Detailed Noise Assessment – Updated Layouts

Scatec 200MW Wind Farm in Egypt

ECO Consult

REV-1

16 February 2025

Report Approval and Revision Record

Template Code		J-UK-50783	Template Revision No.	REV-1
Version	**Date**	**Description**	**Prepared By**	**Approved By**
REV 0	24/11/2024	Scatec Egypt Wind Farm	ECO Consult	
REV 1	16/2/2025	Scatec Egypt Wind Farm	ECO Consult	

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ACRONYMS

dB	Decibel
dB(A)	Decibel A-weighted
DECC	Department of Energy and Climate Change (UK)
DFIG	Doubly-Fed Induction Generator
EHS	Environment, Health and Safety
ETSU	Energy Technology Support Unit (UK Department of Trade and Industry)
GFRP	Glass Fiber Reinforced Polymer
GNM	Grid Noise Map
GPG	Good Practice Guide
Hz	Hertz
IEC	International Electrical Commission
IFC	International Finance Corporation
IOA	Institute of Acoustics
ISO	International Organisation for Standardisation
kW	Kilowatt
kWh	Kilowatt Hour
L_{A90}	Background Noise (90% Noise Percentile)
L_{Aeq}	A-weighted Equivalent continuous sound pressure level
L_P	Sound Pressure Level
L_W	Sound Power Level
m	Metre(s)
MW	Megawatt
NSR	Noise Sensitive Receptor
UK	United Kingdom
WHO	World Health Organisation
WTG	Wind Turbine Generator

1. INTRODUCTION

1.1 Introduction

This document aims to outline the wind turbine generator (WTG) noise source effects on the surrounding community and sensitive receptors by completing noise prediction calculations. The results of the prediction calculation have been evaluated according to local and international regulations and standards, in particular the IFC Standards and Energy Technology Support Unit (ETSU) guidelines.

1.2 Objectives

As part of this specialist noise study, the following main objectives have been identified and therefore proposed as outcomes for this report:

- Review and analysis of baseline noise data measured at two locations.
- Noise prediction calculations and analysis for identified worst-case noise scenario (Ws = 10 m/s).
- Assessment of the above scenario according to IFC and local regulations.
- Noise impact assessment of the Scatec WTG development on the surrounding noise sensitive receptors (NSRs).

1.3 Input Data

The study is based on the following information:

- General arrangement and layout drawings of the wind farm, including topography.
- Wind turbine supplier data (vendor noise data).
- Baseline noise and metrological data.
- NSR locations.

2. PROJECT DETAILS

2.1 Project Background

The project is located off the Gulf of Suez in the eastern part of Egypt. The Scatec wind farm is located approximately 300 km southeast of the capital. The two Scatec layouts consist of 27 and 25 WTGs respectively and covers an area of approximately 25 km^2.

Figure 1 shows the Project location in a regional context, and Figure 2 and Figure 3 shows the Project location in a local context including the layout of the WTGs.

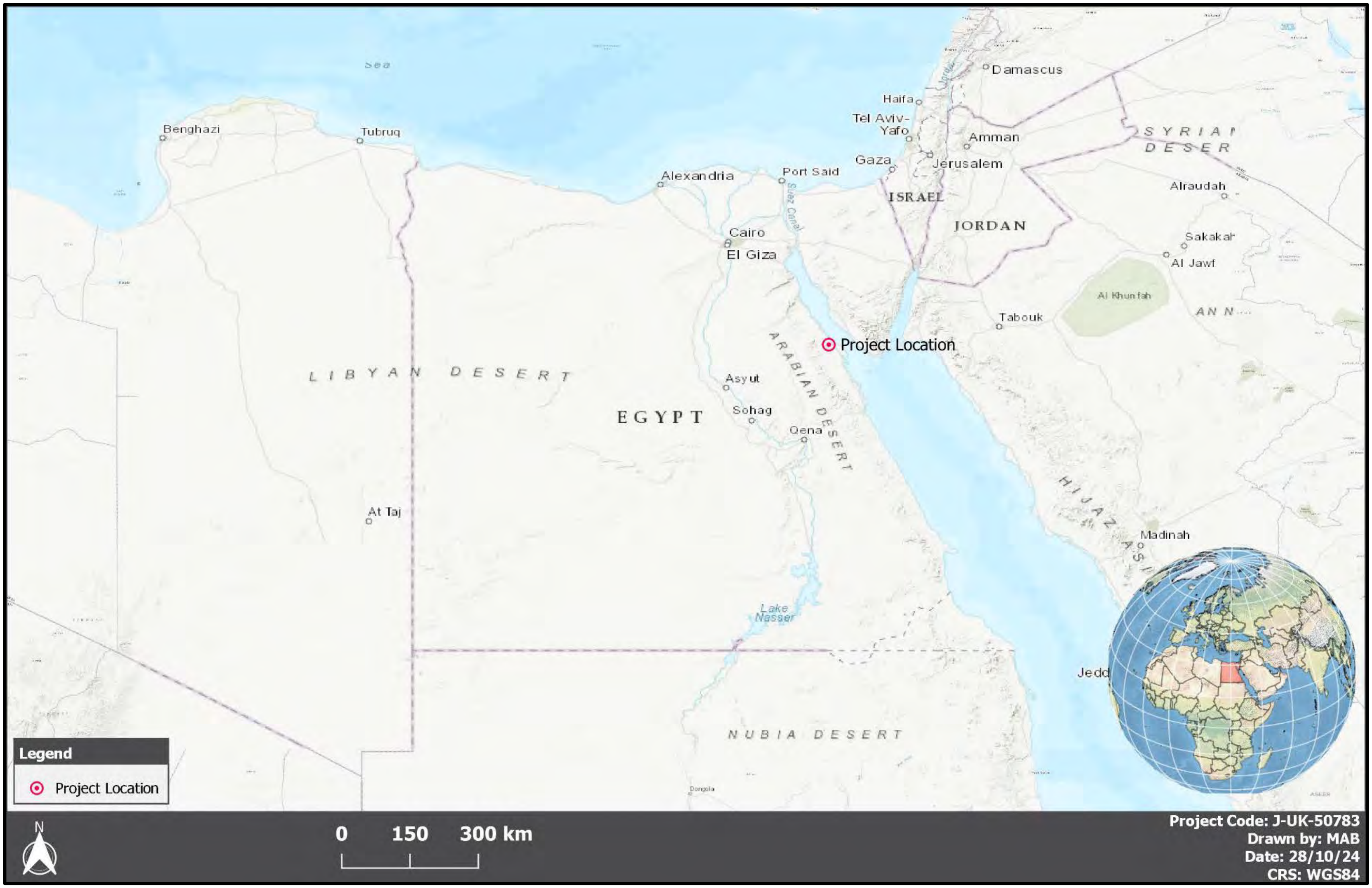

Figure 1: Project Location - Regional Context

Figure 2: Project Location - Local Context - Scatec Layout 1

Figure 3: Project Location - Local Context - Scatec Layout 2

2.2 WTG Technical Specifications

The two layouts for the Scatec wind farm site contain 27 and 25 WTGs respectively. The former each with a power rating of 7.5 MW and a 169.5 m rotor diameter, and the latter each with a power rating of 8.0 MW and 169.5 m rotor diameter.

The summary of the specifications for the Envision EN-169.5/7.5 MW and EN-169.5/8.0 MW to be used for the proposed Project are shown below in Table 1 and Table 2.

Table 1: Wind Turbine Generator Specification (Layout 1)[1]

Manufacturer	Envision
Model Type	EN-169.5/7.5 MW
Rated Power	7,500 kW
Rotor Diameter	169.5 m
Hub Height	100 m
Cut-in Wind Speed	3 m/s
Cut-out Wind Speed	25 m/s
Tower Type	Steel / hybrid – tubular tower
Blade Type	GFRP
Generator Type	DFIG

Table 2: Wind Turbine Generator Specification (Layout 2)[2]

Manufacturer	Envision
Model Type	EN-169.5/8.0 MW
Rated Power	8,000 kW
Rotor Diameter	169.5 m
Hub Height	100 m
Cut-in Wind Speed	3 m/s
Cut-out Wind Speed	25 m/s
Tower Type	Steel / hybrid – tubular tower
Blade Type	GFRP
Generator Type	DFIG

2.3 Noise Sensitive Receptors

Based on a review of Project data and a desktop review of the Project site and surrounding areas, a total of 35 NSRs have been identified near the Scatec wind farm. No other sensitive receptors have been

[1] "Envision, Technical Specification for the Sound Power Level of Envision EN-171/8.0 Wind Turbine Generator, DVP-0037456 B, 26 July 2023"

[2] "Envision, Technical Specification for the Sound Power Level of Envision EN-171/8.0 Wind Turbine Generator, DVP-0037456 B, 26 July 2023"

identified within 2,000 m of any WTGs. Figure 4 and Figure 5 displays the locations of the NSRs and the table below provides their coordinates of the NSRs.

Table 3: Noise Sensitive Receptors

NSR	UTM Coordinates (Zone 36)	
	mE	mN
NSR1	523397	3096856
NSR2	523279	3096627
NSR3	523162	3096619
NSR4	523172	3096781
NSR5	522900	3096702
NSR6	522542	3096304
NSR7	522207	3096304
NSR8	521633	3096530
NSR9	521782	3096199
NSR10	521557	3095902
NSR11	521259	3095529
NSR12	520753	3095702
NSR13	520030	3096184
NSR14	520094	3095446
NSR15	518786	3095195
NSR16	520120	3095195
NSR17	521054	3095253
NSR18	521035	3095080
NSR19	523414	3094699
NSR20	523118	3094477
NSR21	522698	3095475
NSR22	521726	3095417
NSR23	521727	3095302
NSR25	521827	3095647
NSR26	522008	3095582
NSR27	522088	3095846
NSR28	522215	3095936
NSR29	522487	3096077
NSR30	522757	3096184
NSR31	523017	3096269
NSR32	523397	3096856
NSR33	523279	3096627
NSR34	523162	3096619
NSR35	523172	3096781
NSR36	522900	3096702

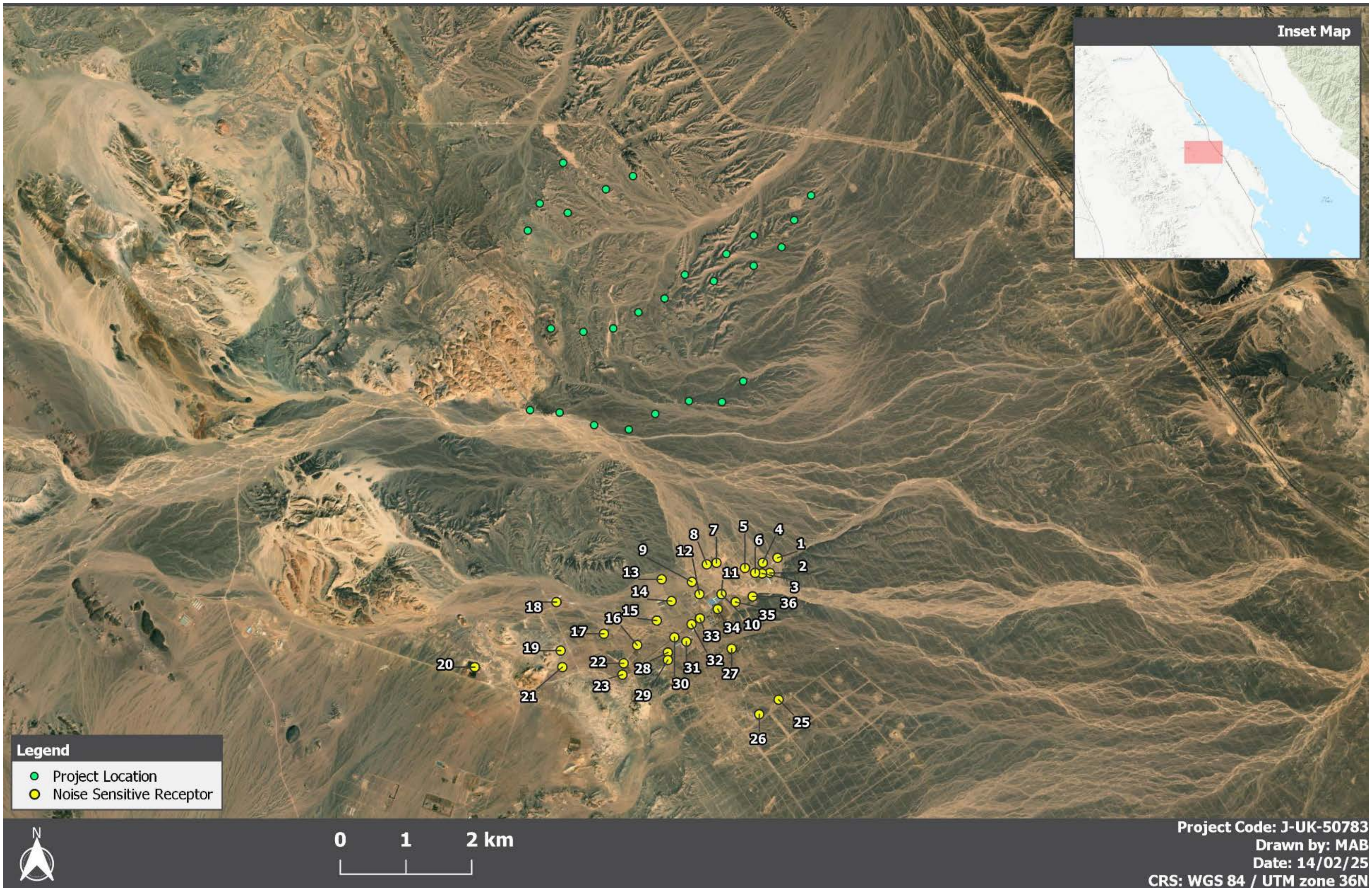

Figure 4: Noise Sensitive Receptors – Scatec Layout 1

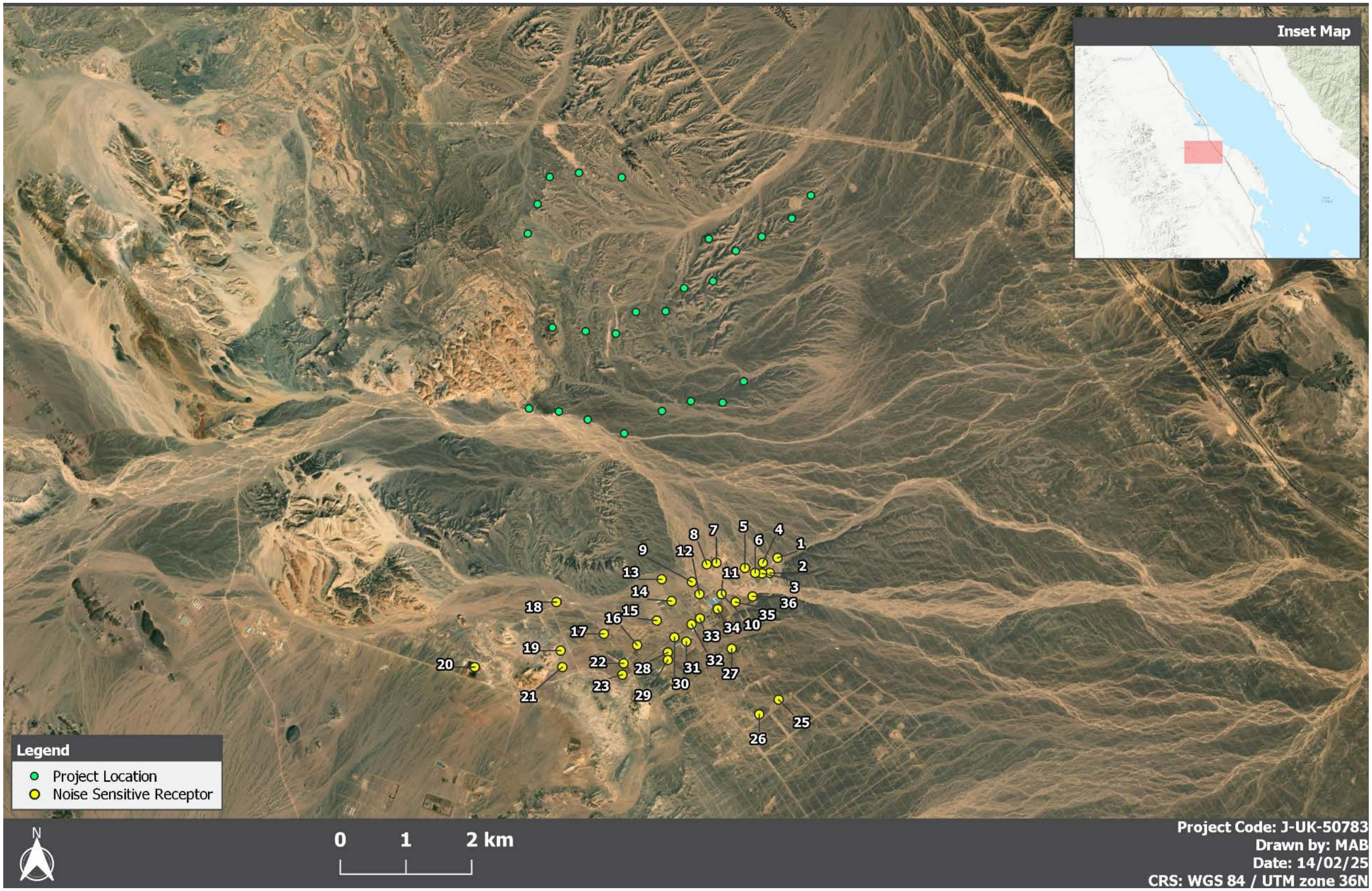

Figure 5: Noise Sensitive Receptors – Scatec Layout 2

2.4 Existing Wind Farms in Surrounding Area

There are existing and / or proposed wind farms present in the surrounding area of the proposed Project locations that have the potential to increase the cumulative noise levels at the identified NSRs. Therefore, the assessment should consider all wind turbine noise emissions that have the potential to increase noise levels at noise sensitive receptors. The figure below shows the locations of the existing wind farms with respect to the Scatec wind farm. These wind farms were included in the model.

