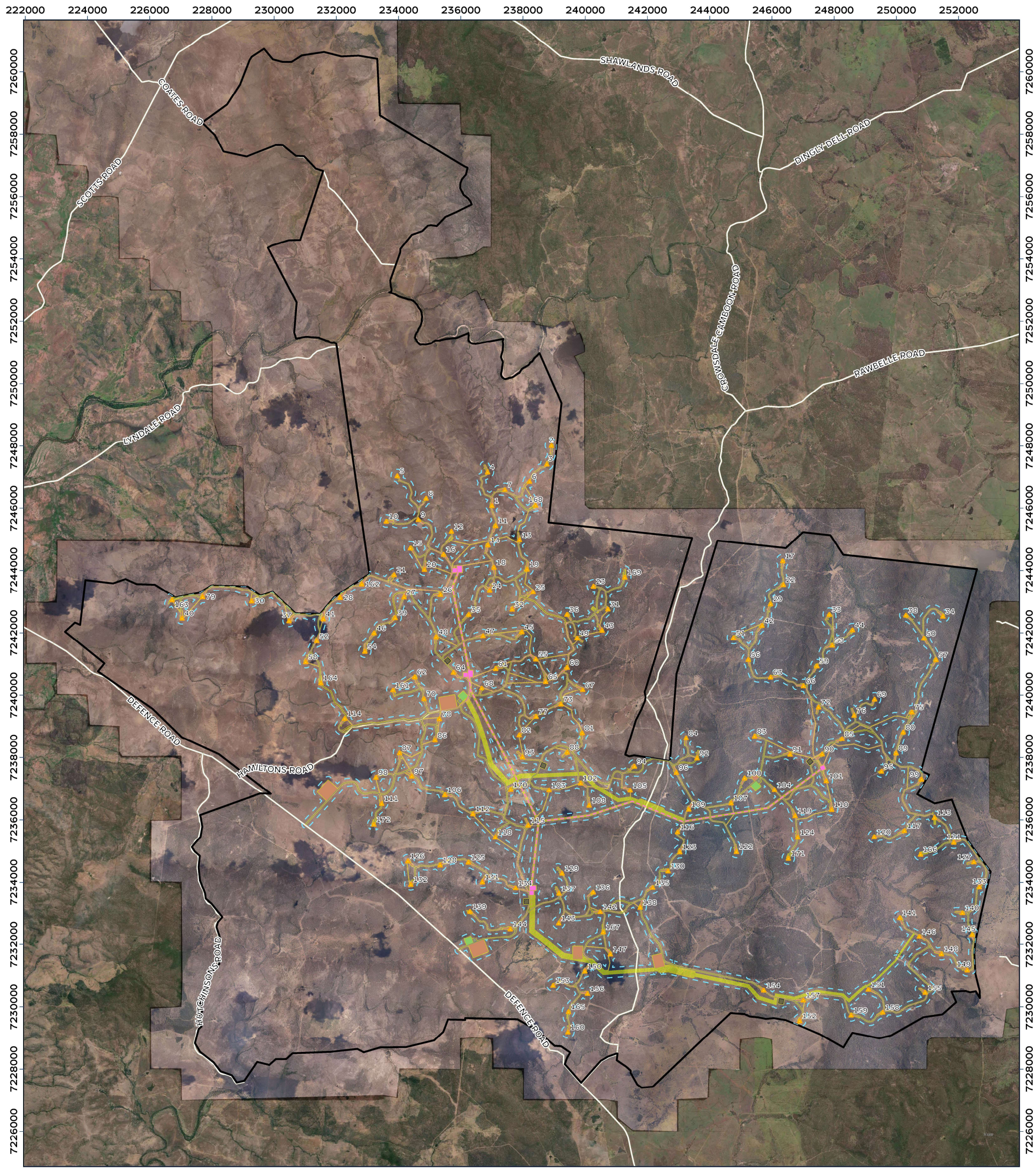
The candidate WTG for the project is the *Vestas V172-7.2MW* producing a total installed capacity of up to 1224 MW. The combined battery storage capacity will be up to 1000 MW / 2000 MWh.

*State code 23: Wind farm development* of the *State Development Assessment Provisions* provides requirements to protect the amenity of existing or approved sensitive land uses from acoustic impacts associated with the WTGs, and the *Environmental Protection (Noise) Policy 2019* provides a method of assessing adverse noise impacts from the BESSs and transformers.

The noise levels generated from renewable energy facilities are well understood and can be predicted. This noise impact assessment (the **assessment**) predicts the noise associated with the WTGs, BESSs, and transformers to ensure the acoustic amenity of the surrounding existing and approved sensitive land uses is not adversely affected by the project.

The layout for the project is shown in Figure 1 below.

