HGC ENGINEERING
noise · vibration · acoustics

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Acoustic Assessment Report
HAF Wind Energy Project
Township of West Lincoln, Ontario

Prepared for:

Vineland Power Inc.
222 Martindale Road
St. Catharines, Ontario
L2R 7A3

Prepared by:

LICENSED PROFESSIONAL ENGINEER
I. R. BONSMA
100100550
25-03-13
PROVINCE OF ONTARIO

Ian R. Bonsma, PEng

And

Brian Howe, MEng, MBA, PEng

March 25, 2013

VERSION CONTROL

HAF Wind Energy Project, Township of West Lincoln, Ontario

Ver.	Date	Version Description	Prepared By
1	December 9, 2010	Original Acoustic Assessment Report supporting an application for a Renewable Energy Approval.	M. Munro
2	September 9, 2011	Acoustic Assessment Report Updated to reflect minor changes to the location of WTG1, WTG2 and WTG3.	M. Munro
3	February 1, 2013	Acoustic Assessment Report updated to add additional receptors and to reflect comments from the MOE.	I. Bonsma
4	March 25, 2013	Acoustic Assessment Report updated to reflect comments from the MOE.	I. Bonsma

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EXECUTIVE SUMMARY

Howe Gastmeier Chapnik Limited ("HGC Engineering") was retained by IPC Energy on behalf of Vineland Power Inc. to assess the acoustic impact of the proposed HAF Wind Energy Project to be located in the Township of West Lincoln, Ontario. The project will consist of five Vestas V100 wind turbine generators, each rated at 1.8 MW. HGC Engineering has assessed the acoustic impact against the acoustic criteria of the Ontario Ministry of Environment ("MOE"). This report comprises a summary of our assessment and is intended as supporting documentation for an application for a Renewable Energy Approval.

The wind farm site is within the Township of West Lincoln, in the Niagara Region. There are a number of residences located in the vicinity of the project. From an acoustic perspective the area is rural with relatively low ambient sound levels during nighttime hours at all locations. Unattended and attended sound level monitoring were conducted by HGC Engineering from August 26 until September 9, 2010 to gain an understanding of the existing background sound levels at several representative noise sensitive receptors. The criteria of the MOE's publication NPC-232 *Sound Level Limits for Stationary Sources in Class 3 Areas (Rural)* are thus relevant. Supplementary guidance is also provided by MOE publication *Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities*.

The sound power data for the Vestas wind turbine generators has been obtained through IPC Energy. This data has been used in a computer model to predict the sound level impact at the closest residential receptors. The results of the modelling demonstrate compliance with the MOE guidelines when all five turbines are operating over their entire speed range, at all but four receptors locations. These receptor locations have entered into lease agreements with the proponent.

Details of our assessment are provided in the main body of this report. The report is structured around the report format suggested by the MOE for Renewable Energy Approval applications for wind farms, with the required summary tables included as Appendix A.

Ministry of the Environment | Ministère de l'Environnement

Ontario

ACOUSTIC ASSESSMENT REPORT CHECK-LIST

Company Name: Vineland Power Inc.

Company Address: 222 Martindale Road

St. Catharines, Ontario, L2R 7A3

Location of Facility: Township of West Lincoln, Ontario

The attached Acoustic Assessment Report was prepared in accordance with the guidance in the ministry document "Information to be Submitted for Approval of Stationary Source of Sound" (NPC 233) dated October 1995 and the minimum required information identified in the check-list on the reverse of this sheet has been submitted.

Company Contact:

Name: Jordan Beekhuis

Title: Project Engineer

Phone Number: 905-684-1111

Signature: [signature]

Date: March 25, 3013

Technical Contact:

Name: Ian Bonsma, PEng

Representing: HGC Engineering

Phone Number: 905-826-4044

Signature: [signature]

Date: March 25, 2013

ACOUSTIC ASSESSMENT REPORT CHECK-LIST

	Required Information		
		Submitted	Explanation/Reference
1.0	**Introduction** (Project Background and Overview)	☒ Yes	Section 1
2.0	**Facility Description**		
	2.1 Operating hours of facility and significant Noise Sources	☒ Yes	
	2.2 Site Plan identifying all significant Noise Sources	☒ Yes	Figure 2
3.0	**Noise Source Summary**		
	3.1 ***Noise Source Summary Table***	☒ Yes	Appendix A
	3.2 Source noise emissions specifications	☒ Yes	Appendix D
	3.3 Source power/capacity ratings	☒ Yes	Appendix D
	3.4 Noise control equipment description and acoustical specifications	☐ No	N/A
4.0	**Point of Reception Noise Impact Calculations**		
	4.1 ***Point of Reception Noise Impact Table***	☒ Yes	Appendix A
	4.2 Point(s) of Reception (POR) list and description	☒ Yes	Table A3, A4
	4.3 Land-use Zoning Plan	☒ Yes	Appendix B
	4.4 Scaled Area Location Plan	☒ Yes	Figure 1
	4.5 Procedure used to assess noise impacts at each POR	☒ Yes	Section 7, Appendix E
	4.6 List of parameters/assumptions used in calculations	☒ Yes	Section 7, Appendix E
5.0	**Acoustic Assessment Summary**		
	5.1 ***Acoustic Assessment Summary Table***	☒ Yes	Appendix A
	5.2 Rationale for selecting applicable noise guideline limits	☒ Yes	Section 6
	5.3 Predictable Worst Case Impacts Operating Scenario	☒ Yes	Figure 4, Table A5 & A6
6.0	**Conclusions**		
	6.1 Statement of compliance with selected noise performance limits	☒ Yes	
7.0	**Appendices** (provide details such as)	☒ Yes	
	Listing of Insignificant Noise Sources	☒ Yes	
	Manufacturer's Noise Specifications	☒ Yes	Appendix D
	Calculations	☒ Yes	Appendix E
	Instrumentation	☒ Yes	
	Meteorology during Sound Level Measurements	☒ Yes	
	Raw Data from Measurements	☒ Yes	N/A
	Drawings (Facility / Equipment)	☒ Yes	Appendix C

1 INTRODUCTION

Howe Gastmeier Chapnik Limited ("HGC Engineering") was retained by IPC Energy on behalf of Vineland Power Inc. to assess the acoustic impact of the proposed HAF Wind Energy Project. The purpose of this report is to determine the acceptability of the predicted sound levels at the nearby residential receptors resulting from the operation of five, 95 metre hub height, Vestas V100 wind turbine generators, rated at 1.8 MW, in relation to the guidelines of the Ontario Ministry of the Environment ("MOE") including Ontario Regulation 359/09. Based on Ontario Regulation 359/09, the project is considered a Class 4 wind facility.

HGC Engineering conducted background sound level monitoring at a number of representative residences within the influence area of the proposed HAF Wind Energy Project. Unattended sound level monitoring was conducted between August 26 and September 9, 2010. Attended sound level measurements were also conducted during this period.

This report is intended as supporting documentation for a Renewable Energy Approval application for the facility.

UPDATES ADDRESSED IN THIS ASSESSMENT REPORT

This report replaces the *Acoustic Assessment Report HAF Wind Energy Project,* Version 3 dated February 1, 2012 [1]. This update has been prepared to address comments from the MOE. Version 2 of the Acoustic Assessment Report included modifications to and the addition of, a number of receptor locations. Table 1 shows the receptor locations and ID's which were modified as part of Version 2.

Table 1: Receptor Modifications

Old Point of Reception ID	UTM Coordinates		New Point of Reception ID	UTM Coordinates		Difference between UTM Coordinates (m)
	Easting	Northing		Easting	Northing	
V10	607871	4774877	R242	607843	4774953	81
V13	608174	4773364	R243	608164	4773488	124
V14	608014	4773320	R244	608024	4773318	11
V15	608076	4773293	R245	608072	4773301	9
V17	607367	4772299	R246	607464	4772330	102
V19	607479	4772131	R247	607470	4772078	54
V21	607117	4772302	R248	607124	4772293	12
V22	607067	4772342	R249	607055	4772362	23
V23	607008	4772370	R250	607002	4772362	10
V24	607016	4772266	R251	607055	4772245	44
V25	607033	4771952	R252	607134	4771769	209
V26	606867	4772428	R253	606898	4772235	196
V34	605062	4771905	R254	605124	4771909	62
V35	605275	4771781	R255	605299	4771766	28
V36	605342	4771759	R256	605349	4771741	19
V37	605462	4771727	R257	605460	4771805	78
V38	606246	4771380	R258	606059	4771413	190

2 GENERAL DESCRIPTION OF WIND TURBINE INSTALLATION SITE AND SURROUNDING ENVIRONMENT

The wind project consists of five wind turbine generators to be located in the Township of West Lincoln, south of Grimsby and east of Hamilton. All of the wind turbine generators will be sited east of Westbrook Road, west of Caistor Centre Road and Abingdon Road, south of 20 Road and north of Concession Road 5. Figure 1a, a wind turbine generator siting drawing prepared by IPC Energy, illustrates the location of the five wind turbine generators, and the location of the nearest residential receptors. Figure 1b, is a scaled location map of the surrounding area.

The area is rural in nature, both acoustically and in general character, with agricultural land uses widely in evidence, including scattered dwellings near the major roadways. Zoning maps obtained from the Township of West Lincoln are included as Appendix B, which illustrate that the project site areas are zoned for Agricultural use, and that small residential and commercial parcels exist, generally near Abingdon along Regional Road 65.

3 DESCRIPTION OF SOUND SOURCES

Five 1.8 MW Vestas V100 wind turbine generators are proposed for the site. They are three bladed, upwind, horizontal axis wind turbines with a rotor diameter of 100 m. The turbine rotor and nacelle are mounted on top of a 95 m high tubular tower. The turbines are anticipated to operate continuously whenever wind conditions allow. Additional details are contained in Appendix C, with acoustic information contained in Appendix D. Electronic topology mapping for the area suggests that the turbines will generally be based at an elevation of between about 195 to 200 metres above sea level. Table 2 provides the UTM coordinates (Zone 17) of the five wind turbine generators.

Table 2: Locations of Wind Turbine Generators (WTG) [m]

Source	Easting	Northing
WTG 1	604718	4775553
WTG 2	604889	4775173
WTG 3	606291	4774905
WTG 4	604359	4774307
WTG 5	606233	4773420

Please note that the Vestas V100 wind turbines have nacelle mounted transformers and therefore there will be no ground level transformers part of this project. The sound power level of the wind turbines includes the sound power of the nacelle mounted transformer. This project does not include a larger step-up transformer. The electrical connection for this project will be at a switching station with UTM coordinates presented in Table 3.

Table 3: Location of Switching Station [m]

Source	Easting	Northing
Switching Station	606822	4773919

4 WIND TURBINE NOISE EMISSION RATINGS

Overall sound power data for the Vestas V100 wind turbines as determined in accordance with IEC 61400-11:2002 [2], are provided by Vestas in the document *Sound Power Level Data for the V100-1.8 MW* [3] and in the form of a letter issued to IPC Energy [4]. CAN/CSA-C61400-11-07 standard, referenced by the MOE, is an adoption without modification of the identically titled IEC Standard IEC 61400-11 (edition 2:2002 consolidated with amendment 1:2006). Additionally, a test report completed by DNV Renewables (USA) Inc., *Acoustic Noise Test Report for a Vestas V100 1.8 MW Turbine at Pueblo, Colorado* [5], is also included under Appendix D. The overall A-weighted sound power levels as a function of 10 meter height wind speed are shown in Table 4.

Table 4: 10 Metre Height Wind Speed vs Turbine Sound Power Level, Based on IEC Sound Power Determination Methodology and Wind Shear of 0.2

Wind Speed [m/s] at 10m Height	6	7	8	9	10 – cutout
Wind Turbine Sound Power Level [dBA]	103.3	105.0	105.0	105.0	105.0

Sound power level data determined under IEC 61400-11 is normalized to a standard “roughness length” value of 0.05 m. The roughness length concept is used to take into account the effect of friction at the ground, which results in lower wind speeds near the ground than at higher elevations. The wind shear exponent quantifies the same concept by describing the rate of change of windspeed with elevation. A roughness length of 0.05 m is generally held to be equivalent to a wind shear value of about 0.2. Meteorological data near the proposed wind project provided by IPC Energy indicates that the average summer nighttime wind shear was found to be on the order of 0.6 (see Appendix F). This means that a 10 m height wind speed of 1.8 m/s can occur simultaneously with a 7 m/s wind speed at the hub height of 95 m, indicating that maximum sound power output may occur during relatively low 10 m level wind speeds. Consequently the maximum sound power level for the wind turbine (corresponding to a hub height wind speed of 7 m/s) has been used in this analysis.

Table 5 presents the typical octave band spectrum for various 10 m height wind speeds received from Vestas, also included in Appendix D. The spectral shape shown for the 10 m height 7 m/s wind speed has been used in the analysis.

Table 5: Wind Turbine Acoustic Emissions Summary

Make and Model:	Vestas V100									
Electrical Rating:	1800 kW									
Hub Height (m):	95m									
Wind Shear Coefficient:	Maximum sound power level utilized to account for average summer nighttime wind shear value of 0.6.									
	Octave Band Sound Power Level [dB]									
	Manufacturer's Emission Levels					**Adjusted Emission Level**				
Wind Speed [m/s]	**6**	**7**	**8**	**9**	**10**	**6**	**7**	**8**	**9**	**10**
Frequency [Hz]										
63	111.4	113.6	113.3	112.9	112.8	113.6	113.6	113.6	113.6	113.6
125	105.7	108.1	107.8	107.4	107.5	108.1	108.1	108.1	108.1	108.1
250	101.6	103.3	102.8	102.2	102.1	103.3	103.3	103.3	103.3	103.3
500	98.6	100.3	99.9	99.3	99.3	100.3	100.3	100.3	100.3	100.3
1000	98.2	99.7	99.5	99.0	99.1	99.7	99.7	99.7	99.7	99.7
2000	95.4	97.0	97.2	97.0	97.0	97.0	97.0	97.0	97.0	97.0
4000	93.6	95.6	96.2	97.7	97.6	95.6	95.6	95.6	95.6	95.6
8000	86.5	90.9	91.4	92.5	93.4	90.9	90.9	90.9	90.9	90.9
Overall A-Weighted	103.3	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0

Vestas has indicated that the tonal audibility value for these wind turbines, as per IEC 61400-11-ed2:2002, will be less than 2 dBA. A tonal penalty has not been applied in this assessment. Additionally, Vestas has also indicated that the sound power levels provided have a measurement uncertainty of +/- 2 dBA. The sound level predictions herein are subject to the degree of uncertainty related to the sound power of the turbine, in addition to the uncertainty related to the fluctuations of atmospheric conditions and the accuracy and limitations inherent in the modelling methodology.

5 POINT OF RECEPTION SUMMARY

As shown in Figure 2, there are several residences in the vicinity of the project, generally sited along the major roadways. The closest noise sensitive receptors have been identified on Figure 2. A table of UTM co-ordinates for 294 receptors, including vacant lots, located near the proposed wind turbine generators was received from Vineland Power Inc.. The existing receptors and vacant lots, together with their coordinates are listed in Tables A3 and A4. For the purposes of this report, each of the 294 receptors was represented by a discrete sound prediction location at the dwelling coordinate, with an assumed height of 4.5 metres above the local grade to represent potential second-story windows. Where vacant lots were identified, the assumed future location of the dwelling was selected to be consistent with the typical building pattern in the area. Vineland Power Inc. has indicated all receptors within the study area are two storey's or less.

A number of the receptors identified have agreements with the developer. These receptors are identified as participating receptors by the MOE. According to the publication *Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities,* October 2008 ("*Interpretation*") [6], a participating receptor "means a property that is associated with the Wind Farm by means of a legal agreement with the property owner for the installation and operation of wind turbines or related equipment located on that property."

Table A3 includes non-participating receptors while Table A4 includes the details of the participating receptors.

6 ASSESSMENT CRITERIA

The MOE publication NPC-232 *Sound Level Limits for Stationary Sources in Class 3 Areas (Rural)* [7] indicates that the applicable sound level limit for a stationary source of sound is the background sound level. However, where background sound levels are low, exclusionary minimum criteria apply, with an exclusionary limit of 40 dBA specified for quiet night time periods, and 45 dBA specified for quiet daytime periods. To determine if the minimum criteria should apply, an ambient baseline sound study was conducted from August 26 to September 9,

2010. Typical L_{EQ} sound levels on the order of 50 dBA were recorded with ninetieth percentile sound levels (L_{90}) falling as low as 37 dBA during nighttime hours. The L_{90} sound levels indicate that the area is acoustically rural, and that the minimum limits apply.

Because wind turbines generate more sound as the wind speeds increase, and because increasing wind speeds tend to cause greater background sound levels, wind turbine generators have been identified by the MOE as a unique case, and the MOE has provided supplementary guidance for the assessment of wind turbine noise in *Interpretation* . This publication provides criteria for the combined impact of all turbines in an area as a function of 10 metre height wind speed. The criteria are presented in A-weighted decibels, as shown in Table 6.

Table 6: Wind Turbine Noise Criteria [dBA]

Wind Speed [m/s] at 10 m Height	4	5	6	7	8	9	10
Wind Turbine Sound Level Limits Class 3 Area, [dBA]	40.0	40.0	40.0	43.0	45.0	49.0	51.0

It should be noted that the MOE guidelines, including NPC-232 and *Interpretation* do not require or imply that a noise source should be inaudible at a point of reception, and inaudibility should not be expected. In fact, even when the sound levels from a source are less than the numeric guideline limits, spectral and temporal characteristics of a sound regularly result in audibility at points of reception. To be clear, wind turbines may be audible at residences even when sound levels are below MOE guidelines noise criteria.

In the case of this assessment, the sound power output is assumed to be constant at the maximum value of 105.0 dBA over the full range of hub height wind speeds due to the summer nighttime wind shear exponent. Thus, this assessment is based on the minimum criteria of 40 dBA and the maximum wind turbine sound power level.

7 IMPACT ASSESSMENT

An acoustic model of the site was created on a computer using Cadna/A (version 4.3.143), a commercial acoustic modeling system. Cadna/A uses the computational procedures of ISO 9613-2, *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* [8], which accounts for reduction in sound level with distance due to geometrical spreading, air absorption, ground attenuation and acoustical shielding by intervening structures (or by topography and foliage where applicable). This is the standard that is specified by *Interpretation* to be used in the assessment of wind project noise.

Topographical data for the site and surrounding area was provided by IPC Energy. Ground attenuation was assumed to be spectral for all sources, with the ground factor (G) assumed to be 0.7 globally. The temperature and relative humidity were assumed to be 10° C and 70%, respectively. Stands of foliage were not modelled. There are no known wind projects, outside of the proposed, within 5 km.

All wind turbine generators were modeled as point sources at a height of 95 metres above grade. Figure 2 presents the acoustic model, with the source and receptor locations shown. Figure 3 is a noise contour map of the area surrounding the facility produced by Cadna/A based on the octave band sound power levels corresponding to the overall 105.0 dBA sound power, at a 10 m height wind speed of 7 m/s. The required summary tables are contained in Appendix A of this report.

Tables A5 and A6 list the sound pressure levels calculated at each of the identified receptor locations. In general, sound levels are predicted to be at or below the 40.0 dBA minimum criterion at all but four participating receptor locations. At these participating receptors, sound levels of up to 42.9 dBA are predicted. The owners of these properties have entered into lease agreements with the proponent and include a wind turbine or related infrastructure on the properties. These receptors are considered herein to be part of the project (i.e. participating receptors) and not sensitive receptors for the purposes of sound level impact. Details of the calculations are provided in Appendix E. The Cadna/A computer model can be provided upon request.

When conducting an acoustic audit of a conventional stationary industrial sound source, the MOE guidelines direct that periods of high wind be excluded. Typically, the noise output of industrial sound sources is independent of wind speed. However, this is not the case for wind plants and there is an intrinsic relationship between wind speed (and therefore ambient noise) and increased sound power levels associated with the wind turbine generators. Complicating matters, there is a large degree of variability related to environmental factors within the wind plant area including, among others, local ground level wind speeds, wind speeds affecting the wind turbine generator blades, the associated wind shear, and the sound power of the wind turbine generators, all of which affect the measured sound levels. Thus, it is not realistic to expect that in practice a single repeatable sound level can or will be measured for a given wind speed at a given setback distance; a simple comparison of single numbers is not sufficient or possible.

8 CONCLUSIONS AND RECOMMENDATIONS

The analysis, performed in accordance with the methods prescribed by the Ontario Ministry of the Environment in publication *Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities*, October 2008, indicates that the operation of the proposed wind project will comply with the requirements of the MOE publication NPC-232 *Sound Level Limits for Stationary Sources in Class 3 Areas (Rural)* for all identified non-participating receptor locations.

REFERENCES

1. Howe Gastmeier Chapnik Limited, *Acoustic Assessment Report*, *HAF Wind Energy Project*, Version 2, February 1, 2013.

2. CAN/CSA-C61400-11-07, *Wind Turbine Generator Systems – Part 11: Acoustic noise measurement techniques*, Edition 2.1, 2006-11.

3. Vestas, *Sound Power Level Data for the V100-1.8MW*

4. Vestas, *Warranted Sound Power Level and Tonality for the Vestas V100-1.8MW for the Vineland Power Inc. and Wainfleet Wind Energy Inc. Projects*, dated December 1, 2010.

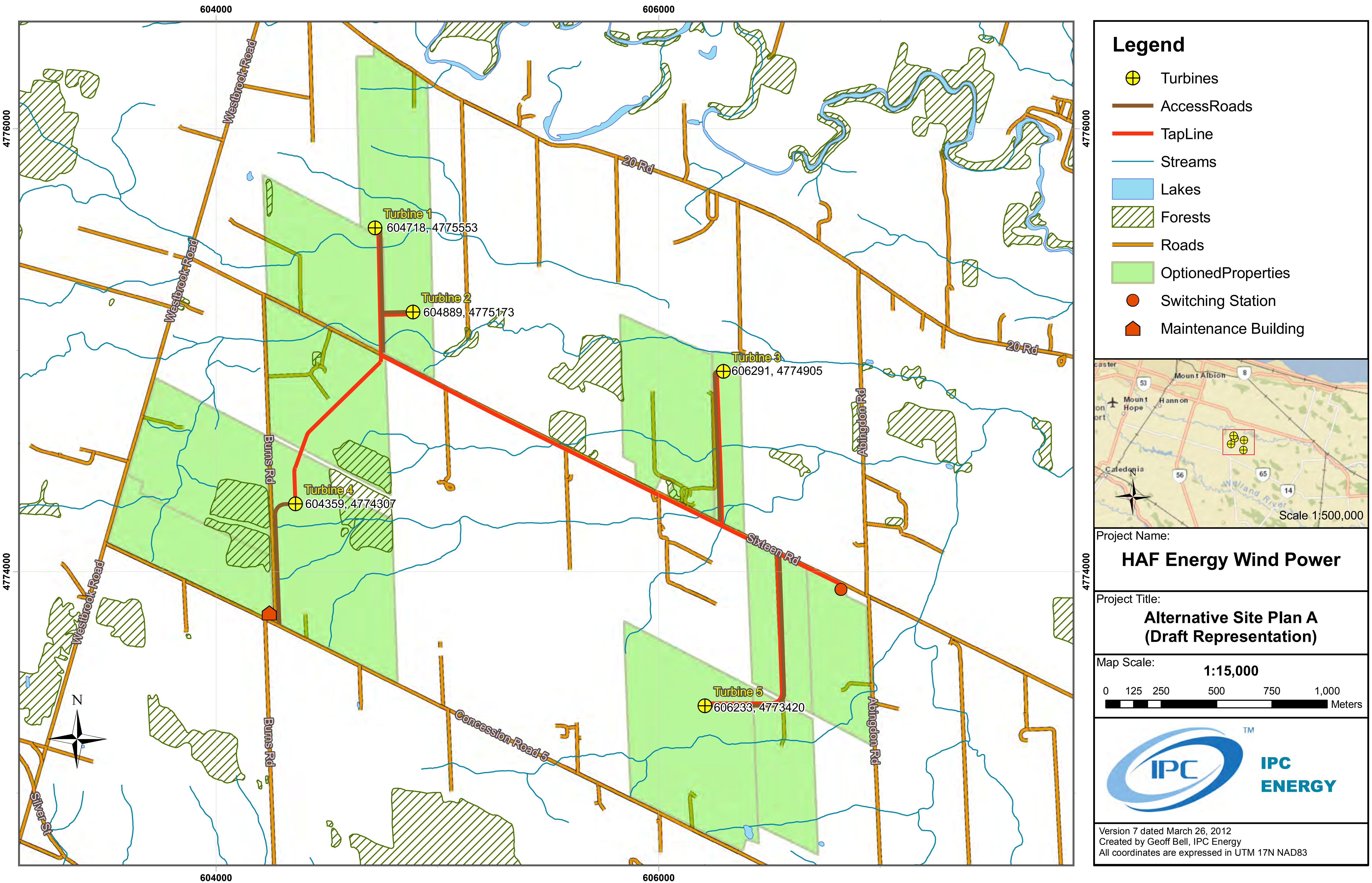
5. DNV Renewables (USA) Inc., *Acoustic Noise Test Report for a Vestas V100 1.8MW Turbine at Pueblo, Colorado*, May 11, 2011.

6. Ontario Ministry of the Environment Publication *Noise Guidelines for Wind Farms, Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities*, October, 2008.

7. Ontario Ministry of the Environment Publication NPC-232, *Sound Level Limits for Stationary Sources in Class 3 Areas (Rural)*, October, 1995.

8. International Organization for Standardization, “Acoustics – Attenuation of Sound during Propagation Outdoors – Part 2: General Method of Calculation,” ISO-9613-2, Switzerland, 1996.

9. Google Maps Aerial Imagery, Internet Application: *maps.google.com*



604000
606000
4776000
4774000
Westbrook Road
Burns Rd
20 Rd
Sixteen Rd
Abingdon Rd
Concession Road 5
Silver St
Turbine 1
604718, 4775553
Turbine 2
604889, 4775173
Turbine 3
606291, 4774905
Turbine 4
604359, 4774307
Turbine 5
606233, 4773420
N
Legend
Turbines
AccessRoads
TapLine
Streams
Lakes
Forests
Roads
OptionedProperties
Switching Station
Maintenance Building
Mount Albion
Mount Hope
Hannon
Caledonia
Welland River
Scale 1:500,000
Project Name:
HAF Energy Wind Power
Project Title:
Alternative Site Plan A
(Draft Representation)
Map Scale:
1:15,000
0 125 250 500 750 1,000
Meters
IPC ENERGY
Version 7 dated March 26, 2012
Created by Geoff Bell, IPC Energy
All coordinates are expressed in UTM 17N NAD83

Figure 1b: Key Location Plan

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Legend
Proposed Turbine Location
550m Setback Distance
Participating Property
Figure 2: Receptors and Wind Turbine Generator Locations
Vineland Power
HAF Wind Energy Project
N
0
0.25
0.5
km
Scale 1:7,500
March 5, 2013
Imagery Source: Google Earth [9]
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FRAME COORDINATES ARE UTM IN METRES
Golf Club Road
S. Grimsby Road 18
Twenty Rd.
Sixteen Rd.
Concession Rd 5
Burns Rd.
Westbrook Rd.
Abingdon Rd.
Silver St.
Concession Road 3
WTG1
WTG2
WTG3
WTG4
WTG5
PR01
PR02
PR03
PR04
PR05
PR06
PR07
PR08
PR09
PV01
Google earth

Figure 3: Predicted Sound Levels, Leq [dBA]
Vineland Power HAF Wind Energy Project
Sound Level Grid Height Calculated at 4.5m

APPENDIX A:
ASSESSMENT SUMMARY TABLES

ACOUSTIC ASSESSMENT SUMMARY TABLES

VERSION CONTROL

HAF Wind Energy Project, Township of West Lincoln, Ontario

Ver.	Date	Issued as Part of AAR?	Revision Description	Prepared By
1	December 9, 2010	Y	Original version of tables as part of Ver. 1 of Acoustic Assessment Report	M. Munro
2	September 9, 2011	Y	Updated tables as part of Ver. 2 of the Acoustic Assessment Report	M. Munro
3	February 1, 2013	Y	Updated tables as part of Ver. 3 of the Acoustic Assessment Report	I. Bonsma
4	March 25, 2013	Y	Updated tables as part of Ver. 4 of the Acoustic Assessment Report	I. Bonsma

Table A1: Vestas V100 Wind Turbine Acoustic Emissions Summary
Vineland Power, HAF Wind Energy Project

Make and Model:	Vestas V100
Electrical Rating:	1800 kW
Hub Height (m):	95m
Wind Shear Coefficient:	Maximum sound power level utilized to account for average summer nighttime wind shear value of 0.6

	Octave Band Sound Power Level [dB]									
	Manufacturer's Emission Levels					**Adjusted Emission Level**				
Wind Speed [m/s]	**6**	**7**	**8**	**9**	**10**	**6**	**7**	**8**	**9**	**10**
Frequency [Hz]										
63	111.4	113.6	113.3	112.9	112.8	113.6	113.6	113.6	113.6	113.6
125	105.7	108.1	107.8	107.4	107.5	108.1	108.1	108.1	108.1	108.1
250	101.6	103.3	102.8	102.2	102.1	103.3	103.3	103.3	103.3	103.3
500	98.6	100.3	99.9	99.3	99.3	100.3	100.3	100.3	100.3	100.3
1000	98.2	99.7	99.5	99.0	99.1	99.7	99.7	99.7	99.7	99.7
2000	95.4	97.0	97.2	97.0	97.0	97.0	97.0	97.0	97.0	97.0
4000	93.6	95.6	96.2	97.7	97.6	95.6	95.6	95.6	95.6	95.6
8000	86.5	90.9	91.4	92.5	93.4	90.9	90.9	90.9	90.9	90.9
Overall A-Weighted	103.3	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0

Table A2: Wind Turbine Locations
Vineland Power, HAF Wind Energy Project

Identifier	Equipment Make & Model	UTM Coordinates	
		Easting	Northing
WTG 1	Vestas V100, 95 m Hub Height	604718	4775553
WTG 2	Vestas V100, 95 m Hub Height	604889	4775173
WTG 3	Vestas V100, 95 m Hub Height	606291	4774905
WTG 4	Vestas V100, 95 m Hub Height	604359	4774307
WTG 5	Vestas V100, 95 m Hub Height	606233	4773420

Table A3: Non-Participating Receptor Locations
Vineland Power, HAF Wind Energy Project