2.4.1 SWE Wind Farms

The SWE wind farms contain a total 69 wind turbine generators, each of which houses an Envision EN-171/8.0 MW wind turbine. The table below details the basic specifications.

Table 4: Wind Turbine Generator Specification[3]

Manufacturer	Envision
Model Type	EN-171/8.0 MW
Rated Power	8,000 kW
Rotor Diameter	171 m
Hub Height	100 m
Tower Type	Steel / hybrid – tubular tower
Blade Type	GFRP
Generator Type	DFIG

2.4.2 JICA, KFW & Spain Wind Farms

The JICA, KFW & Spain wind farms contain a total 290 wind turbine generators, each of which houses a Siemens Gamesa SG G80 2.0 MW wind turbine. The table below details the basic specifications.

Table 5: Siemens Gamsea G80 2.0 MW Wind Turbine Generator Specification[4]

Manufacturer	Siemens Gamesa
Model Type	G80 2.0 MW
Rated Power	2,000 kW
Rotor Diameter	80 m
Hub Height	60 m
Tower Type	Conical Steel Barrel Tube
Blade Type	Siemens Gamesa – Fibreglass reinforced with epoxy or polyester resin
Generator Type	Doubly-fed induction machine

[3] "Envision, Technical Specification for the Sound Power Level of Envision EN-171/8.0 Wind Turbine Generator, DVP-0037456 B, 26 July 2023"

[4] Siemens Gamesa G80 2.0 MW power curve and noise emission levels, GD022912-en, 20/07/18

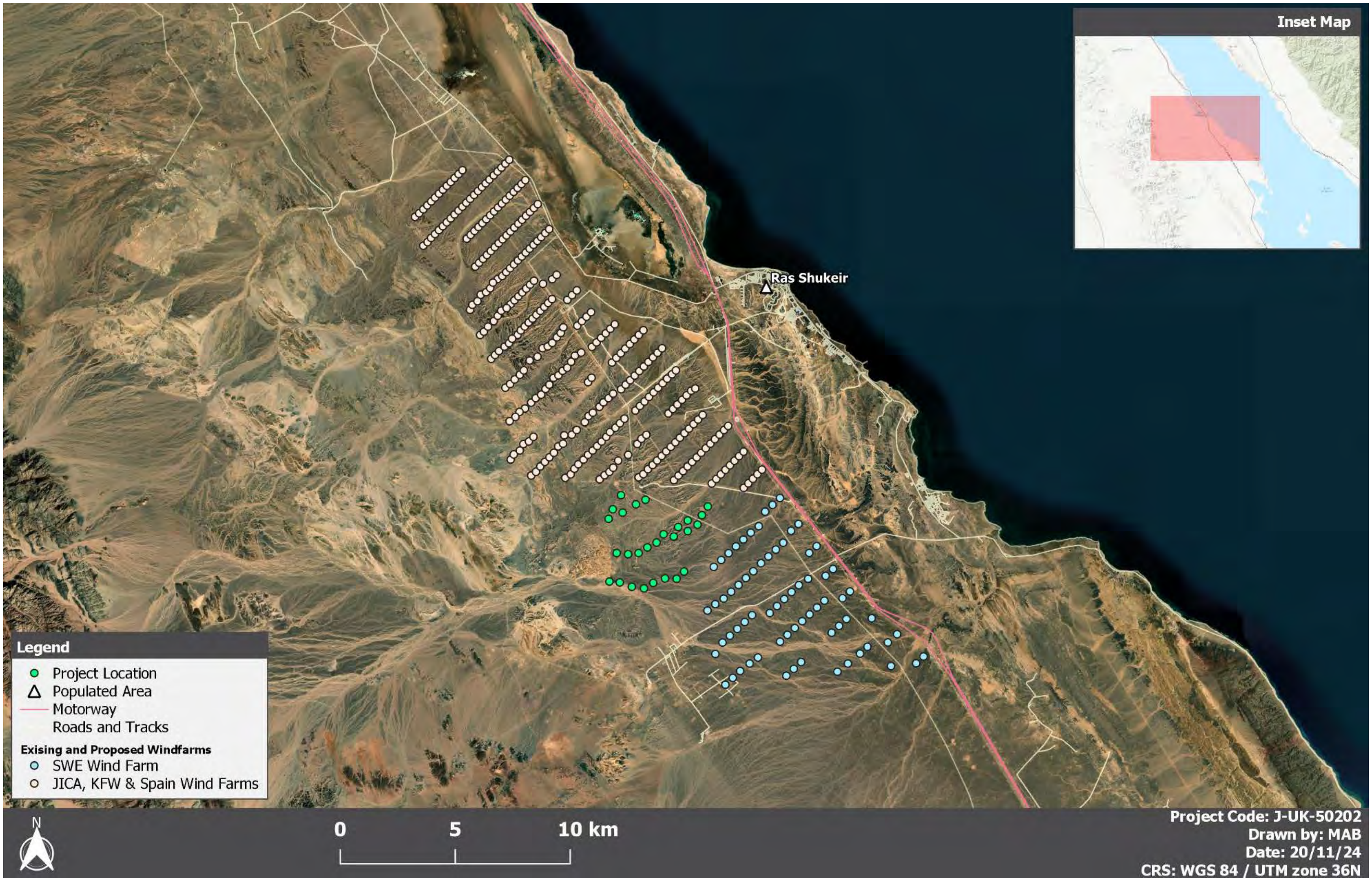

Figure 6: Existing and Proposed Wind Farms – Scatec Layout 1

Figure 7: Existing and Proposed Wind Farms – Scatec Layout 2

3. IDENTIFICATION AND ANALYSIS OF REGULATIONS AND STANDARDS

3.1 Regulatory Framework for Noise Assessments

International guidelines that have been reviewed included the World Health Organisations (WHO) Guideline for Community Noise (WHO 2002)[5] and the World Bank Group / International Finance Corporation (IFC) Environmental Health and Safety (EHS) General Guidance (2007)[6].

A review of international best practices for Wind Turbine Noise is applicable for the noise study, the following are the most applicable:

- ETSU-R-97 'The Assessment and Rating of Noise from Wind Farms produced by the Energy Technology Support Unit (ETSU) for the UK Department of Trade and Industry[7].
- Institute of Acoustics (IOA) Good Practice Guide for Wind Turbine Noise[8].
- The World Bank Group / International Finance Corporation Environmental, Health, and Safety Guidelines for Wind Energy[9].

3.2 Summary of Applicable Standards and Best Practices pertaining to Wind Turbines

The following summarises the main standards and best practice guides to wind turbine noise:

3.2.1 IFC EHS Guidelines on Wind Energy

The IFC EHS Guidelines on Wind Energy refers as follows to noise considerations:

Operational Noise

A description of the main noise producing mechanism is listed along with a general methodology for conducting a noise impact assessment with the following principles:

- Receptors should be chosen according to their environmental sensitivity (human, livestock, or

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[5] World Health Organisation, WHO Guideline for Community Noise, 2002 https://www.who.int/publications/i/item/a68672.

[6] International Finance Corporation, IFC Environmental Health and Safety General Guidance, 2007 https://www.ifc.org/content/dam/ifc/doc/2000/2007-general-ehs-guidelines-en.pdf.

[7] UK Department of Trade and Industry, ETSU-R-97 'The Assessment and Rating of Noise from Wind Farms produced by the Energy Technology Support Unit (ETSU) for the UK Department of Trade and Industry, 1998 https://assets.publishing.service.gov.uk/media/5a798b42ed915d07d35b655a/ETSU_Full_copy__Searchable_.pdf.

[8] Institute of Acoustics, Good Practice Guide for Wind Turbine Noise, 2013 https://www.ioa.org.uk/sites/default/files/IOA%20Good%20Practice%20Guide%20on%20Wind%20Turbine%20Noise%20-%20May%202013.pdf.

[9] International Finance Corporation, Environmental, Health and Safety Guidelines for Wind Energy https://www.ifc.org/en/insights-reports/2015/publications-policy-ehs-wind-energy.

wildlife).

- Preliminary modelling should be carried out to determine whether more detailed investigation is warranted. The preliminary modelling can be as simple as assuming hemispherical propagation (i.e., the radiation of sound, in all directions, from a source point). Preliminary modelling should focus on sensitive receptors within 2,000 meters (m) of any of the turbines in a wind energy facility.
- If the preliminary model suggests that turbine noise at all sensitive receptors is likely to be below an L_{A90} of 35 decibels (dBA) at a wind speed of 10 meters/second (wind speed measured at 10 m height) during day and night times, then this preliminary modelling is likely to be sufficient to assess noise impact; otherwise it is recommended that more detailed modelling be carried out, which may include background ambient noise measurements.
- All modelling should take account of the cumulative noise from all wind energy facilities in the vicinity having the potential to increase noise levels.
- If noise criteria based on ambient noise are to be used, it is necessary to measure the background noise in the absence of any wind turbines. This should be done at one or more noise-sensitive receptors. Often the critical receptors will be those closest to the wind energy facility, but if the nearest receptor is also close to other significant noise sources, an alternative receptor may need to be chosen.
- The background noise should be measured over a series of 10-minute intervals, using appropriate wind screens. At least five of these 10-minute measurements should be taken for each integer wind speed from cut-in speed to 12 m/s.

The above principles are referenced from the following key documents which are described in sections that follow:

- ETSU, Report ETSU-R-97, "The Assessment and Rating of Noise from Wind Farms" (1997).
- Institute of Acoustics (IOA), "A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise", 2013.

3.2.2 ETSU-R-97 "The Assessment and Rating of Noise from Wind Farms" (1997)

Published in September 1996, ETSU Report ETSU-R-97 was a research report produced by the Energy Technology Support Unit (ETSU). ETSU can be regarded as relevant guidance on good practice, it contains a methodology for generating noise limits for a wind turbine and wind farms. ETSU-R-97 is referenced by the UK Government as a best practice guide for UK Legislation.

The assessment procedure of ETSU-R-97 consists of the following steps:

- Predict noise levels from all turbines (existing and proposed) at the nearest receptors.
- Determine a study area.
- Identify potentially affected properties.
- (If required) undertake a measurement survey consisting of simultaneous measurements of

background noise levels at representative properties with wind speed and direction at the proposed turbine site.

- Analyse the data to remove rain affected and atypical data and derive the noise limits for the scheme.
- Update noise predictions & assess compliance with the noise limits for a candidate turbine and provide design advice if compliance with the limits is considered unlikely.

In particular, ETSU-R-97 provides detailed methodology for the setting of external noise limits which are either:

- Relative to the background (L_{A90}); or,
- Fixed when background noise levels are otherwise very low.

3.2.3 IOA Good Practice Guide to ETSU-R-97

The Department of Energy and Climate Change (DECC) invited the Institute of Acoustics (IOA) to form a noise working group to produce a Good Practice Guide (GPG) to the application of ETSU-R-97 in terms of the technical elements only. The document was prepared by a specialist working group and reviewed by a peer group of professionals working in a variety of relevant disciplines. The document should be regarded as a refinement of the ETSU-R-97 guidance to ensure consistency, and this noise assessment follows the guidelines stated therein.

The main guidance in the IOA Good Practice Guide are:

- Background Data Collection.
- Data Analysis and Noise Limit Derivation.
- Noise Prediction Modelling.
- Cumulative Noise Assessment Principles.

Further the GPG clarifies the following main issues from ETSU-R-97:

- ISO 9613 is to be used for Wind Turbine noise predictions, with particular stipulations and limitations.
- The background noise measurements (and thereby defining limits) are to be corrected for wind shear by correlating the background noise measurements with the standardised wind speed at 10 m height which is derived from the hub height wind speed using a standard equation.

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

ISO 9613-2:1996 Part 2[10] describes a method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level (as described in ISO 1996) under meteorological conditions.

The application and further description of the ISO 9613-2 standard is described in Section 7 – Noise Model of this report.

4. BASELINE MEASUREMENTS

4.1 Noise Monitoring Survey

A noise monitoring survey commenced at two locations at the Project site on 27th January 2024 and finished on 10th February 2024. The purpose of the survey was to measure background noise levels across a range of wind speeds. The measurements were taken continuously in 10 minute intervals.

4.2 Sound Level Meter Details

Two B&K 2250's (S/N: 3010390 & 2709811) 'type 1' integrating sound level meters, together with a multi-function acoustic calibrator type 4231, were used for the measurement survey. The selected sound level meters automatically log environmental noise measurement parameters including L_{A90}. Noise measurements were made in accordance with best practice advocated in the International Standard "ISO 1996 Description and Measurement of Environmental Noise" [11] as well as ETSU-R-97 which gives key considerations for the selection of measurement locations.

The factory calibrated noise meter was also field calibrated prior to use and following field measurements in order to detect any potential 'drift' in the measurements. Calibration certificates are presented in Appendix B.

4.3 Microphone Orientation

During the noise measurements, the microphone was placed to ensure protection from air currents, vibrations, electric or magnetic fields, dust, and other influences that may affect the noise reading. There were no reflecting structures (other than the ground) so that the influence of reflections was minimised. The height of the microphone was set at 1.5 m above the ground level.

[10] International Organisation for Standardisation (ISO), ISO9613-2 'Acoustics – Attenuation of Sound During Propagation Outdoors', 2024 https://www.iso.org/standard/74047.html.

[11] "International Organization for Standardisation (ISO) 1996-1: 2003 'Description and Measurement of Environmental Noise'," 1996 https://cdn.standards.iteh.ai/samples/59765/b0c065255b7a45658425773086323f0e/ISO-1996-1-2016.pdf.

4.4 Meteorological Conditions

Weather conditions were generally found to be suitable during baseline noise monitoring. A period of rain was identified during the night hours of 2nd and 3rd February. Wind speed and direction were recorded at 10-minute averaging intervals, extracted from the Project met mast positioned at a hub height of 100 m.

4.5 Noise Survey Location

The IOA GPG states that the 'study area for background noise surveys (and noise assessment) should, as a minimum, be the area within which noise levels from the proposed, consented and existing wind turbine(s) may exceed 35 dB L_{A90} at up to 10 m/s wind speed'.

Considering the above, the selected noise monitoring sites were positioned to the west of the wind farm site, strategically placed within the region where the majority of NSRs are situated and can be considered representative of the other NSRs located within the same area. The location of the noise monitoring point / NSR is shown in Figure 8 and Figure 9 with the coordinates provided in the table below.

Table 6: Noise Sensitive Receptor / Noise Monitoring Location Coordinates

NSR	Coordinates UTM (Zone 36)	
	Easting mE	Northing mN
Noise Measurement Location 1	520901	3096119
Noise Measurement Location 2	521699	3094785

4.5.1 Noise Measurement Methodology

All measurements were taken as per the procedures and requirements set out in ETSU-R-97. The main measurement considerations as summarised by the IOA GPG are as follows:

- Measurements should be made in amenity areas between 3.5 and 20 metres from a dwelling.
- The measurement position should permit measurement of 'background noise levels judged to be typical/indicative of the area around the associated dwelling and any other dwellings for which the measurement location will serve as a proxy.
- The influence of noise from local sources should be taken into account when selecting measurement locations.
- The person selecting background noise monitoring positions and visiting these locations should record subjective impressions of sources contributing to local ambient noise levels.
- Residents should be consulted to establish the occurrence of unusual noise events during the monitoring period.