Figure 1 Project Layout




**Legend**

- Site Boundary
- Wind Turbines
- Access Tracks
- Underground 33 kV Cabling
- Overhead 33kV Cabling
- Overhead 275kV Transmission
- Construction Corridor
- Micrositing Corridor
- Substation/ Switching Station/ Battery
- Operations and Maintenance Compound
- Construction Compounds
- Laydown Areas / Hardstands
- Concrete Batching Plant

RWE

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**Theodore Wind Farm**
**Proposed Wind Farm Site Layout**

*For Information Only - Layout Subject to Change*

0 2 4 6 Km N
GDA2020 MGA Zone 56
Produced By: MW
Reviewed By: HC
10/02/2024 THWF_COMM_001A

Source TED

# Assessment Criteria

## Banana Shire Council Planning Scheme 2021

The project is located within a *Rural Zone* of the *Banana Shire Council Planning Scheme 2021* (the **scheme**).

A renewable energy facility is categorised as an "Assessable Development" under the scheme.

In addition to the assessment requirements for wind farm developments by the State Assessment and Referral Agency (**SARA**), the scheme has the following provisions relating to noise from the ancillary infrastructure:

### Performance Outcome PO5 (Amenity Section)

The acoustic objectives of the *Environmental Protection (Noise) Policy 2019* are maintained for the ongoing operation of the use.

### Performance Outcome PO35 (Renewable energy facility Section)

Operations do not disturb the early morning or late evening amenity of the locality.

## Environmental Protection (Noise) Policy 2019

Performance Outcome PO5 references the *Environmental Protection (Noise) Policy 2019* (the **Policy**).

The Policy provides a management hierarchy for managing noise. Where a noise source is located near a sensitive receptor, the noise must be minimised to ensure:

a) the noise does not have any adverse effect, or potential adverse effect on an environmental value. For continuous noise sources, the "environmental value" is satisfied at residences by achieving the following noise levels:
   - 50 dB(A) outdoors during the daytime and evening
   - 35 dB(A) indoors during the daytime and evening
   - 30 dB(A) indoors during the night-time

b) background creep in an area or place is prevented or minimised.

## State code 23: Wind farm development

SARA is the assessment manager for all wind farm development applications and considers applications against *State code 23: Wind farm development* of the *State Development Assessment Provisions, Version 3.0* (**State code 23**). State code 23 provides the following provisions related to *acoustic amenity*.

### Performance Outcome PO10 (Acoustic Amenity Section)

Development is sited and designed to protect the amenity of existing or approved sensitive land uses on non-host lots from acoustic impacts.

*Acceptable outcome AO10.1* (Acoustic Amenity Section)

A separation distance of at least 1500 metres is achieved between wind turbines and existing or approved sensitive land uses on non-host lots.

### Performance Outcome PO11 (Acoustic Amenity Section)

The predicted acoustic level at all noise affected existing or approved sensitive land uses on **host lots** does not exceed the criteria stated [below as an] outdoor (free-field) night-time (10.00pm to 6.00am) A-weighted equivalent acoustic level ($L_{Aeq}$):

- 45 dB(A)
- the background noise ($L_{A90}$) by more than 5 dB(A)

  whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.

### Performance Outcome PO12 (Acoustic Amenity Section)

The predicted acoustic level at all noise affected existing or approved sensitive land uses on **non-host lots** does not exceed the criteria stated [below as an]:

a) outdoor (free-field) night-time (10.00pm to 6.00am) A-weighted equivalent acoustic level ($L_{Aeq}$)
   - 35 dB(A)
   - the background noise ($L_{A90}$) by more than 5 dB(A)

     whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.

b) outdoor (free-field) day-time (6.00am to 10.00pm) A-weighted equivalent acoustic level ($L_{Aeq}$)
   - 37dB(A)
   - the background noise ($L_{A90}$) by more than 5 dB(A)

     whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.

## Project Criteria

The project criteria have been developed to satisfy both the scheme and State code 23.

### WTG Noise

A key factor in the Policy (as referenced in the scheme) is to *ensure background creep in an area or place is prevented or minimised*.

Whilst State code 23 provides a stand-alone wind farm assessment method, consideration has been made to the scheme's provisions to arrive at an approach for the wind farm which removes the increase in project criteria with an increase in background noise levels.

This approach will satisfy State code 23 (because it achieves its most stringent requirements) and aligns with the environmental values sought by the Policy, by ensuring that the outdoor A-weighted equivalent noise levels ($L_{Aeq}$) from the WTGs do not exceed the following *baseline* noise criteria:

- 45dB(A) at **host lots**
- 35dB(A) at **non-host lots**.

Notwithstanding the above, background noise monitoring has also been conducted to document the ambient noise in the environment. The data will assist in the future noise monitoring plan (a post approval requirement of State code 23) and in determining the legislative criteria of State code 23, which consists of a *baseline* level and a *background noise level plus 5 dB(A)* requirement, whichever is the greater. The results of the background noise monitoring are summarised in *Echo Acoustics* report with reference ID "232-5".

In addition, and notwithstanding compliance with the 35 dB(A) criterion, a separation distance of at least 1500 metres will be maintained between WTGs and existing or approved non-host lots in the absence of a Deed of Release.

### BESS and Transformer Noise

The most onerous "environmental value" of the Policy for a dwelling to protect against adverse impacts is the indoor (night-time) value of 30 dB(A). This equates to an outdoor level of 45 dB(A) based on a typical noise reduction from outside to inside (with a windows open) of 15 dB(A). This noise reduction is consistent with that applied by the Policy during the day and evening periods.