Point of Reception ID	Description	UTM Coordinates	
		Easting	Westing
R001	Non-Participating Receptor	605650	4773240
R002	Non-Participating Receptor	603247	4772605
R003	Non-Participating Receptor	603254	4772672
R004	Non-Participating Receptor	603301	4773589
R005	Non-Participating Receptor	603306	4773633
R006	Non-Participating Receptor	603634	4773998
R007	Non-Participating Receptor	603365	4773808
R008	Non-Participating Receptor	603386	4773180
R009	Non-Participating Receptor	603374	4773842
R010	Non-Participating Receptor	607486	4773574
R011	Non-Participating Receptor	603409	4772552
R012	Non-Participating Receptor	603413	4772587
R013	Non-Participating Receptor	603457	4772569
R014	Non-Participating Receptor	603527	4772509
R015	Non-Participating Receptor	603580	4775203
R016	Non-Participating Receptor	603594	4772427
R017	Non-Participating Receptor	603634	4774736
R018	Non-Participating Receptor	603639	4774864
R019	Non-Participating Receptor	605987	4772878
R020	Non-Participating Receptor	603654	4772358
R021	Non-Participating Receptor	603655	4772473
R022	Non-Participating Receptor	603681	4774892
R023	Non-Participating Receptor	603691	4775182
R024	Non-Participating Receptor	603787	4775428
R025	Non-Participating Receptor	604657	4776539
R026	Non-Participating Receptor	603813	4775415
R027	Non-Participating Receptor	604160	4775998
R028	Non-Participating Receptor	603834	4776027
R029	Non-Participating Receptor	603842	4775407
R030	Non-Participating Receptor	603860	4772369
R031	Non-Participating Receptor	603876	4772600
R032	Non-Participating Receptor	603885	4772362
R033	Non-Participating Receptor	604268	4773661
R034	Non-Participating Receptor	603891	4775200
R035	Non-Participating Receptor	603631	4775471
R036	Non-Participating Receptor	603967	4775619
R037	Non-Participating Receptor	603674	4775789
R038	Non-Participating Receptor	604020	4772236
R039	Non-Participating Receptor	604024	4772292
R040	Non-Participating Receptor	604101	4775955
R041	Non-Participating Receptor	604095	4772175
R042	Non-Participating Receptor	604109	4776608
R043	Non-Participating Receptor	604050	4775904
R044	Non-Participating Receptor	603741	4772522
R045	Non-Participating Receptor	604307	4772252
R046	Non-Participating Receptor	604351	4772223

Point of Reception ID	Description	UTM Coordinates	
		Easting	Westing
R047	Non-Participating Receptor	604392	4772210
R048	Non-Participating Receptor	604433	4772192
R049	Non-Participating Receptor	604450	4772079
R050	Non-Participating Receptor	604481	4772159
R051	Non-Participating Receptor	604670	4776353
R052	Non-Participating Receptor	604981	4776234
R053	Non-Participating Receptor	605034	4776201
R054	Non-Participating Receptor	607019	4773125
R055	Non-Participating Receptor	606902	4774665
R056	Non-Participating Receptor	605020	4776145
R057	Non-Participating Receptor	605305	4776000
R058	Non-Participating Receptor	604805	4776430
R059	Non-Participating Receptor	604999	4773621
R060	Non-Participating Receptor	605060	4774364
R061	Non-Participating Receptor	605410	4776037
R062	Non-Participating Receptor	605568	4775888
R063	Non-Participating Receptor	605590	4774451
R064	Non-Participating Receptor	605657	4775882
R065	Non-Participating Receptor	605708	4775943
R066	Non-Participating Receptor	605710	4772959
R067	Non-Participating Receptor	605882	4774457
R068	Non-Participating Receptor	605726	4774519
R069	Non-Participating Receptor	605833	4775945
R070	Non-Participating Receptor	605819	4774490
R071	Non-Participating Receptor	605832	4774384
R072	Non-Participating Receptor	606537	4775561
R073	Non-Participating Receptor	605907	4775894
R074	Non-Participating Receptor	605996	4774315
R075	Non-Participating Receptor	606977	4773918
R076	Non-Participating Receptor	606997	4773430
R077	Non-Participating Receptor	606402	4774198
R078	Non-Participating Receptor	606473	4775589
R079	Non-Participating Receptor	606410	4775612
R080	Non-Participating Receptor	606111	4775809
R081	Non-Participating Receptor	606335	4775728
R082	Non-Participating Receptor	606243	4775609
R083	Non-Participating Receptor	606492	4775703
R084	Non-Participating Receptor	606988	4775394
R085	Non-Participating Receptor	606557	4772527
R086	Non-Participating Receptor	606736	4775546
R087	Non-Participating Receptor	606815	4772555
R088	Non-Participating Receptor	606965	4774631
R089	Non-Participating Receptor	606965	4774686
R090	Non-Participating Receptor	606756	4772576
R091	Non-Participating Receptor	607037	4775217
R092	Non-Participating Receptor	606699	4772616
R093	Non-Participating Receptor	607071	4774252
R094	Non-Participating Receptor	606479	4772736

Point of Reception ID	Description	UTM Coordinates	
		Easting	Westing
R095	Non-Participating Receptor	606874	4772513
R096	Non-Participating Receptor	606905	4774043
R097	Non-Participating Receptor	606965	4772481
R098	Non-Participating Receptor	607195	4775123
R099	Non-Participating Receptor	606960	4774755
R100	Non-Participating Receptor	607281	4775309
R101	Non-Participating Receptor	607301	4775057
R102	Non-Participating Receptor	607288	4773683
R103	Non-Participating Receptor	607207	4775216
R104	Non-Participating Receptor	607517	4772128
R105	Non-Participating Receptor	607787	4775239
R106	Non-Participating Receptor	607405	4775291
R107	Non-Participating Receptor	607726	4772109
R108	Non-Participating Receptor	607747	4772086
R109	Non-Participating Receptor	607796	4775050
R110	Non-Participating Receptor	607774	4772088
R111	Non-Participating Receptor	607774	4775154
R112	Non-Participating Receptor	607627	4774954
R113	Non-Participating Receptor	607043	4773799
R114	Non-Participating Receptor	607673	4773299
R115	Non-Participating Receptor	606963	4774380
R116	Non-Participating Receptor	606409	4772743
R117	Non-Participating Receptor	605556	4773065
R118	Non-Participating Receptor	606021	4772661
R119	Non-Participating Receptor	603898	4773715
R120	Non-Participating Receptor	606031	4774379
R121	Non-Participating Receptor	606992	4773820
R122	Non-Participating Receptor	606891	4773887
R123	Non-Participating Receptor	607011	4773349
R124	Non-Participating Receptor	606301	4775649
R125	Non-Participating Receptor	604552	4777564
R126	Non-Participating Receptor	604554	4777529
R127	Non-Participating Receptor	604427	4777504
R128	Non-Participating Receptor	604543	4777503
R129	Non-Participating Receptor	604535	4777473
R130	Non-Participating Receptor	604522	4777444
R131	Non-Participating Receptor	604525	4777408
R132	Non-Participating Receptor	604415	4777382
R133	Non-Participating Receptor	604409	4777355
R134	Non-Participating Receptor	604401	4777326
R135	Non-Participating Receptor	604479	4777297
R136	Non-Participating Receptor	604389	4777296
R137	Non-Participating Receptor	604067	4777238
R138	Non-Participating Receptor	604364	4777236
R139	Non-Participating Receptor	604107	4777216
R140	Non-Participating Receptor	604178	4777205
R141	Non-Participating Receptor	604143	4777203
R142	Non-Participating Receptor	604207	4777193

Point of Reception ID	Description	UTM Coordinates	
		Easting	Westing
R143	Non-Participating Receptor	604273	4777181
R144	Non-Participating Receptor	604235	4777181
R145	Non-Participating Receptor	603565	4777166
R146	Non-Participating Receptor	604329	4777163
R147	Non-Participating Receptor	604452	4777135
R148	Non-Participating Receptor	604322	4777092
R149	Non-Participating Receptor	605548	4776935
R150	Non-Participating Receptor	605650	4776892
R151	Non-Participating Receptor	604432	4776882
R152	Non-Participating Receptor	606391	4776835
R153	Non-Participating Receptor	604250	4776823
R154	Non-Participating Receptor	604404	4776811
R155	Non-Participating Receptor	604172	4776799
R156	Non-Participating Receptor	604246	4776785
R157	Non-Participating Receptor	604163	4776773
R158	Non-Participating Receptor	604298	4776751
R159	Non-Participating Receptor	604396	4776743
R160	Non-Participating Receptor	604158	4776719
R161	Non-Participating Receptor	604639	4776529
R162	Non-Participating Receptor	607923	4776049
R163	Non-Participating Receptor	607839	4776021
R164	Non-Participating Receptor	607801	4775831
R165	Non-Participating Receptor	604109	4775818
R166	Non-Participating Receptor	607849	4775780
R167	Non-Participating Receptor	607960	4775761
R168	Non-Participating Receptor	602774	4775603
R169	Non-Participating Receptor	604031	4775587
R170	Non-Participating Receptor	602790	4775563
R171	Non-Participating Receptor	602672	4775545
R172	Non-Participating Receptor	602850	4775540
R173	Non-Participating Receptor	602707	4775533
R174	Non-Participating Receptor	602751	4775531
R175	Non-Participating Receptor	602895	4775506
R176	Non-Participating Receptor	602927	4775486
R177	Non-Participating Receptor	602956	4775479
R178	Non-Participating Receptor	603000	4775466
R179	Non-Participating Receptor	603040	4775452
R180	Non-Participating Receptor	607995	4775436
R181	Non-Participating Receptor	603072	4775427
R182	Non-Participating Receptor	603103	4775417
R183	Non-Participating Receptor	602815	4775417
R184	Non-Participating Receptor	603128	4775413
R185	Non-Participating Receptor	603181	4775397
R186	Non-Participating Receptor	602895	4775397
R187	Non-Participating Receptor	602943	4775389
R188	Non-Participating Receptor	603206	4775388
R189	Non-Participating Receptor	602972	4775386
R190	Non-Participating Receptor	602849	4775373

Point of Reception ID	Description	UTM Coordinates	
		Easting	Westing
R191	Non-Participating Receptor	603015	4775367
R192	Non-Participating Receptor	608029	4775362
R193	Non-Participating Receptor	603063	4775353
R194	Non-Participating Receptor	608017	4775300
R195	Non-Participating Receptor	603371	4775265
R196	Non-Participating Receptor	608022	4775251
R197	Non-Participating Receptor	607957	4775000
R198	Non-Participating Receptor	608019	4774960
R199	Non-Participating Receptor	603672	4774958
R200	Non-Participating Receptor	608302	4774881
R201	Non-Participating Receptor	603410	4774567
R202	Non-Participating Receptor	602782	4773478
R203	Non-Participating Receptor	602524	4773450
R204	Non-Participating Receptor	602575	4773430
R205	Non-Participating Receptor	602618	4773418
R206	Non-Participating Receptor	602722	4773300
R207	Non-Participating Receptor	602888	4773238
R208	Non-Participating Receptor	603001	4773201
R209	Non-Participating Receptor	602973	4773198
R210	Non-Participating Receptor	602980	4773007
R211	Non-Participating Receptor	603098	4772925
R212	Non-Participating Receptor	603068	4772801
R213	Non-Participating Receptor	603182	4772793
R214	Non-Participating Receptor	603065	4772774
R215	Non-Participating Receptor	603053	4772748
R216	Non-Participating Receptor	603139	4772728
R217	Non-Participating Receptor	603123	4772704
R218	Non-Participating Receptor	603180	4772703
R219	Non-Participating Receptor	603284	4772656
R220	Non-Participating Receptor	603802	4772366
R221	Non-Participating Receptor	603733	4772357
R222	Non-Participating Receptor	603984	4772315
R223	Non-Participating Receptor	607077	4772150
R224	Non-Participating Receptor	604975	4771842
R225	Non-Participating Receptor	605013	4771824
R226	Non-Participating Receptor	605139	4771768
R227	Non-Participating Receptor	605760	4771658
R228	Non-Participating Receptor	607032	4771618
R229	Non-Participating Receptor	605598	4771613
R230	Non-Participating Receptor	605620	4771606
R231	Non-Participating Receptor	605673	4771576
R232	Non-Participating Receptor	605525	4771567
R233	Non-Participating Receptor	605700	4771563
R234	Non-Participating Receptor	605759	4771535
R235	Non-Participating Receptor	605594	4771535
R236	Non-Participating Receptor	605625	4771517
R237	Non-Participating Receptor	605860	4771491
R238	Non-Participating Receptor	606843	4771471

Point of Reception ID	Description	UTM Coordinates	
		Easting	Westing
R239	Non-Participating Receptor	605910	4771458
R240	Non-Participating Receptor	605936	4771451
R241	Non-Participating Receptor	605987	4771436
R242	Non-Participating Receptor	607843	4774953
R243	Non-Participating Receptor	608164	4773488
R244	Non-Participating Receptor	608024	4773318
R245	Non-Participating Receptor	608072	4773301
R246	Non-Participating Receptor	607464	4772330
R247	Non-Participating Receptor	607470	4772078
R248	Non-Participating Receptor	607124	4772293
R249	Non-Participating Receptor	607055	4772362
R250	Non-Participating Receptor	607002	4772362
R251	Non-Participating Receptor	607055	4772245
R252	Non-Participating Receptor	607134	4771769
R253	Non-Participating Receptor	606898	4772235
R254	Non-Participating Receptor	605124	4771909
R255	Non-Participating Receptor	605299	4771766
R256	Non-Participating Receptor	605349	4771741
R257	Non-Participating Receptor	605460	4771805
R258	Non-Participating Receptor	606059	4771413
V01	Non-Participating Vacant Lot	604522	4773620
V02	Non-Participating Vacant Lot	607016	4773841
V03	Non-Participating Vacant Lot	604570	4776376
V04	Non-Participating Vacant Lot	605739	4775832
V05	Non-Participating Vacant Lot	606566	4775508
V06	Non-Participating Vacant Lot	606686	4775426
V07	Non-Participating Vacant Lot	606571	4774188
V08	Non-Participating Vacant Lot	603750	4774656
V09	Non-Participating Vacant Lot	606924	4772994
V11	Non-Participating Vacant Lot	608134	4774824
V12	Non-Participating Vacant Lot	607960	4773440
V16	Non-Participating Vacant Lot	608161	4771919
V18	Non-Participating Vacant Lot	607088	4772438
V20	Non-Participating Vacant Lot	607274	4772215
V27	Non-Participating Vacant Lot	606381	4772607
V28	Non-Participating Vacant Lot	606210	4772699
V29	Non-Participating Vacant Lot	606963	4771641
V30	Non-Participating Vacant Lot	606963	4771578
V31	Non-Participating Vacant Lot	604648	4773485
V32	Non-Participating Vacant Lot	605204	4773227
V33	Non-Participating Vacant Lot	604087	4772382
V39	Non-Participating Vacant Lot	605435	4775876
V40	Non-Participating Vacant Lot	605491	4774678
V41	Non-Participating Vacant Lot	606406	4776900
V42	Non-Participating Vacant Lot	607644	4775446
V43	Non-Participating Vacant Lot	608122	4773280

Table A4: Non-Participating Receptor Locations
Vineland Power, HAF Wind Energy Project

Point of Reception ID	Description	UTM Coordinates	
		Easting	Westing
PR01	Participating Receptor	606123	4773010
PR02	Participating Receptor	606895	4773470
PR03	Participating Receptor	604926	4776096
PR04	Participating Receptor	606129	4774317
PR05	Participating Receptor	606543	4773695
PR06	Participating Receptor	604361	4773804
PR07	Participating Receptor	604466	4774951
PR08	Participating Receptor	604092	4774034
PR09	Participating Receptor	604426	4775303
PV01	Participating Vacant Lot	606319	4774265

Table A5: Wind Turbine Noise Impact Summary - Points of Reception
Vineland Power, HAF Wind Energy Project

Point of Reception ID	Description	Height [m]	Distance to Nearest HAF Turbine [m]	Nearest Turbine ID	Calculated Sound Level [dBA] at Selected Wind Speeds (m/s)					Sound Level Limit [dBA]				
					6	7	8	9	10	6	7	8	9	10
R001	Non-Participating Receptor	4.5	610	WTG5	36.6	36.6	36.6	36.6	36.6	40.0	43.0	45.0	49.0	51.0
R002	Non-Participating Receptor	4.5	2033	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R003	Non-Participating Receptor	4.5	1973	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R004	Non-Participating Receptor	4.5	1279	WTG4	29.5	29.5	29.5	29.5	29.5	40.0	43.0	45.0	49.0	51.0
R005	Non-Participating Receptor	4.5	1250	WTG4	29.7	29.7	29.7	29.7	29.7	40.0	43.0	45.0	49.0	51.0
R006	Non-Participating Receptor	4.5	788	WTG4	34.2	34.2	34.2	34.2	34.2	40.0	43.0	45.0	49.0	51.0
R007	Non-Participating Receptor	4.5	1112	WTG4	30.9	30.9	30.9	30.9	30.9	40.0	43.0	45.0	49.0	51.0
R008	Non-Participating Receptor	4.5	1489	WTG4	28.1	28.1	28.1	28.1	28.1	40.0	43.0	45.0	49.0	51.0
R009	Non-Participating Receptor	4.5	1089	WTG4	31.1	31.1	31.1	31.1	31.1	40.0	43.0	45.0	49.0	51.0
R010	Non-Participating Receptor	4.5	1262	WTG5	29.8	29.8	29.8	29.8	29.8	40.0	43.0	45.0	49.0	51.0
R011	Non-Participating Receptor	4.5	1996	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R012	Non-Participating Receptor	4.5	1963	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R013	Non-Participating Receptor	4.5	1958	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R014	Non-Participating Receptor	4.5	1981	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R015	Non-Participating Receptor	4.5	1187	WTG4	33.2	33.2	33.2	33.2	33.2	40.0	43.0	45.0	49.0	51.0
R016	Non-Participating Receptor	4.5	2030	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R017	Non-Participating Receptor	4.5	842	WTG4	34.6	34.6	34.6	34.6	34.6	40.0	43.0	45.0	49.0	51.0
R018	Non-Participating Receptor	4.5	910	WTG4	34.3	34.3	34.3	34.3	34.3	40.0	43.0	45.0	49.0	51.0
R019	Non-Participating Receptor	4.5	595	WTG5	36.5	36.5	36.5	36.5	36.5	40.0	43.0	45.0	49.0	51.0
R020	Non-Participating Receptor	4.5	2073	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R021	Non-Participating Receptor	4.5	1964	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R022	Non-Participating Receptor	4.5	895	WTG4	34.6	34.6	34.6	34.6	34.6	40.0	43.0	45.0	49.0	51.0
R023	Non-Participating Receptor	4.5	1101	WTG4	34.1	34.1	34.1	34.1	34.1	40.0	43.0	45.0	49.0	51.0
R024	Non-Participating Receptor	4.5	1131	WTG2	34.6	34.6	34.6	34.6	34.6	40.0	43.0	45.0	49.0	51.0
R025	Non-Participating Receptor	4.5	1386	WTG2	32.8	32.8	32.8	32.8	32.8	40.0	43.0	45.0	49.0	51.0
R026	Non-Participating Receptor	4.5	1103	WTG2	34.8	34.8	34.8	34.8	34.8	40.0	43.0	45.0	49.0	51.0
R027	Non-Participating Receptor	4.5	1101	WTG2	35.9	35.9	35.9	35.9	35.9	40.0	43.0	45.0	49.0	51.0
R028	Non-Participating Receptor	4.5	1357	WTG2	32.9	32.9	32.9	32.9	32.9	40.0	43.0	45.0	49.0	51.0
R029	Non-Participating Receptor	4.5	1073	WTG2	35.1	35.1	35.1	35.1	35.1	40.0	43.0	45.0	49.0	51.0
R030	Non-Participating Receptor	4.5	2001	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R031	Non-Participating Receptor	4.5	1774	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R032	Non-Participating Receptor	4.5	2002	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R033	Non-Participating Receptor	4.5	652	WTG4	36.0	36.0	36.0	36.0	36.0	40.0	43.0	45.0	49.0	51.0
R034	Non-Participating Receptor	4.5	998	WTG2	35.8	35.8	35.8	35.8	35.8	40.0	43.0	45.0	49.0	51.0
R035	Non-Participating Receptor	4.5	1293	WTG2	33.1	33.1	33.1	33.1	33.1	40.0	43.0	45.0	49.0	51.0
R036	Non-Participating Receptor	4.5	1024	WTG2	36.0	36.0	36.0	36.0	36.0	40.0	43.0	45.0	49.0	51.0
R037	Non-Participating Receptor	4.5	1362	WTG2	32.6	32.6	32.6	32.6	32.6	40.0	43.0	45.0	49.0	51.0
R038	Non-Participating Receptor	4.5	2099	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R039	Non-Participating Receptor	4.5	2043	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R040	Non-Participating Receptor	4.5	1110	WTG2	35.7	35.7	35.7	35.7	35.7	40.0	43.0	45.0	49.0	51.0
R041	Non-Participating Receptor	4.5	2148	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R042	Non-Participating Receptor	4.5	1633	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R043	Non-Participating Receptor	4.5	1113	WTG2	35.5	35.5	35.5	35.5	35.5	40.0	43.0	45.0	49.0	51.0
R044	Non-Participating Receptor	4.5	1889	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R045	Non-Participating Receptor	4.5	2056	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R046	Non-Participating Receptor	4.5	2084	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R047	Non-Participating Receptor	4.5	2097	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R048	Non-Participating Receptor	4.5	2116	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R049	Non-Participating Receptor	4.5	2230	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R050	Non-Participating Receptor	4.5	2151	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R051	Non-Participating Receptor	4.5	1200	WTG2	34.7	34.7	34.7	34.7	34.7	40.0	43.0	45.0	49.0	51.0
R052	Non-Participating Receptor	4.5	1065	WTG2	35.8	35.8	35.8	35.8	35.8	40.0	43.0	45.0	49.0	51.0
R053	Non-Participating Receptor	4.5	1038	WTG2	36.0	36.0	36.0	36.0	36.0	40.0	43.0	45.0	49.0	51.0
R054	Non-Participating Receptor	4.5	840	WTG5	33.2	33.2	33.2	33.2	33.2	40.0	43.0	45.0	49.0	51.0
R055	Non-Participating Receptor	4.5	656	WTG3	36.0	36.0	36.0	36.0	36.0	40.0	43.0	45.0	49.0	51.0
R056	Non-Participating Receptor	4.5	981	WTG2	36.8	36.8	36.8	36.8	36.8	40.0	43.0	45.0	49.0	51.0
R057	Non-Participating Receptor	4.5	926	WTG2	36.4	36.4	36.4	36.4	36.4	40.0	43.0	45.0	49.0	51.0
R058	Non-Participating Receptor	4.5	1260	WTG2	33.9	33.9	33.9	33.9	33.9	40.0	43.0	45.0	49.0	51.0
R059	Non-Participating Receptor	4.5	938	WTG4	34.3	34.3	34.3	34.3	34.3	40.0	43.0	45.0	49.0	51.0
R060	Non-Participating Receptor	4.5	703	WTG4	37.8	37.8	37.8	37.8	37.8	40.0	43.0	45.0	49.0	51.0
R061	Non-Participating Receptor	4.5	1009	WTG2	35.4	35.4	35.4	35.4	35.4	40.0	43.0	45.0	49.0	51.0
R062	Non-Participating Receptor	4.5	986	WTG2	35.4	35.4	35.4	35.4	35.4	40.0	43.0	45.0	49.0	51.0
R063	Non-Participating Receptor	4.5	835	WTG3	36.6	36.6	36.6	36.6	36.6	40.0	43.0	45.0	49.0	51.0
R064	Non-Participating Receptor	4.5	1045	WTG2	34.9	34.9	34.9	34.9	34.9	40.0	43.0	45.0	49.0	51.0
R065	Non-Participating Receptor	4.5	1124	WTG2	34.3	34.3	34.3	34.3	34.3	40.0	43.0	45.0	49.0	51.0

Point of Reception ID	Description	Height [m]	Distance to Nearest HAF Turbine [m]	Nearest Turbine ID	Calculated Sound Level [dBA] at Selected Wind Speeds (m/s)					Sound Level Limit [dBA]				
					6	7	8	9	10	6	7	8	9	10
R066	Non-Participating Receptor	4.5	697	WTG5	35.2	35.2	35.2	35.2	35.2	40.0	43.0	45.0	49.0	51.0
R067	Non-Participating Receptor	4.5	607	WTG3	37.9	37.9	37.9	37.9	37.9	40.0	43.0	45.0	49.0	51.0
R068	Non-Participating Receptor	4.5	684	WTG3	37.3	37.3	37.3	37.3	37.3	40.0	43.0	45.0	49.0	51.0
R069	Non-Participating Receptor	4.5	1136	WTG3	33.8	33.8	33.8	33.8	33.8	40.0	43.0	45.0	49.0	51.0
R070	Non-Participating Receptor	4.5	628	WTG3	37.7	37.7	37.7	37.7	37.7	40.0	43.0	45.0	49.0	51.0
R071	Non-Participating Receptor	4.5	694	WTG3	37.1	37.1	37.1	37.1	37.1	40.0	43.0	45.0	49.0	51.0
R072	Non-Participating Receptor	4.5	701	WTG3	35.4	35.4	35.4	35.4	35.4	40.0	43.0	45.0	49.0	51.0
R073	Non-Participating Receptor	4.5	1061	WTG3	33.9	33.9	33.9	33.9	33.9	40.0	43.0	45.0	49.0	51.0
R074	Non-Participating Receptor	4.5	660	WTG3	37.4	37.4	37.4	37.4	37.4	40.0	43.0	45.0	49.0	51.0
R075	Non-Participating Receptor	4.5	895	WTG5	33.8	33.8	33.8	33.8	33.8	40.0	43.0	45.0	49.0	51.0
R076	Non-Participating Receptor	4.5	764	WTG5	34.3	34.3	34.3	34.3	34.3	40.0	43.0	45.0	49.0	51.0
R077	Non-Participating Receptor	4.5	716	WTG3	37.1	37.1	37.1	37.1	37.1	40.0	43.0	45.0	49.0	51.0
R078	Non-Participating Receptor	4.5	708	WTG3	35.4	35.4	35.4	35.4	35.4	40.0	43.0	45.0	49.0	51.0
R079	Non-Participating Receptor	4.5	717	WTG3	35.3	35.3	35.3	35.3	35.3	40.0	43.0	45.0	49.0	51.0
R080	Non-Participating Receptor	4.5	922	WTG3	34.0	34.0	34.0	34.0	34.0	40.0	43.0	45.0	49.0	51.0
R081	Non-Participating Receptor	4.5	824	WTG3	34.3	34.3	34.3	34.3	34.3	40.0	43.0	45.0	49.0	51.0
R082	Non-Participating Receptor	4.5	706	WTG3	35.7	35.7	35.7	35.7	35.7	40.0	43.0	45.0	49.0	51.0
R083	Non-Participating Receptor	4.5	823	WTG3	34.0	34.0	34.0	34.0	34.0	40.0	43.0	45.0	49.0	51.0
R084	Non-Participating Receptor	4.5	851	WTG3	33.3	33.3	33.3	33.3	33.3	40.0	43.0	45.0	49.0	51.0
R085	Non-Participating Receptor	4.5	950	WTG5	31.8	31.8	31.8	31.8	31.8	40.0	43.0	45.0	49.0	51.0
R086	Non-Participating Receptor	4.5	780	WTG3	34.3	34.3	34.3	34.3	34.3	40.0	43.0	45.0	49.0	51.0
R087	Non-Participating Receptor	4.5	1043	WTG5	30.9	30.9	30.9	30.9	30.9	40.0	43.0	45.0	49.0	51.0
R088	Non-Participating Receptor	4.5	728	WTG3	35.1	35.1	35.1	35.1	35.1	40.0	43.0	45.0	49.0	51.0
R089	Non-Participating Receptor	4.5	709	WTG3	35.3	35.3	35.3	35.3	35.3	40.0	43.0	45.0	49.0	51.0
R090	Non-Participating Receptor	4.5	993	WTG5	31.4	31.4	31.4	31.4	31.4	40.0	43.0	45.0	49.0	51.0
R091	Non-Participating Receptor	4.5	809	WTG3	33.8	33.8	33.8	33.8	33.8	40.0	43.0	45.0	49.0	51.0
R092	Non-Participating Receptor	4.5	929	WTG5	32.0	32.0	32.0	32.0	32.0	40.0	43.0	45.0	49.0	51.0
R093	Non-Participating Receptor	4.5	1017	WTG3	33.1	33.1	33.1	33.1	33.1	40.0	43.0	45.0	49.0	51.0
R094	Non-Participating Receptor	4.5	727	WTG5	34.5	34.5	34.5	34.5	34.5	40.0	43.0	45.0	49.0	51.0
R095	Non-Participating Receptor	4.5	1111	WTG5	30.2	30.2	30.2	30.2	30.2	40.0	43.0	45.0	49.0	51.0
R096	Non-Participating Receptor	4.5	916	WTG5	34.2	34.2	34.2	34.2	34.2	40.0	43.0	45.0	49.0	51.0
R097	Non-Participating Receptor	4.5	1191	WTG5	29.5	29.5	29.5	29.5	29.5	40.0	43.0	45.0	49.0	51.0
R098	Non-Participating Receptor	4.5	930	WTG3	32.5	32.5	32.5	32.5	32.5	40.0	43.0	45.0	49.0	51.0
R099	Non-Participating Receptor	4.5	686	WTG3	35.5	35.5	35.5	35.5	35.5	40.0	43.0	45.0	49.0	51.0
R100	Non-Participating Receptor	4.5	1069	WTG3	31.1	31.1	31.1	31.1	31.1	40.0	43.0	45.0	49.0	51.0
R101	Non-Participating Receptor	4.5	1021	WTG3	31.6	31.6	31.6	31.6	31.6	40.0	43.0	45.0	49.0	51.0
R102	Non-Participating Receptor	4.5	1087	WTG5	31.4	31.4	31.4	31.4	31.4	40.0	43.0	45.0	49.0	51.0
R103	Non-Participating Receptor	4.5	967	WTG3	32.1	32.1	32.1	32.1	32.1	40.0	43.0	45.0	49.0	51.0
R104	Non-Participating Receptor	4.5	1822	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R105	Non-Participating Receptor	4.5	1533	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R106	Non-Participating Receptor	4.5	1179	WTG3	30.2	30.2	30.2	30.2	30.2	40.0	43.0	45.0	49.0	51.0
R107	Non-Participating Receptor	4.5	1987	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R108	Non-Participating Receptor	4.5	2018	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R109	Non-Participating Receptor	4.5	1512	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R110	Non-Participating Receptor	4.5	2037	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R111	Non-Participating Receptor	4.5	1504	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R112	Non-Participating Receptor	4.5	1337	WTG3	29.2	29.2	29.2	29.2	29.2	40.0	43.0	45.0	49.0	51.0
R113	Non-Participating Receptor	4.5	894	WTG5	33.4	33.4	33.4	33.4	33.4	40.0	43.0	45.0	49.0	51.0
R114	Non-Participating Receptor	4.5	1445	WTG5	28.2	28.2	28.2	28.2	28.2	40.0	43.0	45.0	49.0	51.0
R115	Non-Participating Receptor	4.5	853	WTG3	34.2	34.2	34.2	34.2	34.2	40.0	43.0	45.0	49.0	51.0
R116	Non-Participating Receptor	4.5	700	WTG5	34.9	34.9	34.9	34.9	34.9	40.0	43.0	45.0	49.0	51.0
R117	Non-Participating Receptor	4.5	764	WTG5	34.5	34.5	34.5	34.5	34.5	40.0	43.0	45.0	49.0	51.0
R118	Non-Participating Receptor	4.5	788	WTG5	33.8	33.8	33.8	33.8	33.8	40.0	43.0	45.0	49.0	51.0
R119	Non-Participating Receptor	4.5	750	WTG4	34.6	34.6	34.6	34.6	34.6	40.0	43.0	45.0	49.0	51.0
R120	Non-Participating Receptor	4.5	587	WTG3	38.0	38.0	38.0	38.0	38.0	40.0	43.0	45.0	49.0	51.0
R121	Non-Participating Receptor	4.5	858	WTG5	33.9	33.9	33.9	33.9	33.9	40.0	43.0	45.0	49.0	51.0
R122	Non-Participating Receptor	4.5	807	WTG5	34.6	34.6	34.6	34.6	34.6	40.0	43.0	45.0	49.0	51.0
R123	Non-Participating Receptor	4.5	781	WTG5	34.0	34.0	34.0	34.0	34.0	40.0	43.0	45.0	49.0	51.0
R124	Non-Participating Receptor	4.5	744	WTG3	35.2	35.2	35.2	35.2	35.2	40.0	43.0	45.0	49.0	51.0
R125	Non-Participating Receptor	4.5	2415	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R126	Non-Participating Receptor	4.5	2380	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R127	Non-Participating Receptor	4.5	2376	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R128	Non-Participating Receptor	4.5	2356	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R129	Non-Participating Receptor	4.5	2327	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R130	Non-Participating Receptor	4.5	2300	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R131	Non-Participating Receptor	4.5	2264	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R132	Non-Participating Receptor	4.5	2259	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0