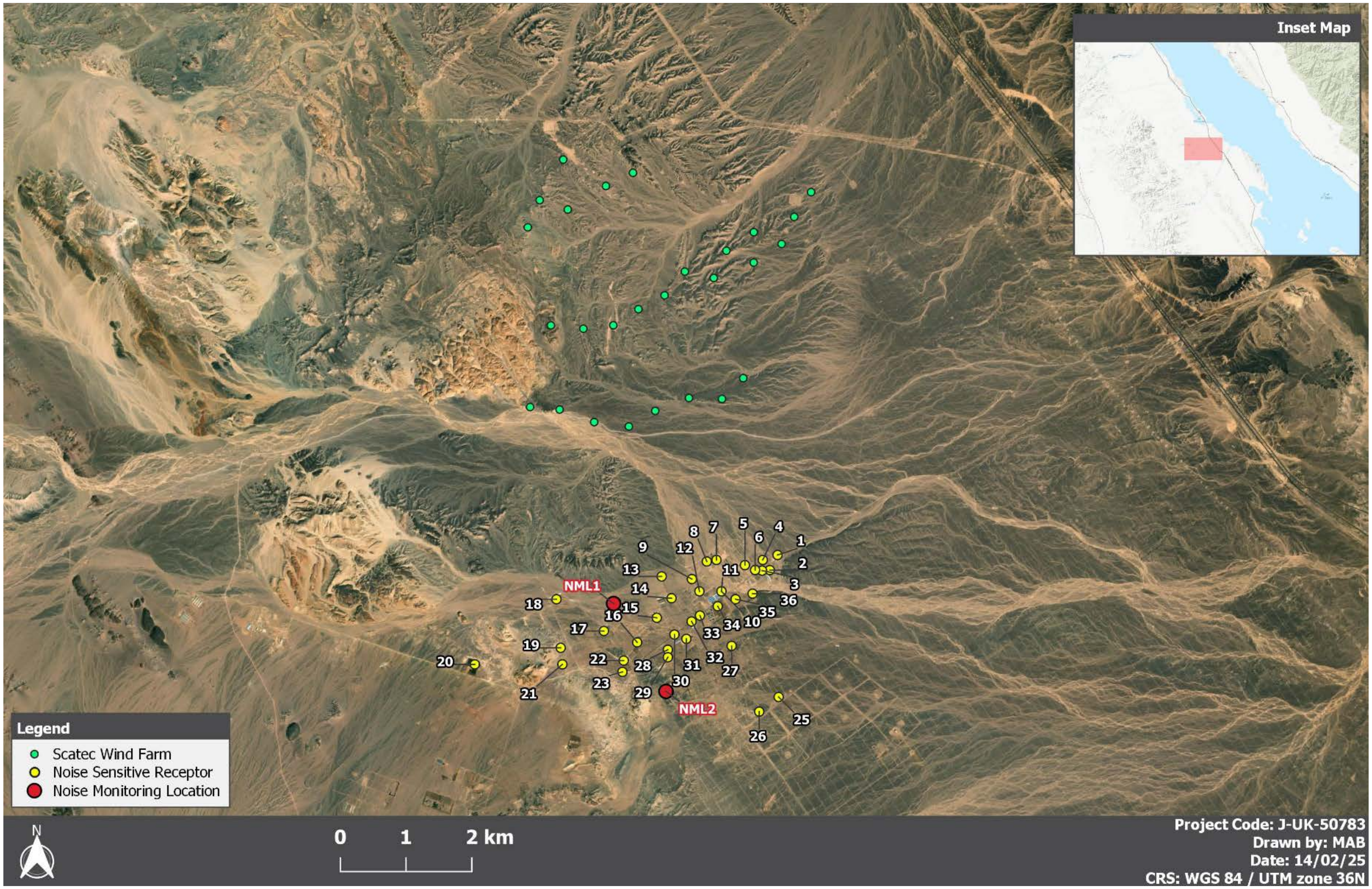

Figure 8: Location of Noise Measurement Site – Scatec Layout 1

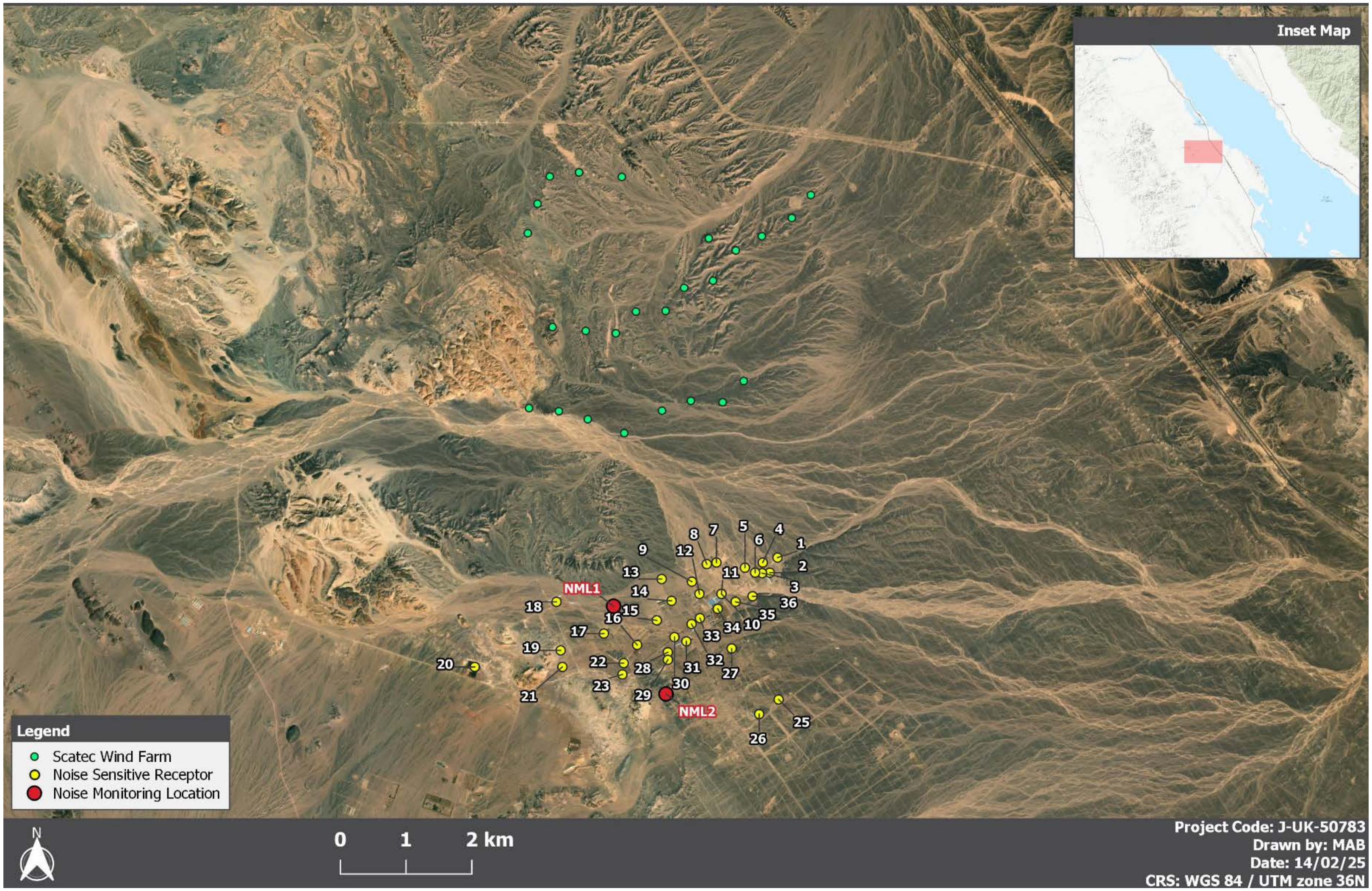

Figure 9: Location of Noise Measurement Site – Scatec Layout 2

4.6 Noise Survey Summary

The survey methodology followed is summarised in the table below.

Table 7: Summary of Noise Survey Methodology

Parameters	L_{Aeq} and L_{A90}
Equipment	Type 1 Sound Level Meter (SLM) Field Calibrator Wind shield Heavy Duty Tripod
Reference method	ISO 1996-1:2003 (International Organization for Standardisation (ISO) 1996-1: 2003 'Description and Measurement of Environmental Noise', 1996)
No. locations	2
Measurement interval	10 minutes
Duration (per location)	15 days
Data Points	NML 1: 2016 NML 2: 2016
Dates covered	27th January 2024 to 10th February 2024
Calibration drift over measurement period	0 dB

Measurement parameters were recorded within the sound level meters' in-built memory and retrieved using the associated software.

4.7 Windspeed

Wind speed data was recorded from a met mast located in the vicinity of the proposed wind farm site. The mast supports a variety of instruments at several heights as per the configuration shown in the table below.

Table 8: Key Component Configuration of Wind Mast

Equipment	Height (m)	Measurement Units	Manufacturer/SN
Anemometer 1	100	m/s	03223704
Anemometer 2	82	m/s	03223703
Anemometer 3	60	m/s	03223701
Wind Vane 1	96	deg	03222135
Wind Vane 2	80	deg	03222137
Wind Vane 3	22	deg	03222132
Thermometer	91	deg C	253753
Barometer	91	mb	B22 0162

The data from all instruments on the mast is captured on a 10-minute averaging period by a data logger. The banked data is then downloaded to cover the requisite monitoring period.

The wind speeds taken from the station were scaled to W_{10} (windspeed at 10 m) as per ETSU-R-97.

5. NUMERICAL ANALYSIS OF BASELINE DATA SET

5.1 Data Analysis and Noise Limit Derivation

ESTU-97-R states that the purpose of data analysis is to provide a representative background noise level across a range of wind speeds for the daytime and night-time hours and therefore define appropriate noise limits for a proposed wind energy development.

The procedure for the analysis of background data is as follows:

- Limiting atypical noise sources during a designated period of noise measurement is essential to capture a representative depiction of the prevailing noise environment at a given measurement location.
- Data filtering of noise, the L_{A90},10-minute noise levels and average 10-minute wind speed data pairs are plotted on a scatter plot. To minimise the influence of atypical noise sources, filtering the data is generally required. Examples of atypical noise sources include low flying aircraft, 'dawn chorus' (morning birds), rainfall and traffic noise.
- Regression analysis using polynomials (unless heavy traffic noise is considered) is used and in most cases third order polynomials should be sufficient to allow reasonable representation of the prevailing background noise levels during the survey period.
- The derived prevailing background noise polynomial curve should not be extended beyond the range of covered by 'adequate' data points and for higher wind speeds it should be restricted to the highest point. Similar corrections should be undertaken for low wind speeds, i.e. the lowest derived background noise level is adopted for all wind speeds below where this derived minimum occurs. The above-described considerations are illustrated in the figure example below.

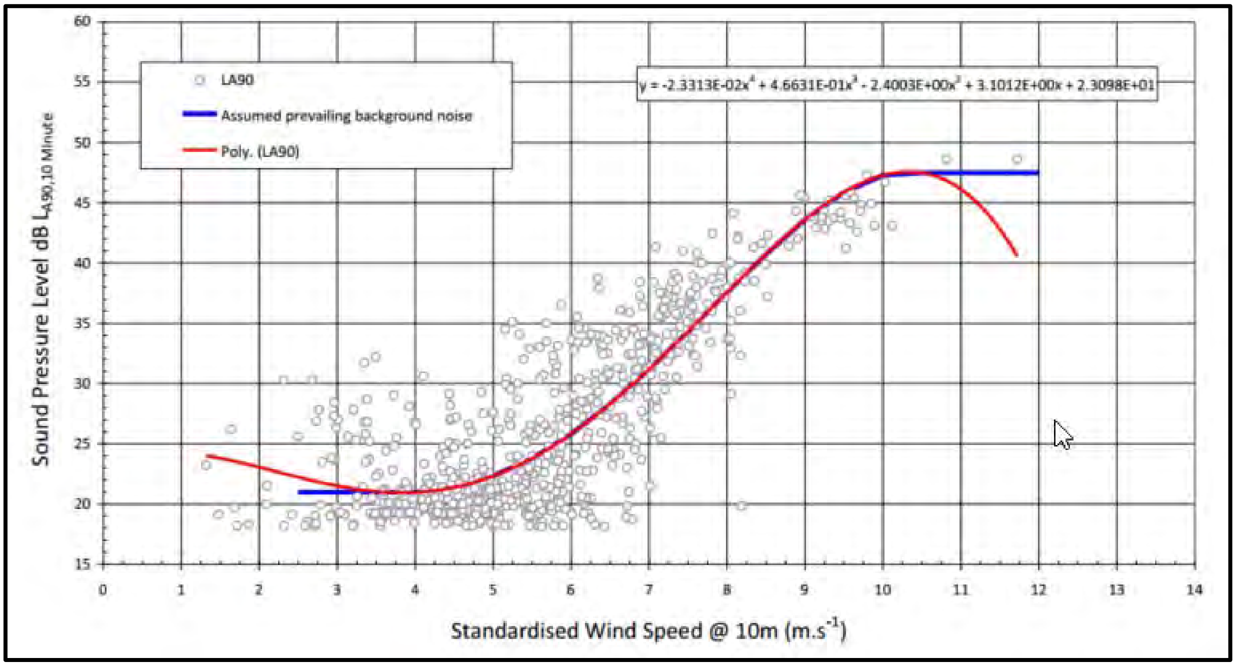

Figure 10: Example of limiting lower and upper prevailing background noise levels[12]

5.2 Correction for Wind Shear

The Institute of Acoustics GPG requires that wind shear on site is taken into account for the noise assessment. Wind Shear (or wind gradient) is a difference in wind speed and/or direction in the atmosphere. Generally pertaining to wind turbines, the horizontal wind shear is considered, which is the change in wind speed with change in altitude.

The use of the standard wind speed at 10 m height is preferred and is derived from the hub height wind speed according to the log law equation. This equation describes the variation in wind speed with height. The ground roughness is set at 0.05 m.

$$V_{10} = V_{hh} \cdot \frac{\ln\left[\frac{10}{Z_0}\right]}{\ln\left[\frac{hh}{Z_0}\right]} \qquad (1)$$

Where:

- V_{10} = Wind speed at 10 m height;
- V_{hh} = Wind speed at hub height; and
- Z_0 = Ground roughness length (0.05 m).

[12] Institute of Acoustics, Good Practice Guide for Wind Turbine Noise, 2013 https://www.ioa.org.uk/sites/default/files/IOA%20Good%20Practice%20Guide%20on%20Wind%20Turbine%20Noise%20-%20May%202013.pdf.

5.2.1 Noise Measurement Results

Noise measurement results from the measurement period is shown in the figures below, plotting sound level versus time for both the background noise level (L_{A90}).

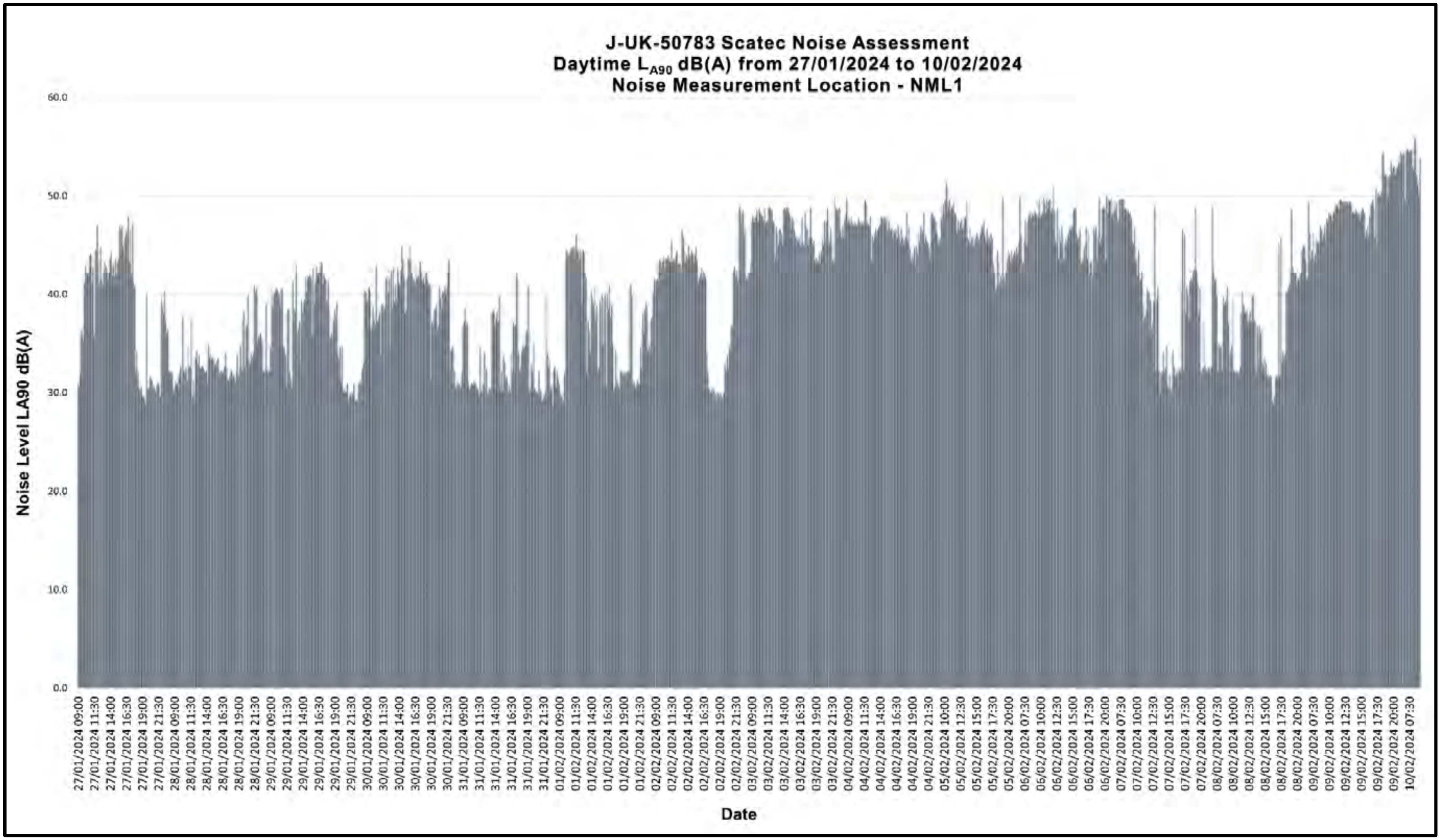

Figure 11: Daytime Noise Plot for Baseline Measurements – Measurement Location NML1