Although designing ancillary infrastructure to 45 dB(A) would achieve the environmental values of the Policy, the recommended approach is to align with the more stringent wind farm criteria. That is, ensure the outdoor A-weighted equivalent noise levels ($L_{Aeq}$) from ancillary infrastructure do not exceed:

- 45 dB(A) at **host lots**
- 35 dB(A) at **non-host lots**.

# Assessment

## WTG Noise

### Noise Model

A three-dimensional model of the project WTGs has been developed based on the algorithm provided by *ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (**ISO 9613-2**).

ISO 9613-2 specifies a method for predicting noise levels at a distance from a source under meteorological conditions favourable to noise propagation. The algorithm also conservatively assumes that these favourable propagation conditions occur simultaneously from all WTGs to all sensitive land uses.

The model incorporates the following:

- sensitive land uses near the project, with locations and host status as detailed in Table 1
- the cumulative operation of all 170 WTGs, with WTG locations as detailed in Table 2
- topographical ground contours
- inputs detailed below, as specified in the *Planning guidance - State code 23: Wind farm development* (**State code 23 guidance**):
    - warranted sound power levels for the candidate WTGs at integer wind speeds
    - 10°C temperature
    - 70% relative humidity
    - 50% acoustically hard ground and 50% acoustically soft ground
    - barrier attenuation of no greater than 2 dB(A)
    - 4m receiver height at each sensitive land use
    - application of a 3 dB(A) correction where a "concave" ground profile exists.

The above State code 23 guidance inputs align with the modelling recommendations of the *Institute of Acoustics* (UK) "*A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*" (the **Good Practice Guide**).

Table 1 Sensitive Land Use Locations and Host Status

| Sensitive Land Use ID | Host | Co-ordinates (MGA Zone 56) | | Sensitive Land Use ID | Host | Co-ordinates (MGA Zone 56) | | Sensitive Land Use ID | Host | Co-ordinates (MGA Zone 56) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Easting | Northing | | | Easting | Northing | | | Easting | Northing |
| H01 | Yes | 226712 | 7261091 | N1 | No | 241081 | 7222943 | N10 | No | 223873 | 7240911 |
| H02 | Yes | 231972 | 7254966 | N2 | No | 241084 | 7222961 | N11 | No | 224961 | 7247057 |
| H03 | Yes | 233035 | 7252302 | N3 | No | 241142 | 7223034 | N12 | No | 243374 | 7248290 |
| H04 | Yes | 228323 | 7240131 | N4 | No | 242138 | 7226929 | N13 | No | 244279 | 7248463 |
| H05 | Yes | 241338 | 7239344 | N5 | No | 229139 | 7227516 | N14 | No | 244202 | 7248474 |
| H06 | Yes | 230793 | 7237878 | N6 | No | 256173 | 7239743 | N15 | No | 229624 | 7250788 |
| H07 | Yes | 230179 | 7237247 | N7 | No | 223936 | 7240879 | N16 | No | 222889 | 7252442 |
| H08 | Yes | 231566 | 7234683 | N8 | No | 223899 | 7240884 | N17 | No | 234261 | 7253504 |
| H09 | Yes | 241083 | 7229248 | N9 | No | 223901 | 7240904 | N18 | No | 223824 | 7256625 |