Point of Reception ID	Description	Height [m]	Distance to Nearest HAF Turbine [m]	Nearest Turbine ID	Calculated Sound Level [dBA] at Selected Wind Speeds (m/s)					Sound Level Limit [dBA]				
					6	7	8	9	10	6	7	8	9	10
R133	Non-Participating Receptor	4.5	2234	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R134	Non-Participating Receptor	4.5	2208	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R135	Non-Participating Receptor	4.5	2163	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R136	Non-Participating Receptor	4.5	2181	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R137	Non-Participating Receptor	4.5	2223	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R138	Non-Participating Receptor	4.5	2129	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R139	Non-Participating Receptor	4.5	2188	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R140	Non-Participating Receptor	4.5	2153	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R141	Non-Participating Receptor	4.5	2163	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R142	Non-Participating Receptor	4.5	2132	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R143	Non-Participating Receptor	4.5	2100	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R144	Non-Participating Receptor	4.5	2112	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R145	Non-Participating Receptor	4.5	2393	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R146	Non-Participating Receptor	4.5	2067	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R147	Non-Participating Receptor	4.5	2010	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R148	Non-Participating Receptor	4.5	2001	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R149	Non-Participating Receptor	4.5	1881	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R150	Non-Participating Receptor	4.5	1880	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R151	Non-Participating Receptor	4.5	1769	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R152	Non-Participating Receptor	4.5	1933	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R153	Non-Participating Receptor	4.5	1769	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R154	Non-Participating Receptor	4.5	1708	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R155	Non-Participating Receptor	4.5	1777	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R156	Non-Participating Receptor	4.5	1736	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R157	Non-Participating Receptor	4.5	1757	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R158	Non-Participating Receptor	4.5	1685	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R159	Non-Participating Receptor	4.5	1646	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R160	Non-Participating Receptor	4.5	1710	WTG2	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R161	Non-Participating Receptor	4.5	1379	WTG2	32.8	32.8	32.8	32.8	32.8	40.0	43.0	45.0	49.0	51.0
R162	Non-Participating Receptor	4.5	1993	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R163	Non-Participating Receptor	4.5	1908	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R164	Non-Participating Receptor	4.5	1771	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R165	Non-Participating Receptor	4.5	1012	WTG2	36.7	36.7	36.7	36.7	36.7	40.0	43.0	45.0	49.0	51.0
R166	Non-Participating Receptor	4.5	1787	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R167	Non-Participating Receptor	4.5	1876	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R168	Non-Participating Receptor	4.5	2047	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R169	Non-Participating Receptor	4.5	953	WTG2	36.8	36.8	36.8	36.8	36.8	40.0	43.0	45.0	49.0	51.0
R170	Non-Participating Receptor	4.5	2010	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R171	Non-Participating Receptor	4.5	2093	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R172	Non-Participating Receptor	4.5	1949	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R173	Non-Participating Receptor	4.5	2057	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R174	Non-Participating Receptor	4.5	2021	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R175	Non-Participating Receptor	4.5	1892	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R176	Non-Participating Receptor	4.5	1855	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R177	Non-Participating Receptor	4.5	1828	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R178	Non-Participating Receptor	4.5	1786	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R179	Non-Participating Receptor	4.5	1747	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R180	Non-Participating Receptor	4.5	1785	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R181	Non-Participating Receptor	4.5	1706	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R182	Non-Participating Receptor	4.5	1676	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R183	Non-Participating Receptor	4.5	1902	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R184	Non-Participating Receptor	4.5	1655	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R185	Non-Participating Receptor	4.5	1605	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R186	Non-Participating Receptor	4.5	1825	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R187	Non-Participating Receptor	4.5	1782	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R188	Non-Participating Receptor	4.5	1580	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R189	Non-Participating Receptor	4.5	1757	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R190	Non-Participating Receptor	4.5	1848	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R191	Non-Participating Receptor	4.5	1712	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R192	Non-Participating Receptor	4.5	1797	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R193	Non-Participating Receptor	4.5	1665	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R194	Non-Participating Receptor	4.5	1771	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R195	Non-Participating Receptor	4.5	1376	WTG4	31.5	31.5	31.5	31.5	31.5	40.0	43.0	45.0	49.0	51.0
R196	Non-Participating Receptor	4.5	1765	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R197	Non-Participating Receptor	4.5	1669	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R198	Non-Participating Receptor	4.5	1729	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R199	Non-Participating Receptor	4.5	946	WTG4	34.4	34.4	34.4	34.4	34.4	40.0	43.0	45.0	49.0	51.0

Point of Reception ID	Description	Height [m]	Distance to Nearest HAF Turbine [m]	Nearest Turbine ID	Calculated Sound Level [dBA] at Selected Wind Speeds (m/s)					Sound Level Limit [dBA]				
					6	7	8	9	10	6	7	8	9	10
R200	Non-Participating Receptor	4.5	2011	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R201	Non-Participating Receptor	4.5	984	WTG4	32.7	32.7	32.7	32.7	32.7	40.0	43.0	45.0	49.0	51.0
R202	Non-Participating Receptor	4.5	1782	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R203	Non-Participating Receptor	4.5	2025	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R204	Non-Participating Receptor	4.5	1988	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R205	Non-Participating Receptor	4.5	1955	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R206	Non-Participating Receptor	4.5	1922	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R207	Non-Participating Receptor	4.5	1818	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R208	Non-Participating Receptor	4.5	1751	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R209	Non-Participating Receptor	4.5	1775	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R210	Non-Participating Receptor	4.5	1895	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R211	Non-Participating Receptor	4.5	1871	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R212	Non-Participating Receptor	4.5	1984	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R213	Non-Participating Receptor	4.5	1918	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R214	Non-Participating Receptor	4.5	2006	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R215	Non-Participating Receptor	4.5	2034	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R216	Non-Participating Receptor	4.5	1995	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R217	Non-Participating Receptor	4.5	2024	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R218	Non-Participating Receptor	4.5	1991	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R219	Non-Participating Receptor	4.5	1970	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R220	Non-Participating Receptor	4.5	2019	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R221	Non-Participating Receptor	4.5	2048	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R222	Non-Participating Receptor	4.5	2027	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R223	Non-Participating Receptor	4.5	1525	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R224	Non-Participating Receptor	4.5	2018	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R225	Non-Participating Receptor	4.5	2009	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R226	Non-Participating Receptor	4.5	1981	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R227	Non-Participating Receptor	4.5	1824	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R228	Non-Participating Receptor	4.5	1971	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R229	Non-Participating Receptor	4.5	1915	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R230	Non-Participating Receptor	4.5	1915	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R231	Non-Participating Receptor	4.5	1927	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R232	Non-Participating Receptor	4.5	1984	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R233	Non-Participating Receptor	4.5	1932	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R234	Non-Participating Receptor	4.5	1944	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R235	Non-Participating Receptor	4.5	1990	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R236	Non-Participating Receptor	4.5	1998	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R237	Non-Participating Receptor	4.5	1965	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R238	Non-Participating Receptor	4.5	2042	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R239	Non-Participating Receptor	4.5	1988	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R240	Non-Participating Receptor	4.5	1991	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R241	Non-Participating Receptor	4.5	1999	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R242	Non-Participating Receptor	4.5	1553	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R243	Non-Participating Receptor	4.5	1932	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R244	Non-Participating Receptor	4.5	1794	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R245	Non-Participating Receptor	4.5	1843	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R246	Non-Participating Receptor	4.5	1644	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R247	Non-Participating Receptor	4.5	1825	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R248	Non-Participating Receptor	4.5	1437	WTG5	27.6	27.6	27.6	27.6	27.6	40.0	43.0	45.0	49.0	51.0
R249	Non-Participating Receptor	4.5	1340	WTG5	28.3	28.3	28.3	28.3	28.3	40.0	43.0	45.0	49.0	51.0
R250	Non-Participating Receptor	4.5	1308	WTG5	28.6	28.6	28.6	28.6	28.6	40.0	43.0	45.0	49.0	51.0
R251	Non-Participating Receptor	4.5	1434	WTG5	27.6	27.6	27.6	27.6	27.6	40.0	43.0	45.0	49.0	51.0
R252	Non-Participating Receptor	4.5	1881	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R253	Non-Participating Receptor	4.5	1359	WTG5	28.2	28.2	28.2	28.2	28.2	40.0	43.0	45.0	49.0	51.0
R254	Non-Participating Receptor	4.5	1874	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R255	Non-Participating Receptor	4.5	1899	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R256	Non-Participating Receptor	4.5	1897	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R257	Non-Participating Receptor	4.5	1790	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
R258	Non-Participating Receptor	4.5	2015	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
V01	Non-Participating Vacant Lot	4.5	706	WTG4	35.5	35.5	35.5	35.5	35.5	40.0	43.0	45.0	49.0	51.0
V02	Non-Participating Vacant Lot	4.5	889	WTG5	33.6	33.6	33.6	33.6	33.6	40.0	43.0	45.0	49.0	51.0
V03	Non-Participating Vacant Lot	4.5	1245	WTG2	34.3	34.3	34.3	34.3	34.3	40.0	43.0	45.0	49.0	51.0
V04	Non-Participating Vacant Lot	4.5	1076	WTG2	34.8	34.8	34.8	34.8	34.8	40.0	43.0	45.0	49.0	51.0
V05	Non-Participating Vacant Lot	4.5	662	WTG3	35.9	35.9	35.9	35.9	35.9	40.0	43.0	45.0	49.0	51.0
V06	Non-Participating Vacant Lot	4.5	654	WTG3	35.9	35.9	35.9	35.9	35.9	40.0	43.0	45.0	49.0	51.0
V07	Non-Participating Vacant Lot	4.5	770	WTG3	36.4	36.4	36.4	36.4	36.4	40.0	43.0	45.0	49.0	51.0
V08	Non-Participating Vacant Lot	4.5	702	WTG4	36.0	36.0	36.0	36.0	36.0	40.0	43.0	45.0	49.0	51.0

Point of Reception ID	Description	Height [m]	Distance to Nearest HAF Turbine [m]	Nearest Turbine ID	Calculated Sound Level [dBA] at Selected Wind Speeds (m/s)					Sound Level Limit [dBA]				
					6	7	8	9	10	6	7	8	9	10
V09	Non-Participating Vacant Lot	4.5	812	WTG5	33.4	33.4	33.4	33.4	33.4	40.0	43.0	45.0	49.0	51.0
V11	Non-Participating Vacant Lot	4.5	1844	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
V12	Non-Participating Vacant Lot	4.5	1727	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
V16	Non-Participating Vacant Lot	4.5	2443	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
V18	Non-Participating Vacant Lot	4.5	1302	WTG5	28.6	28.6	28.6	28.6	28.6	40.0	43.0	45.0	49.0	51.0
V20	Non-Participating Vacant Lot	4.5	1592	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
V27	Non-Participating Vacant Lot	4.5	826	WTG5	33.2	33.2	33.2	33.2	33.2	40.0	43.0	45.0	49.0	51.0
V28	Non-Participating Vacant Lot	4.5	721	WTG5	34.6	34.6	34.6	34.6	34.6	40.0	43.0	45.0	49.0	51.0
V29	Non-Participating Vacant Lot	4.5	1923	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
V30	Non-Participating Vacant Lot	4.5	1982	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
V31	Non-Participating Vacant Lot	4.5	871	WTG4	33.9	33.9	33.9	33.9	33.9	40.0	43.0	45.0	49.0	51.0
V32	Non-Participating Vacant Lot	4.5	1047	WTG5	32.8	32.8	32.8	32.8	32.8	40.0	43.0	45.0	49.0	51.0
V33	Non-Participating Vacant Lot	4.5	1944	WTG4	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
V39	Non-Participating Vacant Lot	4.5	890	WTG2	36.4	36.4	36.4	36.4	36.4	40.0	43.0	45.0	49.0	51.0
V40	Non-Participating Vacant Lot	4.5	779	WTG2	37.6	37.6	37.6	37.6	37.6	40.0	43.0	45.0	49.0	51.0
V41	Non-Participating Vacant Lot	4.5	1998	WTG3	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0
V42	Non-Participating Vacant Lot	4.5	1457	WTG3	28.2	28.2	28.2	28.2	28.2	40.0	43.0	45.0	49.0	51.0
V43	Non-Participating Vacant Lot	4.5	1894	WTG5	-	-	-	-	-	40.0	43.0	45.0	49.0	51.0

'-' Receptors greater than 1500m from project wind turbine generators.

Table A6: Wind Turbine Noise Impact Summary - Participating Receptor Locations
Vineland Power, HAF Wind Energy Project

Point of Reception ID	Description	Height [m]	Distance to Nearest HAF Turbine [m]	Nearest Turbine ID	Calculated Sound Level [dBA] at Selected Wind Speeds (m/s)				
					6	7	8	9	10
PR01	Participating Receptor	4.5	424	WTG5	39.8	39.8	39.8	39.8	39.8
PR02	Participating Receptor	4.5	664	WTG5	35.6	35.6	35.6	35.6	35.6
PR03	Participating Receptor	4.5	924	WTG2	37.9	37.9	37.9	37.9	37.9
PR04	Participating Receptor	4.5	610	WTG3	37.9	37.9	37.9	37.9	37.9
PR05	Participating Receptor	4.5	414	WTG5	40.2	40.2	40.2	40.2	40.2
PR06	Participating Receptor	4.5	503	WTG4	38.5	38.5	38.5	38.5	38.5
PR07	Participating Receptor	4.5	478	WTG2	41.4	41.4	41.4	41.4	41.4
PR08	Participating Receptor	4.5	382	WTG4	40.9	40.9	40.9	40.9	40.9
PR09	Participating Receptor	4.5	481	WTG2	42.9	42.9	42.9	42.9	42.9
PV01	Participating Vacant Lot	4.5	641	WTG3	37.6	37.6	37.6	37.6	37.6

APPENDIX B:
Zoning Map

TOWNSHIP OF WEST LINCOLN

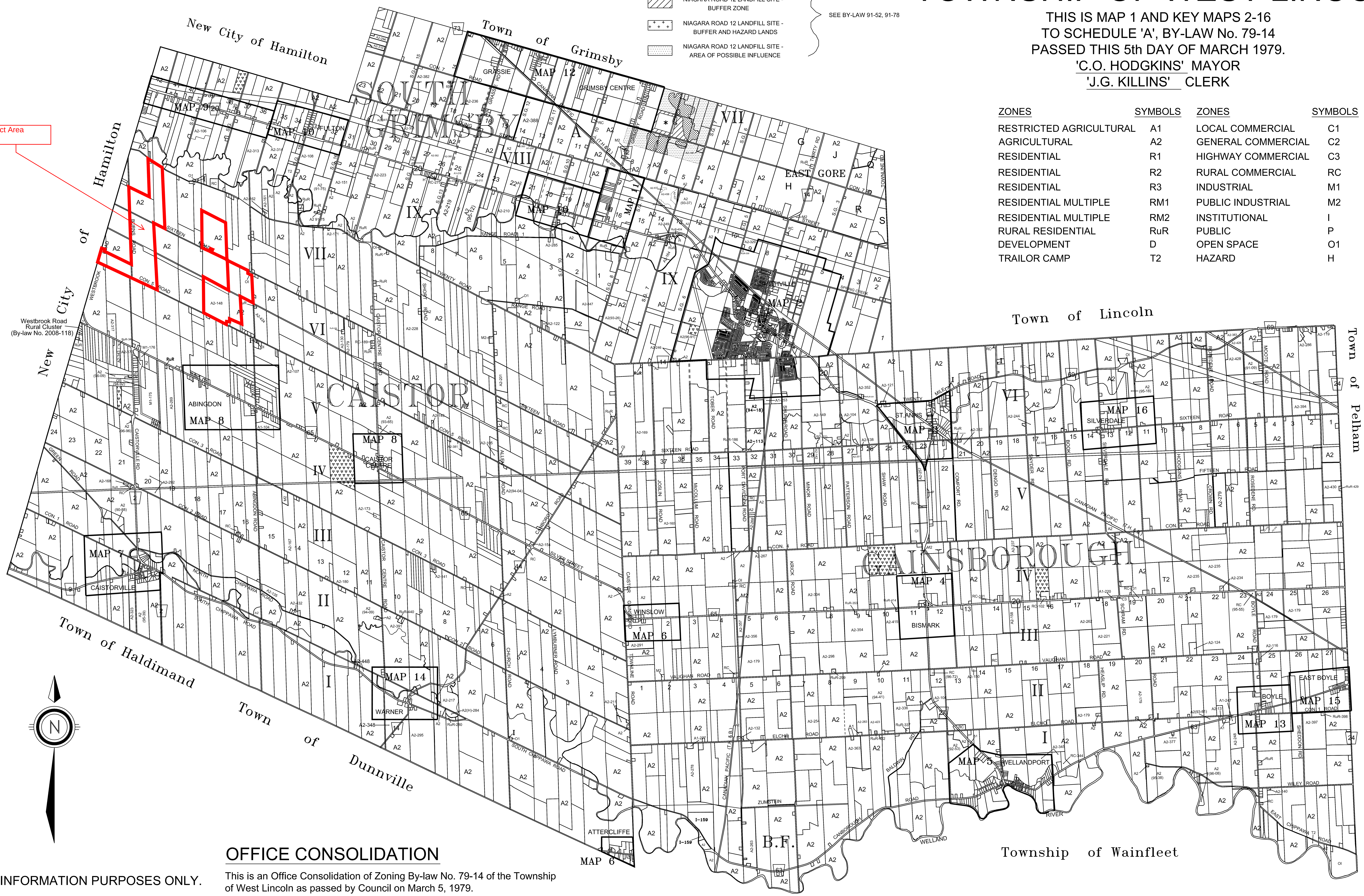
THIS IS MAP 1 AND KEY MAPS 2-16
TO SCHEDULE 'A', BY-LAW No. 79-14
PASSED THIS 5th DAY OF MARCH 1979.
'C.O. HODGKINS' MAYOR
'J.G. KILLINS' CLERK

TEMPORARY USE

NIAGARA ROAD 12 LANDFILL SITE - WASTE DISPOSAL FILL AREA
NIAGARA ROAD 12 LANDFILL SITE - BUFFER ZONE
NIAGARA ROAD 12 LANDFILL SITE - BUFFER AND HAZARD LANDS
NIAGARA ROAD 12 LANDFILL SITE - AREA OF POSSIBLE INFLUENCE

SEE BY-LAW 91-52, 91-78

ZONES	SYMBOLS	ZONES	SYMBOLS
RESTRICTED AGRICULTURAL	A1	LOCAL COMMERCIAL	C1
AGRICULTURAL	A2	GENERAL COMMERCIAL	C2
RESIDENTIAL	R1	HIGHWAY COMMERCIAL	C3
RESIDENTIAL	R2	RURAL COMMERCIAL	RC
RESIDENTIAL	R3	INDUSTRIAL	M1
RESIDENTIAL MULTIPLE	RM1	PUBLIC INDUSTRIAL	M2
RESIDENTIAL MULTIPLE	RM2	INSTITUTIONAL	I
RURAL RESIDENTIAL	RuR	PUBLIC	P
DEVELOPMENT	D	OPEN SPACE	O1
TRAILOR CAMP	T2	HAZARD	H



OFFICE CONSOLIDATION

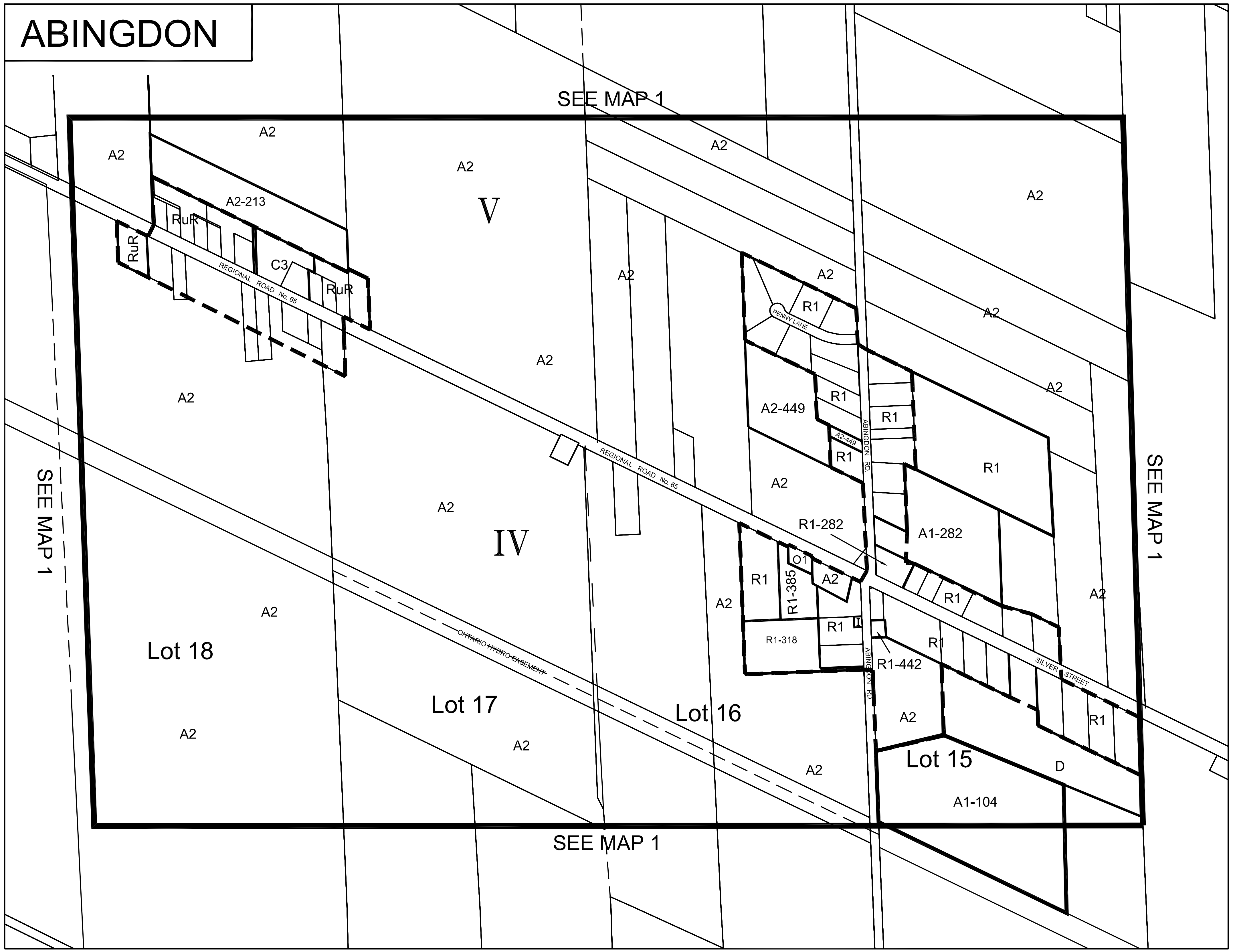
This is an Office Consolidation of Zoning By-law No. 79-14 of the Township of West Lincoln as passed by Council on March 5, 1979.

For accurate reference, recourse should be made to the original Zoning By-law No. 79-14 and amending By-laws.

Consolidated Version November 2009

FOR INFORMATION PURPOSES ONLY.

SCALE N.T.S.



TOWNSHIP OF WEST LINCOLN

THIS IS MAP 8
TO SCHEDULE "A",
BY-LAW No. 79-14
PASSED THIS 5th DAY
OF MARCH 1979.

'C.O. HODGKINS' MAYOR

'J.G. KILLINS' CLERK

ZONES	SYMBOLS
RESTRICTED AGRICULTURAL	A1
AGRICULTURAL	A2
RESIDENTIAL	R1
RESIDENTIAL	R2
RESIDENTIAL MULTIPLE	RM1
RESIDENTIAL MULTIPLE	RM2
RURAL RESIDENTIAL	RuR
DEVELOPMENT	D
TRAILER CAMP	T2
LOCAL COMMERCIAL	C1
GENERAL COMMERCIAL	C2
HIGHWAY COMMERCIAL	C3
RURAL COMMERCIAL	RC
INDUSTRIAL	M1
PUBLIC INDUSTRIAL	M2
INSTITUTIONAL	I
PUBLIC	P
OPEN SPACE	O1
HAZARD	H
SCHEDULE BOUNDARY	
RURAL CLUSTER BOUNDARY (By-Law No. 2008-29 & By-law 2008-115)	

N

FOR INFORMATION PURPOSES ONLY.
MAY NOT BE TO SCALE.

OFFICE CONSOLIDATION

This is an Office Consolidation of Zoning By-law No. 79-14 of the Township of West Lincoln as passed by Council on March 5, 1979.

For accurate reference, recourse should be made to the original Zoning By-law No. 79-14 and amending By-laws.

Consolidated Version November 2009

APPENDIX C:

VESTAS V100-1.8 MW Wind Turbine Generator Information

Exhibit D.1.1

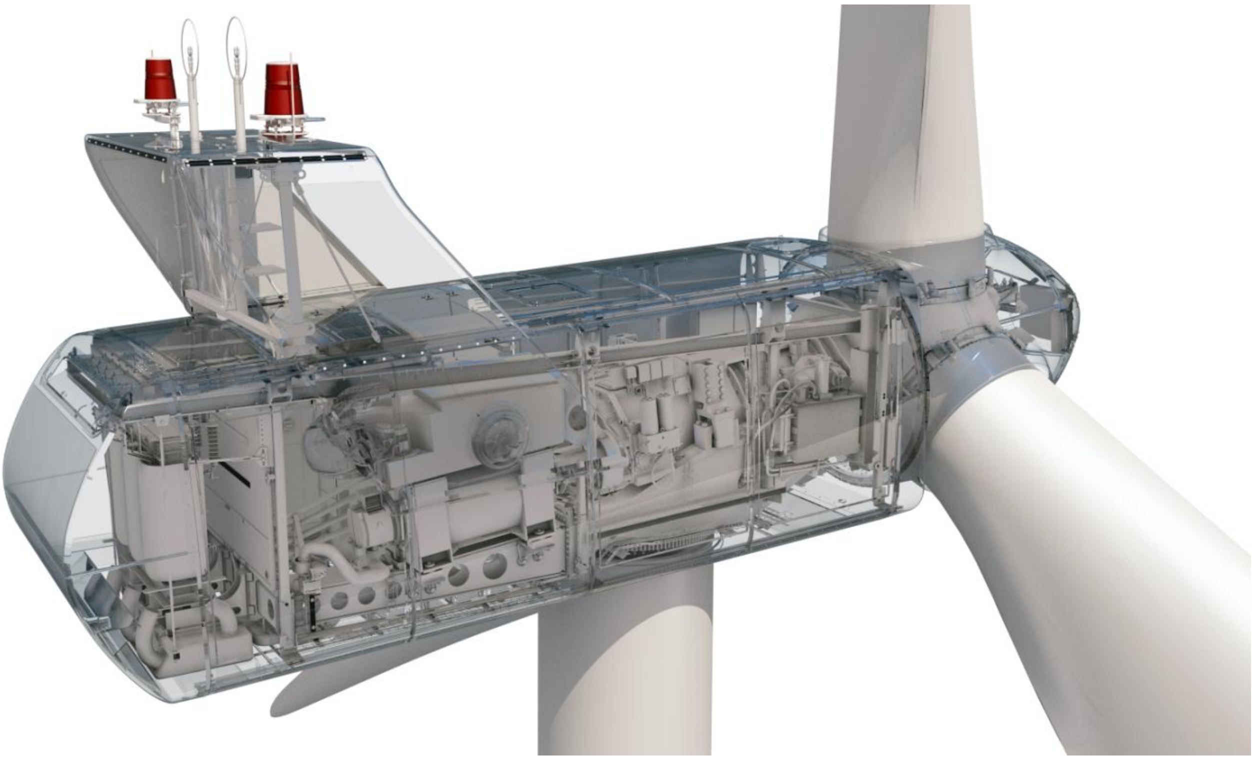
General Specification

PUBLIC

Class 1
Document no.: 0004-3053 V06
2010-10-06

General Specification

V100–1.8 MW VCUS



Vestas Wind Systems A/S · Alsvej 21 · 8940 Randers SV · Denmark · www.vestas.com

Table of Contents

Buyer acknowledges that these general specifications are for Buyer's informational purposes only and do not create or constitute a warranty, guarantee, promise, commitment, or other representation by supplier, all of which are disclaimed by supplier except to the extent expressly provided by supplier in writing elsewhere.

See section 11 General Reservations, Notes and Disclaimers**, p. 36 for general reservations, notes, and disclaimers applicable to these general specifications.**

1 General Description

The Vestas V100-1.8 MW wind turbine is a pitch regulated upwind turbine with active yaw and a three-blade rotor. The Vestas V100-1.8 MW turbine has a rotor diameter of 100 m with a generator rated at 1.8 MW. The turbine utilizes a microprocessor pitch control system called OptiTip® and the Variable Speed concepts (VCUS: Vestas Converter Unity System). With these features the wind turbine is able to operate the rotor at variable speed (RPM), helping to maintain the output at or near rated power.

2 Mechanical Design

2.1 Rotor

The V100-1.8 MW turbine is equipped with a 100 meter rotor consisting of three blades and the hub. Based on the prevailing wind conditions, the blades are continuously positioned to help optimise the pitch angle.

Rotor	
Diameter	100 m
Swept Area	7850 m^2
Rotational Speed Static, Rotor	14.9 rpm
Speed, Dynamic Operation Range	9.3-16.6 rpm
Rotational Direction	Clockwise (front view)
Orientation	Upwind
Tilt	6°
Hub Coning	2°
Number of Blades	3
Aerodynamic Brakes	Full feathering

Table 2-1: Rotor data.

2.2 Blades

The 49 m Prepreg (PP) blades are made of carbon and fibre glass and consist of two airfoil shells bonded to a supporting beam.

PP Blades	
Type Description	Airfoil shells bonded to supporting beam
Blade Length	49 m
Material	Fibreglass reinforced epoxy and carbon fibres
Blade Connection	Steel roots inserted
Air Foils	RISØ P + FFA –W3
Chord	3.9 m
Blade Root Outer Diameter	1.88 m

PP Blades	
PCD of Steel Root Inserts	1.80 m
R49	0.54 m
Twist (Blade root/blade tip)	24,5°/-0,5°
Approximate Weight	7500 kg

Table 2-2: PP blades data.

2.3 Blade Bearing

The blade bearings are double row 4-point contact ball bearings.

Blade Bearing	
Type	2 row 4-point contact ball bearing
Lubrication	Grease lubrication, automatic lubrication pump

Table 2-3: Blade bearing data.

2.4 Pitch System

The energy input from the wind to the turbine is adjusted by pitching the blades according to the control strategy. The pitch system also works as the primary brake system by pitching the blades out of the wind. This causes the rotor to idle.

Double row 4-point contact ball bearings are used to connect the blades to the hub. The pitch system relies on hydraulics and uses a cylinder to pitch each blade. Hydraulic power is supplied to the cylinder from the hydraulic power unit in the nacelle through the main gearbox and the main shaft via a rotating transfer.

Hydraulic accumulators inside the rotor hub ensure sufficient power to blades in case of failure.