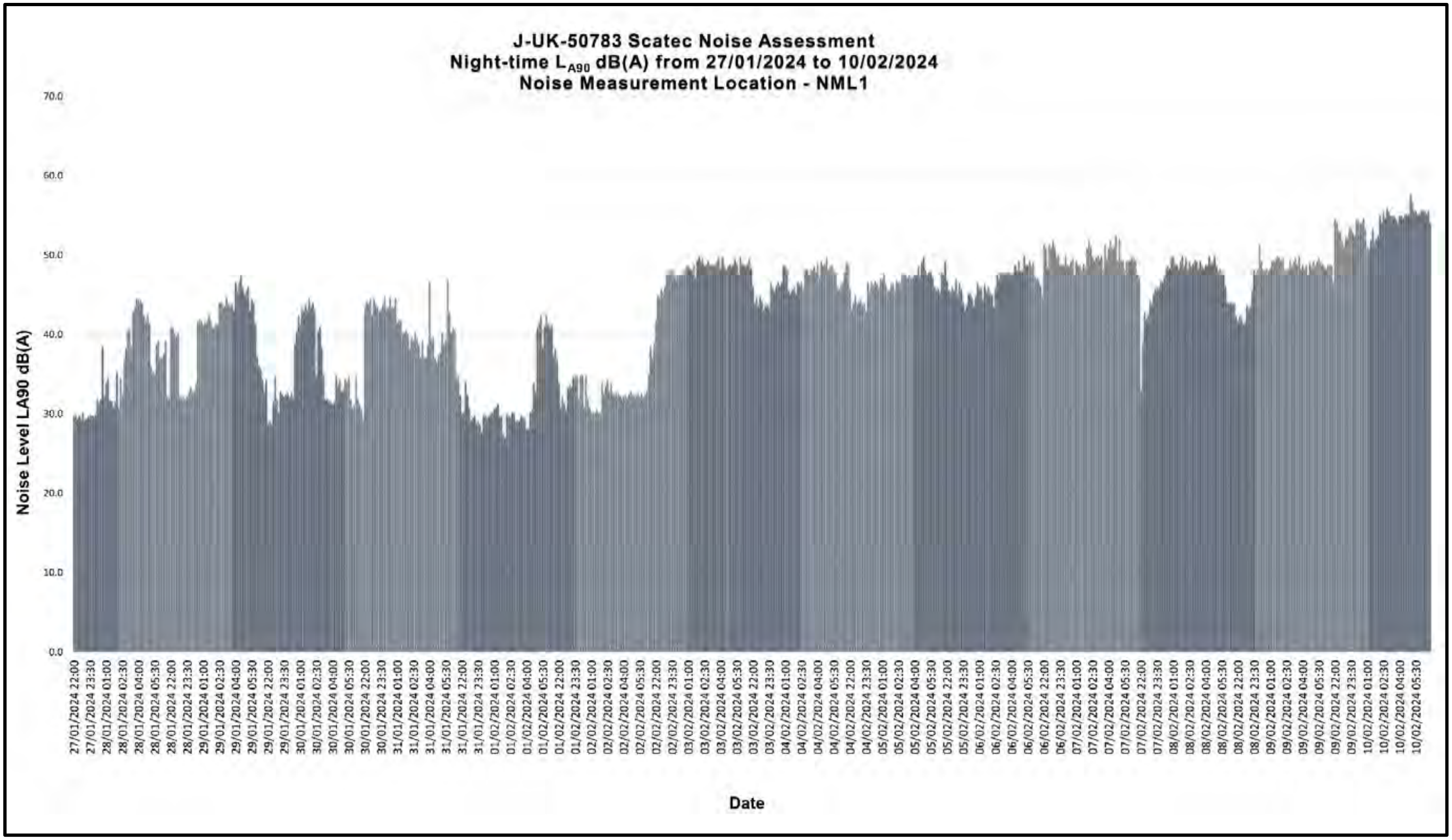

Figure 12: Night-time Noise Plot for Baseline Measurements – Measurement Location NML1

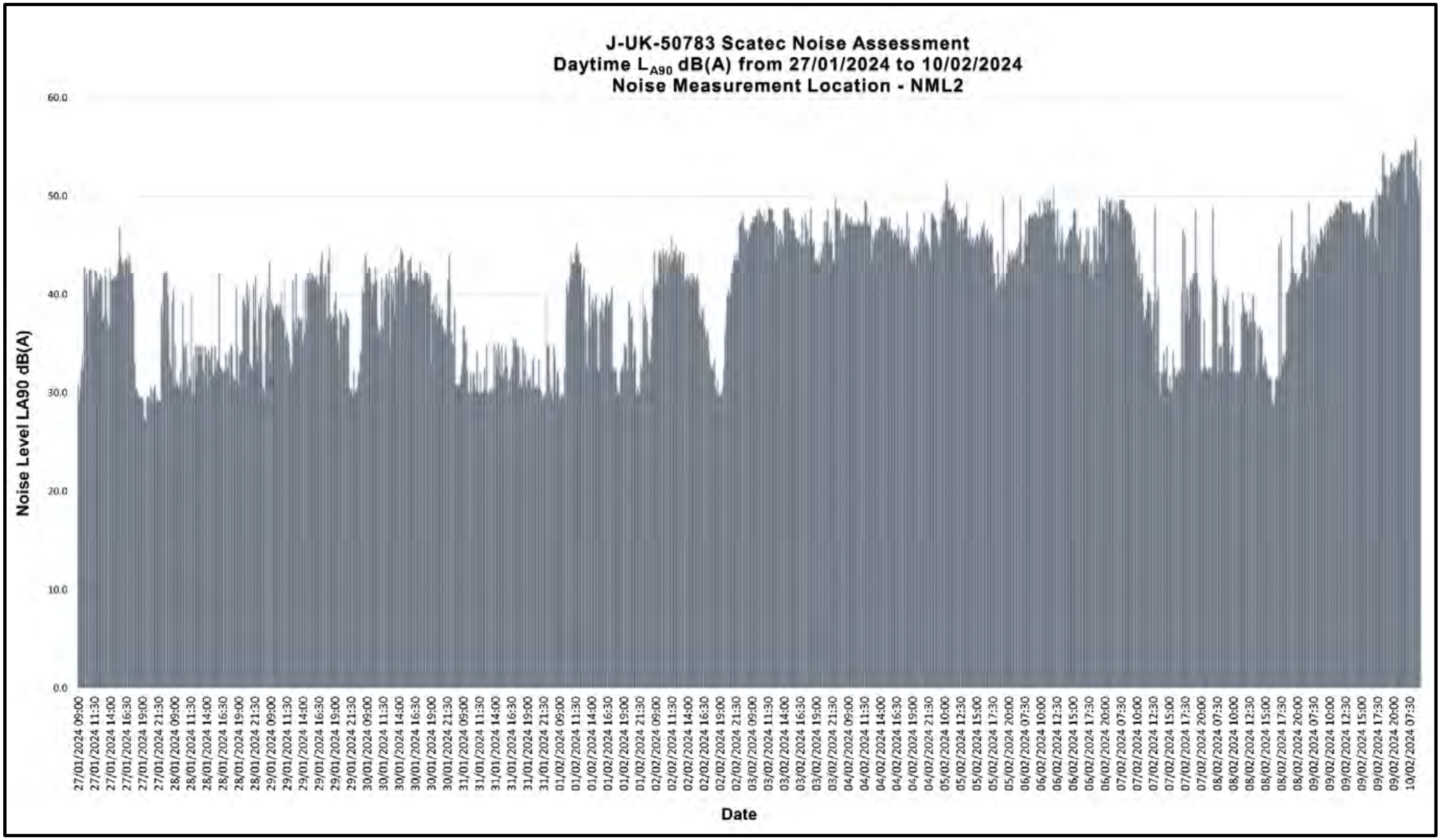

Figure 13: Daytime Noise Plot for Baseline Measurements – Measurement Location NML2

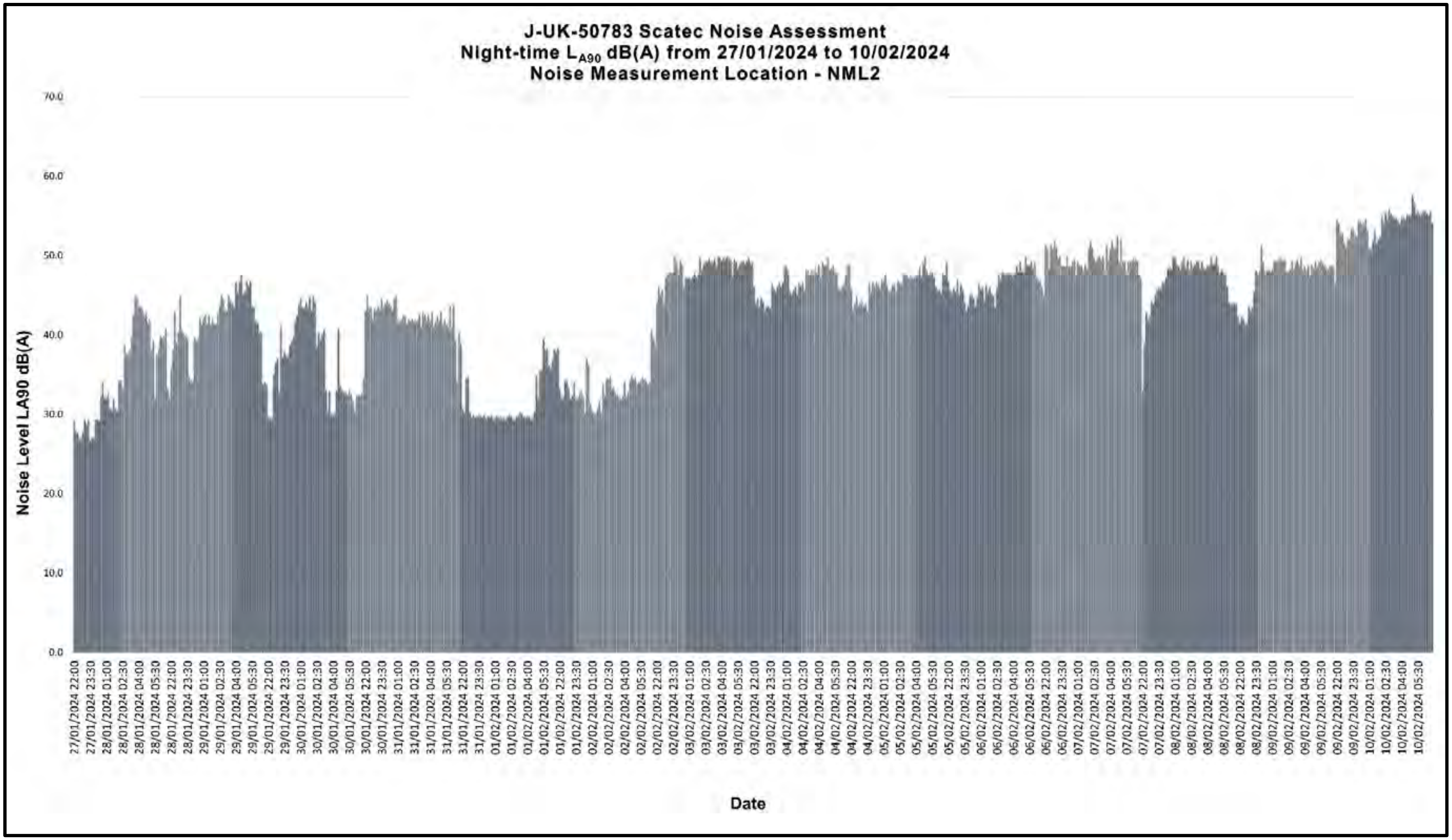

Figure 14: Night-time Noise Plot for Baseline Measurements – Measurement Location NML2

5.2.2 Determination of Background Noise vs. Wind Speed Relationship

Baseline data was filtered and divided into daytime and night-time hours as per defined time periods of ETSU-R-97 and IFC guidelines. The data points were then plotted in a scatter plot with L_{A90} (considered representative of background noise) displayed as a function of windspeed. A polynomial regression of the relationship between these parameters was then calculated. Where there were periods of rain, these data points were removed from the dataset.

The relationships derived for L_{A90} as a function of windspeed for the daytime and night-time periods over the course of this monitoring campaign are shown in Figure 15 and Figure 16.