Table 2 WTG Locations

| WTG ID | Co-ordinates (MGA Zone 56) | | WTG ID | Co-ordinates (MGA Zone 56) | | WTG ID | Co-ordinates (MGA Zone 56) | | WTG ID | Co-ordinates (MGA Zone 56) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing |
| 1 | 237000 | 7246091 | 44 | 248589 | 7242105 | 89 | 249991 | 7238146 | 132 | 234393 | 7233944 |
| 2 | 238910 | 7248019 | 45 | 237963 | 7242047 | 90 | 247614 | 7238116 | 133 | 252670 | 7233856 |
| 3 | 238766 | 7247426 | 46 | 233213 | 7242008 | 91 | 246583 | 7238107 | 134 | 237762 | 7233828 |
| 4 | 236860 | 7247174 | 47 | 236713 | 7241918 | 92 | 243593 | 7237989 | 135 | 242171 | 7233841 |
| 5 | 233957 | 7247054 | 48 | 235205 | 7241884 | 93 | 237982 | 7238021 | 136 | 240256 | 7233687 |
| 6 | 238207 | 7246878 | 49 | 239734 | 7241844 | 94 | 241582 | 7237727 | 137 | 239155 | 7233650 |
| 7 | 237418 | 7246613 | 50 | 250883 | 7241836 | 95 | 249518 | 7237567 | 138 | 241765 | 7233198 |
| 8 | 234884 | 7246325 | 51 | 244761 | 7241849 | 96 | 242928 | 7237531 | 139 | 236292 | 7233066 |
| 9 | 234632 | 7245646 | 52 | 231369 | 7241752 | 97 | 234422 | 7237412 | 140 | 252124 | 7233025 |
| 10 | 233604 | 7245590 | 53 | 247939 | 7241608 | 98 | 233272 | 7237374 | 141 | 250106 | 7232867 |
| 11 | 237120 | 7245448 | 54 | 232915 | 7241413 | 99 | 250809 | 7237317 | 142 | 240481 | 7233060 |
| 12 | 235697 | 7245268 | 55 | 238411 | 7241167 | 100 | 245123 | 7237356 | 143 | 239147 | 7232697 |
| 13 | 237888 | 7244991 | 56 | 245239 | 7241153 | 101 | 247747 | 7237263 | 144 | 237590 | 7232506 |
| 14 | 236872 | 7244824 | 57 | 251276 | 7241148 | 102 | 239848 | 7237196 | 145 | 252433 | 7232330 |
| 15 | 234378 | 7244726 | 58 | 231016 | 7241081 | 103 | 238837 | 7236966 | 146 | 250734 | 7232262 |
| 16 | 235444 | 7244523 | 59 | 247447 | 7240951 | 104 | 246083 | 7236975 | 147 | 240804 | 7231695 |
| 17 | 246345 | 7244317 | 60 | 239419 | 7240903 | 105 | 241445 | 7236958 | 148 | 251449 | 7231702 |
| 18 | 237065 | 7244113 | 61 | 237122 | 7240864 | 106 | 235486 | 7236815 | 149 | 252279 | 7231190 |
| 19 | 238129 | 7244052 | 62 | 234514 | 7240601 | 107 | 244688 | 7236550 | 150 | 239988 | 7231153 |
| 20 | 234830 | 7244043 | 63 | 245957 | 7240595 | 108 | 240125 | 7236479 | 151 | 249099 | 7230565 |
| 21 | 233857 | 7243876 | 64 | 235762 | 7240745 | 109 | 243328 | 7236349 | 152 | 246892 | 7229560 |
| 22 | 246368 | 7243560 | 65 | 238729 | 7240452 | 110 | 247920 | 7236343 | 153 | 238965 | 7230701 |
| 23 | 240261 | 7243510 | 66 | 247013 | 7240318 | 111 | 233456 | 7236533 | 154 | 245735 | 7230540 |
| 24 | 236926 | 7243370 | 67 | 239916 | 7240189 | 112 | 236389 | 7236203 | 155 | 250925 | 7230466 |
| 25 | 238324 | 7243323 | 68 | 236673 | 7240242 | 113 | 251225 | 7236084 | 156 | 240070 | 7230431 |
| 26 | 235345 | 7243239 | 69 | 249299 | 7239881 | 114 | 232270 | 7239264 | 157 | 247009 | 7230224 |
| 27 | 234176 | 7243161 | 70 | 234816 | 7239898 | 115 | 238167 | 7235838 | 158 | 249562 | 7229837 |
| 28 | 232125 | 7243141 | 72 | 247497 | 7239626 | 116 | 242965 | 7235626 | 159 | 248543 | 7229742 |
| 29 | 245953 | 7242944 | 73 | 239220 | 7239723 | 117 | 250259 | 7235665 | 160 | 239444 | 7229198 |
| 30 | 229273 | 7243037 | 75 | 250502 | 7239469 | 118 | 237106 | 7235453 | 161 | 233815 | 7240177 |
| 31 | 240728 | 7242777 | 76 | 248641 | 7239358 | 119 | 246745 | 7236141 | 162 | 232819 | 7243578 |
| 32 | 237649 | 7242770 | 77 | 238421 | 7239326 | 120 | 249287 | 7235465 | 163 | 226721 | 7243071 |
| 33 | 247844 | 7242604 | 78 | 235312 | 7239249 | 121 | 251846 | 7235283 | 164 | 231503 | 7240412 |
| 34 | 251496 | 7242544 | 79 | 227701 | 7243168 | 122 | 244858 | 7234985 | 165 | 239460 | 7229854 |
| 35 | 236255 | 7242605 | 80 | 250220 | 7238825 | 123 | 243039 | 7234976 | 166 | 250776 | 7234900 |
| 36 | 239410 | 7242604 | 81 | 239904 | 7238799 | 124 | 246830 | 7235451 | 167 | 240578 | 7232411 |
| 37 | 230479 | 7242398 | 82 | 237877 | 7238735 | 125 | 236240 | 7234652 | 168 | 238403 | 7246101 |
| 38 | 250305 | 7242578 | 83 | 245442 | 7238693 | 126 | 234295 | 7234690 | 169 | 241271 | 7243797 |
| 39 | 233889 | 7242498 | 84 | 243242 | 7238636 | 127 | 252490 | 7234660 | 170 | 237604 | 7236981 |
| 40 | 227041 | 7242484 | 85 | 248254 | 7238609 | 128 | 235333 | 7234561 | 171 | 246529 | 7234775 |
| 41 | 231579 | 7242459 | 86 | 235172 | 7238566 | 129 | 239255 | 7234299 | 172[1] | 233205 | 7235867 |
| 42 | 245681 | 7242247 | 87 | 234031 | 7238155 | 130 | 242661 | 7234370 | | | |
| 43 | 240539 | 7242093 | 88 | 239423 | 7238175 | 131 | 236693 | 7234024 | | | |

[1] Table 2 references 170 WTGs. The project does not include WTG 71 or WTG 74.