Pitch System	
Type	Hydraulic
Cylinder	Ø125/80 – 760
Number	1 pcs./ blade
Range	-5º to 90º

Table 2-4: Pitch system data.

Hydraulic System	
Pump Capacity	50 l/min
Working Pressure	200-230 bar
Oil Quantity	260 l
Motor	20 kW

Table 2-5: Hydraulic system data.

2.5 Hub

The hub supports the 3 blades and transfers the reaction forces to the main bearing. The hub structure also supports blade bearings and pitch cylinder.

Hub	
Type	Cast ball shell hub
Material	Cast iron EN GJS 400-18U-LT / EN1560

Table 2-6: Hub data.

2.6 Main Shaft

Main Shaft	
Type	Forged, trumpet shaft
Material	42 CrMo4 QT / EN 10083

Table 2-7: Main shaft data.

2.7 Bearing Housing

Bearing Housing	
Type	Cast foot housing with lowered centre
Material	Cast iron EN GJS 400-18U-LT / EN1560

Table 2-8: Bearing housing data.

2.8 Main Bearings

Main Bearings	
Type	Spherical roller bearings
Lubrication	Grease lubrication, manually re-greased

Table 2-9: Main bearings data.

2.9 Gearbox

The main gearbox transmits torque and revolutions from the rotor to the generator.

The main gearbox consists of a planetary stage combined with a two-stage parallel gearbox, torque arms and vibration dampers.

Torque is transmitted from the high-speed shaft to the generator via a flexible composite coupling, located behind the disc brake. The disc brake is mounted directly on the high-speed shaft.

Gearbox	
Type	1 planetary stage + 2 helical stages
Ratio	1:92.8 nominal
Cooling	Oil pump with oil cooler
Oil heater	2 kW
Max Gear Oil Temp	80°C
Oil Cleanliness	-/15/12 ISO 4406

Table 2-10: Gearbox data.

2.10 Generator Bearings

The bearings are greased and grease is supplied continuously from an automatic lubrication unit when the nacelle temperature is above -10°C. The yearly grease flow is approximately 2400 cm³.

2.11 High Speed Shaft Coupling

The flexible coupling transmits the torque from the gearbox high speed output shaft to the generator input shaft. The flexible coupling is designed to compensate misalignments between gearbox and generator. The coupling consists of two composite discs and an intermediate tube with two aluminium flanges and a fibre glass tube. The coupling is fitted to 3-armed hubs on the brake disc and the generator hub.

High Speed Shaft Coupling	
Type Description	VK 420

Table 2-11: High speed shaft coupling data.

2.12 Yaw System

The yaw system is designed to keep the turbine upwind. The nacelle is mounted on the yaw plate, which is bolted to the turbine tower. The yaw bearing system is a plain bearing system with built-in friction. Asynchronous yaw motors with brakes enable the nacelle to rotate on top of the tower.

The turbine controller receives information of the wind direction from the wind sensor. Automatic yawing is deactivated when the mean wind speed is below 3 m/s.

Yaw System	
Type	Plain bearing system with built-in friction
Material	Forged yaw ring heat-treated Plain bearings PETP
Yawing Speed	< 0.5˚/sec.

Table 2-12: Yaw system data.

Yaw Gear	
Type	Non-locking combined worm gear and planetary gearbox Electrical motor brake
Motor	1.5 kW, 6 pole, asynchronous
Number of Yaw Gears	6
Ratio Total (4 Planetary Stages)	1,120: 1
Rotational Speed at Full Load	Approximately 1 rpm at output shaft

Table 2-13: Yaw gear data.

2.13 Crane

The nacelle houses the service crane. The crane is a single system chain hoist.

Crane	
Lifting Capacity	Max. 800 kg

Table 2-14: Crane data.

2.14 Tower Structure

Tubular towers with flange connections, certified according to relevant type approvals, are available in different standard heights. Magnets provide load support in a horizontal direction for tower internals, such as platforms, ladders, etc. Tower internals are supported vertically (i.e. in the gravitational direction) by a mechanical connection.

The hub heights listed include a distance from the foundation section to the ground level of approximately 0.6 m depending on the thickness of the bottom flange and a distance from the tower top flange to the centre of the hub of 1.70 m.

Tower Structure	
Type Description	Conical tubular
Hub Heights (HH)	80 m/95 m
Material	S355 according to EN 10024 A709 according to ASTM
Weight	80 m IEC S 160 metric tonnes* 95 m IEC S 205 metric tonnes**

Table 2-15: Tower structure (Onshore) data.

NOTE */** Typical values. Dependent on wind class, and can vary with site / project conditions.

2.15 Nacelle Bedplate and Cover

The nacelle cover is made of fibre glass. Hatches are positioned in the floor for lowering or hoisting equipment to the nacelle and evacuation of personnel.

The roof is equipped with wind sensors and skylights which can be opened from inside the nacelle to access the roof and from outside to access the nacelle. The nacelle cover is mounted on the girder structure. Access from the tower to the nacelle is through the yaw system.

The nacelle bedplate is in two parts and consists of a cast iron front part and a girder structure rear part. The front of the nacelle bedplate is the foundation for the drive train, which transmits forces from the rotor to the tower, through the yaw system. The bottom surface is machined and connected to the yaw bearing and the yaw-gears are bolted to the front nacelle bedplate.

The nacelle bedplate carries the crane girders through vertical beams positioned along the site of the nacelle. Lower beams of the girder structure are connected at the rear end.

The rear part of the bedplate serves as foundation for controller panels, generator and transformer.

Type Description	Material
Nacelle Cover	GRP
Base Frame Front	Cast iron EN GJS 400-18U-LT / EN1560
Base Frame Rear	Welded grid structure

Table 2-16: Nacelle base-frame and cover data.

2.16 Cooling

The cooling of the main components (gearbox, hydraulic power pack and VCUS converter) in the turbine is done by a water cooling system. The generator is air cooled by nacelle air and the high voltage (HV) transformer is cooled by mainly ambient air.

Component	Cooling Type	Internal Heating at Low temperature
Nacelle	Forced air	Yes
Hub/spinner	Natural air	No (Yes Low Temperature (LT) turbine)
Gearbox	Water/oil	Yes
Generator	Forced air/air	No (heat source)
Slip rings	Forced air/air	Yes
Transformer	Forced air	No (heat source)
VCUS	Forced water/air	Yes
VMP section	Forced air/air	Yes
Hydraulics	Water/oil	Yes

Table 2-17: Cooling, summary.

All other heat generating systems are also equipped with fans and or coolers but are considered as minor contributors to nacelle thermodynamics.

2.17 Water Cooling System

The water cooling system is designed as semi-closed systems (closed system but not under pressure) with a free wind water cooler on the roof of the nacelle. This means that the heat loss from the systems (components) is transferred to the water system and the water system is cooled by ambient air.

The water cooling system has three parallel cooling circuits that cool the gearbox, the hydraulic power unit and the VCUS converter.

The water cooling system is equipped with a 3-way thermostatic valve, which is closed (total water flow is bypassing the water cooler) if the temperature of the cooling water is below 35°C and fully open (total water flow is led to the water cooler) if the temperature is above 43°C.

2.18 Gearbox Cooling

The gearbox cooling system consists of two oil circuits that remove the gearbox losses through two plate heat exchangers (oil coolers). The first circuit is equipped with a mechanical driven oil pump and a plate heat exchanger and the second circuit is equipped with an electrical driven oil pump and a plate heat exchanger. The water circuit of the two plate heat exchangers are coupled in serial.

Gearbox Cooling	
Gear Oil Plate Heat Exchanger 1 (Mechanically driven oil pump)	
Nominal oil flow	50 l/min
Oil inlet temperature	80°C
No. of passes	2
Cooling capacity	24.5 kW
Gear Oil Plate Heat Exchanger 2 (Electrically driven oil pump)	
Nominal oil flow	85 l/min
Oil inlet temperature	80°C
No. of passes	2
Cooling capacity	41.5 kW
Water Circuit	
Nominal water flow	App. 150 l/min (50% glycol)
Water inlet temperature	Max. 54°C
No. of passes	1
Heat load	66 kW

Table 2-18: Cooling, gearbox data.

2.19 Hydraulic Cooling

The hydraulic cooling system consists of a plate heat exchanger which is mounted on the power pack. In the plate heat exchanger the heat from the hydraulics is transferred to the water cooling system.

Hydraulic Cooling	
Hydraulic Oil Plate Heat Exchanger	
Nominal oil flow	40 l/min
Oil inlet temperature	66°C
Cooling capacity	10.28 kW
Water Circuit	
Nominal water flow	App. 45 l/min (50% glycol)
Water inlet temperature	Max. 54°C
Heat load	10.28 kW

Table 2-19: Cooling, hydraulic data.

2.20 VCUS Converter Cooling

The converter cooling system consists of a number of switch modules which is mounted on cooling plates where the cooling water is lead through.

Converter Cooling	
Nominal water flow	Approximately 45 l/min (50% glycol)
Water inlet pressure	Maximum 2.0 bar
Water inlet temperature	Maximum 54ºC
Cooling capacity	10 kW

Table 2-20: Cooling, converter data.

2.21 Generator Cooling

The generator cooling systems consists of an air to air cooler mounted on the top of the generator and two internal and one external fan. All the fans can run at low or high speed.

Generator Cooling	
Air inlet temperature – external	50°C
Nominal air flow – internal	8000 m^3/h
Nominal air flow – external	7500 m^3/h
Cooling capacity	60 kW

Table 2-21: Cooling, generator data.

2.22 HV Transformer Cooling

The transformer is equipped with forced air cooling. The cooling system consists of a central fan, which is located under the service floor, an air distribution manifold and six hoses leading to locations beneath and between the HV and LV windings.

Transformer Cooling	
Nominal air flow	1920 m^3/h
Air inlet temperature	Maximum 40°C

Table 2-22: Cooling, transformer data.

2.23 Nacelle Conditioning

The nacelle conditioning system consists of one fan and two air heaters. There are two main circuits of the nacelle conditioning system:

1. Cooling of the HV transformer.
2. Heating and ventilation of the nacelle.

For both systems, the airflow enters the nacelle through louver dampers in the weather shield underneath the nacelle.

The cooling of the HV transformer is described in section 2.22 HV Transformer Cooling, p. 13.

The heating and ventilation of the nacelle is done by means of two air heaters and one fan. To avoid condensation in the nacelle, the two air heaters keep the nacelle temperature +5°C above the ambient temperature. At start-up in cold conditions, the heaters will also heat the air around the gearbox.
The ventilation of the nacelle is done by means of one fan, removing hot air from the nacelle, which is generated by mechanical and electrical equipment.

Nacelle Cooling	
Nominal air flow	1.2 m^3/s
Air inlet temperature	Maximum 50°C

Table 2-23: Cooling, nacelle data.

Nacelle Heating	
Rated power	2 x 6 kW

Table 2-24: Heating, nacelle data.

3 Electrical Design

3.1 Generator

The generator is a 3-phase asynchronous generator with wound rotor, which is connected to the Vestas Converter Unity System (VCUS) via a slip ring system. The generator is an air-to-air cooled generator with an internal and external cooling circuit. The external circuit uses air from the nacelle and exhausts it out through the rear end of the nacelle.

The generator has six poles. The generator is wound with form windings in both rotor and stator. The stator is connected in star at low power and delta at high power. The rotor is connected in star and is insulated from the shaft. A slip ring is mounted to the rotor for the purpose of the VCUS control.

Generator	
Type Description	Asynchronous with wound rotor, slip rings and VCUS
Rated Power (PN)	1.8 MW
Rated Apparent Power	1.8 MVA (Cosφ = 1.00)
Frequency	60 Hz
Voltage, Generator	690 Vac
Voltage, Converter	480 Vac
Number of Poles	6
Winding Type (Stator/Rotor)	Form/Form
Winding Connection, Stator	Star/Delta
Rated Efficiency (Generator only)	> 96.5%
Power Factor (cos)	1.0
Over Speed Limit acc. to IEC (2 min.)	2400 rpm
Vibration Level	≤ 1.8 mm/s
Weight	Approx. 8,100 kg
Generator Bearing - Temperature	2 PT100 sensors
Generator Stator Windings - Temperature	3 PT100 sensors placed at hot spots and 3 as back-up

Table 3-1: Generator data.

3.2 HV Cables

The high voltage cable runs from the transformer in the nacelle down the tower to the switchgear located in the bottom of the tower (switchgear is not included). The high voltage cable is a 4-core rubber insulated halogen free high voltage cable.

HV Cables	
High Voltage Cable Insulation Compound	Improved ethylene-propylene (EP) based material – EPR or high modulus or hard grade ethylene-propylene rubber – HEPR
Conductor Cross Section	3x70/70 mm^2
Rated Voltage	12/20 kV (24 kV) or 20/35 kV (42 kV) depending on the transformer voltage

Table 3-2: HV cables data.

3.3 Transformer

The transformer is located in a separate locked room in the nacelle with surge arresters mounted on the high voltage side of the transformer. The transformer is a two winding, three-phase dry-type transformer. The windings are delta-connected on the high voltage side unless otherwise specified.

The low voltage windings have a voltage of 690 V and a tapping at 480 V and are star-connected. The 690 V and 480 V systems in the nacelle are a TN-system, which means the star point is connected to earth.

Transformer	
Type Description	Dry-type cast resin
Primary Voltage	6-34.5 kV
Rated Apparent Power	2100 kVA
Secondary Voltage 1	690 V
Rated Power 1 at 690 V	1,900 kVA
Secondary Voltage 2	480 V
Rated Power 2 at 480 V	200 kVA
Vector Group	Dyn5 (option YNyn0)
Frequency	60 Hz
HV-tappings	±2 x 2.5% offload
Insulation Class	F
Climate Class	C2
Environmental Class	E2
Fire Behaviour Class	F1

Table 3-3: Transformer data.

3.4 Converter

The converter controls the energy conversion in the generator. The VCUS converter feeds power from the grid into the generator rotor at sub sync speed and feeds power from the generator rotor to the grid at super sync speed.

Converter	
Rated Slip	12%
Rated RPM	1344 RPM
Rated Rotor Power (@rated slip)	193 kW
Rated Grid Current (@ rated slip, PF = 1 & 480V)	232 A
Rated Rotor Current (@ rated slip & PF = 1)	573 A

Table 3-4: Converter data.

3.5 AUX System

The AUX System is supplied from the 690/480 V socket from the HV transformer. All motors, pumps, fans and heaters are supplied from this system.

All 110 V power sockets are supplied from a 690/110 V transformer.

Power Sockets	
Single Phase	110 V (20 A)
Three Phase	690 V Crane (16 A)

Table 3-5: AUX system data.

3.6 Wind Sensors

The turbine is equipped with two ultrasonic wind sensors with built-in heaters.

Wind Sensors	
Type	FT702LT
Principle	Acoustic Resonance
Built-in Heat	99 W

Table 3-6: Wind sensor data.

3.7 Turbine Controller

The turbine is controlled and monitored by the System 3500 controller hardware and Vestas controller software.

The turbine controller is based on four main processors (Ground, Nacelle, Hub and Converter) which are interconnected by an optical-based 2.5 Mbit ArcNet network.

I/O modules are connected either as rack modules in the System 3500 rack or by CAN.

The turbine control system serves the following main functions:

- Monitoring and supervision of overall operation.
- Synchronizing of the generator to the grid during connection sequence in order to limit the inrush current.
- Operating the wind turbine during various fault situations.
- Automatic yawing of the nacelle.
- OptiTip® - blade pitch control.
- Noise emission control.
- Monitoring of ambient conditions.
- Monitoring of the grid.

The turbine controller hardware is built from the following main modules:

Module	Function	Network
CT3603	Main processor. Control and monitoring (nacelle and hub).	ArcNet, CAN, Ethernet, seriel
CT396	Main processor. Control, monitoring, external communication (ground).	ArcNet, CAN, Ethernet, seriel
CT360	Main processor. Converter control and monitoring.	ArcNet, CAN, Ethernet
CT3218	Counter/encoder module. RPM, Azimuth and wind measurement.	Rack module
CT3133	24 VDC digital input module. 16 channels.	Rack module
CT3153	24 VDC digital output module. 16 channels.	Rack module
CT3320	4 channel analogue input (0-10V, 4-20mA, PT100).	Rack module
CT6061	CAN I/O controller	CAN node
CT6221	3 channel PT100 module	CAN I/O module
CT6050	Blade controller.	CAN node
Balluff	Position transducer	CAN node
Rexroth	Proportional valve	CAN node

Table 3-7: Turbine controller hardware.

3.8 Uninterruptible Power Supply (UPS)

The UPS supplies power to critical wind turbine components.

The actual back up time for the UPS system is proportional to the power consumption. Actual back-up time may vary.

UPS		
Battery Type	Valve-Regulated Lead Acid (VRLA)	
Rated Battery Voltage	2 x 8 x 12 V (192 V)	
Converter Type	Double conversion online	
Rated Output Voltage	230 V AC	
Rated Output Voltage	230 V AC	
Converter Input	230 V ±20%	
Back-up Time*	Controller system	30 seconds
	Safety systems	35 minutes
Re-charging Time	Typical	Approx. 2.5 hours

Table 3-8: UPS data.

NOTE * For alternative back-up times, consult Vestas!

4 Turbine Protection Systems

4.1 Braking Concept

The main brake on the turbine is aerodynamic. Braking the turbine is done by feathering the three blades. During emergency stop all three blades will feather simultaneously to full end stop and thereby slowing the rotor speed.

In addition there is a mechanical disc brake on the high speed shaft of the gearbox. The mechanical brake is only used as a parking brake, and when activating the emergency stop push buttons.

4.2 Short Circuit Protections

Breakers	**Generator / Q8 ABB E2B 2000 690 V**	**Controller / Q15 ABB S3X 690 V**	**VCS-VCUS / Q7 ABB S5H 400 480 V**
Breaking Capacity I_{cu}, I_{cs}	42, 42 kA	75, 75 kA	40, 40 kA
Making Capacity I_{cm} (415V Data)	88 kA	440 kA	143 kA
Thermo Release I_{th}	2000 A	100 A	400 A

Table 4-1: Short circuit protection data.

4.3 Overspeed Protection

The generator RPM and the main shaft RPM are registered by inductive sensors and calculated by the wind turbine controller in order to protect against overspeed and rotating errors.

The turbine is also equipped with a VOG (Vestas Overspeed Guard), which is an independent computer module measuring the rotor RPM, and in case of an overspeed situation the VOG activates the emergency feathered position (full feathering) of the three blades.

Overspeed Protection	
VOG Sensors Type	Inductive
Trip Levels	17.3 (Rotor RPM) / 1597 (Generator RPM)

Table 4-2: Overspeed protection data.

4.4 EMC System

The turbine and related equipment must fulfil the EU EMC-Directive with later amendments:

- Council Directive 2004/108/EC of 15 December 2004 on the approximation of the laws of the Member States relating to Electromagnetic Compatibility.
- The (Electromagnetic Compatibility) EMC-Directive with later amendments.

4.5 Lightning System

The Lightning Protection System (LPS) consists of three main parts.

- Lightning receptors.
- Down conducting system.
- Earthing System.

Lightning Protection Design Parameters			**Protection Level I**
Current Peak Value	i_{max}	[kA]	200
Total Charge	Q_{total}	[C]	300
Specific Energy	W/R	[MJ/Ω]	10
Average Steepness	di/dt	[kA/μs]	200

Table 4-3: Lightning design parameters.

NOTE The Lightning Protection System is designed according to IEC standards (see section 7.7 Design Codes – Lightning Protection, p. 27). Lightning strikes are considered force majeure, i.e. damage caused by lightning strikes is not warranted by Vestas.

4.6 Earthing (also known as grounding)

The Vestas Earthing System is based on foundation earthing.

Vestas document no. 0000-3388 contains the list of documents regarding Vestas Earthing System.

Requirements in the Vestas Earthing System specifications and work descriptions are minimum requirements from Vestas and IEC. Local and national requirements may require additional measures.

4.7 Corrosion Protection

Classification of corrosion categories for atmospheric corrosion is according to ISO 9223:1992.

Corrosion Protection	External Areas	Internal Areas
Nacelle	C5	C3 and C4 Climate strategy: Heating the air inside the nacelle compared to the outside air temperature lowers the relative humidity and helps ensure a controlled corrosion level.
Hub	C5	C3
Tower	C5-I	C3

Table 4-4: Corrosion protection data for nacelle, hub and tower.

5 Safety

The safety specifications in this safety section provide limited general information about the safety features of the turbine and are not a substitute for Buyer and its agents taking all appropriate safety precautions, including but not limited to (a) complying with all applicable safety, operation, maintenance, and service agreements, instructions, and requirements, (b) complying with all safety-related laws, regulations, and ordinances, (c) conducting all appropriate safety training and education and (d) reading and understanding all safety-related manuals and instructions. See section 5.13 Manuals and Warnings, p. 23 for additional guidance.

5.1 Access

Access to the turbine from the outside is through the bottom of the tower. The door is equipped with a lock. Access to the top platform in the tower is by a ladder or service lift. Access to the nacelle from the top platform is by ladder. Access to the transformer room in the nacelle is equipped with a lock. Unauthorised access to electrical switch boards and power panels in the turbine is prohibited according to IEC 60204-1 2006.

5.2 Escape

In addition to the normal access routes, alternative escape routes from the nacelle are through the crane hatch.

The hatch in the roof can be opened from both the inside and outside.

Escape from the service lift is by ladder.

5.3 Rooms/Working Areas

The tower and nacelle are equipped with connection points for electrical tools for service and maintenance of the turbine.

5.4 Platforms, Standing and Working Places

The bottom tower section has three platforms. There is one platform at the entrance level (door level), one safety platform approximately three metres above the entrance platform and finally a platform in the top of the tower section.

Each middle tower section has one platform in the top of the tower section.

The top tower section has two platforms. A top platform and a service lift platform - where the service lift stops - below the top platform.

There are places to stand at various locations along the ladder.

The platforms have anti-slip surfaces.

Foot supports are placed in the turbine for maintenance and service purposes.

5.5 Climbing Facilities

A ladder with a fall arrest system (rigid rail or wire system) is mounted through the tower.

Rest platforms are provided at maximum intervals of 9 metres along the tower ladder between platforms.

There are anchorage points in the tower, nacelle, hub and on the roof for attaching a fall arrest equipment (full body harness).

Over the crane hatch there is an anchorage point for the emergency descent equipment. The anchorage point is tested to 22.2 kN.

Anchorage points are coloured yellow and are calculated and tested to 22.2 kN.

5.6 Moving Parts, Guards and Blocking Devices

Moving parts in the nacelle are shielded.

The turbine is equipped with a rotor lock to block the rotor and drive train.

It is possible to block the pitch of the cylinder with mechanical tools in the hub.

5.7 Lighting

The turbine is equipped with light in the tower, nacelle and in the hub.

There is emergency light in case of loss of electrical power.

5.8 Noise

When the turbine is out of operation for maintenance, the sound level in the nacelle is below 80 dB(A). In operation mode ear protection is required.

5.9 Emergency Stop

There are emergency stops in the nacelle and in the bottom of the tower.

5.10 Power Disconnection

The turbine is designed to allow for disconnection from all its power sources during inspection or maintenance. The switches are marked with signs and are located in the nacelle and in the bottom of the tower.

5.11 Fire Protection/First Aid

A 5 kg CO_2 fire extinguisher must be located in the nacelle at the left yaw gear. The location of the fire extinguisher, and how to use it, must be confirmed before operating the turbine.

A first aid kit must be placed by the wall at the back end of the nacelle. The location of the first aid kit, and how to use it, must be confirmed before operating the turbine.

Above the generator there must be a fire blanket which can be used to put out small fires.

5.12 Warning Signs

Additional warning signs inside or on the turbine must be reviewed before operating or servicing of the turbine.

5.13 Manuals and Warnings

Vestas OH&S manual and manuals for operation, maintenance and service of the turbine provide additional safety rules and information for operating, servicing or maintaining the turbine.

6 Environment

6.1 Chemicals

Chemicals used in the turbine are evaluated according to Vestas Wind Systems A/S Environmental system certified according to ISO 14001:2004.

- Anti-freeze liquid to help prevent the cooling system from freezing.
- Gear oil for lubricating the gearbox.
- Hydraulic oil to pitch the blades and operate the brake.
- Grease to lubricate bearings.
- Various cleaning agents and chemicals for maintenance of the turbine.

7 Approvals, Certificates and Design Codes

7.1 Type Approvals

The turbine is type certified according to the certification standards listed below:

Certification	Wind Class	Hub Height
Type Certificate after IEC WT01 and IEC 61400-1:2005	IEC S*	80 m
	IEC S*	95 m

Refer to section 9.1 Climate and Site Conditions, p. 28 for details.

Table 7-1: Type approvals.

7.2 Design Codes – Structural Design

The structural design has been developed and tested with regard to, but not limited to, the following main standards.

Design Codes – Structural Design	
Nacelle and Hub	IEC 61400-1:2005 EN 50308 ANSI/ASSE Z359.1-2007
Bedframe	IEC 61400-1:2005
Tower	IEC 61400-1:2005 Eurocode 3 DIBt: Richtlinie für Windenergieanlagen, Einwirkungen und Standsicherheitsnachweise für Turm und Gründung, 4th edition.

Table 7-2: Structural design codes.

7.3 Design Codes – Mechanical Equipment

The mechanical equipment has been developed and tested with regard to, but not limited to, the following main standards:

Design Codes – Mechanical Equipment	
Gear	Designed in accordance to rules in ISO 81400-4
Blades	DNV-OS-J102 IEC 1024-1 IEC 60721-2-4 IEC 61400 (Part 1, 12 and 23) IEC WT 01 IEC DEFU R25 ISO 2813 DS/EN ISO 12944-2

Table 7-3: Mechanical equipment design codes.

7.4 Design Codes – Electrical Equipment

The electrical equipment has been developed and tested with regard to, but not limited to, the following main standards:

Design Codes – Electrical Equipment	
High Voltage AC Circuit Breakers	IEC 60056
High Voltage Testing Techniques	IEC 60060
Power Capacitors	IEC 60831
Insulating Bushings for AC Voltage above 1kV	IEC 60137
Insulation Co-ordination	BS EN 60071
AC Disconnectors and Earth Switches	BS EN 60129
Current Transformers	IEC 60185
Voltage Transformers	IEC 60186
High Voltage Switches	IEC 60265
Disconnectors and Fuses	IEC 60269
Flame Retardant Standard for MV Cables	IEC 60332
Transformer	IEC 60076-11
Generator	IEC 60034
Specification for Sulphur Hexafluoride for Electrical Equipment	IEC 60376
Rotating Electrical Machines	IEC 34

Design Codes – Electrical Equipment	
Dimensions and Output Ratings for Rotating Electrical Machines	IEC 72 & IEC 72A
Classification of Insulation, Materials for Electrical Machinery	IEC 85
Safety of Machinery – Electrical Equipment of Machines	IEC 60204-1

Table 7-4: Electrical equipment design codes.

7.5 Design Codes – I/O Network System

The distributed I/O network system has been developed and tested with regard to, but not limited to, the following main standards:

Design Codes – I/O Network System	
Salt Mist Test	IEC 60068-2-52
Damp Head, Cyclic	IEC 60068-2-30
Vibration Sinus	IEC 60068-2-6
Cold	IEC 60068-2-1
Enclosure	IEC 60529
Damp Head, Steady State	IEC 60068-2-56
Vibration Random	IEC 60068-2-64
Dry Heat	IEC 60068-2-2
Temperature Shock	IEC 60068-2-14
Free Fall	IEC 60068-2-32

Table 7-5: I/O Network system design codes.

7.6 Design Codes – EMC System

To fulfil EMC requirements the design must be as recommended for lightning protection, see section 7.7 Design Codes – Lightning Protection, p. 27.

Design Codes – EMC System	
Designed according to	IEC 61400-1: 2005
Further robustness requirements according to	TPS 901785

Table 7-6: EMC system design codes.

7.7 Design Codes – Lightning Protection

The LPS is designed according to Lightning Protection Level (LPL) I:

Design Codes – Lightning Protection	
Designed according to	IEC 62305-1: 2006 IEC 62305-3: 2006 IEC 62305-4: 2006
Non Harmonized Standard and Technically Normative Documents	IEC/TR 61400-24:2002

Table 7-7: Lightning protection design codes.

7.8 Design Codes – Earthing

The Vestas Earthing System design is based on and complies with the following international standards and guidelines:

- IEC 62305-1 Ed. 1.0: Protection against lightning – Part 1: General principles.
- IEC 62305-3 Ed. 1.0: Protection against lightning – Part 3: Physical damage to structures and life hazard.
- IEC 62305-4 Ed. 1.0: Protection against lightning – Part 4: Electrical and electronic systems within structures.
- IEC/TR 61400-24. First edition. 2002-07. Wind turbine generator systems - Part 24: Lightning protection.
- IEC 60364-5-54. Second edition 2002-06. Electrical installations of buildings - Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors.
- IEC 61936-1. First edition. 2002-10. Power installations exceeding 1kV a.c.- Part 1: Common rules.

8 Colour and Surface Treatment

8.1 Nacelle Colour and Surface Treatment

Surface Treatment of Vestas Nacelles	
Standard Nacelle Colours	RAL 7035 (light grey)
Gloss	According to ISO 2813

Table 8-1: Surface treatment, nacelle.

8.2 Tower Colour and Surface Treatment

Surface Treatment of Vestas Tower Section		
	External:	**Internal:**
Tower Colour Variants	RAL 7035 (light grey)	RAL 9001 (cream white)
Gloss	50-75% UV resistant	Maximum 50%

Table 8-2: Surface treatment, tower.

8.3 Blades Colour

Blades Colour	
Blade Colour	RAL 7035 (Light Grey)
Tip-End Colour Variants	RAL 2009 (Traffic Orange), RAL 3000 (Flame Red), RAL 3020 (Traffic Red)
Gloss	< 20%

Table 8-3: Colours, blades.

9 Operational Envelope and Performance Guidelines

Actual climatic and site conditions have many variables and must be considered in evaluating actual turbine performance. The design and operating parameters set forth in this section do not constitute warranties, guarantees, or representations as to turbine performance at actual sites.

NOTE As evaluation of climate and site conditions is complex, it is needed to consult Vestas for every project.

9.1 Climate and Site Conditions

Values refer to hub height:

Extreme Design Parameters	
Wind Climate	**IEC S**
Ambient Temperature Interval (Normal Temperature Turbine)	-30° to +50°C
Extreme Wind Speed (10 min. average)	42.5 m/s
Survival Wind Speed (3 sec. gust)	59.5 m/s

Table 9-1: Extreme design parameters.

Average Design Parameters	
Wind Climate	**IEC S**
Wind Speed	7.5 m/s
A-factor	8.45 m/s
Form Factor, c	2.0
Turbulence Intensity acc. to IEC 61400-1, including Wind Farm Turbulence (@15 m/s – 90% quantile)	18%
Wind Shear	0.20
Inflow Angle (vertical)	8°

Table 9-2: Average design parameters.

9.1.1 Complex Terrain

Classification of complex terrain acc. to IEC 61400-1:2005 Chapter 11.2.

For sites classified as complex appropriate measures are to be included in site assessment.

9.1.2 Altitude

The turbine is designed for use at altitudes up to 1500 m above sea level as standard.

Above 1500 m special considerations must be taken regarding e.g. HV installations and cooling performance. Consult Vestas for further information.

9.1.3 Wind Farm Layout

Turbine spacing is to be evaluated site-specifically. Spacing in any case not below three rotor diameters (3D).

DISCLAIMER

As evaluation of climate and site conditions is complex, consult Vestas for every project. If conditions exceed the above parameters Vestas must be consulted!