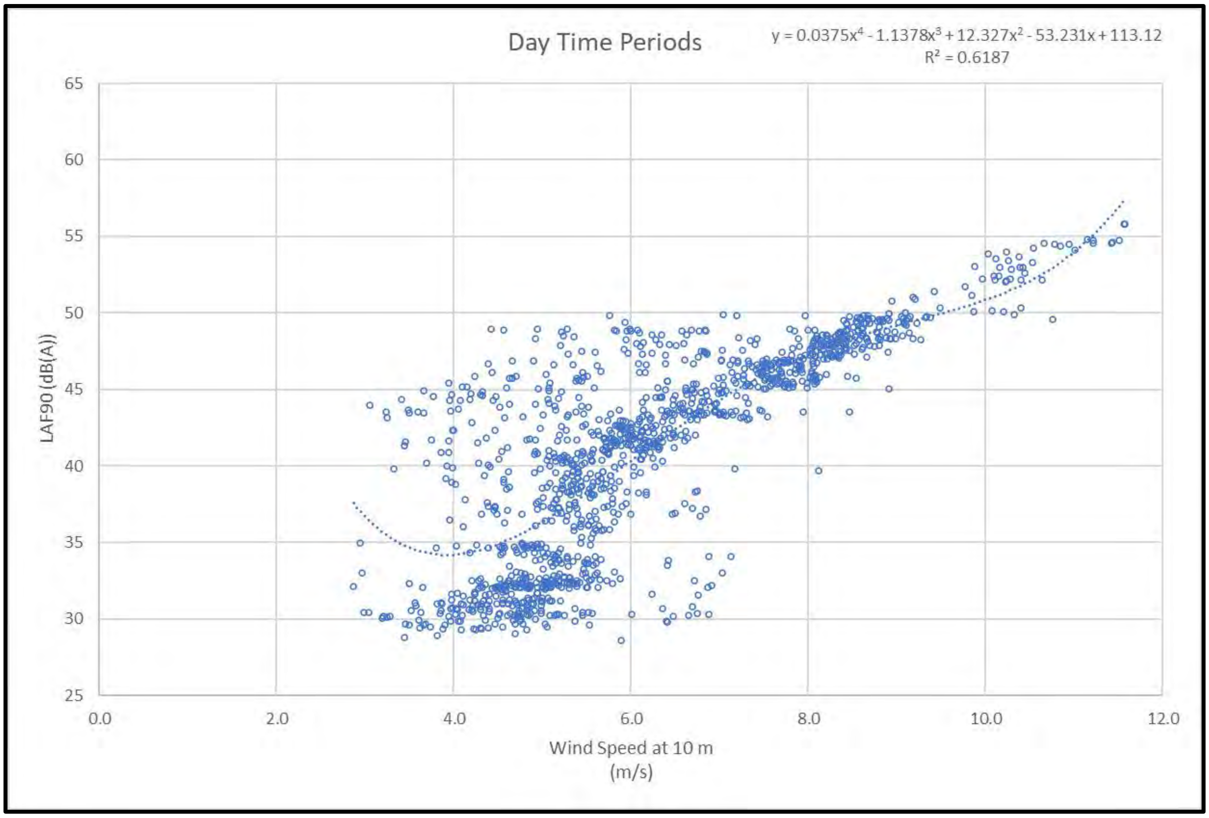

Figure 15: NM1 - Background Noise as a Function of Windspeed – Daytime

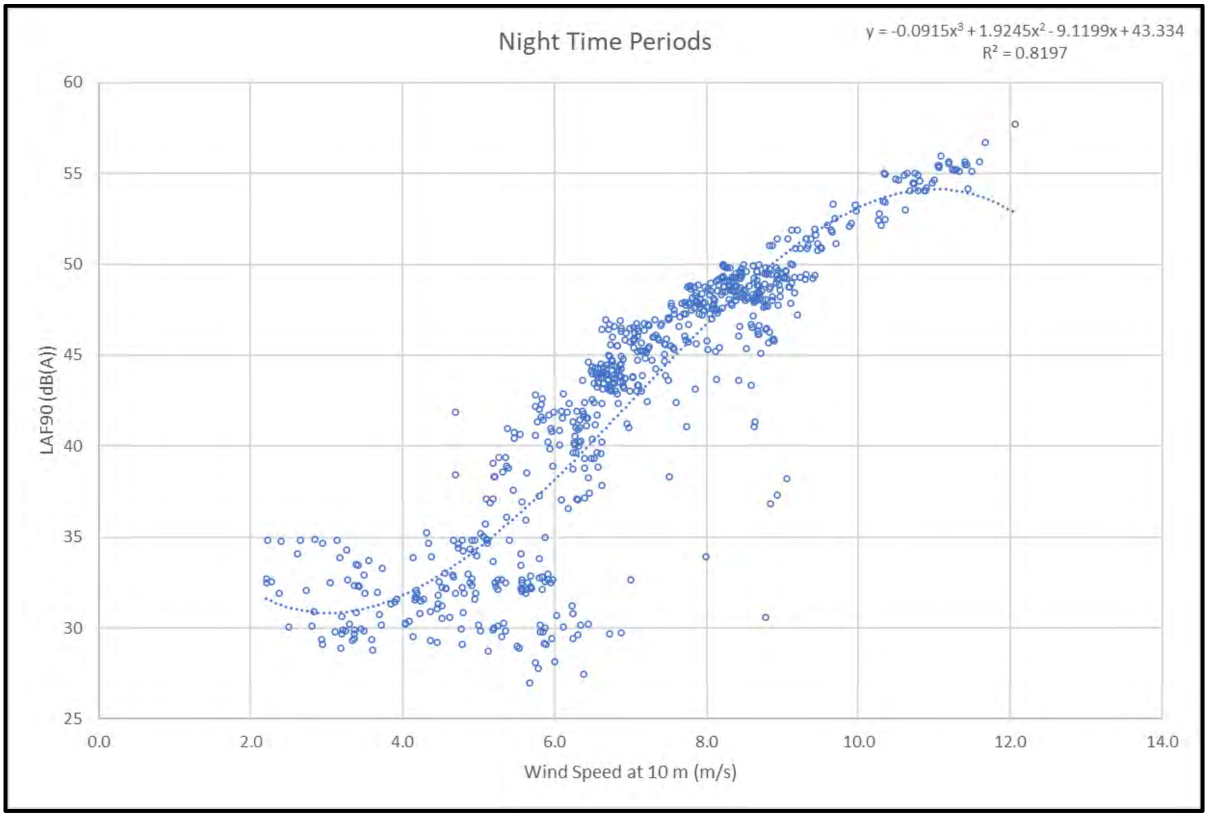

Figure 16: NM1 - Background Noise as a Function of Windspeed – Night-time

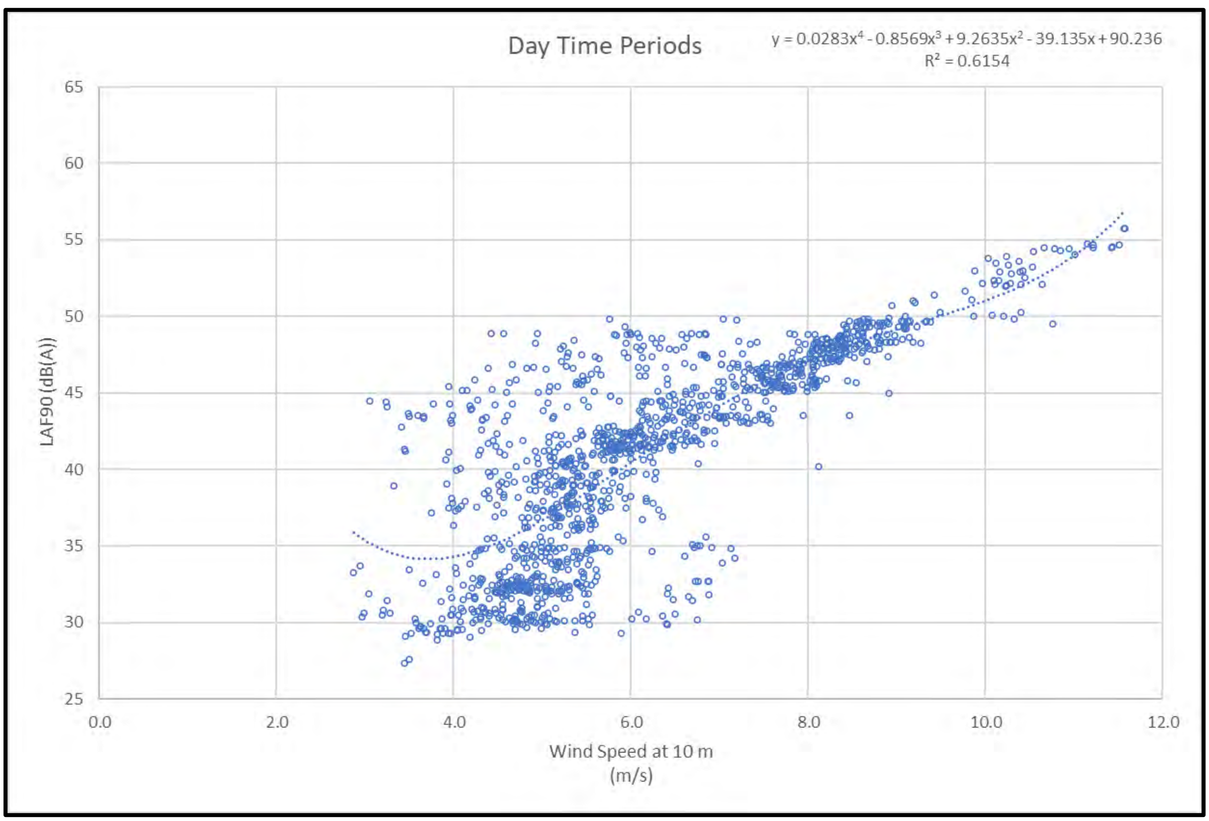

Figure 17: NM2 - Background Noise as a Function of Windspeed – Daytime

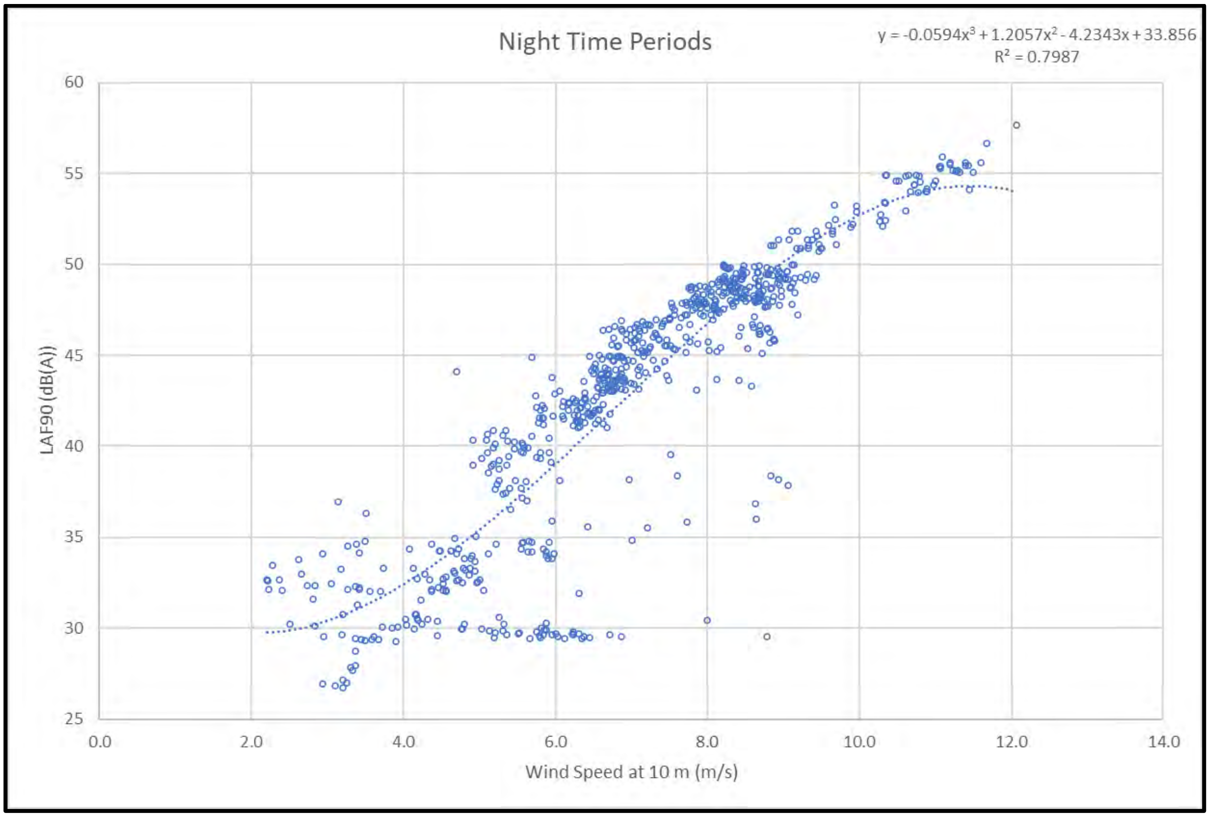

Figure 18: NM2 - Background Noise as a Function of Windspeed – Night-time

6. WIND TURBINE GENERATOR

6.1 Description of Wind Turbine Noise

There are two main generated noise sources from wind turbines:

- Aerodynamic Noise – produced from the flow of air around the blades.
- Mechanical Noise – produced from the mechanical and electrical components within the nacelle (the cover housing the generating components of a WTG).

6.1.1 Aerodynamic Noise

Aerodynamic noise is produced from the flow of air around the blades. These acoustic emissions can be either tonal or broadband. Broadband noise has a frequency spectrum where there are no discreet or dominant tones (non-periodic and relatively random phase and amplitude), whereas tonal noise is dominated by specific frequencies which are clearly identifiable. The figure below is a simplified representation of the airflow over a wind turbine blade.

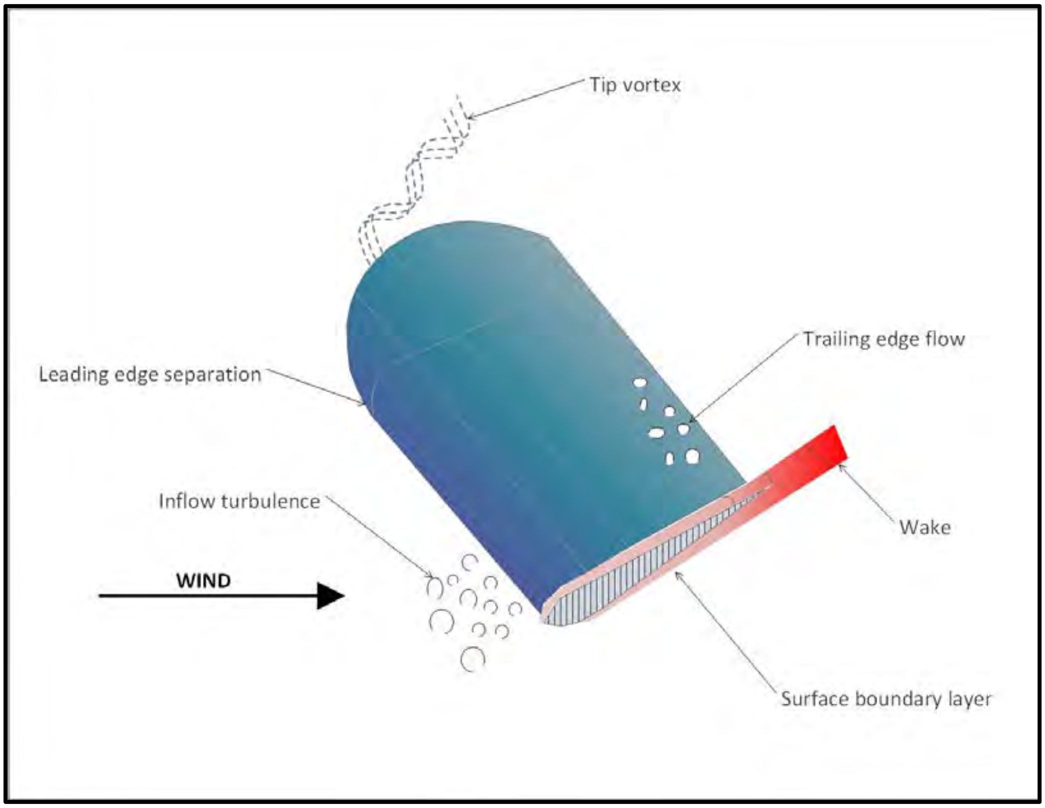

Figure 19: Simplified representation of airflow over a WTG blade

Aerodynamic broadband noise from wind turbines is emitted as the blades spin and interact with atmospheric turbulence as the displaced air flows along the blade surfaces. This produces a so-called "wooshing" sound through several mechanisms:

- Inflow turbulence noise occurs when the rotor blades encounter atmospheric turbulence as they pass through the air. Uneven pressure on a rotor blade causes variations in the local angle of attack, which affects the lift and drag forces to cause aerodynamic loading fluctuations. This generates noise that varies across a wide range of frequencies but is most significant at levels below 500 Hz.
- Trailing edge noise is produced as boundary-layer turbulence around the air foil passes into the wake, or trailing edge, of the blade. This noise is distributed across a wide frequency range but is most notable at high frequencies between 700 Hz and 2 kHz.
- Tip vortex noise occurs when tip turbulence interacts with the surface of the blade tip. While this is audible near the turbine, it tends to be a small component of the overall noise further away.
- Stall or separation noise occurs due to the interaction of turbulence with the blade surface.

6.1.2 Mechanical Noise

Mechanical noise is produced and is emitted by the mechanical and electro-mechanical machinery located within the nacelle. The figure below shows a basic view of the nacelle and components common to most wind turbines.

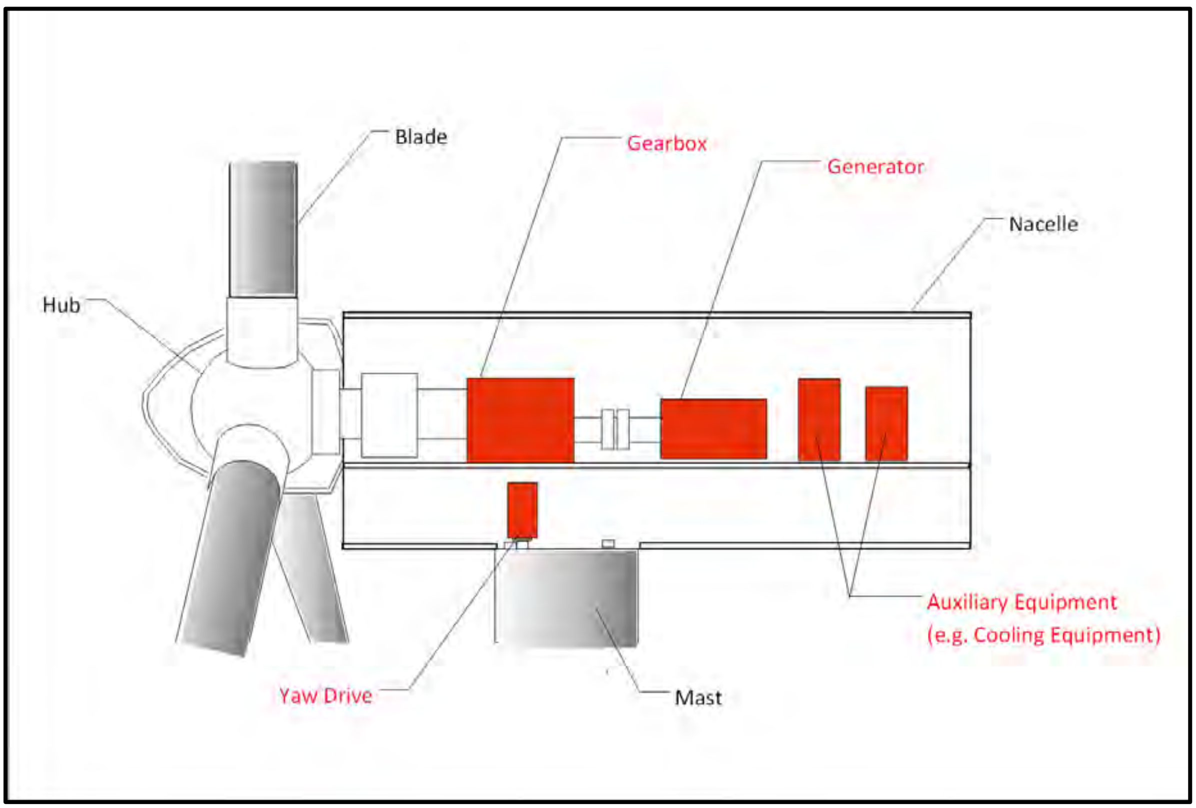

Figure 20: Schematic of WTG hub and nacelle of typical WTG

6.2 Envision EN-169.5/7.5 MW and EN-169.5/8.0 MW Wind Turbine Generator

The EN-169.5/7.5 MW wind turbine generator (WTG) features a power rating of 7.5 MW and 169.5 m rotor diameter, while the EN-169.5/8.0 MW wind turbine generator (WTG) features a power rating of 8.0 MW with the same rotor diameter. They both feature a three bladed fibreglass infusion-molded construction, mounted upwind of the tower. The gearbox has 3 stages of high speed, and the generator is a doubly-fed asynchronous three phase generator with a wound rotor motor, connected to a frequency Pulse-Width Modulation (PWM) converter.

The specifications for the EN-169.5/7.5 MW and the EN-169.5/8.0 MW wind turbines to be used for the proposed Project are shown in the table below.

Table 9: EN-169.5/7.5 MW Specification

General Details	
Rated Power	7,500 kW
Wind Class	N/A
Rotor Diameter	169.5 m
Swept Area	28,730.25 m^2
Power Density	261.05 W/m^2
Gearbox	3 Stage
Generator	DFIG
Frequency	50 Hz
Blades	
Length	83.9
Airfoil / Blade Type	Conventional design with structural shells
Physical Dimensions	
Hub Height	100 m
Tower Type	Steel/hybrid – tubular tower

Table 10: EN-169.5/8.0 MW Specification

General Details	
Rated Power	8,000 kW
Wind Class	N/A
Rotor Diameter	169.5 m
Swept Area	28,730.25 m^2
Power Density	278.45 W/m^2
Gearbox	3 Stage
Generator	DFIG
Frequency	50 Hz
Blades	
Length	83.9
Airfoil / Blade Type	Conventional design with structural shells
Physical Dimensions	
Hub Height	100 m
Tower Type	Steel/hybrid – tubular tower

6.2.1 Envision Noise Source Data

Noise source emission data, sound level performance specifications, noise emission analysis and sound warranties for the proposed Envision turbines are described below.

Sound power levels are derived from acoustics test measurements in accordance with IEC 61400-11 ed. 3 Wind Turbine Generator Systems – Part 11: Acoustic noise measurement techniques[13].