## Candidate WTGs

The assessment has been based on the *Vestas V172-7.2MW* (*PO7200-0S* operating mode) *without* serrated trailing edges and a 166m hub height.

### *Sound Power Levels*

The sound power levels are based on the original equipment manufacturer (**OEM**) noise level data for integer wind speeds (at hub height) from wind turbine cut-in wind speed to the wind speed of the rated power.

The assessment has been based on one-third octave band data between 6.3 Hz and 16 kHz, which is subject to commercial in confidence provisions imposed by the OEM. The total sound power level data presented in Table 3 provides an indication of the noise generated by the WTG. Where required, the OEM one-third octave band data can be provided (subject to the completion of a non-disclosure agreement).

Table 3 Sound Power Levels

| Candidate WTG | Integer Hub Height Wind Speed (m/s) | Total Sound Power Level (dB(A)) |
|---|---|---|
| *Vestas V172-7.2MW* (*PO7200-0S operating mode*) *without* serrated trailing edges | 3 | **97.8** |
| | 4 | **97.8** |
| | 5 | **98.4** |
| | 6 | **101.8** |
| | 7 | **105.4** |
| | 8 | **108.8** |
| | 9 to 15 | **110.1** |

The measurement of noise levels and contractual agreements to arrive at warranted sound power levels can introduce variations to the noise data. The noise model incorporates an adjustment (addition) of 2 dB(A) to the total sound power levels in Table 3. This adjustment is understood to be greater (more conservative) than what is typically applied to a *Vestas* WTG but is consistent with the *good practice guide* recommendation for uncertainties which are not expressly specified.

### *Tonality*

The one-third octave band data available for the *Vestas V172-7.2MW* WTG indicates that tonality is not a characteristic of the candidate WTG. As noted above, the one-third octave band data can be accessed subject to completion of a non-disclosure agreement.

The assessment has been made on the basis that the WTG selection will not exhibit tonal characteristics. If the final WTG exhibits tonality, then predicted noise levels will be adjusted in accordance with State code 23 guidance as part of a final noise modelling process.

## Final Noise Modelling

Details affecting the predicted noise levels can alter during the design, development, and/or procurement stages to suit site constraints, micro-siting requirements and/or OEM selection. The assessment should be updated to reflect changes which can arise through the design and procurement process, to ensure ongoing compliance of the project with the project criteria.

## Predicted Noise Levels

Noise level predictions have been made using the noise model in combination with the inputs and assumptions detailed above. Table 4 provides the predicted noise level at each sensitive land use from the cut-in wind speed to the wind speed at rated power in integer steps. The distance to the closest WTG from each sensitive land use is also provided for comparison with *Acceptable outcome AO10.1*.

Table 4 *Vestas V172-7.2MW PO7200-0S operating mode* - Predicted Noise Levels

| Sensitive Land Use ID | Closest WTG (m) | Criterion | Noise level at hub height integer wind speed (dB(A)) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 3 m/s | 4 m/s | 5 m/s | 6 m/s | 7 m/s | 8 m/s | 9 to 15 m/s |
| H01 | 15799 | 45 | 9 | 8 | 9 | 13 | 16 | 20 | 21 |
| H02 | 8163 | 45 | 16 | 15 | 16 | 20 | 24 | 27 | 28 |
| H03 | 5338 | 45 | 18 | 18 | 18 | 22 | 26 | 29 | 31 |
| H04 | 2691 | 45 | 25 | 25 | 26 | 30 | 33 | 37 | 38 |
| H05 | 1542 | 45 | 32 | 32 | 33 | 36 | 40 | 43 | 45 |
| H06 | 2032 | 45 | 27 | 27 | 28 | 31 | 35 | 39 | 40 |
| H07 | 2910 | 45 | 25 | 25 | 26 | 29 | 33 | 37 | 38 |
| H08 | 2031 | 45 | 26 | 26 | 27 | 30 | 34 | 37 | 39 |
| H09 | 1574 | 45 | 29 | 29 | 30 | 33 | 37 | 40 | 42 |
| N1 | 6471 | 35 | 16 | 16 | 16 | 20 | 24 | 27 | 29 |
| N2 | 6455 | 35 | 16 | 16 | 16 | 20 | 24 | 27 | 29 |
| N3 | 6399 | 35 | 16 | 16 | 16 | 20 | 24 | 27 | 29 |
| N4 | 3529 | 35 | 22 | 22 | 23 | 26 | 30 | 34 | 35 |
| N5 | 8306 | 35 | 13 | 13 | 14 | 18 | 21 | 25 | 26 |
| N6 | 5100 | 35 | 19 | 19 | 20 | 24 | 27 | 31 | 32 |
| N7 | 3507 | 35 | 19 | 19 | 20 | 23 | 27 | 31 | 32 |
| N8 | 3537 | 35 | 19 | 19 | 20 | 23 | 27 | 30 | 32 |
| N9 | 3526 | 35 | 19 | 19 | 20 | 23 | 27 | 30 | 32 |
| N10 | 3548 | 35 | 19 | 19 | 20 | 23 | 27 | 30 | 32 |
| N11 | 4365 | 35 | 18 | 18 | 18 | 22 | 26 | 29 | 31 |
| N12 | 4479 | 35 | 22 | 22 | 22 | 26 | 30 | 33 | 35 |
| N13 | 4639 | 35 | 21 | 21 | 22 | 25 | 29 | 33 | 34 |
| N14 | 4683 | 35 | 21 | 21 | 22 | 25 | 29 | 33 | 34 |
| N15 | 5729 | 35 | 18 | 18 | 19 | 22 | 26 | 30 | 31 |
| N16 | 10127 | 35 | 13 | 13 | 14 | 18 | 21 | 25 | 26 |
| N17 | 6581 | 35 | 17 | 17 | 17 | 21 | 25 | 28 | 30 |
| N18 | 13862 | 35 | 10 | 10 | 11 | 15 | 18 | 22 | 23 |