9.2 Operational Envelope – Temperature and Wind

Values refer to hub height and as determined by the sensors and control system of the turbine.

Operational Envelope – Temperature and Wind	
Ambient Temperature Interval (Normal Temperature Turbine)	-20° to +40° C
Cut-in (10 min. average)	3 m/s
Cut-out (100 sec. exponential average)	20 m/s
Re-cut in (100 sec. exponential average)	18 m/s

Table 9-3: Operational envelope - temperature and wind.

9.3 Operational Envelope – Grid Connection *

Values refer to hub height and as determined by the sensors and control system of the turbine.

Operational Envelope - Grid Connection		
Nominal Phase Voltage	$U_{P,\ nom}$	400 V
Nominal Frequency	f_{nom}	60 Hz
Max. Steady State Voltage Jump	±2%	
Max. Frequency Gradient	±4 Hz/sec	
Max. Negative Sequence Voltage	3%	

Table 9-4: Operational envelope - grid connection.

The generator and the converter will be disconnected if:

	U_P	U_N
Voltage above 110% of nominal for 60 sec.	440 V	759 V
Voltage above 115% of nominal for 2 sec.	460 V	794 V
Voltage above 120% of nominal for 0.08 sec.	480 V	828 V
Voltage above 125% of nominal for 0.005 sec	500 V	863 V
Voltage below 90% of nominal for 60 sec.	360 V	621 V
Voltage below 85% of nominal for 11 sec.	340 V	586 V
Frequency is above [Hz] for 0.2 sec.	63.6 Hz	
Frequency is below [Hz] for 0.2 sec.	56.4 Hz	

Table 9-5: Generator and converter disconnecting values.

NOTE * Over the turbine lifetime, grid drop-outs are to occur at an average of no more than 50 times a year.

9.4 Performance – Fault Ride Through

The turbine is equipped with a reinforced Vestas Converter System in order to gain better control of the generator during grid faults. The controllers and contactors have a UPS backup system in order to keep the turbine control system running during grid faults.

The pitch system is optimised to keep the turbine within normal speed conditions and the generator speed is accelerated in order to store rotational energy and be able to resume normal power production faster after a fault and keep mechanical stress on the turbine at a minimum.

The turbine is designed to stay connected during grid disturbances within the voltage tolerance curve in Figure 9-1, p. 31.

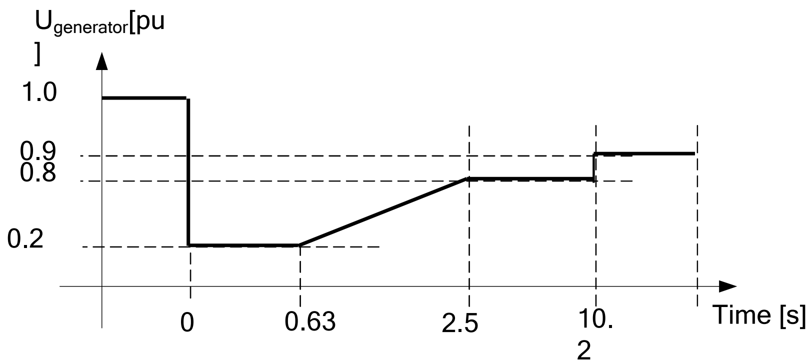


Figure 9-1: Low voltage tolerance curve for symmetrical and asymmetrical faults.

For grid disturbances outside the protection curve in Figure 9-2, p. 31, the turbine will be disconnected from the grid.

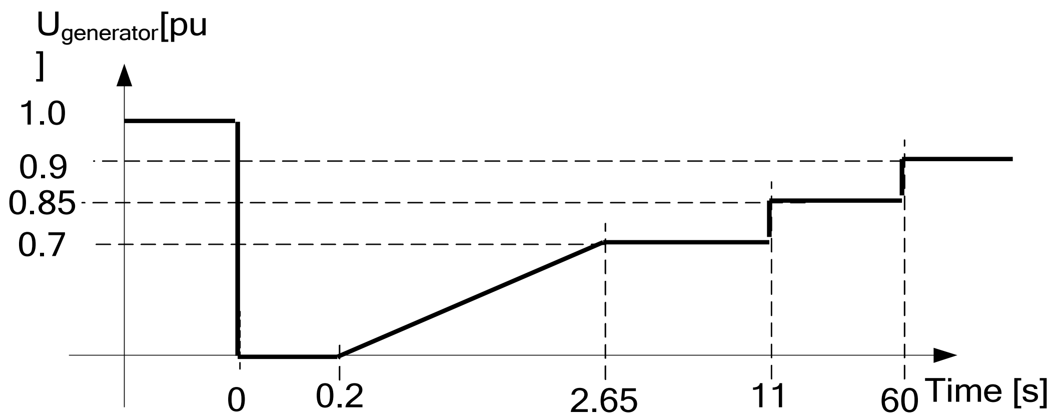


Figure 9-2: Default low voltage protection settings for symmetrical and asymmetrical faults.

Power Recovery Time	
Power recovery to 90% of pre-fault level	Max 1.0 sec

9.5 Current Contribution

During the grid dip the generator is typical magnetized from the converter. The controller setpoints are set to keep the reactive current exchange with the grid close to zero and keep as much torque on the generator as possible.

9.6 Performance – Multiple Voltage Dips

The turbine is designed to handle re-closure events and multiple voltage dips within a short period of time, due to the fact that voltage dips are not evenly distributed during the year. As an example 6 voltage dips of duration of 200 ms down to 20% voltage within 30 minutes will normally not lead to a problem for the turbine.

9.7 Performance – Active Power Control

The turbine is designed for control of active power via the VestasOnline™ SCADA system.

Max. Ramp Rates for External Control	
Active Power	0.1 pu/sec

To protect the turbine active power cannot be controlled to values below the curve in Figure 9-3, p. 32.

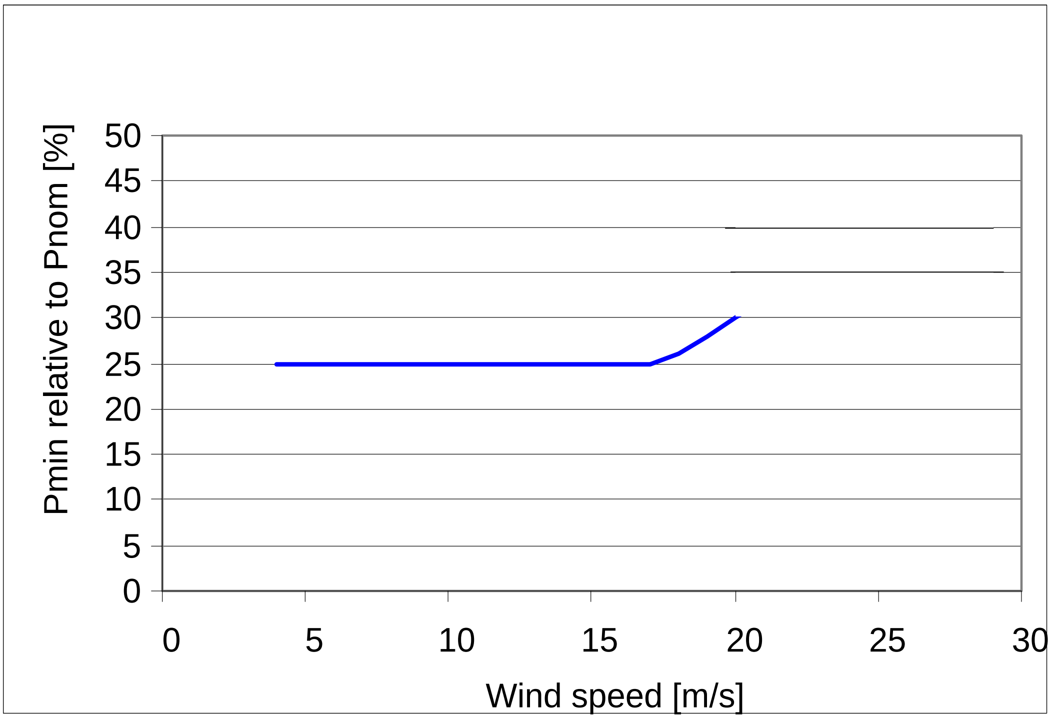


Figure 9-3: Minimum active power output dependant of wind speed.

9.8 Performance – Frequency Control

The turbine can be configured to perform frequency control by decreasing the output power as a linear function of the grid frequency (over frequency).

Dead band and slope for the frequency control function are configurable.

9.9 Performance – Own Consumption

The consumption of electrical power by the wind turbine is defined as consumption when the wind turbine is not producing energy (generator is not connected to the grid). This is defined in the control system as Production Generator (zero).

The following components have the largest influence on the power consumption of the wind turbine:

Own Consumption	
Hydraulic Motor	20 kW
Yaw Motors 6 x 1.75 kW	10.5 kW
Oil Heating 3 x 0.76 kW	2.3 kW
Air Heaters 2 x 6 kW (std) **3 x 6 kW (LT)**	12 kW (Standard) 18 kW (Low Temperature)
Oil Pump for Gearbox Lubrication	3.5 kW
HV Transformer located in the nacelle has a no-load loss of	Max. 3.9 kW

Table 9-6: Own consumption data.

9.10 Operational Envelope Conditions for Power Curve, C_t Values (at Hub Height)

See appendix section 12.1 Mode 0, p. 37, 12.2 Mode 1, p. 41 and 12.3 Mode 2, p. 45 for power curve, C_t values and noise level.

Conditions for Power Curve, C_t Values (at Hub Height)	
Wind Shear	0.10 - 0.16 (10 min. average)
Turbulence Intensity	8 - 12% (10 min. average)
Blades	Clean
Rain	No
Ice/Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ± 2 °
Grid Frequency	60 ± 0.5 Hz

Table 9-7: Conditions for power curve, C_t values.

10 Drawings

10.1 Structural Design – Illustration of Outer Dimensions

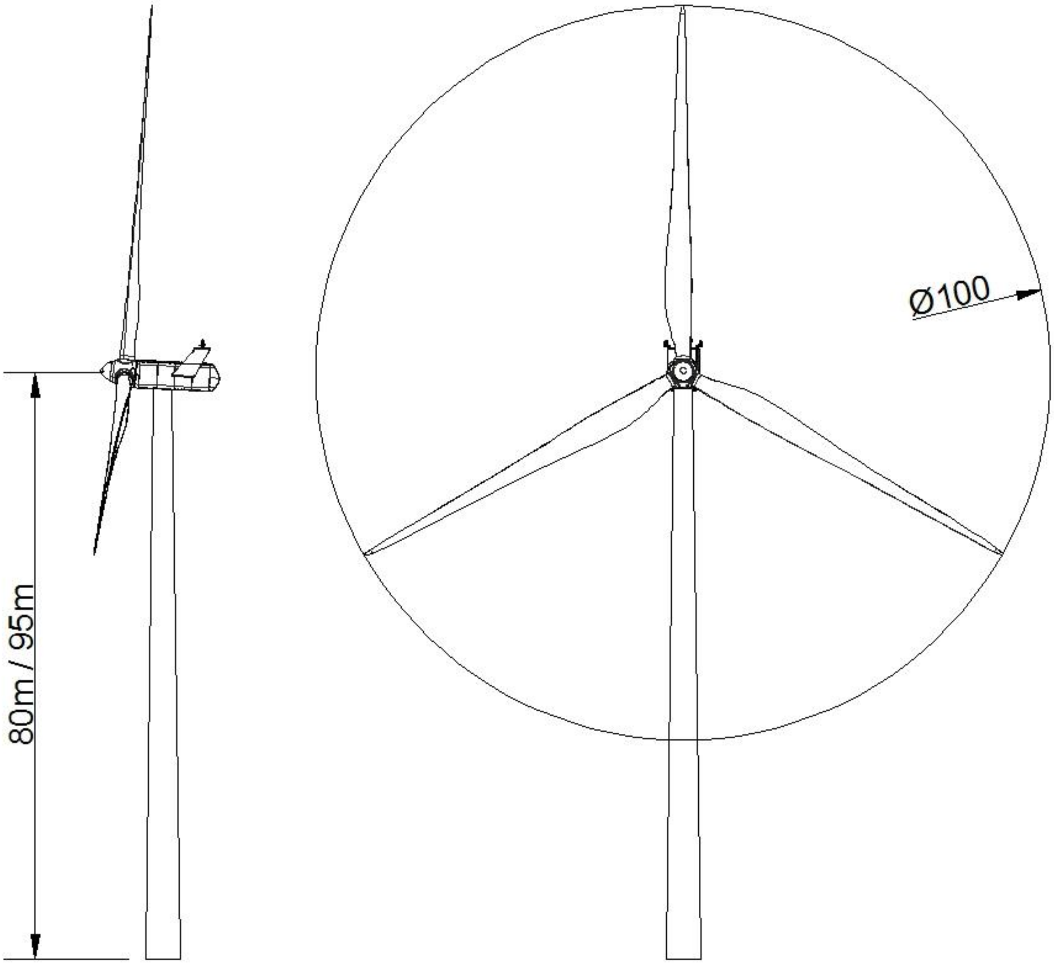


Figure 10-1: Illustration of outer dimensions – structure.

10.2 Structural Design – Side View Drawing

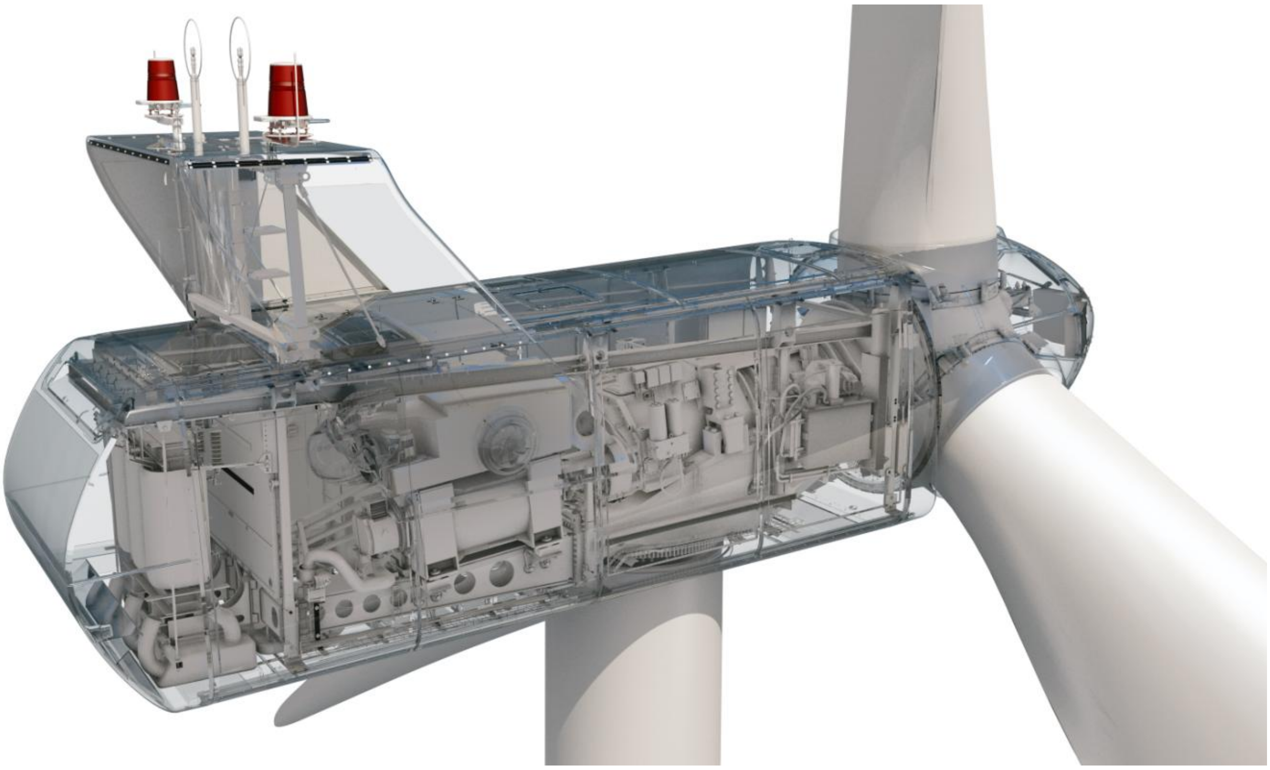


Figure 10-2: Side view drawing.

11 General Reservations, Notes and Disclaimers

- These general specifications apply to the current version of the V100 wind turbine. Updated versions of the V100 wind turbine, which may be manufactured in the future, may have general specifications that differ from these general specifications. In the event that Vestas supplies an updated version of the V100 wind turbine, Vestas will provide updated general specifications applicable to the updated version.
- Periodic operational disturbances and generator power de-rating may be caused by combination of high winds, low voltage or high temperature.
- Vestas recommends that the grid be as close to nominal as possible with little variation in frequency.
- A certain time allowance for turbine warm-up must be expected following grid dropout and/or periods of very low ambient temperature.
- The estimated power curve for the different estimated noise levels (sound power levels) is for wind speeds at 10 minute average value at hub height and perpendicular to the rotor plane.
- All listed start/stop parameters (e. g. wind speeds and temperatures) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
- The earthing system must comply with the minimum requirements from Vestas, and be in accordance with local and national requirements, and codes of standards.
- Lightning strikes are considered force majeure, i.e. damage caused by lightning strikes is not warranted by Vestas.
- For the avoidance of doubt, this document 'General Specifications' is not, and does not contain, any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method). Any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method) must be agreed to separately in writing.

12 Appendices

Power Curve, C_t values and Sound Power Levels for Mode 0 to 2 are defined below.

12.1 Mode 0

12.1.1 Mode 0, Power Curve

Mode 0, Power curve														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**13**	9	9	9	10	10	11	11	11	12	12	13	14	15
3.5	**53**	34	36	38	39	41	43	45	46	48	50	52	55	57
4	**112**	80	83	86	89	92	95	98	101	104	106	109	115	118
4.5	**181**	136	140	144	148	152	156	160	165	169	173	177	185	189
5	**260**	198	203	209	215	220	226	232	237	243	248	254	265	271
5.5	**353**	270	278	285	293	300	308	315	323	330	338	345	360	368
6	**462**	356	365	375	385	395	404	414	424	433	443	453	472	481
6.5	**581**	443	455	468	481	493	506	518	531	544	556	569	594	606
7	**736**	563	579	595	611	626	642	658	673	689	705	720	751	767
7.5	**911**	700	720	739	758	777	796	816	835	854	873	892	930	949
8	**1108**	856	879	902	925	948	971	994	1017	1040	1063	1086	1131	1153
8.5	**1321**	1028	1055	1082	1110	1137	1163	1190	1216	1243	1269	1295	1347	1372
9	**1524**	1212	1243	1273	1304	1335	1363	1392	1421	1449	1474	1499	1547	1570
9.5	**1679**	1397	1429	1460	1491	1522	1547	1572	1597	1622	1641	1660	1695	1710
10	**1766**	1566	1591	1616	1641	1666	1682	1699	1716	1733	1744	1755	1773	1780
10.5	**1800**	1689	1705	1721	1737	1753	1762	1770	1779	1788	1792	1796	1802	1804
11	**1811**	1764	1772	1779	1786	1794	1797	1800	1803	1807	1808	1809	1812	1813
11.5	**1815**	1796	1799	1802	1805	1808	1809	1811	1812	1813	1814	1814	1815	1815
12	**1815**	1808	1810	1811	1812	1814	1814	1814	1815	1815	1815	1815	1815	1815
12.5	**1815**	1813	1814	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
13	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
13.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
14	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
14.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
15	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
15.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Mode 0, Power curve														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
16.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
18	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
18.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
20	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Table 12-1: Mode 0, power curve.

12.1.2 Mode 0, C_t values

Mode 0, C_t values														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**0.874**	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874
3.5	**0.891**	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891
4	**0.877**	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877
4.5	**0.847**	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847
5	**0.820**	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820
5.5	**0.806**	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806
6	**0.802**	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802	0.802
6.5	**0.814**	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814
7	**0.807**	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807
7.5	**0.804**	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804	0.804
8	**0.795**	0.800	0.800	0.799	0.799	0.799	0.799	0.798	0.798	0.797	0.796	0.796	0.794	0.793
8.5	**0.768**	0.786	0.784	0.783	0.782	0.780	0.779	0.777	0.776	0.774	0.772	0.770	0.766	0.764
9	**0.716**	0.756	0.754	0.751	0.749	0.746	0.743	0.739	0.736	0.732	0.727	0.721	0.710	0.704
9.5	**0.636**	0.713	0.708	0.703	0.698	0.693	0.685	0.678	0.670	0.663	0.654	0.645	0.627	0.617
10	**0.545**	0.657	0.648	0.639	0.630	0.621	0.610	0.599	0.589	0.578	0.567	0.556	0.535	0.524
10.5	**0.459**	0.587	0.576	0.564	0.552	0.540	0.528	0.517	0.505	0.493	0.482	0.471	0.449	0.439
11	**0.389**	0.514	0.501	0.488	0.475	0.462	0.451	0.440	0.428	0.417	0.408	0.398	0.380	0.372
11.5	**0.333**	0.442	0.430	0.418	0.406	0.395	0.385	0.376	0.366	0.357	0.349	0.341	0.325	0.318
12	**0.288**	0.381	0.370	0.360	0.350	0.340	0.332	0.324	0.316	0.308	0.301	0.294	0.282	0.276
12.5	**0.251**	0.330	0.322	0.313	0.305	0.296	0.289	0.282	0.275	0.269	0.263	0.257	0.246	0.241
13	**0.222**	0.289	0.282	0.275	0.267	0.260	0.254	0.248	0.242	0.236	0.231	0.227	0.217	0.213
13.5	**0.197**	0.256	0.249	0.243	0.237	0.230	0.225	0.220	0.215	0.210	0.206	0.201	0.193	0.189
14	**0.176**	0.227	0.222	0.216	0.211	0.205	0.201	0.196	0.192	0.187	0.184	0.180	0.173	0.169
14.5	**0.158**	0.203	0.199	0.194	0.189	0.184	0.180	0.176	0.172	0.168	0.165	0.161	0.155	0.152
15	**0.142**	0.183	0.178	0.174	0.170	0.165	0.162	0.158	0.155	0.151	0.148	0.145	0.140	0.137
15.5	**0.129**	0.165	0.161	0.157	0.153	0.150	0.146	0.143	0.140	0.137	0.134	0.132	0.127	0.124
16	**0.117**	0.150	0.146	0.143	0.139	0.136	0.133	0.130	0.127	0.125	0.122	0.120	0.115	0.113
16.5	**0.107**	0.137	0.133	0.130	0.127	0.124	0.121	0.119	0.116	0.114	0.112	0.109	0.105	0.103
17	**0.098**	0.125	0.122	0.119	0.116	0.114	0.111	0.109	0.107	0.104	0.102	0.100	0.097	0.095
17.5	**0.091**	0.115	0.112	0.109	0.107	0.104	0.102	0.100	0.098	0.096	0.094	0.092	0.089	0.087
18	**0.084**	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.087	0.085	0.082	0.081
18.5	**0.077**	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.079	0.076	0.075
19	**0.072**	0.090	0.088	0.086	0.084	0.082	0.081	0.079	0.078	0.076	0.075	0.073	0.071	0.069

Mode 0, C_t values														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
19.5	**0.067**	0.084	0.082	0.080	0.078	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.066	0.065
20	**0.062**	0.078	0.076	0.075	0.073	0.071	0.070	0.069	0.067	0.066	0.065	0.063	0.061	0.060

Table 12-2: Mode 0, C_t values.

12.1.3 Mode 0, Sound Power Levels

Sound Power Level at Hub Height, Mode 0		
Conditions for Sound Power Level	**Verification standard: IEC 61400-11 Ed. 2.** **Wind shear 0.15** **Max turbulence at 10 meter height: 16%** **Inflow angle (vertical): 0 ± 2°** **Air density: 1.225 kg/m^3**	
Hub Height	80 m	95 m
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	93.8 4.2	93.8 4.3
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	96.0 5.6	96.4 5.7
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	100.1 7.0	100.7 7.2
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.9 8.4	104.4 8.6
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 9.8	105.0 10.0
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 11.2	105.0 11.5
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 12.6	105.0 12.9
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 13.9	105.0 14.3
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 15.3	105.0 15.8
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 16.7	105.0 17.2
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 18.1	105.0 18.6

Table 12-3: Sound power level at hub height: Mode 0.

12.2 Mode 1

12.2.1 Mode 1, Power Curves

Mode 1, Power curves														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**13**	9	9	9	10	10	11	11	11	12	12	13	14	15
3.5	**53**	34	36	38	39	41	43	45	46	48	50	52	55	57
4	**112**	80	83	86	89	92	95	98	101	104	106	109	115	118
4.5	**180**	134	139	143	147	151	155	159	163	167	171	175	184	188
5	**256**	195	200	206	211	217	223	228	234	239	245	250	261	267
5.5	**346**	265	273	280	287	295	302	310	317	324	332	339	354	361
6	**453**	349	358	368	377	387	396	406	415	425	434	444	463	472
6.5	**576**	439	451	464	476	489	501	514	526	539	551	564	588	601
7	**728**	558	573	589	604	620	635	651	666	682	697	713	744	759
7.5	**902**	693	712	731	750	769	788	807	826	845	864	883	920	939
8	**1098**	847	870	893	916	939	961	984	1007	1030	1053	1075	1120	1143
8.5	**1312**	1019	1046	1073	1100	1127	1154	1180	1207	1234	1260	1286	1338	1364
9	**1519**	1204	1234	1265	1296	1326	1355	1384	1413	1443	1468	1494	1542	1565
9.5	**1678**	1392	1423	1455	1486	1518	1543	1569	1594	1619	1639	1658	1693	1709
10	**1766**	1562	1588	1613	1638	1664	1681	1698	1715	1732	1743	1754	1773	1780
10.5	**1799**	1687	1703	1720	1736	1753	1761	1770	1779	1788	1791	1795	1801	1803
11	**1811**	1764	1772	1779	1787	1794	1798	1801	1804	1807	1808	1810	1812	1813
11.5	**1814**	1796	1799	1802	1805	1809	1810	1811	1812	1813	1813	1814	1815	1815
12	**1815**	1809	1810	1811	1812	1813	1814	1814	1814	1815	1815	1815	1815	1815
12.5	**1815**	1813	1814	1814	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815
13	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
13.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
14	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
14.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
15	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
15.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
18	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Mode 1, Power curves														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
18.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
20	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Table 12-4: Mode 1, power curve.

12.2.2 Mode 1, C_t values

Mode 1, C_t values														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**0.874**	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874
3.5	**0.890**	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890	0.890
4	**0.863**	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863	0.863
4.5	**0.809**	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809
5	**0.764**	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764
5.5	**0.741**	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741	0.741
6	**0.733**	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733	0.733
6.5	**0.766**	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766
7	**0.755**	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755
7.5	**0.750**	0.749	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
8	**0.748**	0.749	0.749	0.749	0.749	0.749	0.749	0.749	0.749	0.749	0.748	0.748	0.748	0.747
8.5	**0.735**	0.745	0.744	0.744	0.743	0.742	0.741	0.741	0.740	0.739	0.738	0.737	0.734	0.733
9	**0.699**	0.729	0.727	0.726	0.724	0.722	0.720	0.717	0.715	0.712	0.708	0.703	0.694	0.689
9.5	**0.631**	0.699	0.695	0.691	0.687	0.683	0.676	0.669	0.663	0.656	0.648	0.639	0.622	0.613
10	**0.544**	0.652	0.643	0.634	0.626	0.617	0.607	0.597	0.586	0.576	0.565	0.555	0.533	0.522
10.5	**0.458**	0.585	0.574	0.562	0.551	0.539	0.527	0.516	0.504	0.492	0.481	0.470	0.448	0.438
11	**0.388**	0.514	0.501	0.488	0.475	0.462	0.451	0.440	0.428	0.417	0.408	0.398	0.380	0.371
11.5	**0.333**	0.442	0.430	0.418	0.406	0.395	0.385	0.376	0.366	0.356	0.349	0.341	0.325	0.318
12	**0.288**	0.381	0.370	0.360	0.350	0.340	0.332	0.324	0.316	0.308	0.301	0.294	0.282	0.276
12.5	**0.251**	0.331	0.322	0.313	0.305	0.296	0.289	0.282	0.275	0.269	0.263	0.257	0.246	0.241
13	**0.222**	0.289	0.282	0.275	0.267	0.260	0.254	0.248	0.242	0.236	0.231	0.227	0.217	0.213
13.5	**0.197**	0.256	0.249	0.243	0.237	0.230	0.225	0.220	0.215	0.210	0.206	0.201	0.193	0.189
14	**0.176**	0.227	0.222	0.216	0.211	0.205	0.201	0.196	0.192	0.187	0.184	0.180	0.173	0.169

Mode 1, C_t values														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
14.5	**0.158**	0.203	0.199	0.194	0.189	0.184	0.180	0.176	0.172	0.168	0.165	0.161	0.155	0.152
15	**0.142**	0.183	0.178	0.174	0.170	0.165	0.162	0.158	0.155	0.151	0.148	0.145	0.140	0.137
15.5	**0.129**	0.165	0.161	0.157	0.153	0.150	0.146	0.143	0.140	0.137	0.134	0.132	0.127	0.124
16	**0.117**	0.150	0.146	0.143	0.139	0.136	0.133	0.130	0.127	0.125	0.122	0.120	0.115	0.113
16.5	**0.107**	0.137	0.133	0.130	0.127	0.124	0.121	0.119	0.116	0.114	0.112	0.109	0.105	0.103
17	**0.098**	0.125	0.122	0.119	0.116	0.114	0.111	0.109	0.107	0.104	0.102	0.100	0.097	0.095
17.5	**0.091**	0.115	0.112	0.109	0.107	0.104	0.102	0.100	0.098	0.096	0.094	0.092	0.089	0.087
18	**0.084**	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.087	0.085	0.082	0.081
18.5	**0.077**	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.079	0.076	0.075
19	**0.072**	0.090	0.088	0.086	0.084	0.082	0.081	0.079	0.078	0.076	0.075	0.073	0.071	0.069
19.5	**0.067**	0.084	0.082	0.080	0.078	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.066	0.065
20	**0.062**	0.078	0.076	0.075	0.073	0.071	0.070	0.069	0.067	0.066	0.065	0.063	0.061	0.060

Table 12-5: Mode 1, C_t values.

12.2.3 Mode 1, Sound Power Levels

Sound Power Level at Hub Height, Mode 1		
Conditions for Sound Power Level	**Verification standard: IEC 61400-11 Ed. 2.** **Wind shear 0.15** **Max turbulence at 10 meter height: 16%** **Inflow angle (vertical): 0 ± 2°** **Air density: 1.225 kg/m³**	
Hub Height	80 m	95 m
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	93.7 4.2	93.7 4.3
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	95.3 5.6	95.7 5.7
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	99.1 7.0	99.7 7.2
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	102.9 8.4	103.4 8.6
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 9.8	105.0 10.0
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 11.2	105.0 11.5
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 12.6	105.0 12.9
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 13.9	105.0 14.3
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 15.3	105.0 15.8
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 16.7	105.0 17.2
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 18.1	105.0 18.6

Table 12-6: Sound power level at hub height: Mode 1.