The sound power level at full rated power output for EN-169/7.5 MW and EN-169.5/8.0 MW (high rpm) is 110.1 dB(A) and 111.1 dB(A) respectively and is therefore considered a worst-case scenario.

A 2 dB correction has been applied to take into account uncertainty.

Table 11: Envision Modelling Scenario for Assessment (EN-169.5/7.5 MW)

Scenario Description	Wind Speed (at 10 m)	Sound Power Level dB(A)	Correction for Uncertainty
Worst-Case	10 m/s	110.1	+ 2 dB

Table 12: Envision Modelling Scenario for Assessment (EN-169.5/8.0 MW)

Scenario Description	Wind Speed (at 10 m)	Sound Power Level dB(A)	Correction for Uncertainty
Worst-Case	10 m/s	111.1	+ 2 dB

6.2.2 SWE and JICA, KFW, & Spain Wind Farm Noise Data

Noise source emission data for SWE wind farm is provided in Table 13 below.

Table 13: Envision Modelling Scenario for Assessment (EN-171/8.0 MW)

Scenario Description	Wind Speed (at 10 m)	Sound Power Level dB(A)	Correction for Uncertainty
Worst-Case	10 m/s	110.1	+ 2 dB

Noise source emission data for JICA, KFW, & Spain wind farm is provided in Table 14 below.

Table 14: Envision Modelling Scenario for Assessment (Siemens Gamesa SG G80 2.0 MW)

Scenario Description	Wind Speed (at 10 m)	Sound Power Level dB(A)	Correction for Uncertainty
Worst-Case	10 m/s	103.1	+ 2 dB

[13] IEC, Wind Turbine Generator Systems - Part 11: Acoustic noise measurement techniques, 2012 https://webstore.iec.ch/en/publication/5428.

7. NOISE MODEL

The noise model used for this noise impact study was implemented using the industry recognised software SoundPLAN 9.1, incorporating ISO 9613-2 noise prediction standard as per the IOA GPG.

7.1 Propagation of Sound Outdoors

Sound is a sequence of pressure waves which propagate through fluid medium. In the case of all outdoor propagation of sound in air the following factors affect the propagation and resultant sound levels from the source.

- Type of source (point, line or area)
- Distance from the source
- Atmospheric absorption
- Wind
- Temperature and temperature gradient
- Obstacles such as barriers and buildings (Barrier effects)
- Ground Absorption
- Reflections
- Humidity and Precipitation

A brief description of the above is given as follows:

7.1.1 Types of Sources

Point sources are considered where the dimensions of a source are small compared to the distance of the receiver. An example of point sources are stacks and fans. Sound energy spreads spherically and the sound pressure level is the same for all points at the same distance from the source.

If the source is narrow and long in one direction perpendicular to the distance of the receiver, it is called a line source. The sound level propagates cylindrically such that the sound pressure level is equal at all points at the same distance from the line.

7.1.2 Barriers

Noise reduction caused by barriers is dependent on two main factors:

1. Path difference of the sound wave as it travels over the barrier compared with the direct transmission to the receiver.
2. The sound frequency of the noise in question.

7.1.3 Atmospheric Attenuation

Atmospheric attenuation is complex and therefore will be summarised in short. Atmospheric attenuation is dependent on the following main factors:

- Distance from source
- Frequency content of the noise
- Ambient temperature
- Relative Humidity
- Ambient Pressure

Distance from source and frequency content are the most influential to the atmospheric attenuation.

7.1.4 Wind and Temperature

Wind and temperature influence noise propagation in terms of directivity or focusing of propagation and increasing the distance of noise propagation. With wind effects, it is important to note that the upwind effect is far greater than the downwind dB difference.

Temperature effects noise through the mechanism of temperature gradients. The effects are similar to that of wind gradients, however, unlike wind gradients, the effects are omni-directional within the localised region where the temperature gradient exists. The nett effect is that sound travels further where a temperature inversion exists, as the sound waves travel assisted by favourable meteorological conditions for sound propagation.

7.1.5 Ground Effects

Reflections by the ground interact (interfere) with directly propagated sound and effect the receiver level depending on the ground covering and surface. The ground effect varies according to the ground type. Generally hard ground (e.g. water or concrete) is reflective and adds an additional 3 dB, whereas soft ground (e.g. grass and vegetation) decreases the sound at the receiver (varies with frequency).

Therefore, to effectively predict noise levels for the project, the above would need to be considered and effectively modelled with the chosen software package for noise propagation prediction modelling.

7.2 Modelling the Propagation of Sound

7.2.1 SoundPLAN 9.1 – ISO 9613-2 Calculations

Noise prediction modelling for the Project has been completed using leading noise modelling software program SoundPLAN 9.1. The program allows for the calculation of sound pressure levels due to various sources using empirical calculation algorithms of the applicable International Standards and Regulations.

The propagation methodology adopted for this noise study, and the equations used within the SoundPLAN model are based on the International Organisation for Standardisation (ISO) 9613:2024 'Acoustics – Attenuation of Sound during Propagation Outdoors' – Part 2: Engineering Method for the Prediction of Sound Pressure Levels Outdoors (ISO 9613-2) as per the modelling requires of IOA GPG. The complete standard can be reviewed by obtaining a licenced copy of the standard from the International Organisation for Standardisation (ISO). The following is a concise summary of the standard and applicable details.

ISO 9613-2 is a general-purpose standard for outdoor noise propagation, the standard specifies a method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources.

The method predicts the equivalent continuous A-weighted sound pressure level (L_{Aeq}) under meteorological conditions favourable to propagation from sources of known sound emission. The standard takes into account the following physical effects on sound:

- Geometrical divergence;
- Atmospheric absorption;
- Ground effect;
- Reflection from surfaces; and
- Screening by obstacles.

Noise from WTGs is reduced by distance, atmospheric losses, screening effects and other 'miscellaneous' losses. ISO 9613-2 empirical formula calculates the predicted sound pressure level at a specified distance by taking into account the sound power level in octave frequency bands and subtracting a number of attenuating factors as described generally above.

The predicted noise level for each octave band is calculated by the following equation (1) and the modelling equation as applied by the calculation software is shown as per equation (2).

$$\mathbf{L_{90} = L_{w(eq)} + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc} - 2\ dB} \qquad \mathbf{(1)}$$

Where:

$L_{90:}$ sound Level exceeded 90% of the time.

$L_{w(eq)}$: equivalent continuous sound power level (dB)

D: directivity (dB)

A_{geo}: attenuation over distance (dB)

A_{atm}: atmospheric attenuation (dB)

A_{gr}: attenuation due to ground cover (dB)

A_{bar}: barrier attenuation (dB)

A_{misc}: miscellaneous attenuation factors (dB)

The 2 dB represents a correction used to convert the L_{Aeq} levels, as used to describe the turbine sound power to the L_{A90} parameter, used in the ETSU-R-97 assessment.

The applied equation for the Standard computed is as follows:

$$\boldsymbol{L_s = [L_W + D_1 + K_0] - [D_S + \sum D]} \quad \textbf{(2)}$$

Where:

L_s: sound pressure level for a single frequency

L_W: sound power

D_1: directivity of the source

K_0: spherical model ($K_0 = 10\log\left[\frac{4\pi}{\sigma}\right]$ where σ is the spatial angle)

D_S: geometrical spreading ($D_S = 10\log(dist.source, receiver) + 11\ dB(A)$)

$\sum D$: contributing factors – air absorption, ground absorption, meteorological effects, volume type absorption and screening

Summary of the calculation settings and standards are detailed in the table below.

Table 15: Model Calculation and Parameter Settings for ISO 9613-2

Model Parameter	Parameter Setting / Standard							
Calculation Standard	(ISO) 9613-2 'Acoustics – Attenuation of Sound during Propagation Outdoors – Part 2: Engineering method for the prediction of sound pressure levels outdoors (ISO, 2024)' *Application as per IOA GPG*							
Wind Speed	10.0 m/s							
Ground Absorption Coefficient	0.5							
Receiver Height	4 m							
Meteorological Data[14]	Humidity 70% Air Pressure 1013.3 mbar T = 25ºC							
Atmospheric Attenuation Coefficients (dB / km)	63 Hz 0.1	125 Hz 0.3	250 Hz 1.1	500 Hz 2.8	1 kHz 5.0	2 kHz 9.0	4 kHz 22.9	8 kHz 76.6

7.3 Modelling Assumptions and Limitations

The following assumptions have been made for the modelling assessment, and wherever possible, a conservative approach has been taken:

- ISO 9613-2 calculates predicted noise levels with the assumption that SRs are located downwind of the turbine noise as this is considered to be the most conservative. Therefore, directivity and attenuation due to metrological factors such as wind speed and wind direction upwind from a source have not been taken into account.
- Due to the surrounding area being a mix of hard and soft ground surfaces, an absorption coefficient of 0.5 has been assumed.

[14] International Organisation for Standardisation (ISO), ISO9613-2 'Acoustics – Attenuation of Sound During Propagation Outdoors', 2024 https://www.iso.org/standard/74047.html.

8. PREDICTED NOISE LEVELS

Noise modelling calculations were carried out for the worst-case downwind scenario, including a gridded calculation and a separate discrete receiver calculation, in order to generate overall grid noise maps, and to undertake a tabulated assessment at NSRs respectively. The model results are covered in sections that follow.

8.1 Noise Contour Maps

Noise contour maps for the worst-case noise scenario have been calculated for both the isolated and cumulative assessments and are presented in Figure 21 and Figure 22 (for Layout 1) and Figure 23 and Figure 24 (for Layout 2) on the following pages. The maps show contour lines and noise propagation level areas or 'zones' between the contour lines. The purpose of the noise contour map is to provide an overview of noise levels over a geographic area and therefore allowing a quick basic analysis of the noise propagation for identification of specific NSRs. The modelling specification for the noise contour map modelling is as per the table below.

Table 16: Noise contour map setup specification – ISO 9613-2

Parameter Description	Noise Map Parameter
WTG Operation	Worst Case – All WTGs operating
Mapping Grid Resolution	25 x 25 m
Mapping Result Range	35 – 70 dB(A)

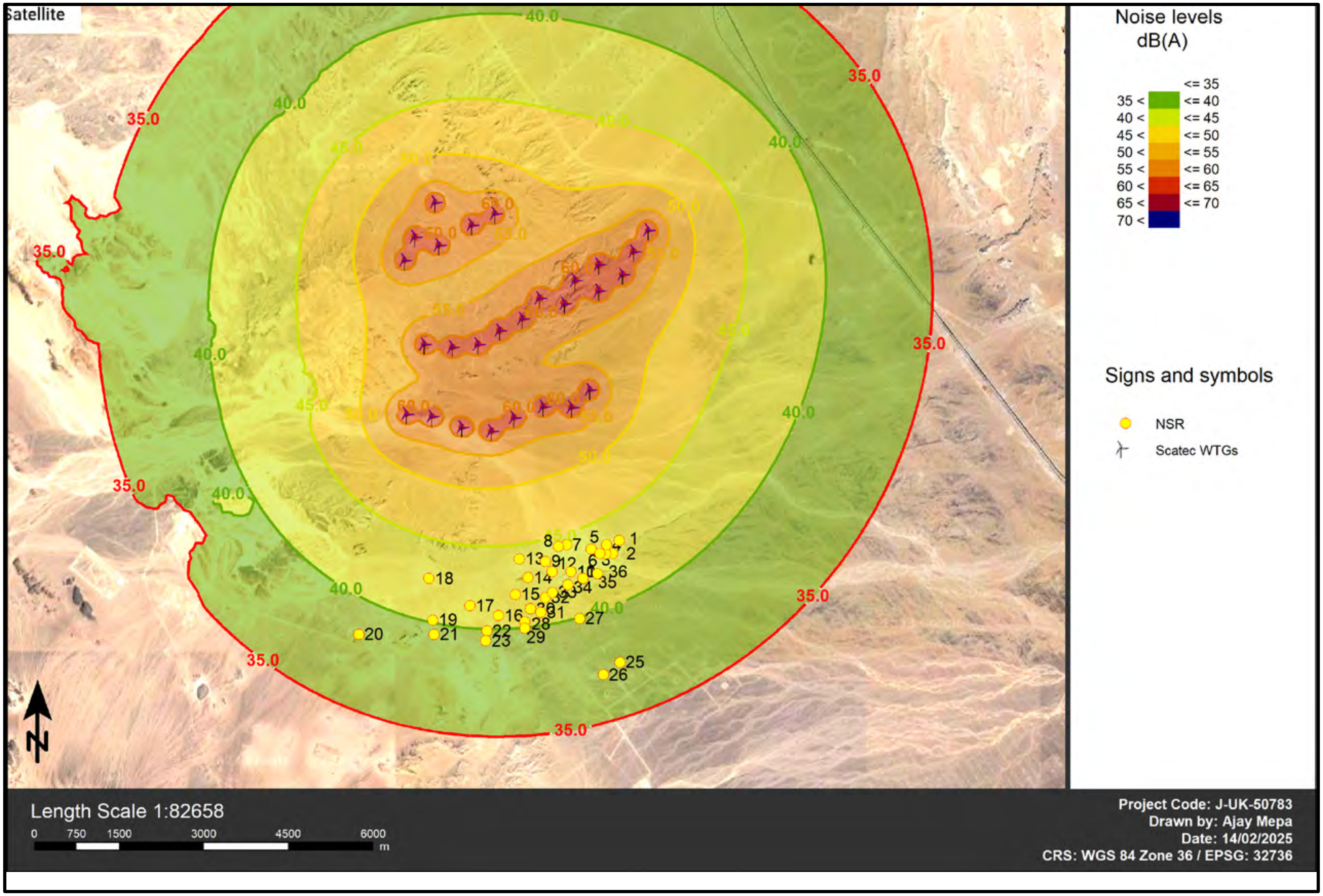

Figure 21: Noise Contour Map for Scatec Layout 1 - W_{10}: 10 m/s (Isolated Assessment)

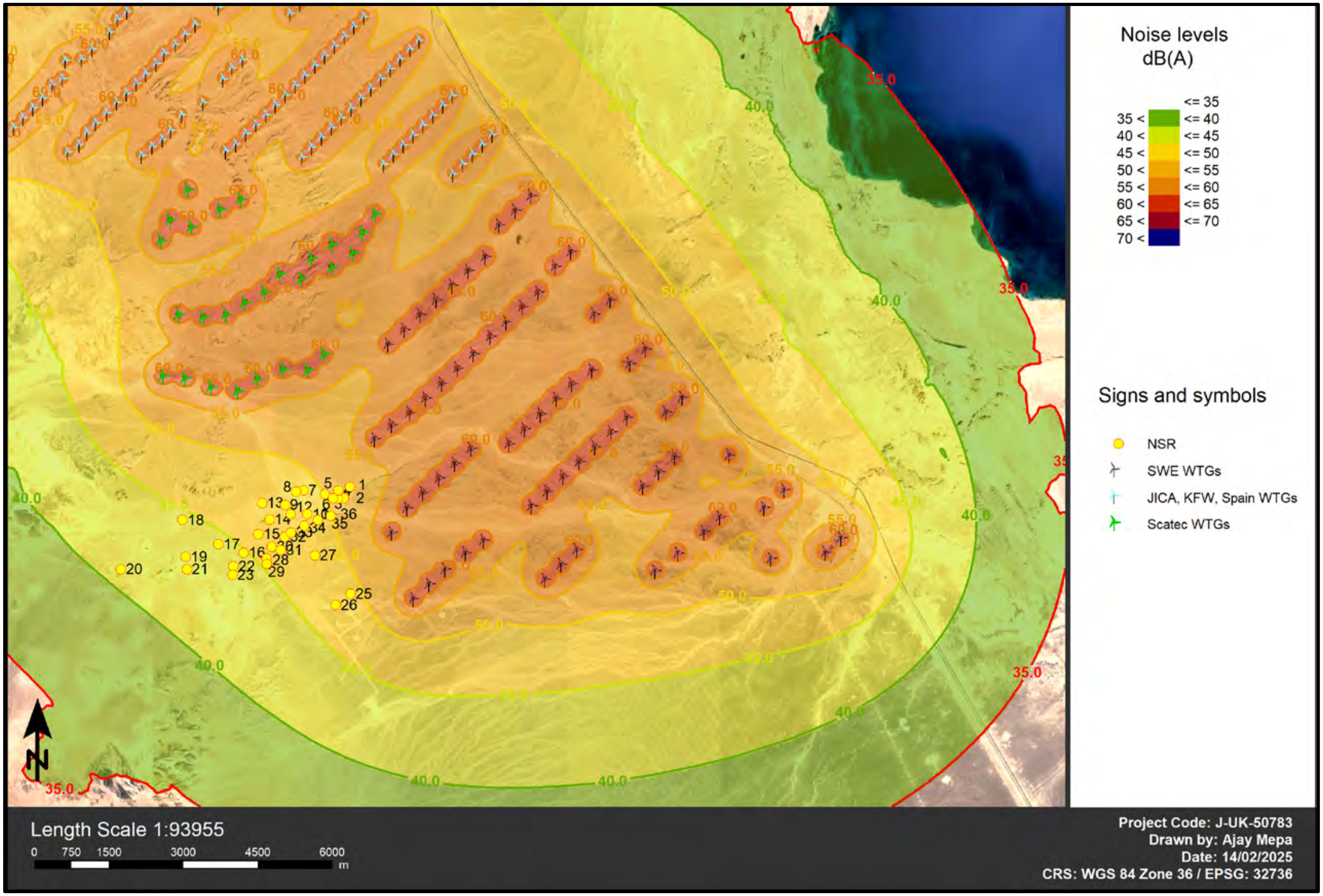

Figure 22: Noise Contour Map for Scatec Layout 1 - W_{10}: 10 m/s (Cumulative Assessment)