The above predicted noise levels indicate that with the *Vestas V172-7.2MW* (*PO7200-0S* operating mode) *without* serrated trailing edges and a 166m hub height as the candidate WTG:

- the 45 dB(A) criterion will be achieved at all **host lots**
- the 35 dB(A) criterion will be achieved at all **non-host lots**

In addition, the proposed layout results in the closest WTG to any **non-host lot** being more than the 1500m requirement of *State code 23 Acceptable outcome AO10.1*.

Based on the above, the project can readily satisfy PO10, AO10.1, PO11, and PO12 in accordance with State code 23.

### *Noise Prediction Contours*

The highest noise prediction contours (hub height wind speed of 9m/s and greater[2]) for the *Vestas V172-7.2MW* (PO7200-0S operating mode) without serrated trailing edges and a 166m hub height are provided in Appendix A.

# BESS and Transformer Noise

## Noise Model

A three-dimensional model of the project BESSs and associated transformers has been developed based on the algorithm provided by ISO 9613-2.

ISO 9613-2 specifies a method for predicting noise levels at a distance from a source under meteorological conditions favourable to noise propagation. The algorithm also conservatively assumes that these favourable propagation conditions occur simultaneously from all BESSs and transformers to all sensitive land uses.

The model incorporates the following:

- sensitive land uses near the project, with locations and host status as detailed in Table 1
- topographical ground contours
- 10°C temperature
- 70% relative humidity
- 50% acoustically hard ground and 50% acoustically soft ground
- 3m source height
- 1.5m receiver height at each sensitive land use
- substation locations as detailed in Table 5 below.

Table 5 Substation Locations

| Substation ID | Co-ordinates (MGA Zone 56) | |
|---|---|---|
| | Easting | Northing |
| 1 | 235800 | 7244000 |
| 2 | 236150 | 7240650 |
| 3 | 238250 | 7233650 |
| 4 | 247600 | 7237650 |

## BESS

The project will include up to four BESSs (one at each of the four substations) each with a capacity of up to 250MW / 500 MWh.

The final BESS equipment for the project is yet to be determined and will be confirmed during the detailed design, OEM selection and procurement stages.

[2] The noise generated from a WTG increases with wind speed and then plateaus at 9m/s. The contours show the highest noise level from the WTGs after this plateau in noise.

### *Sound Power Levels*

Potential BESS equipment has been reviewed and whilst commercial sensitivities preclude identification of the specific models or data, this assessment has been based on a BESS that represents a conservative selection from a noise perspective (highest likely noise level).

A BESS operation will vary in load and usage depending on the time of day and the demand of the electricity network.

An assumed cumulative sound power level of 120 dB(A) is utilised by the assessment for each BESS with a capacity of 250 MW / 500 MWh (one at each of the four substations). This represents continuous full load operation of all BESS components with cooling fans at 100% capacity, and therefore is a conservative assumption, particularly for the night period.

## Transformers

The noise predictions have been based on one 300 MVA rated transformer located at each of the four substations.

A sound power level of 101 dB(A) has been assumed for each of the 300 MVA transformers as derived from *Australian Standard 60076.10:2023 Power transformers, Part 10: Determination of sound levels*.

## Predicted Noise Levels

Noise level predictions have been made using the noise model in combination with the inputs and assumptions detailed above. The predictions indicate that the noise level for the most conservative potential equipment selection operating at 100% capacity is 23 dB(A) at the closest *sensitive land use,* being host lot *H05*. The predicted noise level at all other host lots and non-host lots will be less than 20 dB(A).

The noise from the BESSs can exhibit tonal noise characteristics when in close proximity. However, the BESSs will incorporate a large number of individual cooling fans that will operate at different speeds, the effect of which will be to mask any dominant tonal characteristics of any one particular fan. Given the above, tonality is unlikely to be a characteristic in practice, particularly when considered in combination with the distances to the sensitive land uses for the project.

Based on the proposed layout and the representative equipment selections, the BESSs and transformers are expected to easily achieve the project criteria by a significant margin. The noise levels and presence of any tonal noise characteristics will be confirmed for the final equipment selections as they are developed by TED.

### *Noise Prediction Contours*

Noise prediction contours for the BESSs and transformers operating at 100% capacity are provided in Appendix B.

# Conclusion

Noise impact assessments predict the noise levels from renewable energy facilities based on established input data and compares those noise levels against specific requirements.