12.3 Mode 2

12.3.1 Mode 2, Power Curves

Mode 2, Power curves														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**13**	9	9	9	10	10	11	11	11	12	12	13	14	15
3.5	**53**	34	36	38	39	41	43	45	46	48	50	52	55	57
4	**112**	80	83	86	89	92	95	98	101	104	106	109	115	118
4.5	**181**	136	140	144	148	152	156	160	165	169	173	177	185	189
5	**260**	198	203	209	215	220	226	231	237	243	248	254	265	271
5.5	**353**	270	278	285	293	300	308	315	323	330	338	345	360	367
6	**462**	355	365	375	384	394	404	413	423	433	442	452	471	481
6.5	**581**	443	455	468	480	493	506	518	531	543	556	568	594	606
7	**735**	563	579	594	610	626	642	657	673	688	704	720	751	766
7.5	**908**	697	717	736	755	774	793	812	831	851	870	889	926	945
8	**1090**	840	863	886	909	932	954	977	999	1022	1045	1067	1113	1135
8.5	**1271**	981	1008	1034	1061	1087	1113	1140	1166	1192	1218	1244	1297	1323
9	**1437**	1112	1142	1172	1201	1231	1261	1290	1320	1349	1379	1408	1465	1494
9.5	**1580**	1227	1260	1293	1325	1358	1390	1423	1455	1487	1518	1549	1607	1634
10	**1689**	1331	1367	1402	1437	1473	1506	1540	1573	1607	1634	1661	1709	1729
10.5	**1757**	1425	1462	1499	1536	1573	1604	1635	1666	1697	1717	1737	1768	1780
11	**1792**	1512	1549	1585	1622	1659	1683	1708	1732	1757	1768	1780	1797	1802
11.5	**1805**	1592	1624	1657	1690	1722	1738	1755	1771	1787	1793	1799	1808	1811
12	**1811**	1666	1691	1715	1740	1764	1774	1783	1792	1802	1805	1808	1812	1813
12.5	**1813**	1726	1742	1757	1773	1789	1794	1799	1804	1809	1810	1812	1814	1814
13	**1814**	1765	1774	1784	1793	1802	1805	1807	1810	1812	1813	1814	1815	1815
13.5	**1815**	1786	1791	1797	1803	1808	1810	1811	1813	1814	1815	1815	1815	1815
14	**1815**	1802	1805	1808	1811	1813	1814	1814	1814	1815	1815	1815	1815	1815
14.5	**1815**	1812	1812	1813	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815
15	**1815**	1813	1813	1814	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815
15.5	**1815**	1814	1814	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
18	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Mode 2, Power curves														
	Air density kg/m³													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
18.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19.5	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
20	**1815**	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Table 12-7: Mode 2, power curve.

12.3.2 Mode 2, C_t values

Mode 2, C_t values														
	Air density kg/m³													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
3	**0.874**	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874
3.5	**0.891**	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891
4	**0.877**	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877
4.5	**0.847**	0.847	0.847	0.847	0.847	0.846	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847
5	**0.818**	0.818	0.818	0.818	0.818	0.817	0.818	0.818	0.818	0.818	0.818	0.818	0.818	0.818
5.5	**0.801**	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801
6	**0.796**	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796
6.5	**0.811**	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811
7	**0.800**	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
7.5	**0.783**	0.783	0.783	0.783	0.783	0.782	0.783	0.783	0.783	0.783	0.783	0.783	0.783	0.783
8	**0.747**	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747
8.5	**0.695**	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695
9	**0.634**	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634
9.5	**0.569**	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.569	0.567	0.565
10	**0.505**	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.512	0.512	0.509	0.507	0.500	0.496
10.5	**0.441**	0.462	0.462	0.462	0.462	0.462	0.460	0.458	0.456	0.454	0.450	0.445	0.435	0.428
11	**0.381**	0.417	0.416	0.415	0.415	0.414	0.410	0.407	0.403	0.400	0.394	0.388	0.375	0.368
11.5	**0.330**	0.377	0.375	0.373	0.371	0.369	0.364	0.359	0.354	0.349	0.342	0.336	0.323	0.317
12	**0.287**	0.342	0.339	0.335	0.331	0.328	0.322	0.316	0.311	0.305	0.299	0.293	0.281	0.275
12.5	**0.251**	0.310	0.305	0.300	0.295	0.290	0.285	0.279	0.273	0.267	0.262	0.257	0.246	0.241
13	**0.222**	0.279	0.274	0.268	0.263	0.258	0.252	0.247	0.241	0.236	0.231	0.226	0.217	0.213
13.5	**0.197**	0.250	0.245	0.240	0.235	0.229	0.224	0.220	0.215	0.210	0.206	0.201	0.193	0.189
14	**0.176**	0.225	0.220	0.215	0.210	0.205	0.201	0.196	0.192	0.187	0.184	0.180	0.173	0.169

Mode 2, C_t values														
	Air density kg/m^3													
Wind speed [m/s]	**1.225**	**0.95**	**0.975**	**1**	**1.025**	**1.05**	**1.075**	**1.1**	**1.125**	**1.15**	**1.175**	**1.2**	**1.25**	**1.275**
14.5	**0.158**	0.203	0.198	0.193	0.189	0.184	0.180	0.176	0.172	0.168	0.165	0.161	0.155	0.152
15	**0.142**	0.182	0.178	0.174	0.169	0.165	0.162	0.158	0.155	0.151	0.148	0.145	0.140	0.137
15.5	**0.129**	0.165	0.161	0.157	0.153	0.150	0.146	0.143	0.140	0.137	0.134	0.132	0.127	0.124
16	**0.117**	0.150	0.146	0.143	0.139	0.136	0.133	0.130	0.127	0.125	0.122	0.120	0.115	0.113
16.5	**0.107**	0.137	0.133	0.130	0.127	0.124	0.121	0.119	0.116	0.114	0.112	0.109	0.105	0.103
17	**0.098**	0.125	0.122	0.119	0.116	0.114	0.111	0.109	0.107	0.104	0.102	0.100	0.097	0.095
17.5	**0.091**	0.115	0.112	0.109	0.107	0.104	0.102	0.100	0.098	0.096	0.094	0.092	0.089	0.087
18	**0.084**	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.087	0.085	0.082	0.081
18.5	**0.077**	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.079	0.076	0.075
19	**0.072**	0.090	0.088	0.086	0.084	0.082	0.081	0.079	0.078	0.076	0.075	0.073	0.071	0.069
19.5	**0.067**	0.084	0.082	0.080	0.078	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.066	0.065
20	**0.062**	0.078	0.076	0.075	0.073	0.071	0.070	0.069	0.067	0.066	0.065	0.063	0.061	0.060

Table 12-8: Mode 2, C_t values.

12.3.3 Mode 2, Sound Power Levels

Sound Power Level at Hub Height, Mode 2		
Conditions for Sound Power Level	**Verification standard: IEC 61400-11 Ed. 2.** **Wind shear 0.15** **Max turbulence at 10 meter height: 16%** **Inflow angle (vertical): 0 ± 2°** **Air density: 1.225 kg/m^3**	
Hub Height	80 m	95 m
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	93.8 4.2	93.8 4.3
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	96.0 5.6	96.4 5.7
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	100.1 7.0	100.7 7.2
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 8.4	103.0 8.6
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 9.8	103.0 10.0
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 11.2	103.0 11.5
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 12.6	103.0 12.9
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 13.9	103.0 14.3
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 15.3	103.0 15.8
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 16.7	103.0 17.2
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 18.1	103.0 18.6

Table 12-9: Sound power level at hub height: Mode 2.

APPENDIX D:
VESTAS V100-1.8 MW SOUND POWER DATA

CONFIDENTIAL – These materials have been supplied to the Ontario Ministry of the Environment.

Sound Power Level Data for the V100-1.8MW

These values are valid for the following conditions

WTG Type	V100-1.8 MW	
Max Rated Power	1.8	MW
Hub Height [m]	95	m
Shear factor	0.16	
Max turbulence at 10m height	0.16	
Inflow angle	0 +/-2 deg	
Air Density	1.225	kg/m3
Measurement Standard:	ICE 61400-11:2002, using amendments procedure above 95% RP	

Wind Speed@10m [m/s]	3	4	5	6	7	8	9	10	11	12	13	14
16Hz [dB(A)]	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
31.5Hz [dB(A)]	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
63Hz [dB(A)]	NaN	NaN	NaN	85.2	87.4	87.1	86.7	86.6	NaN	NaN	NaN	NaN
125Hz [dB(A)]	NaN	NaN	NaN	89.6	92	91.7	91.3	91.4	NaN	NaN	NaN	NaN
250Hz [dB(A)]	NaN	NaN	NaN	93	94.7	94.2	93.6	93.5	NaN	NaN	NaN	NaN
500Hz [dB(A)]	NaN	NaN	NaN	95.4	97.1	96.7	96.1	96.1	NaN	NaN	NaN	NaN
1000Hz [dB(A)]	NaN	NaN	NaN	98.2	99.7	99.5	99	99.1	NaN	NaN	NaN	NaN
2000Hz [dB(A)]	NaN	NaN	NaN	96.6	98.2	98.4	98.2	98.2	NaN	NaN	NaN	NaN
4000Hz [dB(A)]	NaN	NaN	NaN	94.6	96.6	97.2	98.7	98.6	NaN	NaN	NaN	NaN
8000Hz [dB(A)]	NaN	NaN	NaN	85.4	89.8	90.3	91.4	92.3	NaN	NaN	NaN	NaN

Spectra Value [dB(A)]	NaN	NaN	NaN	103.3	105	105	105	105	NaN	NaN	NaN	0

Notes:
1. NAN indicates data not available due to insufficient data collection at this wind speed.
2. Disclaimer:
The values are valid for the A-weighted sound power levels
Octave band values must be regarded as informative
Site specific values are not warranted
3. Measurement standard - ICE 61400-11:2002, using amendments procedure above 95% RP

Confidential

IPC Energy
December 01, 2010

Attention: Sunny Galia / John Andrews / Terry Hawrysh

IPC Energy
2550 Argentia Rd. Suite 105
Mississauga, ON, Canada
L5N 5R1

Reference: Warranted Sound Power Level and Tonality for the Vestas V100-1.8MW for the Vineland Power Inc. and Wainfleet Wind Energy Inc. Projects.

Dear Sunny/John/Terry,

Vestas is pleased to provide the following clarification regarding the sound characteristics of the V100-1.8MW wind turbine. The V100-1.8 wind turbine will be used by Vineland Power Inc and Wainfleet Wind Energy Inc. located respectively in Vineland ON, and Wainfleet ON, Canada to power their projects and supply power to the OPA. This letter provides clarification of the V100-1.8 sound characteristics and is not intended as a warranty, the above projects will be covered by warranties provided to the above contracts as part of the Ontario FIT award and as such constitute a special offer to only these FIT contracts.

Warranted Sound Power Level and Tonality V100 – 1.8MW WTG IEC Class IIIA

Sound Power Level:

When measured in accordance with the Sound Level Testing Procedures attached as Exhibit N.2 to the Wind Turbine Supply Agreement to which this Exhibit N.1 is attached, the V100 1.8MW WTG IEC Class IIIA warranted sound power level at 8m/s (10m height) is

Lwa = 105.0 dB(A).

This warranted sound level is subject to a tolerance for measurement uncertainties of the greater of (i) the actual measurement uncertainty determined in accordance with the Sound Level Test Standard and (ii) ± 2dB(A). If the measured sound power level is at or below the warranted sound power level plus the uncertainty, the standard has been met.

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IPC Energy
December 01, 2010

Tonality:

The supplier will warrant the tonality of the sound generated by the Wind Turbines as measured by the Sound Level Testing Procedures attached as Exhibit N.2 (IEC 61400-11-ed2:2002 standard), such that the tonal audibilities, $\Delta L_{a,k}$ are not greater than two (2) DBa.

The above commitments will be captured in the contracts for IPC Energy Wainfleet and Vineland that are in the process of being finalized.

Thank you for the opportunity to clarify our position with respect to the V100 sound characteristics.
Vestas prides itself on its excellent working relationships with owners of wind turbines worldwide. Our goal is to provide you with the highest levels of customer service in order to support you in creating a successful project. If you have any questions, please do not hesitate to contact me at your convenience.

Sincerely,

Timothy Koivu

Timothy Koivu (MESc)
Senior Contract and Business Development Manager
Vestas-American Wind Technology, Inc.
65 Queen Street, Suite 2000, Box 56
Toronto, Ontario, Canada
Direct: 416-254-6238

Exhibit N

Sound Level Performance Standard

Warranted Sound Power Level V100 – 1.8MW WTG IEC Class III

When measured in accordance with the Sound Level Testing Procedures attached as Exhibit O to the Wind Turbine Supply Agreement to which this Exhibit N is attached, the V100 – 1.8MW WTG IEC Class S warranted sound power level at 8m/s (10m height) is

Lwa = 105.0 dB(A).

This warranted sound level is subject to a tolerance for measurement uncertainties of the greater of (i) the actual measurement uncertainty determined in accordance with the Sound Level Test Standard and (ii) ± 2dB(A). If the measured sound power level is at or below the warranted sound power level plus the uncertainty, the standard has been met.

Supplier also warrants that the sound generated by any Wind Turbine shall not contain any tone greater than +2dB when measured in accordance with the Sound Level Test Standard.

Acoustic Noise Test Report for a Vestas V100 1.8 MW Turbine at Pueblo, Colorado

CONFIDENTIAL

Vestas American Wind Technology, Inc.
1881 SW Naito Parkway #100
Portland, OR 97201

TESTING CERT #2564.01

DNV Report No.: ANRP0105
May 12, 2011

Acoustic Noise Test Report for a Vestas V100 1.8 MW Turbine at Pueblo, Colorado			DNV Renewables (USA) Inc. 1809 7th Avenue, Suite 900 Seattle, WA 98101 USA Tel: 1-206-387-4200 Fax: 1-206-387-4201 http://www.dnv.com/windenergy
For: Vestas – American Wind Technology, Inc. 1881 SW Naito Parkway #100 Portland, OR 97201 Customer Name: Galvin Clancy			
Date of First Issue:	May 11, 2011	Project No.:	PP003349
Report No.:	ANRP0105	Organization Unit:	ACGUS364
Version:	B		

Summary:

This report presents the methods, assumptions, and results of acoustic noise testing conducted by DNV on one V100 1.8 MW wind turbine at the Pueblo, Colorado Vestas manufacturing plant grounds.

Prepared by:	Sarah Taubitz, Test Engineer	Signature	[signature]
Verified by:	Collin Sad, Test Engineer	Signature	[signature]
Approved by:	Luke Simmons, Group Leader, Performance and Acoustic Testing	Signature	[signature]

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1 INTRODUCTION

1.1 Scope

This report presents the results of an acoustic noise test conducted on one Vestas V100 1.8 MW wind turbine located at Vestas' tower manufacturing facility in Pueblo, Colorado (the Project). The test turbine is a prototype turbine, designated number WTG1, and is the only turbine currently built on the plant property. The test was conducted in accordance with the Test Plan [1] to document acoustic noise emissions from the test turbine in accordance with the IEC acoustic noise measurement standard (the IEC Standard) [2]. The test was conducted during the early hours of February 20, 2011. This report describes the methodology, equipment, assumptions, and the results of the acoustic noise test. This test does not meet all the requirements of the IEC Standard; exceptions are given in Section 3.

A Power Performance Test will be conducted by DNV on the same test turbine. Newly installed met tower instrumentation, planned for use on the Power Performance Test, was therefore utilized for this Acoustic Noise Test.

This test was conducted and the report was prepared by DNV's Seattle-based Technology Group, an organization that is accredited by the American Association for Laboratory Accreditation (A2LA) to perform acoustic noise testing of wind turbines (Certificate number 2564.01).

The results given in this report relate only to this particular wind turbine; the same turbine type installed at a different site or operating with a different control scheme may provide different results.

1.2 Background

The power curve used in this report is the theoretical curve provided in the turbine's General Specification, supplied by Vestas [3]. Using a measured power curve is preferable to a theoretical one; however since the turbine is a prototype no measured power curve yet exists. Additional uncertainty was assigned to the sound power levels and third octave sound pressure levels reported herein.

1.3 Turbine Description

The V100 wind turbine is an upwind, 3-bladed, active yaw turbine incorporating full-span pitch control and constant-speed operation. Table 1-1 lists general details of the test turbine as noted in the General Specification [3]. Table 1-2 lists the serial numbers of the turbine and significant components.

Table 1-1. Turbine Description

Item	Value
IEC Class	S
Grid Frequency	60 Hz
Special Features	-
Rated Power	1815 kW
Rotor Diameter	100 m
Rotor Speed	9.3 – 16.6 RPM, 14.5 RPM nominal
Generator Speed	1345 RPM
Gearbox Ratio	1:92.8 nominal
Power Regulation	Pitch Regulated, Variable Speed
Shaft Tilt	6°
Hub Height	80 m
Distance from Rotor Center to Tower Center Line	4480 mm (per Appendix D)
Tower Type	Tubular steel
Cut-in Wind Speed	3 m/s
Rated Wind Speed	12 m/s
Cut-out Wind Speed	20 m/s
Generator Voltage	6 pole, 690 Vac
Power Factor (cos)	1.0

Table 1-2. Turbine and Turbine Component Identification (per Vestas)

Item	Manufacturer/Model	Serial Number
Turbine	Vestas V100-1.8MW VCUS Mk7	38733
Blades	Vestas 49M	781302WHD90177 781302WHD90179 781302WHD90187
Gearbox	Bosch Rexroth GPV 442	72802018635
Generator	Vestas/Weier DVSG 560/6M	620451
Controller Software Version	VMPGlobal v. 10.05.03	N/A

1.4 Site Description

The test turbine is located on arid, bare land approximately 12 km south of Pueblo, Colorado, at an elevation of approximately 1490 m. The latitude and longitude coordinates for the turbine under measurement are 38.16341° N by 104.62135° W. Figure 1-1 shows the site layout and topography of the Project and surrounding areas. The BNSF and UPNW railway is located approximately 0.5 km east of the turbine; Interstate-25 is located approximately 1.5 km northwest of the turbine. The access road to the plant is approximately 130 m from the turbine at its nearest point. Traffic on this access road, Vestas plant noise, along with the railway and highway noise, necessitate data collection on the weekend and preferably at nighttime; even so, trains and highway traffic noise invalidated a significant amount of data during the test period. The terrain within the Project is very flat with little to no vegetation. As can be seen on Figure 1-1, the microphone is located in the IEC Standard reference downwind position of R_0 = 133.9 m (where the IEC Standard specifies 130 m ± 20%), the permanent meteorological (met) tower was located alongside the turbine, approximately 250 m to the southeast.

The site bearings were measured using a Garmin Nuvi GPS (accuracy ± 1.5°) validated with a compass at several locations around the turbine, and distances were measured with a TruPulse 200 rangefinder (accuracy ± 0.3 m).

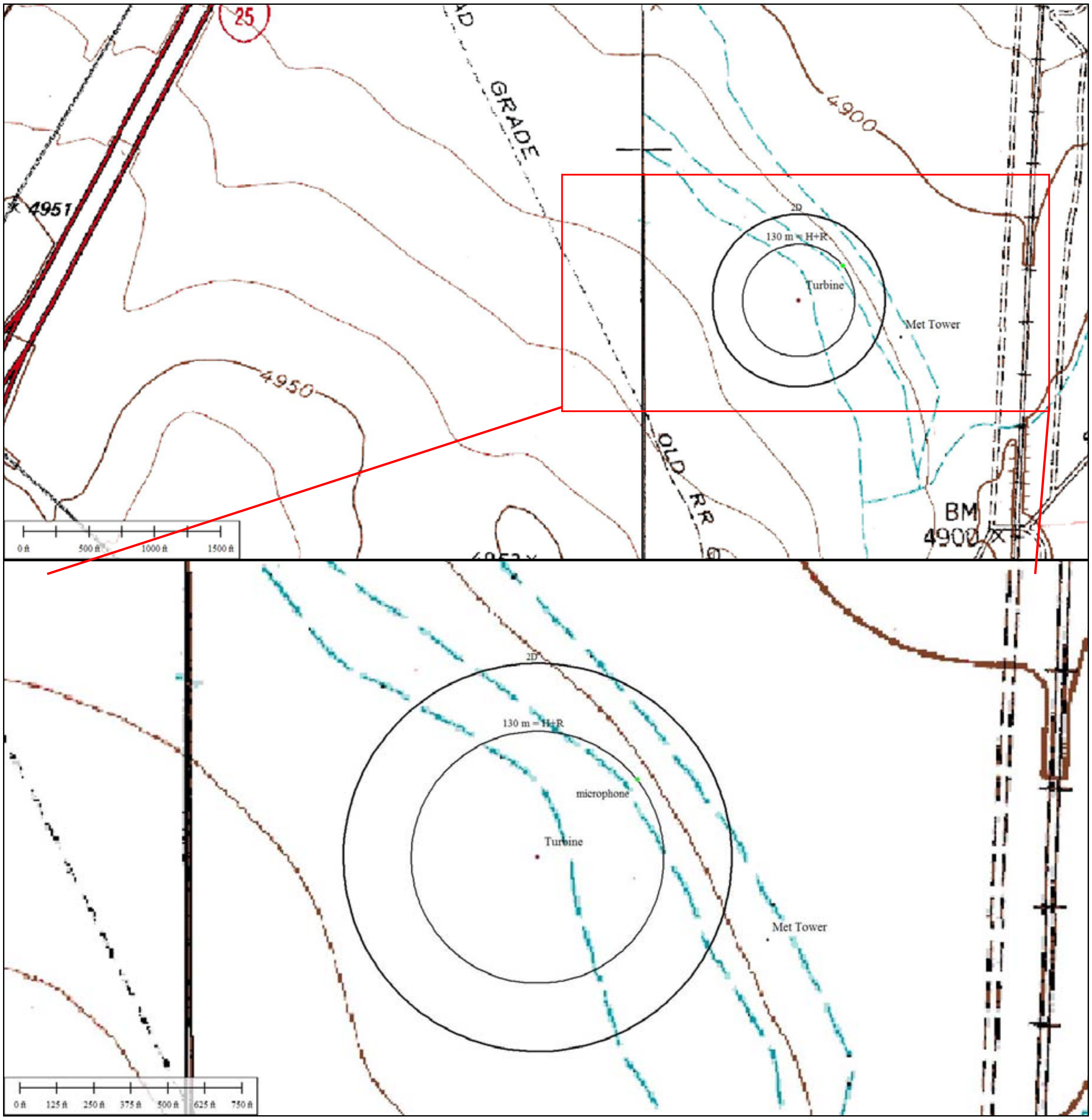


Figure 1-1. Test Site Topography and Measurement Locations (zoomed image below)

1.5 Site Conditions

The Project test site had a clear sky and no precipitation during the nighttime test period; the ranges of environmental conditions are displayed in Table 1-3, with a clear sky and no precipitation. The minimum and maximum values are taken from the 1-minute averaged 1 Hz data. There was no precipitation in the data set used for analysis.

Table 1-3. Meteorological Conditions during the Test Period of 01:52 to 06:12

Variable	Average	Minimum	Maximum
80 m Height Measured Wind Speed (m/s)	11.5	4.8	21.7
Air Pressure (hPa)	826.8	825.8	828.0
Air Temperature (°C)	9.4	8.0	11.0
Air Density (kg/m^3)*	1.020	1.014	1.025
Relative Humidity (%)	44.0	43.4	44.4

* Calculated from temperature and pressure according to the IEC Standard [1].

2 TECHNICAL APPROACH

2.1 Test Instrumentation

The IEC Standard requires that wind speed is determined for noise measurements when the turbine is operating by measuring the electrical output and determining wind speed, using a representative power curve, or from direct measurement with an anemometer. The former technique is mandatory for certification purposes, and was used for this test.

The 80 m permanent met tower was used for all meteorological data. For background noise measurements, measuring wind speed with an anemometer is required. For the wind direction encountered during this noise test, the 10 m temporary met mast could not be placed in an IEC-compliant location, due to a tall chain-link fence. Instead, DNV measured wind speeds using the primary anemometer mounted on the permanent 80 m height met tower, located 2.5 rotor diameters (250 m) southeast (108° with respect to true north) of the test turbine. DNV also measured temperature and barometric pressure using DNV-installed instrumentation on the met tower. Figure 2-1 shows the permanent met tower configuration at the site. In Appendix B, Figures B-1 and B-4 display the met tower and anemometers. The met tower instrumentation has been installed in anticipation of a power performance test.

DNV obtained the turbine power signal from IEC-compliant measurement equipment recently installed in the turbine by DNV for the power performance test.

All data were sampled at 1 Hz for the duration of this test, and later averaged in 1-minute periods.

The microphone was located at a distance of 133.9 m from the turbine tower center, and 47° true relative to the turbine (for a downwind location of 227°), and was mounted on a round 1 m diameter acoustically hard sound board made from 3/4-inch-thick plywood. In Appendix B, Figure B-2 shows the microphone and board relative to the turbine. The microphone power supply and measurement system were located near the microphone on the ground, in mild weather.

It has become industry accepted to utilize the yaw position of the turbine as the wind direction indicator, since the correlation to noise is better than with a wind direction transducer. Using a compass, DNV verified on site that the yaw position of the turbine was set to zero degrees at true North. There was no specified yaw position offset in the turbine controller. DNV utilized a GPS unit to verify compass readings at several locations around the turbine, and all were found to be in compliance within the IEC Standard's requirements.

Table 2-1 summarizes the instrumentation utilized, along with the calibration information. The instrument calibration sheets are attached as Appendix C.

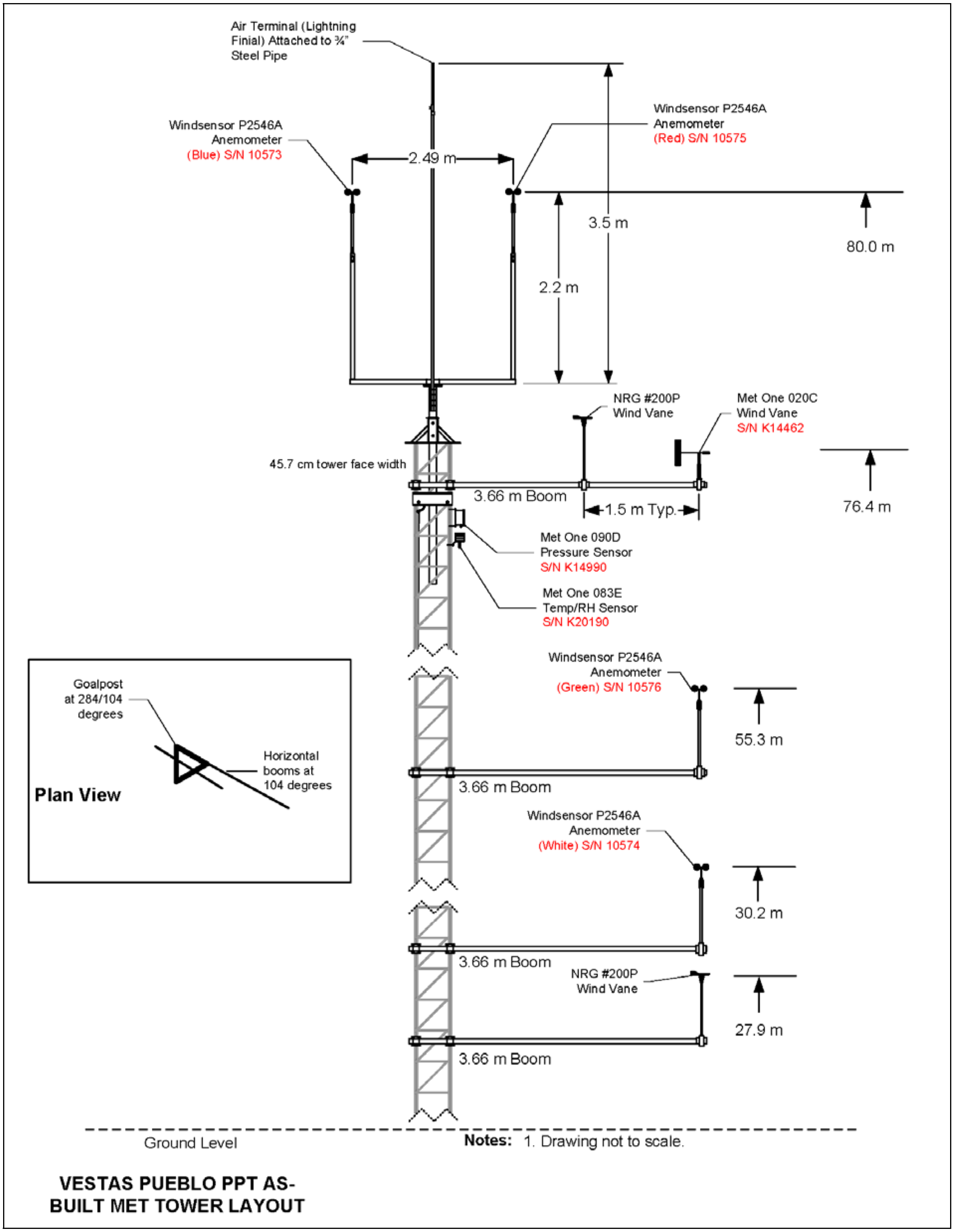


Figure 2-1. Met Tower Top Instrumentation Drawing

Table 2-1. Test Instrumentation and Calibration

Item	Manufacturer and Model	Serial Number	Calibration By, Date
Integrated Sound Level Meter, which includes Laptop, Data Acquisition Board, Cabling, Realtime Analyzer and Playback/Recorder, Microphone with Preamplifier	See below	1546B35	Scantek, January 21, 2011
Data Acquisition System	National Instruments NI-9233	1546B35	See Integrated Sound Level Meter line item
Real Time Analyzer, Playback/Recorder	Delta NoiseLab 3.0	N/A	See Integrated Sound Level Meter line item
Microphone and Preamplifier	PCB 378B02	105577	Scantek, January 2, 1011
Laptop	D830	F1PT3H1	N/A
Windscreen	Open cell foam, Brüel & Kjær UA-0237	N/A	N/A
Sound Board	¾"-thick particle board, N/A	N/A	N/A
Acoustic Calibrator	PCB Larson Davis CAL200	8053	Scantek, January 21, 2011
Wind Speed	Windsensor P2546A	10573	Svend Ole Hansen, December 5, 2010
Wind Direction	Turbine Yaw Position	N/A	N/A
Barometric Pressure	Met One 090D	K14990	February 14, 2011
Air Temperature	Met One 083E-1-35	K20290	February 14, 2011
Power Transducers	N/A	N/A	Logged and provided by Vestas
Data Logger	Campbell Scientific CR1000	38384	SIMCO, January 17, 2011

2.2 Data Reduction Methodology

The following subsections describe DNV's general method for collecting and processing the test data.

Test data were collected between 01:52 and 06:12 on February 20, 2011. The integrated sound level meter measured and recorded sound pressure levels, sampled at 50 kHz. DNV collected meteorological and turbine signals using Campbell Scientific loggers at a sampling rate of 1 Hz, and were subsequently averaged in 1-minute periods. One-minute averages of overall sound pressure levels were processed in Delta NoiseLab after data collection was complete. One-minute energy averaged one-third octave spectra, from 0 to 20,000 Hz, were also generated in post processing. Data available in the files included the fields described in Table 2-2. After measured wind speed and wind speed derived from turbine power were converted to standardized wind speed (at standard roughness length of 0.05 m and 10 m height, "V_S") for all the data, 1-minute records could be selected for tonality analysis at integer standardized wind speed (V_S) for the test period, after the field measurement was completed.

Table 2-2. Recorded Data

Signal	Logged Measurement	Unit
Date and Time	Time at end of sample period	Julian day 24 hour clock
Wind Speed	Average	m/s
Yaw Position	Average	Degrees relative to wind turbine
Air Temperature	Average	°C
Barometric Pressure	Average	hPa
Turbine Output Power	Average	kW
Sound Pressure Level	Scaled signal representing time series sound pressure	dB

2.2.1 Data Selection

Data corresponding to the following circumstances were removed from the valid data set:

1. Wind direction was outside the valid measurement sector of 212° to 242° relative to true north.
2. Interrupting noise sources such as a passing vehicle, train, or airplane that showed influence on the acoustic measurement.