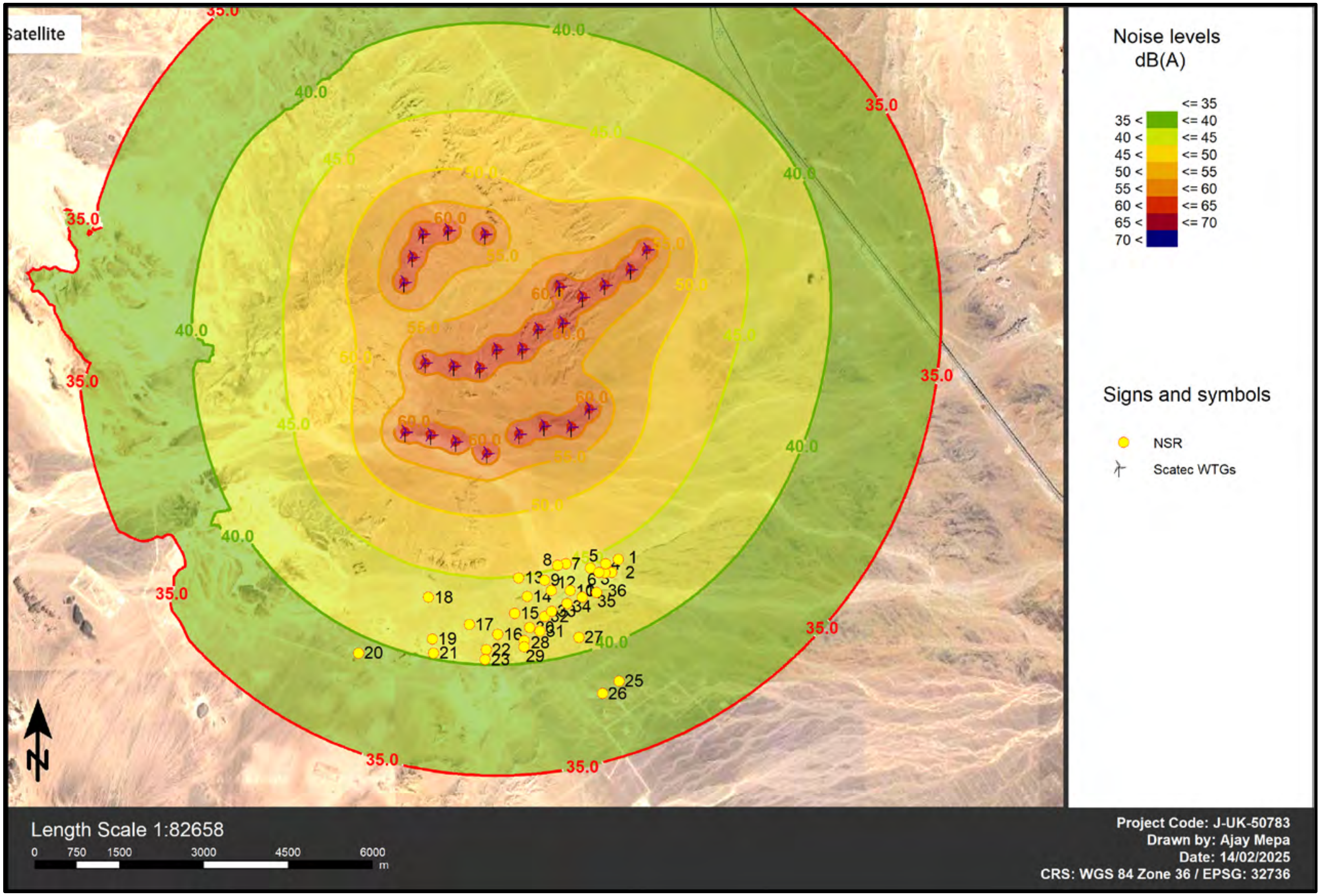

Figure 23: Noise Contour Map for Scatec Layout 2 - W_{10}: 10 m/s (Isolated Assessment)

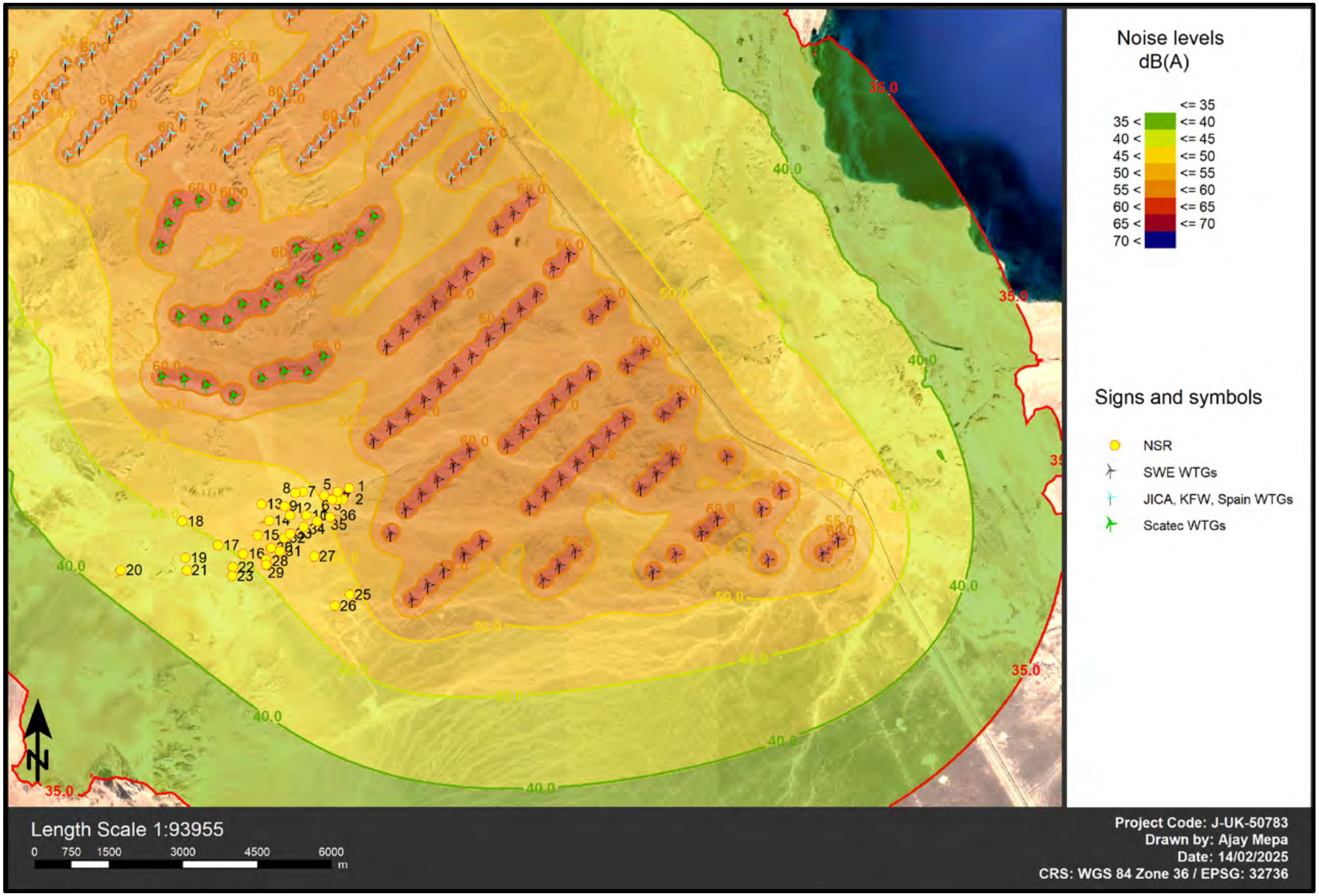

Figure 24: Noise Contour Map for Scatec Layout 2 - W_{10}: 10 m/s (Cumulative Assessment)

8.2 Predicted Noise Result at NSRs (Layout 1)

Based on the results of the noise contour map and the identification of the NSRs, the table below displays the predicted noise level results at each NSR from Layout 1 of the Scatec wind farm for both the isolated and cumulative WTG assessments.

Table 17: Predicted noise levels at NSRs from Scatec Wind Farm (Isolation & Cumulative) (W_{10}) – Layout 1

Noise Sensitive Receptor	Predicted Contribution Noise Level at 10 m/s Wind Speed (W_{10}) – dB(A)	
	Scatec (Isolation)	Scatec (Cumulative)
NSR1	43.2	51.9
NSR2	42.7	51.2
NSR3	42.8	50.8
NSR4	43.3	51.0
NSR5	43.4	50.1
NSR6	43.0	50.4
NSR7	44.3	49.1
NSR8	44.3	48.8
NSR9	43.6	47.9
NSR10	42.6	48.6
NSR11	42.6	48.6
NSR12	42.9	47.8
NSR13	44.0	47.3
NSR14	42.8	46.9
NSR15	41.9	46.0
NSR16	40.7	44.9
NSR17	41.2	44.4
NSR18	42.4	44.4
NSR19	40.1	43.0
NSR20	38.2	40.8
NSR21	39.4	42.6
NSR22	39.9	44.0
NSR23	39.4	43.7
NSR25	37.3	48.8
NSR26	37.0	47.3
NSR27	39.9	47.8
NSR28	40.3	45.5
NSR29	40.0	45.3

Noise Sensitive Receptor	Predicted Contribution Noise Level at 10 m/s Wind Speed (W_{10}) – dB(A)	
	Scatec (Isolation)	Scatec (Cumulative)
NSR30	41.0	46.0
NSR31	40.7	46.3
NSR32	41.5	46.9
NSR33	41.7	47.3
NSR34	41.9	48.1
NSR35	42.0	49.0
NSR36	41.9	49.9

8.3 Predicted Noise Result at NSRs (Layout 2)

Based on the results of the noise contour map and the identification of the NSRs, the table below displays the predicted noise level results at each NSR from Layout 2 of the Scatec wind farm for both the isolated and cumulative WTG assessments.

Table 18: Predicted noise levels at NSRs from Scatec Wind Farm (Isolation & Cumulative) (W_{10}) – Layout 2

Noise Sensitive Receptor	Predicted Contribution Noise Level at 10 m/s Wind Speed (W_{10}) – dB(A)	
	Scatec (Isolation)	Scatec (Cumulative)
NSR1	44.0	52.0
NSR2	43.5	51.3
NSR3	43.7	50.9
NSR4	44.2	51.2
NSR5	44.3	50.3
NSR6	43.9	50.6
NSR7	45.1	49.4
NSR8	45.2	49.1
NSR9	44.4	48.3
NSR10	43.4	48.8
NSR11	43.4	48.8
NSR12	43.7	48.1
NSR13	44.9	47.7
NSR14	43.6	47.2
NSR15	42.7	46.3
NSR16	41.6	45.2
NSR17	42.1	44.8
NSR18	43.3	45.0

Noise Sensitive Receptor	Predicted Contribution Noise Level at 10 m/s Wind Speed (W_{10}) – dB(A)	
	Scatec (Isolation)	Scatec (Cumulative)
NSR19	41.0	43.5
NSR20	39.1	41.3
NSR21	40.3	43.0
NSR22	40.8	44.4
NSR23	40.3	44.1
NSR25	38.1	48.9
NSR26	37.8	47.4
NSR27	40.8	47.9
NSR28	41.2	45.7
NSR29	40.8	45.5
NSR30	41.8	46.3
NSR31	41.5	46.5
NSR32	42.3	47.1
NSR33	42.5	47.5
NSR34	42.8	48.3
NSR35	42.8	49.2
NSR36	42.8	50.1

9. NOISE IMPACT ASSESSMENT

9.1 Noise Limit Determination

IOA Good Practice to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise interprets the ETSU-R-97 determination of the noise limits as per the following summary from Section 3.2 of IOA GPG.

9.1.1 Determination of the ETSU-R-97 Daytime Noise Limit

The daytime noise limit in ETSU-R-97 is set on the basis of protecting the amenity of people whilst outside their domestic dwellings. The daytime noise limit is based on the relationship between the prevailing background noise level and wind speed, with an allowance of + 5 dB.

9.1.2 Determination of the ETSU-R-97 Night-Time Noise Limit

ETSU-R-97 indicates that for the protection of sleep of occupants within buildings, an external free-field level of 43 dB L_{A90} is appropriate when background noise levels are considered low. When background noise levels are sufficiently high, then the noise limits are set to the prevailing background + 5 dB.

9.1.3 Summary of ETSU-R-97 Limits

The table below summarises the applicable available limits as described by ETSU-R-97.

Table 19: Summary of ETSU-R-97 Noise Limits

Assessment Period	Limits
Daytime	35 dB(A) or 5 dB above prevailing background, whichever is greater.
Night-time	43 dB(A) or 5 dB above prevailing background, whichever is greater.

9.2 Project Background Noise and Assessment Limits

9.2.1 Derived Background Noise L_{A90}

Using the methodology laid out in ETSU-R-97, the daytime and night-time background noise level at NM1 and NM2 was calculated and is presented graphically in the figures below.

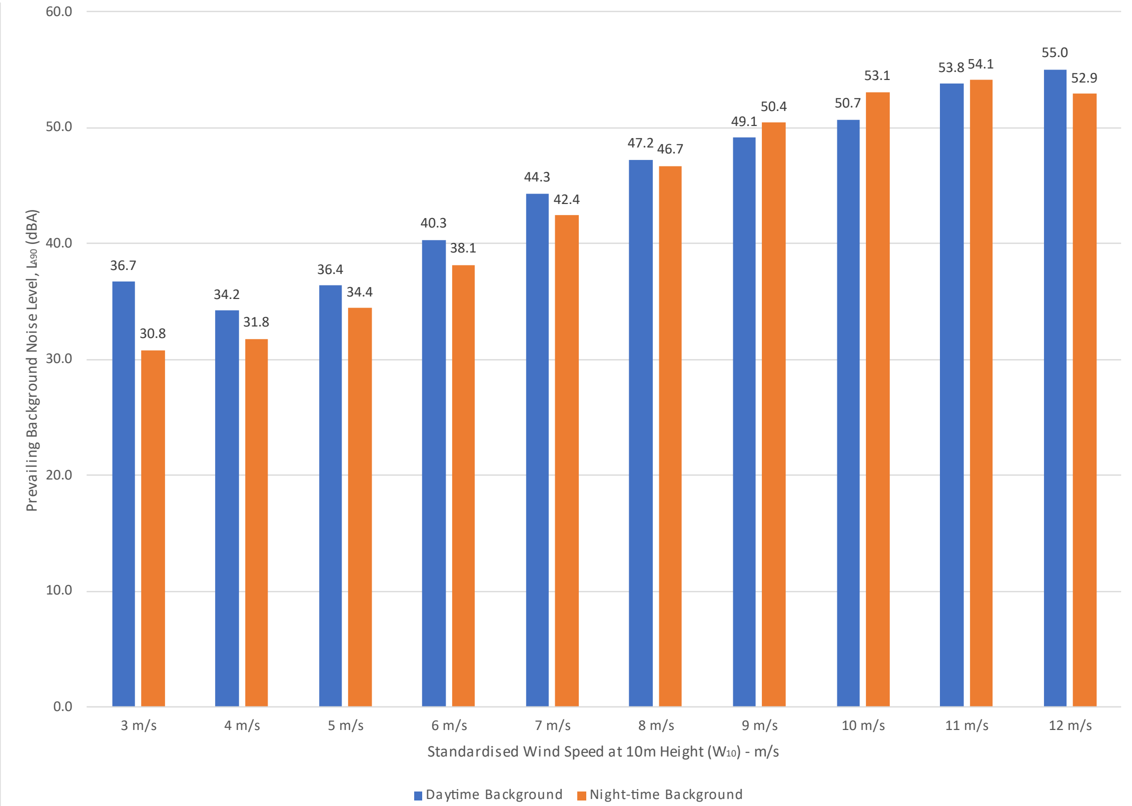

Figure 25: Prevailing Background Noise level according to standardized wind speed W_{10} at NM1

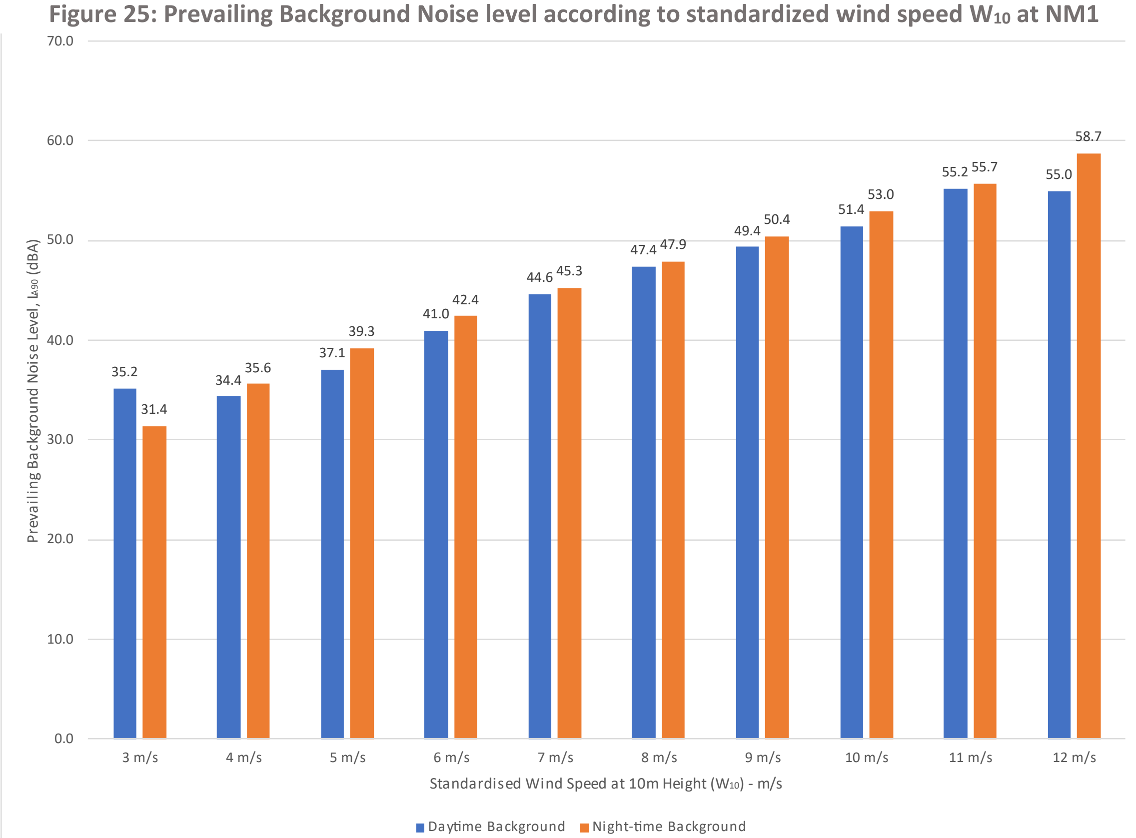

Figure 26: Prevailing Background Noise level according to standardized wind speed W_{10} at NM2

9.2.2 Determination of Assessment Noise Limits

For the daytime and night-time period, the limit is based on the background noise level +5 dB. The proposed assessment noise limits are set out in the table below.