The Theodore Wind Farm noise impact assessment, conducted in accordance with *State code 23: Wind farm development* (**State code 23**), considers 170 wind turbine generators with a total installed capacity of 1224 MW, battery energy storage systems with a combined battery storage capacity of 1000 MW / 2000 MWh, and associated transformers.

The assessment determines the Theodore Wind Farm can achieve the allowable noise levels and separation distances required for wind turbine generators by State code 23 and the *State Development Assessment Provisions* at all sensitive land uses.

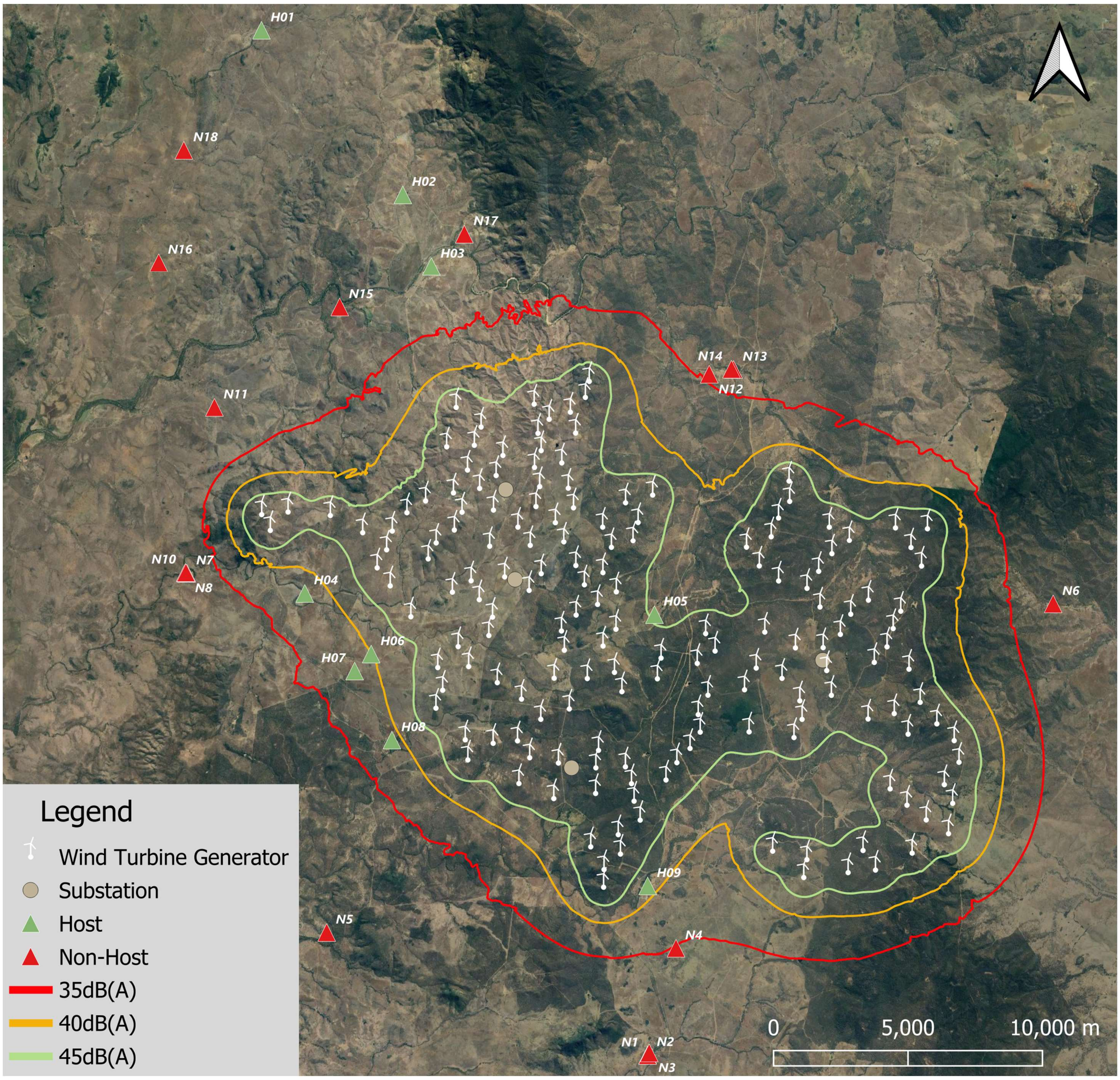
The battery energy storage systems and transformers can achieve the consolidated requirements of the *Environmental Protection (Noise) Policy 2019* to ensure those components do not adversely impact on sensitive land uses.

The assessment confirms the Theodore Wind Farm has been designed to achieve the *baseline* level of State code 23 without reliance on background noise monitoring results.