The IEC Standard requires that a minimum of three one-minute averaged records be collected for each integer wind speed of V_S from 6 to 10 m/s; this requirement was not met for background noise during this test period; only a single one-minute record was collected at 8 m/s and none were collected at 9 or 10 m/s. As an alternative, the one-minute record at 8 m/s and the highest wind speed in the 7 m/s bin were utilized to background correct the one-third octave data and narrowband spectra used for tonality analysis. This is noted as a deviation in Section 3. Although this deviates from the IEC Standard, DNV believes that carrying out background correction in this manner on the data in these bins still provides useful information on the turbine's noise characteristics at these wind speeds; it can be expected that the one-third octave and tonality results at 8 through 10 m/s are somewhat more conservative, since background noise levels increase with increasing wind speed.

2.2.2 Wind Speed Correction

Consistent with the IEC Standard, for turbine operating acoustic measurements, DNV calculated the V_S at standard sea-level reference conditions, 10 m height, and 0.05 m roughness length using the 1-minute average measured electrical power and a measured sea-level density power curve. V_S is corrected for the reference conditions using Equation 1. Table 2-3 defines the variables for Equation 1. The power curve used to determine V_S is included as Appendix A. This curve is the sea-level-adjusted measured power curve published in the General Specification [3].

$$V_S = V_z \left[\frac{\ln\frac{z_{ref}}{z_{oref}} \ln\frac{H}{z_o}}{\ln\frac{H}{z_{oref}} \ln\frac{z}{z_o}} \right]$$ **Equation 1**

Table 2-3. Variables for Standardizing Wind Speed

Parameter	Description	Value	Unit
V_S	Standardized wind speed	N/A	m/s
V_z	Wind speed measured at anemometer height z	N/A	m/s
z_{oref}	Reference roughness length	0.05	m
z_o	Roughness length	0.05	m
H	Rotor center height	80	m
z_{ref}	Reference height	10	m
z	Anemometer height (turbine rotor)	80	m

DNV derived the linear relationship between wind speed derived from power and wind speed measured by the nacelle anemometer for power between 5% and 95% of rated power; the nacelle anemometer method is preferred over the kappa method by the IEC Standard. For background noise measurements, turbine power is unavailable for determining V_S; so for background noise wind speeds the kappa method was utilized, which provided a better correlation than the logarithmic Equation 5 from the IEC Standard. For noise measurements when the turbine power is greater than 95% of rated power, calculating wind speed from power output is not accurate; this linear relationship between wind speed derived from power and nacelle anemometer wind speeds, shown in Figure E-1 of Appendix E, was then utilized for these periods to determine V_S.

2.2.3 A-Weighted Sound Power Level

DNV plotted the measured A-weighted sound pressure levels against wind speed data, and utilized the fourth-order polynomials to determine the average sound pressure level, L_{Aeq}, for both total and background noise at each integer wind speed V_S (6, 7, 8, 9, and 10 m/s) per the IEC Standard. DNV utilized background noise data at wind speeds up to 13 m/s, since there were insufficient data between 8 and 10 m/s, and the Pearson regression coefficients (R-squared) for the fourth-order fit had a very high correlation that still provides a high degree of confidence in the resulting “predicted” background noise levels for each V_S. Noncompliance with the minimum data collection requirements and use of background noise data at wind speeds higher than 10 m/s are both exceptions to the IEC Standard and are listed in Section 3. This analysis yields the background noise level at each integer V_S, which is used to correct the turbine operating data for background noise at all integer wind speeds 6 to 10 m/s.

As an alternative method of mitigating the risk of the lack of background data for 8 though 10 m/s, the background noise value found using the fourth-order regression analysis at 7 m/s was utilized to correct the total noise levels determined by regression analysis to determine sound power levels; these are also included in the results in Table 4-2.

2.2.4 A-Weighted One-Third Octave Band Levels

The one-third octave band sound pressure levels of the noise signal at the microphones were obtained using spectrum analysis software Delta Noiselab, concurrent with the one-minute sound pressure level calculations. As in the L_{Aeq} analysis, the turbine operating data were background corrected; where insufficient background noise data were collected (at 8 through 10 m/s), DNV utilized background noise at 7 and 8 m/s to provide a background correction, as described in Section 2.2.1.

2.2.5 Tonality Analysis

To analyze the tonality of the turbine, valid noise data were selected at the wind speeds closest to each integer V_S, per the IEC Standard. DNV performed the tonality analysis at wind speeds between 4 and 10 m/s. Sufficient operating data were available for all wind speeds between 4 and 10 m/s. Insufficient background noise data were unavailable between 8 and 10 m/s; in these cases, DNV utilized background noise data at 7 and 8 m/s for the corrections. The same was done for one-third octave analysis. DNV analyzed each measurement using a fast Fourier transform (FFT) with a 3-Hz resolution Hanning window from 3 to 20 kHz. Consistent with the IEC Standard, twelve 10-second energy-averaged narrowband spectra from turbine-operational data were analyzed in order to compare any suspected tones with the masking level in the tone's critical band. Two 60-second background-noise spectra closest to the integer wind speed (or at the highest wind speeds available in the case of 8 through 10 m/s, as described in Section 2.2.1) were energy averaged to get one spectra that was analyzed for each integer V_S and used to correct the operating spectra. Although an exception to the IEC Standard, utilizing background noise data from lower wind speeds for correction is expected to yield conservative results, since background noise levels are typically lower at lower wind speeds.

Each line in the identified tone's critical band was then classified according to the following criteria:

1. Lines are classified as masking if their RMS-averaged levels are less than 6 dB above the $L_{70\%}$ sound pressure level. The $L_{70\%}$ sound pressure level is the energy average of the 70% of spectral lines in the critical band with the lowest levels.
2. Lines are classified as tones if their RMS-averaged levels are more than 6 dB above the $L_{pn,avg}$ sound pressure level. The $L_{pn,avg}$ sound pressure level is the energy average of the spectral lines classified as masking.
3. Where there are several adjacent lines classified as tones, the line with the greatest level is identified. Adjacent lines are then classified as tones only if their levels are within 10 dB of the highest level.

4. Lines are classified as neither tones nor masking if their RMS-averaged levels:
   - Are greater than 6 dB above the $L_{70\%}$ sound pressure level and
   - Are less than 6 dB above the $L_{pn,avg}$ sound pressure level
5. Individual tones from each of the 12 background-corrected operating spectra (or a substitute lower-wind speed spectra in the case of 8 to 10 m/s) were energy averaged to determine their audibility.

The wind turbine noise tonality and tonal audibility are then calculated from the processed and categorized narrow band spectra. The tonal audibility as defined in the IEC Standard is a frequency-dependent criteria that has been determined from listening tests. A summary of these results is provided in Table 2-4.

2.2.6 A-Weighted Apparent Sound Power Level

The category A uncertainty for the apparent sound power level, L_{WA}, is the standard error of the estimated A-weighted sound pressure level, L_{Aeq}, at each integer V_S (Equation 2), and is obtained from the linear regression analysis.

$$U_A = \sqrt{\frac{\Sigma(y - y_{est})^2}{N-2}} \qquad \textbf{Equation 2}$$

Where: U_A = Category A uncertainty for apparent sound power level,
y = measured sound pressure level,
y_{est} = estimated sound pressure level using linear regression,
N = number of measurements used in the linear regression.

The category A apparent sound power level uncertainty analysis resulted in a calculated uncertainty value, U_A, of 0.83 dB. DNV calculated this value using 143 data points at integer V_S values of 4 through 11 m/s. Uncertainty on the nacelle anemometer correlation was found to be 0.83 using Equation 2 above for data between 5% and 95% of rated power.

The category B uncertainty is calculated using Equation 3. The category B components are listed in Table 2-4. Two different values of U_{B9} were used, a higher value for the 8 to 10 m/s bins.

Total uncertainty values, U_C, are included in Table 4-4.

Table 2-4. Category B Uncertainty Components

Parameter	Description	Value	Unit	Source
U_B	Category B uncertainty for apparent sound power level	0.9	dB	Calculation
U_{B1}	Calibration of the instruments	0.2	dB	Calibrator calibration
U_{B2}	Tolerances on the measurement chain	0.3	dB	Estimate
U_{B3}	Sound board	0.3	dB	Estimate
U_{B4}	Distance from microphone to hub	0.1	dB	Estimate
U_{B5}	Acoustic impedance of air	0.1	dB	Estimate
U_{B6}	Turbulence	0.5	dB	Estimate
U_{B7}	Wind speed, measured Wind speed, derived	0.83 0.2	dB	Calculated using Equation 2 New anemometer install
U_{B8}	Wind direction	0.3	dB	Sensor calibration and mounting estimate
U_{B9}	Background correction, 4-7 m/s Background correction, 8-10 m/s	0.25 1.3	dB	Applied background correction Maximum correction assuming 3<SNR>6

$$U_B = \sqrt{U_{B1}^2 + U_{B2}^2 + U_{B3}^2 + U_{B4}^2 + U_{B5}^2 + U_{B6}^2 + U_{B7}^2 + U_{B8}^2 + U_{B9}^2} \quad \textbf{Equation 3}$$

Category A and B uncertainties are combined into one standard uncertainty by Equation 4:

$$U_C = \sqrt{U_A^2 + U_B^2} \quad \textbf{Equation 4}$$

Where: U_C = Overall standard uncertainty for apparent sound power level.

2.2.7 One-Third Octave Spectra

For the one-third octave band, U_A for each band is the standard error on the averaged band level, computed as the standard deviation divided by $(N-1)^{1/2}$, where N is the number of measured spectra. The value for U_{B3} is considered much larger than for L_{WA}, and is estimated to be 1.7 dB for one-third octave bands. Uncertainties on the one-third octaves are included in Table 4-3.

2.2.8 Tonality

Per the IEC Standard, U_A for each tone is the standard error, defined above, on the averaged tone level. The values of U_{B1}, U_{B4}, and U_{B6} can be estimated to be smaller than for L_{WA}. The value of U_{B3} is estimated to be 1.7 dB. Uncertainties are provided along with the tonality results in Table 4-5. Because 1 minute of background noise at 7 m/s and 8 m/s were utilized to background correct the total noise at 8 through 10 m/s, the background noise portion of uncertainty calculation, U_{B9}, was raised to a maximum value of 0.8, which DNV views as very conservative.

3 EXCEPTIONS TO THE IEC STANDARD

1. Insufficient background noise was recorded at the standardized wind speeds (V_S) of 8 through 10 m/s; only 1 minute of background noise at 8 m/s was recorded, and none at 9 m/s or 10 m/s was recorded. Background noise recorded at lower wind speeds (7 and 8 m/s) were utilized as a substitute for background corrections for overall sound pressure levels. For one-third octave data between 4 and 7 m/s, sufficient background noise data were available to calculate uncertainties per the IEC Standard. For one-third octave data at 8 to 10 m/s, no uncertainties are reported because these values are merely indicative and not to be relied upon.
2. Due to insufficient background noise at 8 through 10 m/s, measured background noise up to 13 m/s was utilized to derive the fourth-order regression equation utilized for background correction of operating noise. Uncertainty on the resulting calculated sound power levels (L_{WA}) and one-third octave turbine sound pressure levels have therefore been increased to account for this.
3. The turbine's yaw position data were utilized for determining wind direction instead of a wind vane transducer; yaw position has been shown to provide better correlation to acoustic noise output.

4 RESULTS

4.1 Collected Data

Data collected from 01:52 to 06:12 on February 20, 2011, were utilized in the subsequent results. Table 4-1 details the amount of data collected and the data removed for the specified reasons. Figure 4-1 displays the distribution of the collected data.

Table 4-1. Summary of Collected Data

Item	Number of 1 Minute Data Points
Total collected data, V_S = 4 – 13 m/s	261
Removed data for invalid wind direction	19
Removed data for turbine operating outside normal parameters	24
Removed for spurious noises, turbine shutdown/startup periods	51
Valid data used, turbine operating	114
Valid data used, background	53

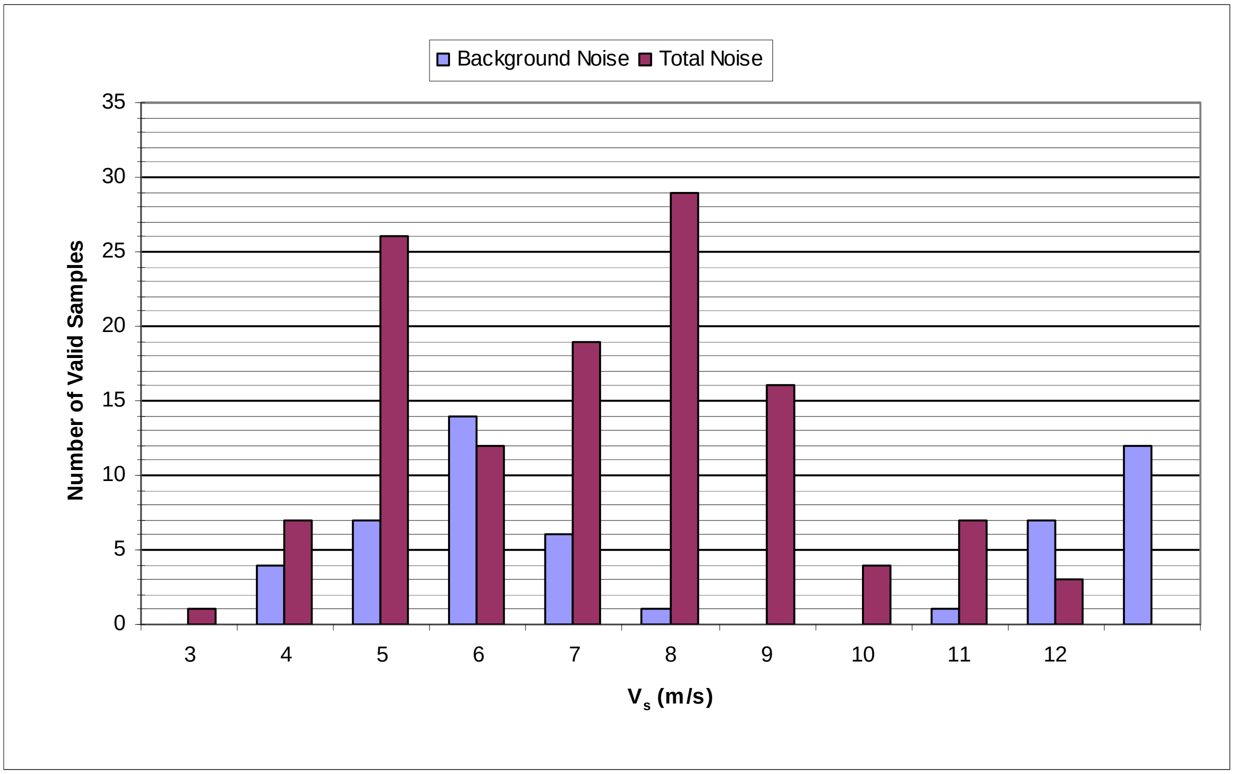


Figure 4-1. Valid Collected Data

4.2 Results

4.2.1 Overall Sound Pressure and Power Levels

As described in Section 2, DNV processed data into a set of valid data for use in the final results. The measured valid sound pressure levels for background and total (turbine operating) noise is displayed graphically in Figure 4-2. The fourth-order polynomials of total and background noise were used, since the resulting correlation coefficients were greater than 0.8, according to the IEC Standard. Because only one data point existed in the 8 m/s bin, and none in the 9 and 10 m/s bins, background noise at 11 through 13 m/s was utilized to determine the fourth-order regression. Table 4-2 lists the measured sound pressure levels for background and total noise, the background corrected “turbine-only” noise, and the subsequent sound power level for each standardized wind speed.

Figure 4-2 displays the sound pressure levels for both turbine operating and background noise measurements. Table 4-2 lists the total noise (wind turbine plus background) and background noise levels for each wind speed using fourth-order regression analysis per the IEC Standard, along with the calculated apparent sound power levels and the corresponding total uncertainties for each standardized wind speed. Although there was insufficient background noise measured at 8 m/s and none at 9 m/s and 10 m/s, including background noise at 12 and 13 m/s provides a fourth-order polynomial with a very high correlation factor (R-squared); therefore, although an exception to the IEC Standard, DNV believes this to be an accurate prediction of the background noise at these wind speeds. DNV also applied additional uncertainty to these L_{WA} at 8 through 10 m/s to account for this.

Additionally, Figure 4-2 shows sound power levels calculated using the 7 m/s background noise correction, to remove the uncertainty that may exist with the method above (using the fourth-order polynomial prediction without having any measured background data in the bin). Since it is in any case expected that the background noise will be higher at 8 m/s through 10 m/s than at 7 m/s, these calculated sound power levels for 8 m/s through 10 m/s are meant to provide an additional level of confidence in the results.

Figure 4-3 shows the turbine operating sound pressure levels versus the measured wind speed (labeled “V_{met}” in the figure) at 10 m height. Figure 4-4 shows the turbine operating sound pressure levels versus turbine electrical power.

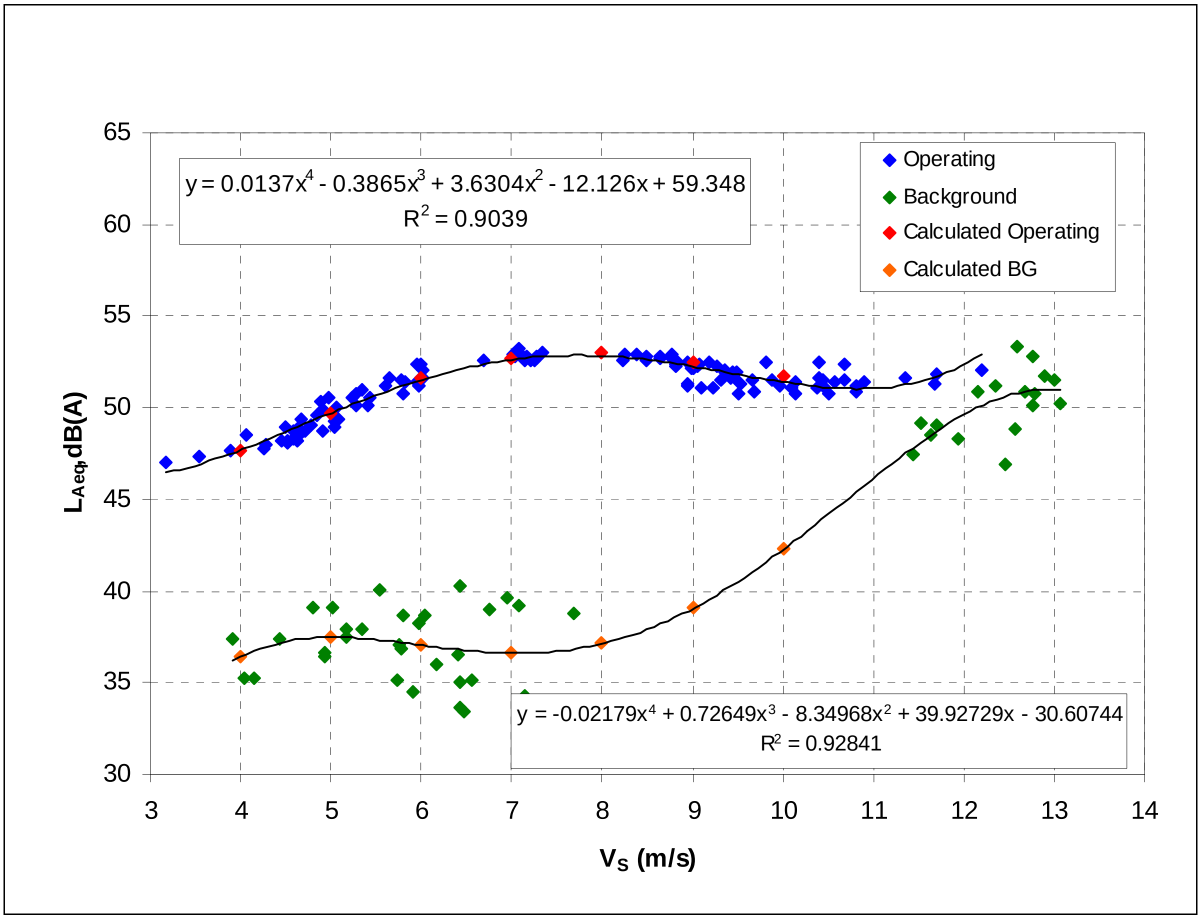


Figure 4-2. A-Weighted, Valid Measured Sound Pressure Levels versus Standardized Wind Speed, Operating and Background

Table 4-2. A-Weighted Sound Pressure and Power Level (L_{WA}) Summary, V_S = 4 – 10 m/s

Standardized Wind Speed, V_S (m/s)	4	5	6	7	8	9	10
Wind Turbine + Background Noise, $L_{Aeq,k}$ (dB)	47.7	49.7	51.6	52.7	53.0	52.5	51.8
Background Noise, $L_{Aeq,k}$ (dB)	36.4	37.5	37.0	36.6	37.1	39.1	42.3
Wind Turbine Noise, $L_{Aeq,c,k}$ (dB)	47.4	49.5	51.4	52.6	52.9	52.3	51.2
Wind Turbine Apparent Sound Power Level, $L_{WA,k}$ (dB)	96.3	98.4	100.3	101.5	101.8	101.2	100.2
Uncertainty (± dB)	0.9	1.0	0.9	0.9	1.6	1.7	1.7
Wind Turbine Noise using 7m/s Background Noise Correction of 36.6 dB, $L_{Aeq,c,k}$ (dB)					52.9	52.4	51.6
Apparent Sound Level using 7 m/s Background Correction (dB)					101.8	101.4	100.7

Note: For 8 to 10 m/s bins, insufficient background noise exists; LWA were calculated using a fourth-order polynomial for background noise.

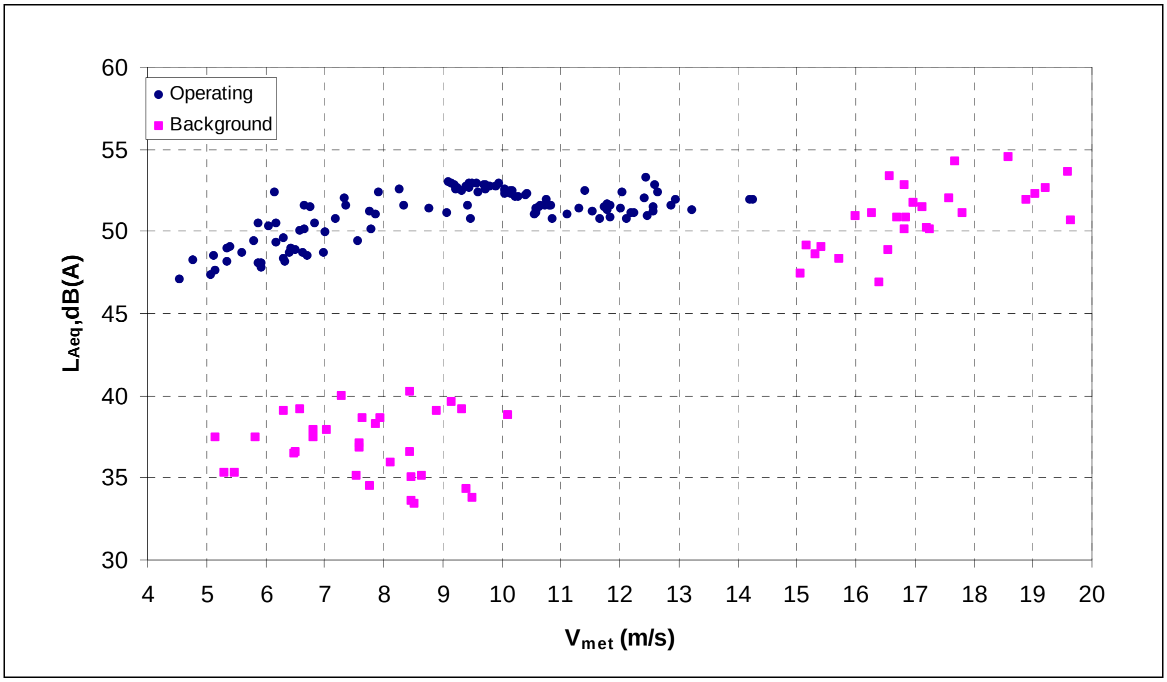


Figure 4-3. A-Weighted Sound Pressure Levels, Turbine Operating and Background Measurements versus Density-Corrected Measured Wind Speed at 80 m Height

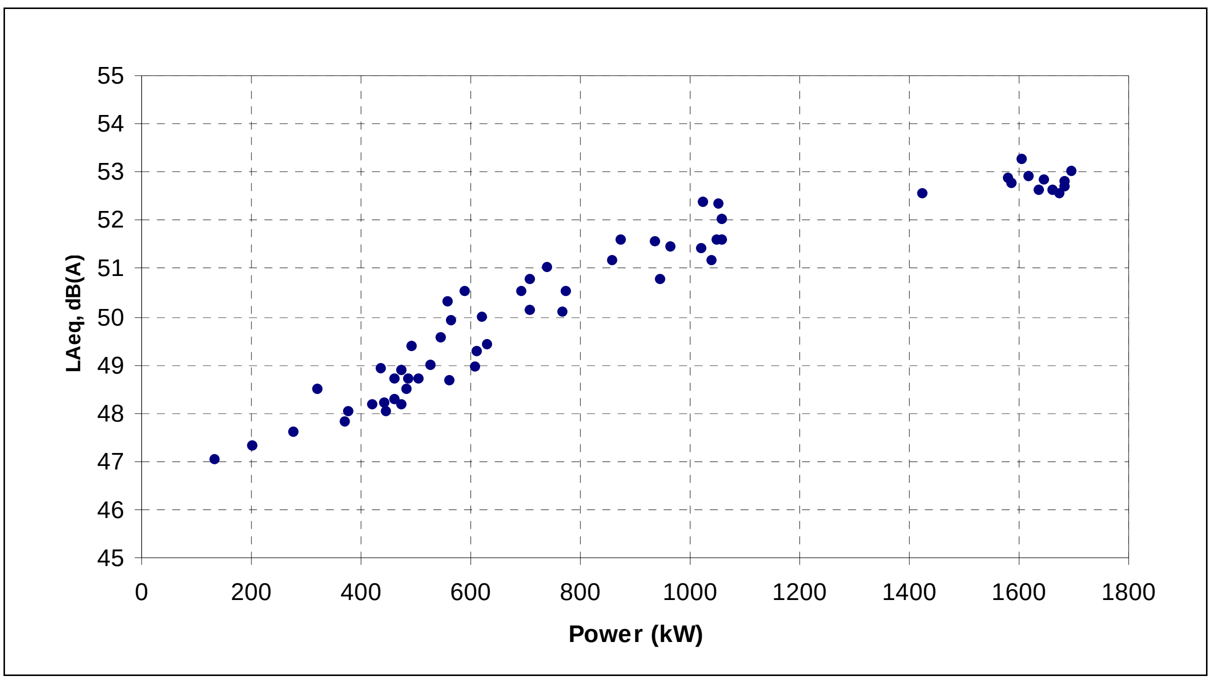


Figure 4-4. A-Weighted Sound Pressure Levels, Turbine Operating Versus Measured Electrical Power

4.2.2 A-Weighted One-Third Octave Analysis

Results of A-weighted one-third octave spectra analysis for integer standardized wind speeds of 4 through 10 m/s, with background noise correction, are displayed in Table 4-3 and Table 4-4.

Because only 1 minute of background noise was available at 8 m/s and none was available at 9 or 10 m/s, the lower wind speed background noise available at 8 m/s was utilized for background corrections of the one-third octave data; this is a deviation from the IEC Standard and is listed in Section 3. Since background noise is expected to be lower at lower wind speeds, the one-third octave levels of background-corrected turbine noise can generally be considered a more conservative result. Note that for all integer wind speeds, the background noise influences the wind turbine noise above 6300 Hz.

Table 4-3. A-Weighted One-Third Octave Sound Pressure Levels, V_S = 4 – 10 m/s

		Standardized Wind Speed Bin (m/s)						
		4	**5**	**6**	**7**	**8**	**9**	**10**
One-Third Octave Center Frequency (Hz)	**20**	5.4	6.4*	9.7	11.3	7.6*	11#	14.5#
	25	9.4*	10.9*	12.4	14.8	11.4*	14#	17.2#
	31.5	14.3	15.5	17.0	18.5	13.9	17#	20.5#
	40	18.3	19.5	21.8	22.3	18.8	20.7#	23.8#
	50	21.4	22.3	24.9	25.5	22.2	23.8#	26.6#
	63	27.7	28.3	29.6	29.9	28.1	28.4#	30.4#
	80	26.0	26.6	30.2	31.3	29.5	29.4#	31.2#
	100	27.3	28.8	32.3	33.2	31.7	31.1#	32.7#
	125	30.3	31.6	35.2	36.3	35.8	35.3#	36.4#
	160	30.6	32.5	35.8	36.9	35.9	34.2#	34.4#
	200	30.9	32.6	36.2	37.2	36.2	34.8#	34.7#
	250	32.6	34.0	37.5	40.4	40.4	38#	37.7#
	315	36.7	38.0	39.9	40.6	40.3	39.7#	39.7#
	400	36.1	38.0	40.3	41.4	41.4	41.1#	41.4#
	500	35.3	37.0	39.6	40.8	40.6	39.6#	39.1#
	630	36.9	39.0	41.5	43.4	43.4	43.2#	42.4#
	800	37.4	39.5	41.4	42.4	42.4	41.4#	40.5#
	1000	37.5	39.2	41.4	42.5	42.3	41.5#	40.6#
	1250	37.3	38.7	41.2	42.3	42.3	41.6#	40.6#
	1600	37.7	39.0	40.7	41.7	41.8	41#	39.9#
	2000	37.0	37.8	39.7	40.7	40.8	40.2#	38.7#
	2500	36.7	37.0	38.4	38.9	39.1	38.5#	36.6#
	3150	31.6	32.8	35.1	36.3	36.6	36#	33.4#
	4000	27.4	28.8	31.0	32.4	32.7	32.2#	28.8#
	5000	+	25.1#	26.7#	28.0	28.3	27.8#	25#
	6300	+	+	+	+	+	+	+
	8000	+	+	+	+	+	+	+
	10000	+	+	+	+	+	+	+
	12500	+	+	+	+	+	+	+
	16000	+	+	+	+	+	+	+

* Operating-to-background level less than 6 dB but more than 3 dB

+ Operating-to-background level less than 3 dB

Corrected with only available one-minute record of 8 m/s data

Table 4-4. Uncertainties U_C (± dB) for One-Third Octave Results, V_S = 4 – 7 m/s

		Standardized Wind Speed V_S (m/s)			
		4	**5**	**6**	**7**
One-Third Octave Center Frequency (dB)	**20**	2.1	3.0	2.1	3.3
	25	2.2	3.9	2.3	3.2
	31.5	2.1	3.4	2.3	3.8
	40	2.1	3.2	2.2	3.5
	50	2.1	2.7	2.3	3.5
	63	1.9	2.1	2.0	2.6
	80	2.2	2.6	2.2	2.9
	100	2.1	2.4	2.1	2.5
	125	2.0	2.2	2.0	2.1
	160	2.0	2.2	2.0	2.1
	200	2.0	2.2	1.9	2.0
	250	2.0	2.1	1.9	2.1
	315	1.9	2.0	1.9	1.9
	400	2.0	2.1	1.9	1.9
	500	2.0	2.1	1.9	1.9
	630	2.0	2.3	1.9	1.9
	800	2.0	2.2	1.9	1.9
	1000	2.0	2.1	1.9	1.9
	1250	1.9	2.1	1.9	1.9
	1600	1.9	2.0	1.9	1.9
	2000	1.9	2.0	1.9	1.9
	2500	1.9	1.9	1.9	1.9
	3150	1.9	2.0	1.9	2.0
	4000	1.9	2.0	1.9	2.1
	5000	1.9	2.0	1.9	2.1
	6300	1.9	1.9	1.9	2.0
	8000	1.9	1.9	1.9	1.9
	10000	1.9	1.9	1.9	1.9
	12500	1.9	1.9	1.9	1.9
	16000	1.9	1.9	1.9	1.9

4.2.3 Tonality

A summary of the tonality analysis is provided in Table 4-5. Results of the tonality analysis at each standardized wind speed are provided in Table 4-6 through Table 4-12. Graphs of each tone determined to be reportable per Equation 17 of the IEC Standard are provided in Appendix E, as well as narrowband spectra of the total noise utilized in this analysis for all wind speeds. As per the IEC Standard, the average frequency within the critical bandwidths for the tones at 674 Hz and 2490 Hz were used for determining audibility, since the frequencies of these two tones varied in each spectra analyzed but stayed within 10% of the critical bandwidth. Tones at 300 Hz and 360 Hz, respectively, stayed constant at those frequencies.