Table 20: Proposed Noise Limits for WTG Noise Assessment

Location / Area	Standardised Wind Speed at 10 m Height, m/s			
	ETSU-R-97 Noise Limits, L_{A90} dB for the worst-case, 10 m/s			
	Daytime Background L_{A90} dB(A)	Daytime Limit L_{A90} dB(A) (i.e. background + 5 dB(A))	Night-time Background L_{A90} dB(A)	Night-time Limit L_{A90} dB(A)
NML1	**50.7**	**55.7**	53.1	58.1
NML2	51.4	56.4	**53.0**	**58.0**

Although the two wind speed data sets are similar, to remain conservative, the lowest derived daytime and night-time noise limit from the two monitoring locations is applied for all NSRS. This means that the daytime noise limit is 55.7 dB(A), and the night-time noise limit is 58 dB(A).

9.3 Noise Impact Assessment

The following sections and tables summarise the assessment of the noise at the defined NSRs in terms of the ETSU-R-97 limits for the worst-case noise modelling case.

9.3.1 Worst-case Scenario: Ws = 10 m/s – Layout 1

The tables below show the assessments for daytime and night-time periods, respectively, for a wind speed of W_{10} of 10 m/s, representing the worst-case scenario for Layout 1 of the Scatec windfarm. For a conservative approach, the predicted noise contribution from the WTGs includes the cumulative noise levels from all WTGs in the surrounding area.

Table 21: Noise impact assessment for day-time periods, W_{10} = 10 m/s – Layout 1

Noise Sensitive Receptor	Predicted Noise Contribution	Total Noise (Contribution + Background)	ETSU-R-97 Day-time Limit (background for 10 m/s + 5 dB)	Maximum Exceedance Value
	dB L_{A90}	dB L_{A90}	dB L_{A90}	dB
NSR1	51.9	54.4	55.7	0
NSR2	51.2	54.0	55.7	0
NSR3	50.8	53.8	55.7	0
NSR4	51.0	53.9	55.7	0
NSR5	50.1	53.4	55.7	0
NSR6	50.4	53.6	55.7	0
NSR7	49.1	53.0	55.7	0
NSR8	48.8	52.9	55.7	0

Noise Sensitive Receptor	Predicted Noise Contribution	Total Noise (Contribution + Background)	ETSU-R-97 Day-time Limit (background for 10 m/s + 5 dB)	Maximum Exceedance Value
	dB L_{A90}	dB L_{A90}	dB L_{A90}	dB
NSR9	47.9	52.5	55.7	0
NSR10	48.6	52.8	55.7	0
NSR11	48.6	52.8	55.7	0
NSR12	47.8	52.5	55.7	0
NSR13	47.3	52.3	55.7	0
NSR14	46.9	52.2	55.7	0
NSR15	46.0	52.0	55.7	0
NSR16	44.9	51.7	55.7	0
NSR17	44.4	51.6	55.7	0
NSR18	44.4	51.6	55.7	0
NSR19	43.0	51.4	55.7	0
NSR20	40.8	51.1	55.7	0
NSR21	42.6	51.3	55.7	0
NSR22	44.0	51.5	55.7	0
NSR23	43.7	51.5	55.7	0
NSR25	48.8	52.9	55.7	0
NSR26	47.3	52.3	55.7	0
NSR27	47.8	52.5	55.7	0
NSR28	45.5	51.8	55.7	0
NSR29	45.3	51.8	55.7	0
NSR30	46.0	52.0	55.7	0
NSR31	46.3	52.0	55.7	0
NSR32	46.9	52.2	55.7	0
NSR33	47.3	52.3	55.7	0
NSR34	48.1	52.6	55.7	0
NSR35	49.0	52.9	55.7	0
NSR36	49.9	53.3	55.7	0

Table 22: Noise impact assessment for night-time period, W_{10} = 10 m/s – Layout 1

Noise Sensitive Receptor	Predicted Noise Contribution	Total Noise (Contribution + Background)	ETSU-R-97 Night-time Limit (background for 10 m/s + 5 dB)	Maximum Exceedance Value
	dB L_{A90}	dB L_{A90}	dB L_{A90}	dB
NSR1	51.9	55.5	58	0
NSR2	51.2	55.2	58	0
NSR3	50.8	55.0	58	0
NSR4	51.0	55.1	58	0
NSR5	50.1	54.8	58	0

Noise Sensitive Receptor	Predicted Noise Contribution	Total Noise (Contribution + Background)	ETSU-R-97 Night-time Limit (background for 10 m/s + 5 dB)	Maximum Exceedance Value
	dB L_{A90}	dB L_{A90}	dB L_{A90}	dB
NSR6	50.4	54.9	58	0
NSR7	49.1	54.5	58	0
NSR8	48.8	54.4	58	0
NSR9	47.9	54.2	58	0
NSR10	48.6	54.3	58	0
NSR11	48.6	54.3	58	0
NSR12	47.8	54.1	58	0
NSR13	47.3	54.0	58	0
NSR14	46.9	54.0	58	0
NSR15	46.0	53.8	58	0
NSR16	44.9	53.6	58	0
NSR17	44.4	53.6	58	0
NSR18	44.4	53.6	58	0
NSR19	43.0	53.4	58	0
NSR20	40.8	53.3	58	0
NSR21	42.6	53.4	58	0
NSR22	44.0	53.5	58	0
NSR23	43.7	53.5	58	0
NSR25	48.8	54.4	58	0
NSR26	47.3	54.0	58	0
NSR27	47.8	54.1	58	0
NSR28	45.5	53.7	58	0
NSR29	45.3	53.7	58	0
NSR30	46.0	53.8	58	0
NSR31	46.3	53.8	58	0
NSR32	46.9	54.0	58	0
NSR33	47.3	54.0	58	0
NSR34	48.1	54.2	58	0
NSR35	49.0	54.5	58	0
NSR36	49.9	54.7	58	0

9.3.2 Worst-case Scenario: Ws = 10 m/s – Layout 2

The tables below show the assessments for daytime and night-time periods, respectively, for a wind speed of W_{10} of 10 m/s, representing the worst-case scenario for Layout 2 of the Scatec windfarm. For a conservative approach, the predicted noise contribution from the WTGs includes the cumulative noise levels from all WTGs in the surrounding area.

Table 23: Noise impact assessment for day-time periods, W_{10} = 10 m/s – Layout 2

Noise Sensitive Receptor	Predicted Noise Contribution	Total Noise (Contribution + Background)	ETSU-R-97 Day-time Limit (background for 10 m/s + 5 dB)	Maximum Exceedance Value
	dB L_{A90}	dB L_{A90}	dB L_{A90}	dB
NSR1	52.0	54.4	55.7	0
NSR2	51.3	54.0	55.7	0
NSR3	50.9	53.8	55.7	0
NSR4	51.2	54.0	55.7	0
NSR5	50.3	53.5	55.7	0
NSR6	50.6	53.7	55.7	0
NSR7	49.4	53.1	55.7	0
NSR8	49.1	53.0	55.7	0
NSR9	48.3	52.7	55.7	0
NSR10	48.8	52.9	55.7	0
NSR11	48.8	52.9	55.7	0
NSR12	48.1	52.6	55.7	0
NSR13	47.7	52.5	55.7	0
NSR14	47.2	52.3	55.7	0
NSR15	46.3	52.0	55.7	0
NSR16	45.2	51.8	55.7	0
NSR17	44.8	51.7	55.7	0
NSR18	45.0	51.7	55.7	0
NSR19	43.5	51.5	55.7	0
NSR20	41.3	51.2	55.7	0
NSR21	43.0	51.4	55.7	0
NSR22	44.4	51.6	55.7	0
NSR23	44.1	51.6	55.7	0
NSR25	48.9	52.9	55.7	0
NSR26	47.4	52.4	55.7	0
NSR27	47.9	52.5	55.7	0
NSR28	45.7	51.9	55.7	0
NSR29	45.5	51.8	55.7	0
NSR30	46.3	52.0	55.7	0
NSR31	46.5	52.1	55.7	0
NSR32	47.1	52.3	55.7	0
NSR33	47.5	52.4	55.7	0
NSR34	48.3	52.7	55.7	0
NSR35	49.2	53.0	55.7	0
NSR36	50.1	53.4	55.7	0

Table 24: Noise impact assessment for night-time period, W_{10} = 10 m/s – Layout 2

Noise Sensitive Receptor	Predicted Noise Contribution	Total Noise (Contribution + Background)	ETSU-R-97 Night-time Limit (background for 10 m/s + 5 dB)	Maximum Exceedance Value
	dB LA90	dB LA90	dB LA90	dB
NSR1	52.0	55.5	58	0
NSR2	51.3	55.2	58	0
NSR3	50.9	55.1	58	0
NSR4	51.2	55.2	58	0
NSR5	50.3	54.9	58	0
NSR6	50.6	55.0	58	0
NSR7	49.4	54.6	58	0
NSR8	49.1	54.5	58	0
NSR9	48.3	54.3	58	0
NSR10	48.8	54.4	58	0
NSR11	48.8	54.4	58	0
NSR12	48.1	54.2	58	0
NSR13	47.7	54.1	58	0
NSR14	47.2	54.0	58	0
NSR15	46.3	53.8	58	0
NSR16	45.2	53.7	58	0
NSR17	44.8	53.6	58	0
NSR18	45.0	53.6	58	0
NSR19	43.5	53.5	58	0
NSR20	41.3	53.3	58	0
NSR21	43.0	53.4	58	0
NSR22	44.4	53.6	58	0
NSR23	44.1	53.5	58	0
NSR25	48.9	54.4	58	0
NSR26	47.4	54.1	58	0
NSR27	47.9	54.2	58	0
NSR28	45.7	53.7	58	0
NSR29	45.5	53.7	58	0
NSR30	46.3	53.8	58	0
NSR31	46.5	53.9	58	0
NSR32	47.1	54.0	58	0
NSR33	47.5	54.1	58	0
NSR34	48.3	54.3	58	0
NSR35	49.2	54.5	58	0
NSR36	50.1	54.8	58	0

9.4 Summary of Noise Impact Assessment

The main conclusions from the assessment results are summarised in the following sections.

9.4.1 Daytime Impact Assessment

For the worst-case scenario W_{10} of 10 m/s scenario for both Layout 1 and Layout 2, the resulting cumulative noise levels were predicted to be below the ETSU-R-97 daytime noise limit for all NSRs.

9.4.2 Night-time Impact Assessment

For the worst-case scenario W_{10} of 10 m/s scenario for both Layout 1 and Layout 2, the resulting cumulative noise levels were predicted to be below the ETSU-R-97 night-time noise limit for all NSRs.

10. CONCLUSIONS AND RECOMMENDATIONS

An assessment was undertaken to assess the potential noise impact from the two proposed layouts of the Scatec Wind Farm Project, located in Egypt. The assessment focused on NSRs in the immediate surrounding areas where residential areas are located.

A baseline noise survey was conducted at two noise measurement sites located in the vicinity of the NSRs, adjacent to the wind farm development. Noise limits were derived from the baseline data and noise predictions were calculated with SoundPLAN 9.1 software according to ISO 9613-2 with input parameters and limitations stipulated as per IOA GPG.

The proposed wind turbine generators are the Envision EN-169.5/7.5 MW (Layout 1) and Envision EN-169.5/8.0 MW (Layout 2). Sound power data was provided in the form of vendor data sheets.

The assessment focused on the worst-case noise level scenario, involving all WTGs including existing WTGs, operating at maximum sound power output (10 m/s). No exceedances of the ETSU-R-97 derived limit were predicted during daytime or night-time at any of the NSRs.

Based on the results of this noise study no specific mitigation or curtailment for noise is required for the Project, however, the following recommendations are made:

- Grievance mechanism will be established to follow up any noise related grievance.
- In case of grievance, 48 hours continuous noise measurements will be conducted immediately on the area where grievance is received. Based on the outcomes and results, appropriate management and mitigations measures should be determined and agreed with the griever (e.g. installation of noise insulation measures at the structure such as double glazed windows, vegetative buffers, etc.).
- Noise monitoring campaigns will be conducted annually on the first 2 years of operation phase. In the case results indicate that levels are within allowable limits and no grievances are received, no further requirements are needed. Should grievances be received, then requirements in first point apply.

Upon completion of the construction of the wind farm, during the commissioning period a detailed long-term verification noise monitoring programme should be implemented. The monitoring programme should be carefully designed with specific planning of equipment, measurement locations and periods.

APPENDIX A – WTG COORDINATES

Table 25: Scatec Wind Farm Layout 1 WTG Coordinates (Zone 36)

Wind Turbine Generator (WTG)	Longitude (UTM Easting) (mE)	Latitude (UTM Northing) (mN)
A01	519593.3	3101832.3
A02	519774.8	3102245.4
A03	520202.1	3102103
A04	520132.4	3102861
A05	520782.7	3102460.4
A06	521195.5	3102661.1
B07	519945.2	3100343.6
B08	520439.6	3100292.9
B09	520895.6	3100344.3
B10	521277.5	3100589.5
B11	521676.5	3100799.3
B12	521985.1	3101160.8
B13	522425.8	3101063.6
B14	522618	3101477
B15	523033	3101297.6
B16	523034.7	3101758.6
B17	523458.7	3101579.9
B18	523650.9	3101991.4
B19	523908.1	3102366.7
C20	519628.4	3099103.1
C21	520077.7	3099065.4
C22	520604.3	3098874.7
C23	521132	3098807.8
C24	521534.1	3099044.6
C25	522048.1	3099240.4
C26	522550.8	3099226.4
C27	522874.9	3099541.6

Table 26: Scatec Wind Farm Layout 2 WTG Coordinates (Zone 36)

Wind Turbine Generator (WTG)	Longitude (UTM Easting) (mE)	Latitude (UTM Northing) (mN)
A01	519593.1	3101785.8
A02	519741.4	3102233.7
A03	519927.8	3102647.5
A04	520373.7	3102709.6
A05	521025.1	3102640.9
B06	519968.8	3100358.5
B07	520475.1	3100301.3
B08	520934.2	3100265
B09	521240	3100595.1
B10	521692.4	3100605.4
B11	521974.3	3100956.4
B12	522414	3101063.1
B13	522350.2	3101706.8
B14	522761.1	3101523.5
B15	523157.8	3101739.8
B16	523614.4	3102017.2
B17	523905.2	3102366.4
C18	519611.5	3099127.8
C19	520066.9	3099081
C20	520506.9	3098958.4
C21	521062.5	3098748.4
C22	521637.9	3099088.8
C23	522077	3099238.1
C24	522561.1	3099216.9
C25	522881.4	3099538.9

Date: 18-06-2023
Ref: 06/2023

Calibration Certificate

We here by certify that the **Following Sound Level Analyzers**

TYPE	S/N
2250	**2709811**

Were calibrated in our workshop using Multi-Function Acoustic Calibrator Type 4231 according to the supplier's standard procedure for calibration.

Calibration Date: 18/06/2023

Next Calibration 17/06/2024

Director General

Eng. Mohamed Moustafa Omar

شركة دلتا للالكترونيات
Delta Co. for Electronics

شركـة دلتـــا للالكترونيـــات

DELTA COMPANY FOR ELECTRONICS

Date: 22-11-2023
Ref: 11/2023

Calibration Certificate

We here by certify that the **Following Sound Level Analyzers**

TYPE	S/N
2250L	**3010309**

Were calibrated in our workshop using Multi-Function Acoustic Calibrator Type 4231 according to the supplier's standard procedure for calibration.

Calibration Date: 22/11/2023

Next Calibration
22/11/2024

Delta Co. for Electronics

Director General

Eng. Mohamed Moustafa Omar

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