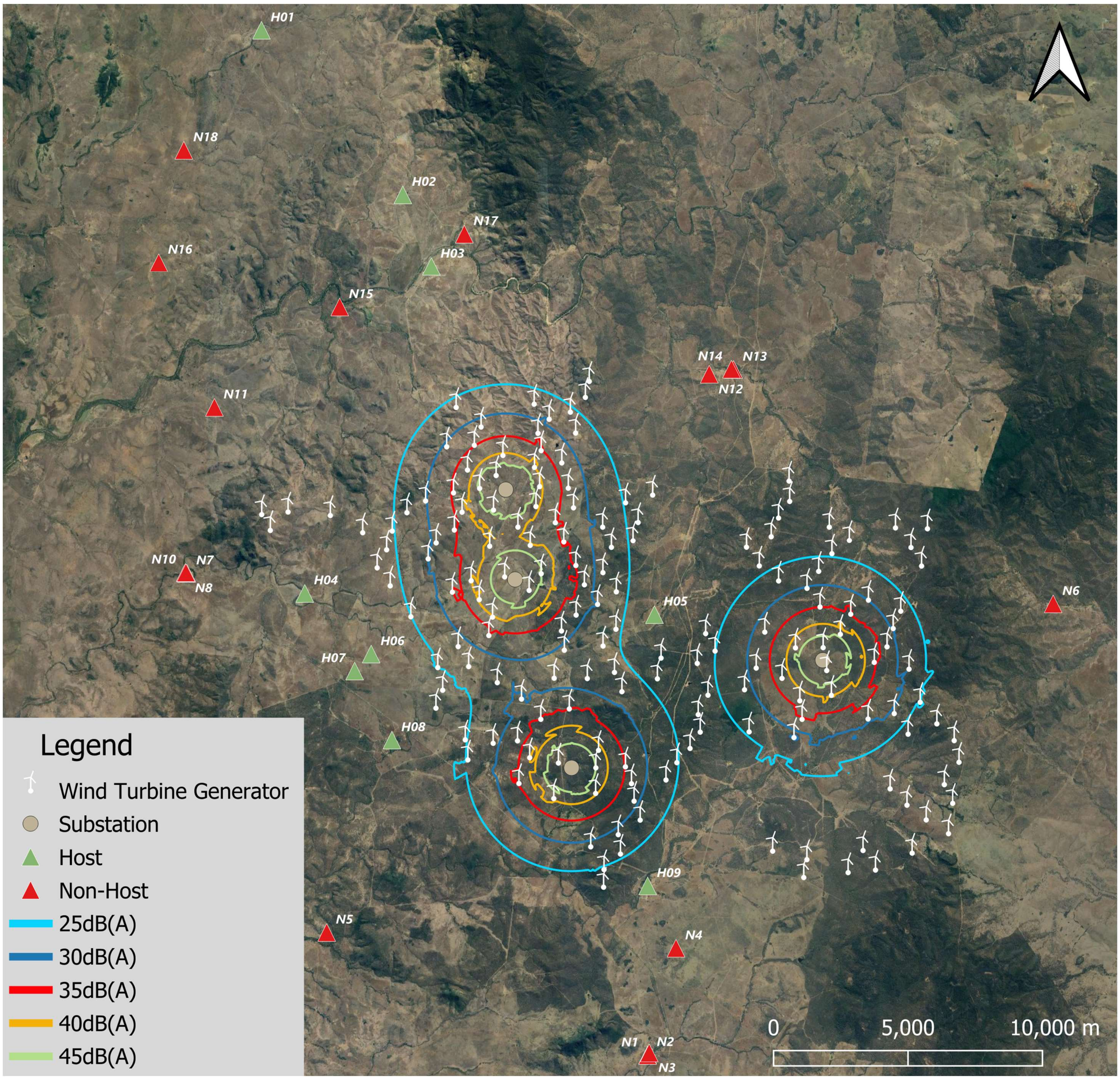
Notwithstanding this design approach, background noise monitoring has been conducted to document the ambient noise in the environment. The data will assist in the future noise monitoring plan (a post approval requirement of State code 23), inform the legislative criteria under State code 23, and provide historical baseline information on the ambient environment should it be required as the project progresses. The results of the background noise monitoring are separately summarised in *Echo Acoustics* report with reference ID "232-5".

Based on the noise impact assessment, the proposed Theodore Wind Farm will satisfy the relevant *State Development Assessment Provisions* and the *Banana Shire Council Planning Scheme* provisions which seek to ensure the project will not unreasonably impact on the acoustic amenity of existing or approved sensitive land uses.

# Appendix A: WTG Noise Prediction Contour



# Appendix B: BESS and Transformer Noise Prediction Contour



# References

*Australian Standard 60076.10:2023 Power transformers, Part 10: Determination of sound levels*

*Banana Shire Council Planning Scheme 2021*

*Environmental Protection Act 1994*

*Environmental Protection (Noise) Policy 2019*

*Environmental Protection (Noise) Policy 2019 - Explanatory notes for SL 2019 No. 154 made under the Environmental Protection Act 1994*

*Institute of Acoustics* (UK) *"A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise", 2013*

*ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*

*Planning guidance - State code 23: Wind farm development February 2022*

*State code 23: Wind farm development* of the *State Development Assessment Provision, Version 3.0, February 2022*

*Vestas Power Solutions - Third octave noise emission EnVentus™ V172-7.2MW – (restricted) Document no 0128-4336_00, dated 30 June 2022*

# Document Details

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