Table 4-5. Tonality Analysis Summary

Standardized Wind Speed, V_s (10 m height)	Frequency (Hz)	ΔL_k (dB)	ΔL_a (dB)	$\Delta L_{a,k}$ (dB)	Uncertainty on Tonality (± dB)	Reportable per IEC
4	60	-10.56	-2.00	-8.55	1.85	No
4	300	-4.52	-2.11	-2.41	2.49	Yes
4	360	-11.89	-2.16	-9.73	2.46	No
4	711	-14.74	-2.53	-12.21	2.46	No
4	2490	-3.67	-3.75	0.08	3.42	Yes
4	3300	-12.38	-4.05	-8.33	2.96	No
5	60	-2.14	-2.00	-0.14	2.98	Yes
5	120	-10.67	-2.01	-8.66	2.20	No
5	300	-8.21	-2.06	-1.22	1.87	Yes
5	360	-12.10	-2.16	-9.94	2.10	No
5	474	-5.76	-2.24	-3.52	2.72	No
5	639	-8.75	-2.36	-6.39	2.43	No
5	711	-7.09	-2.53	-4.56	2.31	No
5	1549	-12.67	-3.25	-9.42	2.36	No
5	2553	-5.42	-3.77	-1.64	3.17	Yes
5	3129	-17.91	-3.99	-13.92	2.17	No
5	4518	-18.65	-4.39	-14.26	2.31	No
6	450	-8.60	-2.25	-6.35	2.42	No
6	710	-13.21	-2.53	-10.59	2.09	No
6	2451	-19.35	-3.73	-15.62	1.93	No
7	237	-8.21	-2.06	-6.15	2.48	No
7	357	-11.38	-2.15	-9.22	2.16	No
7	474	-10.08	-2.27	-7.81	2.24	No
7	639	-10.42	-2.45	-7.97	2.34	No
7	711	-13.05	-2.53	-10.52	2.10	No
8	120	-6.82	-2.01	-4.81	2.38	No
8	359	-5.32	-2.16	-3.16	2.34	No
8	474	-14.33	-2.27	-12.06	2.44	No
8	658	-6.46	-2.47	-3.99	3.16	No
9	120	-6.42	-2.01	-4.41	2.24	No
9	237	-15.97	-2.06	-13.91	2.04	No
9	359	-2.97	-2.16	-0.82	2.24	Yes
9	474	-6.70	-2.27	-4.43	3.07	No
9	674	-3.18	-2.49	-0.69	3.00	Yes
10	120	-6.94	-2.01	-4.93	2.49	No
10	237	-14.23	-2.06	-12.17	2.17	No
10	294	-12.38	-2.10	-10.28	2.36	No
10	359	-5.85	-2.16	-3.69	2.87	No
10	470	-12.51	-2.27	-10.24	2.59	No
10	564	-16.72	-2.37	-14.35	2.26	No
10	665	-6.05	-2.48	-3.57	3.34	No

Table 4-6. Tonality and Tonal Audibility Results, V_S = 4 m/s

Frequency of Identified Tone (Hz)	Difference between Tone and Masking Noise Level in each 10-second Period $\Delta L_{tn,j,k}$ (dB)				Energy Average ΔL_k (dB)	Tonal Audibility $\Delta L_{a,k}$ (dB)	Uncertainty $\Delta L_{a,k}$ (± dB)
60	-11.25	-11.25	-11.25	-11.25	-10.56	-8.55	1.85
	-11.25	-11.25	-11.25	-11.25			
	-11.25	-11.25	-6.37	-3.96			
300	-5.02	-18.24	-5.82	-3.31	-4.52	-2.41	2.49
	-2.40	-0.93	-4.41	-18.24			
	-4.78	-4.66	-4.60	-3.96			
360	-5.88	-6.91	-7.04	-19.03	-11.89	-9.73	2.46
	-18.86	-17.94	-19.03	-19.03			
	-19.03	-19.03	-19.03	-19.03			
711	-21.99	-21.99	-21.99	-21.99	-14.75	-12.21	2.46
	-21.99	-21.99	-21.99	-21.99			
	-21.99	-7.35	-21.99	-8.10			
2490	-27.43	-1.49	-3.77	-1.25	-3.67	0.08	3.42
	-3.73	-1.27	-3.86	-3.93			
	-17.43	-2.62	-10.50	-1.86			
3300	-28.65	-28.65	-28.65	-28.65	-12.38	-8.33	2.96
	-28.65	-1.68	-28.65	-28.65			
	-28.65	-28.65	-28.65	-28.65			

Table 4-7. Tonality and Tonal Audibility Results, V_S = 5 m/s

Frequency of Identified Tone (Hz)	Difference between Tone and Masking Noise Level in each 10-second Period $\Delta L_{tn,j,k}$ (dB)				Energy Average ΔL_k (dB)	Tonal Audibility $\Delta L_{a,k}$ (dB)	Uncertainty $\Delta L_{a,k}$ (± dB)
60	-3.08	-15.24	-15.24	-15.24	-2.14	-0.14	2.98
	-15.24	-15.24	0.68	1.16			
	0.19	0.39	0.446	-0.17			
120	-15.27	-15.27	-15.27	-15.27	-10.67	-8.66	2.20
	-15.27	-15.27	-5.66	-5.99			
	-15.27	-15.27	-6.25	-15.27			
300	-3.36	-6.68	-4.96	-3.85	-3.89	-1.78	1.84
	-5.41	-4.47	-2.82	-2.30			
	-3.66	-4.99	-4.06	-2.25			
360	-15.61	-15.61	-15.61	-15.61	-12.10	-9.94	2.10
	-15.61	-15.61	-15.61	-15.61			
	-15.61	-15.61	-6.53	-6.15			
450	-5.97	-1.36	2.93	-15.80	-5.76	-3.52	2.72
	-15.80	-15.80	-15.80	-15.80			
	-15.80	-15.80	-15.80	-15.80			
555	-6.94	-3.08	-7.05	-16.06	-8.75	-6.39	2.43
	-16.06	-16.06	-5.71	-16.06			
	-5.72	-16.06	-16.06	-16.06			
711	-5.20	-6.85	-16.48	-6.65	-7.09	-4.56	2.31
	-7.06	-6.54	-5.47	-4.80			
	-6.75	-16.48	-16.48	-5.12			
1549	-18.89	-18.89	-18.89	-18.89	-12.67	-9.42	2.36
	-18.89	-18.89	-18.89	-18.89			
	-18.89	-10.45	-7.94	-5.50			
2553	-8.58	-21.20	-21.20	-21.20	-5.42	-1.65	3.17
	-12.89	-21.20	-2.39	-0.38			
	-6.15	-3.46	-2.41	-3.35			
3129	-22.26	-22.26	-22.26	-22.26	-17.91	-13.92	2.17
	-14.24	-22.26	-22.26	-22.26			
	-22.26	-13.63	-22.26	-12.25			
4518	-24.27	-24.27	-24.27	-24.27	-18.65	-14.26	2.31
	-24.27	-24.27	-14.13	-13.11			
	-24.27	-24.27	-24.27	-13.71			

Table 4-8. Tonality and Tonal Audibility Results, V_S = 6 m/s

Frequency of Identified Tone (Hz)	Difference between Tone and Masking Noise Level in each 10-second Period $\Delta L_{tn,j,k}$ (dB)				Energy Average ΔL_k (dB)	Tonal Audibility $\Delta L_{a,k}$ (dB)	Uncertainty $\Delta L_{a,k}$ (± dB)
450	-5.26	-3.83	-15.80	-7.32	-8.60	-6.35	2.42
	-3.99	-15.80	-15.80	-15.80			
	-7.54	-15.80	-15.80	-15.80			
711	-16.48	-16.48	-16.48	-16.48	-13.12	-10.59	2.09
	-16.48	-16.48	-16.48	-16.48			
	-16.48	-16.48	-6.91	-8.06			
2450	-21.00	-21.00	-12.85	-21.00	-19.35	-15.62	1.93
	-21.00	-21.00	-21.00	-21.00			
	-21.00	-21.00	-21.00	-21.00			

Table 4-9. Tonality and Tonal Audibility Results, V_S = 7 m/s

Frequency of Identified Tone (Hz)	Difference between Tone and Masking Noise Level in each 10-second Period $\Delta L_{tn,j,k}$ (dB)				Energy Average ΔL_k (dB)	Tonal Audibility $\Delta L_{a,k}$ (dB)	Uncertainty $\Delta L_{a,k}$ (± dB)
237	-3.50	-2.77	-15.40	-15.40	-8.21	-6.15	2.48
	-15.40	-15.40	-15.40	-15.40			
	-15.40	-2.39	-15.40	-15.40			
357	-15.60	-15.60	-7.22	-15.60	-11.38	-9.22	2.16
	-15.60	-15.60	-15.60	-15.60			
	-15.60	-15.60	-7.16	-6.13			
474	-15.86	-15.86	-15.86	-15.86	-10.10	-7.81	2.24
	-15.86	-15.86	-15.86	-15.86			
	-15.86	-15.86	-0.49	-15.86			
639	-16.28	-16.28	-16.28	-16.28	-10.42	-7.97	2.34
	-16.28	-16.28	-4.99	-5.65			
	-5.39	-16.28	-16.28	-16.28			
711	-7.30	-7.37	-16.48	-16.48	-13.05	-10.52	2.10
	-16.48	-16.48	-16.48	-16.48			
	-16.48	-16.48	-16.48	-16.48			

Table 4-10. Tonality and Tonal Audibility Results, V_S = 8 m/s

Frequency of Identified Tone (Hz)	Difference between Tone and Masking Noise Level in each 10-second Period $\Delta L_{tn,j,k}$ (dB)				Energy Average ΔL_k (dB)	Tonal Audibility $\Delta L_{a,k}$ (dB)	Uncertainty $\Delta L_{a,k}$ (± dB)
120	-14.26	-14.26	-14.26	-5.59	-6.82	-4.81	2.38
	-14.26	-6.56	-4.18	-4.01			
	-10.42	-4.88	-4.42	-5.35			
359	-5.68	-4.32	-2.31	-4.34	-5.32	-3.16	2.34
	-19.01	-5.50	-2.89	-6.85			
	-7.42	-7.32	-5.49	-5.79			
474	-20.23	-20.23	-20.23	-20.23	-14.33	-12.06	2.44
	-20.23	-20.23	-20.23	-20.23			
	-20.23	-7.59	-19.43	-7.66			
658	-21.65	-21.65	-21.65	-4.73	-6.46	-3.99	3.16
	-4.37	-21.65	-3.48	-1.66			
	-7.72	-7.59	-5.42	-6.59			

Table 4-11. Tonality and Tonal Audibility Results, V_S = 9 m/s

Frequency of Identified Tone (Hz)	Difference between Tone and Masking Noise Level in each 10-second Period $\Delta L_{tn,j,k}$ (dB)				Energy Average ΔL_k (dB)	Tonal Audibility $\Delta L_{a,k}$ (dB)	Uncertainty $\Delta L_{a,k}$ (± dB)
120	-9.81	-6.44	-14.26	-5.40	-6.42	-4.41	2.24
	-15.10	-6.91	-5.55	-5.42			
	-6.50	-4.18	-4.59	-17.22			
237	-17.22	-17.22	-17.22	-17.22	-15.97	-13.91	2.04
	-17.22	-10.23	-17.22	-17.22			
	-17.22	-17.22	-17.22	-17.22			
359	-6.75	-2.85	-3.28	0.38	-2.97	-0.82	2.24
	-13.58	-2.45	-0.94	-3.87			
	-6.25	-3.11	-0.97	-4.04			
474	-1.74	-1.42	-20.23	-11.35	-6.70	-4.43	3.07
	-4.28	-6.67	-20.23	-20.23			
	-20.23	-7.45	-18.74	-5.51			
674	-0.86	-21.75	-4.40	-0.57	-3.18	-0.69	3.00
	-3.35	-2.22	-4.52	-1.66			
	-21.75	-1.04	-5.85	-2.58			

Table 4-12. Tonality and Tonal Audibility Results, V_S = 10 m/s

Frequency of Identified Tone (Hz)	Difference between Tone and Masking Noise Level in each 10-second Period $\Delta L_{tn,j,k}$ (dB)				Energy Average ΔL_k (dB)	Tonal Audibility $\Delta L_{a,k}$ (dB)	Uncertainty $\Delta L_{a,k}$ (± dB)
120	-7.01	-14.26	-14.26	-14.26	-6.94	-4.93	2.49
	-14.26	-14.26	-14.26	-6.37			
	-1.80	-5.19	-4.10	-3.79			
237	-17.22	-17.22	-17.22	-17.22	-14.23	-12.17	2.17
	-12.83	-17.22	-17.22	-17.22			
	-17.22	-17.22	-6.75	-17.22			
294	-18.15	-18.15	-18.15	-18.15	-12.38	-10.28	2.36
	-18.15	-18.15	-18.15	-2.80			
	-18.15	-18.15	-18.15	-18.15			
359	-19.02	-19.02	-6.40	-2.61	-5.85	-3.69	2.87
	-16.31	-2.41	-6.15	-6.43			
	-19.02	-7.22	-2.20	-3.51			
470	-20.19	-20.19	-20.19	-20.19	-12.51	-2.27	-10.24
	-7.38	-20.19	-20.19	-20.19			
	-20.19	-20.19	-20.19	-4.04			
564	-20.98	-20.98	-20.98	-20.98	-16.72	-14.35	2.26
	-20.98	-20.98	-20.98	-20.98			
	-20.98	-7.76	-20.98	-20.98			
665	-21.70	-21.70	-21.70	-5.83	-6.05	-3.57	3.34
	-21.70	-2.72	-6.85	-21.70			
	-7.32	-6.75	-4.65	-0.81			

5 REFERENCES

1. ANTP0102, *Draft Acoustic Noise Test Plan for the V100 1.8MW Wind Turbine in Pueblo, CO*, DNV document, January 21, 2011.
2. *Wind turbine generator systems - Part 11: Acoustic noise measurement techniques.* IEC 61400-11:2002 +A1:2006(E). International Electrotechnical Commission, Geneva, Switzerland.
3. 0004-3053 V07, *General Specification V100-1.8MW*, Vestas document, dated November 22, 2010.

APPENDIX A
POWER CURVE USED FOR WIND SPEED CALIBRATION [3]

Table A-1. Measured Electrical Power Output for "Mode 0" at 1.225 kg/m^3 Air Density

Normalized Hub-Height Wind Speed (m/s)	Power Output (kW)
3.0	13
3.5	53
4.0	112
4.5	181
5.0	260
5.5	353
6.0	462
6.5	581
7.0	736
7.5	911
8.0	1108
8.5	1321
9.0	1524
9.5	1679
10.0	1766
10.5	1800
11.0	1811
11.5	1815
12.0	1815
12.5	1815
13.0	1815
13.5	1815
14.0	1815
14.5	1815
15.0	1815
15.5	1815
16.5	1815
17.0	1815
17.5	1815
18.0	1815
18.5	1815
19.0	1815
19.5	1815
20.0	1815

APPENDIX B
SITE PHOTOS

Figure B-1. Met Tower

Figure B-2. Wind Turbine Under Measurement and Microphone

Figure B-3. Wind Turbine Under Measurement from Met Tower

Figure B-4. Met Tower Hub Height Anemometers

APPENDIX C
INSTRUMENTATION CALIBRATIONS

Blue - Pueblo

Installed 2/15/11
LS OK
PO 1156

Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 7 · DK-1615 KØBENHAVN V · DENMARK
TEL.: (+45) 33 25 38 38 · FAX: (+45) 33 25 38 39 · WWW.SOHANSEN.DK

WIND ENGINEERING FLUID DYNAMICS

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 10.02.7183
Date of issue: December 6, 2010
Type: WindSensor P2546A Cup Anemometer
Serial number: 10573
Manufacturer: WindSensor, Søkrogen 9, 4000 Roskilde, Denmark
Client: WindSensor, Søkrogen 9, 4000 Roskilde, Denmark

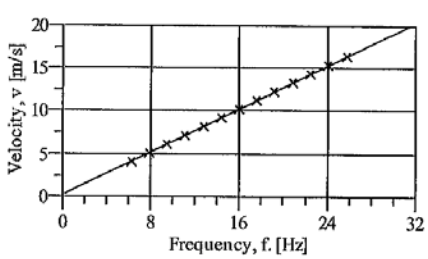
Anemometer received: November 26, 2010
Anemometer calibrated: December 5, 2010
Calibrated by: asj
Calibration procedure: IEC 61400-12-1, MEASNET
Certificate prepared by: jsa
Approved by: Calibration engineer, soh

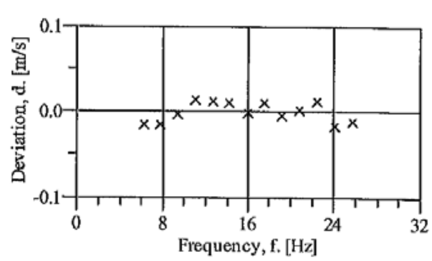
Svend Ole Hansen

Calibration equation obtained: v [m/s] = 0.63038 · f [Hz] + 0.21284
Standard uncertainty, slope: 0.00089
Standard uncertainty, offset: 0.04502
Covariance: -0.0000050 (m/s)²/Hz
Coefficient of correlation: ρ = 0.999996
Absolute maximum deviation: -0.017 m/s at 15.379 m/s

Barometric pressure: 991.4 hPa
Relative humidity: 21.0%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.89	25.7	20.2	4.141	6.2557	-0.015	0.028
4	15.30	25.5	20.2	5.151	7.8559	-0.014	0.032
6	21.80	25.4	20.2	6.147	9.4188	-0.003	0.037
8	29.90	25.3	20.1	7.197	11.0563	0.015	0.043
10	39.17	25.2	20.1	8.237	12.7085	0.013	0.048
12	49.23	25.1	20.1	9.233	14.2904	0.012	0.054
13-last	60.79	25.1	20.1	10.259	15.9383	-0.001	0.060
11	73.68	25.2	20.1	11.296	17.5645	0.011	0.066
9	87.16	25.3	20.1	12.289	19.1631	-0.004	0.072
7	102.53	25.4	20.2	13.331	20.8054	0.003	0.078
5	118.66	25.5	20.2	14.344	22.3960	0.013	0.084
3	136.36	25.6	20.2	15.379	24.0852	-0.017	0.090
1-first	155.19	25.9	20.2	16.415	25.7202	-0.011	0.096





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DANAK
CAL Reg.nr. 452
Accreditation to ISO 17025

SIMCO electronics
5764 PACIFIC CENTER BLVD.
SAN DIEGO, CA 92121

A2LA ACCREDITED
CALIBRATION CERT. 1395.08

Certificate No. **5090107**

LS OK
Installed 2/15/11
PO 1155

CERTIFICATE OF CALIBRATION
FOR
DNV RENEWABLES
1809 7TH AVE. STE. 900
SEATTLE, WA 98101

Description: **MET ONE, 064-1, Temperature Sensor**

Serial No: **K20290** Asset No: Simco ID: **42492-695**

Dept: **NONE** PO No: **11154**

Calibration Date: **02/14/11**	Calibration Interval: **24 Months**	Recall Date: **02/14/13**
Arrival Condition: **MEETS MANUFACTURER'S SPEC'S.**	Service: **CALIBRATED & CLEANED**	

Procedure: **635-0030 REV 3**
Temperature: **73°F** Relative Humidity: **36%**

Standards Used:

Type	Simco ID	Due Date	Intvl Mos	Acc/Unc	Trace No.
TEMPERATURE/HUMIDITY CHAMBER	1016*152	07/31/11	6	+/-0.5 deg C	B0902021
PRT	1016*121	06/08/11	9	-200to500 deg C	B0902021
PRT	1016*121	06/08/11	9	+/-0.010 deg C	B0902021
THERMOMETER READOUT	1016*120	07/31/11	9	+/-0.004 deg C	B0A26025
MULTIMETER	1006*523	06/30/11	6	RES+/-0.011%	817/277427-09

Detail Of Work Performed:
UPDATED MODEL NUMBER FROM 064-2.

Calibration Data:

Parameter	Nominal	Measured Before	Measured After	Tolerance
SEE	ATTACHED			

There are 1 Supplementary Data Sheet(s) attached.

Work performed by: [signature] Reviewed by: [signature]
Jeremy Cooper
Calibration Technician B (17162)

SIMCO Electronics' quality management system conforms to ISO 9001:2008, ISO/IEC 17025:2005, and ANSI/NCSL Z540-1-1994. All calibrations are performed using internationally recognized standards traceable to the International System of Units (SI Units). Traceability is achieved through calibrations by the National Institute of Standards and Technology (NIST), other National Measurement Institutes (NMIs'), or by using natural physical constants, intrinsic standards or ratio calibration techniques. Instruments are calibrated with a test uncertainty ratio of 4:1 or greater, otherwise measurement uncertainty analysis and/or guard bands are applied during the measurement process. The information shown on this certificate applies only to the instrument identified above and may not be reproduced, except in full, without prior written consent from SIMCO Electronics. There is no implied warranty that the instrument will maintain its specified tolerances during the calibration interval due to possible drift, environment, or other factors beyond our control. **This is an A2LA Accredited calibration.**

Dated: **02/14/11**

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SIMCO electronics
1178 BORDEAUX DRIVE
SUNNYVALE, CA 94089

ACCREDITED
CALIBRATION CERT. 1396.17

Certificate No. **5090106**

Installed 2/15/11
LS OK
PO 11154

CERTIFICATE OF CALIBRATION
FOR
DNV RENEWABLES
1809 7TH AVE. STE. 900
SEATTLE, WA 98101

Description: **MET ONE, 090D, Barometer**

Serial No: **K14990** Asset No: Simco ID: **42492-696**

Dept: **NONE** PO No: **11154**

Calibration Date: **02/14/11**	Calibration Interval: **24 Months**	Recall Date: **02/14/13**

Arrival Condition:	Service:
MEETS MANUFACTURER'S SPEC'S.	**CALIBRATED TO MFR SPEC,& CLEAN**

Procedure: **TO33K6-4-1425-1 6/02**
Temperature: **71°F** Relative Humidity: **40%**

Standards Used:

Type	Simco ID	Due Date	Intvl Mos	Acc/Unc	Trace No.
Pressure Calibrator	**35363*93**	**05/20/11**	**12**	**+/-0.012% RNG**	**REPORT#69683**
Precision DMM	**35363*35**	**07/22/11**	**12**	**dcV +/-0.004%**	**817/276744-08**

There are 2 Supplementary Data Sheet(s) attached.

Work performed by: Reviewed by:
John Durr
Calibration Technician D (317)

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Dated: **02/14/11**

Page 1 of 1

Scantek, Inc.
CALIBRATION LABORATORY

ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1
ACCREDITED by NVLAP (an ILAC and APLAC signatory)

NVLAP®

NVLAP Lab Code: 200625-0

Calibration Certificate No.23173

Instrument:	**Acoustical Calibrator**	*Date Calibrated:* **1/21/2011**	*Cal Due:*
Model:	**CAL200**		
Manufacturer:	**Larson Davis**		
Serial number:	**8056**		
Class (IEC 60942):	**1**		
Barometer type:			
Barometer s/n:			

Status:	**Received**	**Sent**
In tolerance:	**X**	**X**
Out of tolerance:		
See comments:		

Contains non-accredited tests: ___Yes _X_ No

Customer: **DNV Renewables (USA) Inc.**
Tel/Fax: **1-206-387-4240 / -4201**
Address: **1809 7th Ave. Suite #500, Seattle, WA 90181**

Tested in accordance with the following procedures and standards:
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005

Instrumentation used for calibration: Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	25747	Jan 4, 2011	Scantek, Inc./ NVLAP	Jan 4, 2012
DS-360-SRS	Function Generator	61646	Nov 13, 2009	ACR Env. / A2LA	Nov 13, 2011
34401A-Agilent Technologies	Digital Multimeter	MY41022043	Nov 17, 2010	ACR Env. / A2LA	Nov 17, 2011
DPI 141-Druck	Pressure Indicator	790/00-04	Dec 13, 2010	ACR Env. / A2LA	Dec 13, 2012
8903A-HP	Audio Analyzer	2514A05691	Dec 1, 2010	ACR Env./ A2LA	Dec 1, 2013
HMP233-Vaisala Oyj	Humidity & Temp. Transmitter	V3820001	Nov 25, 2009	ACR Env./ A2LA	May 25, 2011
PC Program 1018 Norsonic	Calibration software	v.5.0	Validated July 2009	-	
1253-Norsonic	Calibrator	28326	Dec 6, 2010	Scantek, Inc./ NVLAP	Dec 6, 2011
1203-Norsonic	Preamplifier	14059	Jan 5, 2011	Scantek, Inc./ NVLAP	Jan 5, 2012
4180-Brüel&Kjær	Microphone	2246115	Dec 14, 2009	NPL (UK) / UKAS	Dec 14, 2011

Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK)

Calibrated by	Valentin Buzduga	Checked by	Mariana Buzduga
Signature	[signature]	Signature	[signature]
Date	1/21/2011	Date	1/21/2011

Document stored as: Z:\Calibration Lab\Cal 2011\LDCAL200_8056_M1.doc

Page 1 of 2

OK Tourbine 1/26/11

Scantek, Inc.
CALIBRATION LABORATORY

ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1
and relevant requirements of ISO 9002:1994
ACCREDITED by NVLAP (an ILAC and APLAC signatory)

NVLAP®

NVLAP Lab Code: 200625-0

Calibration Certificate No.23175

Instrument:	**Microphone**	*Date Calibrated:*	**1/7/2011** *Cal Due:*
Model:	**377B02**		
Manufacturer:	**PCB Piezotronics**		
Serial number:	**119659**		

Status:	Received	Sent
In tolerance:	X	X
Out of tolerance:		
See comments:		

Contains non-accredited tests: __Yes _X_ No

Customer:	**DNV Renewables (USA) Inc.**	*Address:*	**1809 7th Ave. Suite #500**
Tel/Fax:	**1-206-387-4240/1-206-387-4201**		**Seattle, WA 90181**

Tested in accordance with the following procedures and standards:
Procedure for Calibration of Measurement Microphones, Scantek Inc., 06/15/2005

Instrumentation used for calibration: N-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	31052	Sep 10, 2010	Scantek, Inc./NVLAP	Sep 10, 2011
DS-360-SRS	Function Generator	33584	Oct 5, 2009	ACR. Env / A2LA	Oct 5, 2011
34401A-Agilent Technologies	Digital Voltmeter	US36120731	Sep 3, 2010	ACR Env. / A2LA	Sep 3, 2011
HM30-Thommen	Meteo Station	1040170/39633	Jun 26, 2010	ACR Env. / A2LA	Dec 26, 2011
PC Program 1017 Norsonic	Calibration software	v.5.0	Validated July 2009	-	-
1253-Norsonic	Calibrator	28326	Dec 6, 2010	Scantek, Inc./ NVLAP	Dec 6, 2011
1203-Norsonic	Preamplifier	92268	Dec 6, 2010	Scantek, Inc./ NVLAP	Dec 6, 2011
4180-Bruel&Kjaer	Microphone	2246115	Dec 14, 2009	NPL (UK) / UKAS	Dec 14, 2011

Instrumentation and test results are traceable to SI - BIPM through standards maintained by NPL (UK) and NIST (USA)

Calibrated by	Alex Buzduga	Checked by	Valentin Buzduga
Signature	Buzduga AB	Signature	VB
Date	1/7/2011	Date	1/21/2011

Calibration Certificates or Test Reports shall not be reproduced, except in full, without written approval of the laboratory.
This Calibration Certificate or Test Reports shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the federal government.
Document stored as: Z:\Calibration Lab\Mic 2010\PCB377B02_119659_M1.doc

OK Sarah Taubitz 1/26/11 PO 1011749

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Scantek, Inc.
CALIBRATION LABORATORY

ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1
ACCREDITED by NVLAP (an ILAC and APLAC signatory)

NVLAP®

NVLAP Lab Code: 200625-0

Calibration Certificate No.23176

Instrument:	**Sound Measuring System**	*Date Calibrated:* **1/21/2011**	*Cal Due:*
Model:	**noiseLab3-NI-9233**	*Status:*	**Received** / **Sent**
Manufacturer:	**Delta**	*In tolerance:*	X / X
Serial number:	**1546B35**	*Out of tolerance:*	
Tested with:	**Mic. 377B02 s/n 119761 & 119659** **Preamp. 426E01 s/n 017604 & 017614** **150 ft extension cables, Belden type 1C20**	*See comments:*	X
		Contains non-accredited tests: __Yes X No	
		Calibration service: __ Basic X Standard	
Type (class):	**1**		
Customer:	**DNV Renewables (USA) Inc.**	*Address:*	**1809 7th Ave. Suite #500** **Seattle, WA 90181**
Tel/Fax:	**1-206-387-4240 / 1-206-387-4201**		

Tested in accordance with the following procedures and standards:
Calibration of Sound Level Meters, Scantek Inc., 06/07/2005
SLM & Dosimeters – Acoustical Tests, Scantek Inc., 06/15/2005

Instrumentation used for calibration: Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	31071	Jul 6, 2010	Scantek, Inc./ NVLAP	Jul 6, 2011
DS-360-SRS	Function Generator	88077	Aug 17, 2010	ACR Env./ A2LA	Aug 17, 2012
34401A-Agilent Technologies	Digital Voltmeter	MY47011118	Aug 17, 2010	ACR Env./ A2LA	Aug 17, 2011
HM30-Thommen	Meteo Station	1040170/39633	Jun 26, 2010	ACR Env./ A2LA	Dec 26, 2011
PC Program 1019 Norsonic	Calibration software	v.5.0	Validated July 2009	-	-
1251-Norsonic	Calibrator	30878	Dec 7, 2010	Scantek, Inc./ NVLAP	Dec 7, 2011

Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK).

Environmental conditions:

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
23.2 °C	99.38 kPa	48.5 %RH

Calibrated by	Mariana Buzduga	**Checked by**	Valentin Buzduga
Signature	[signature]	Signature	[signature]
Date	1/21/2011	Date	1/21/2011

Document stored as: Z:\Calibration Lab\SLM 2011\DeltaNoiseLab3-9233_1546B35_M1.doc

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APPENDIX D
OTHER TURBINE INFORMATION PROVIDED BY VESTAS

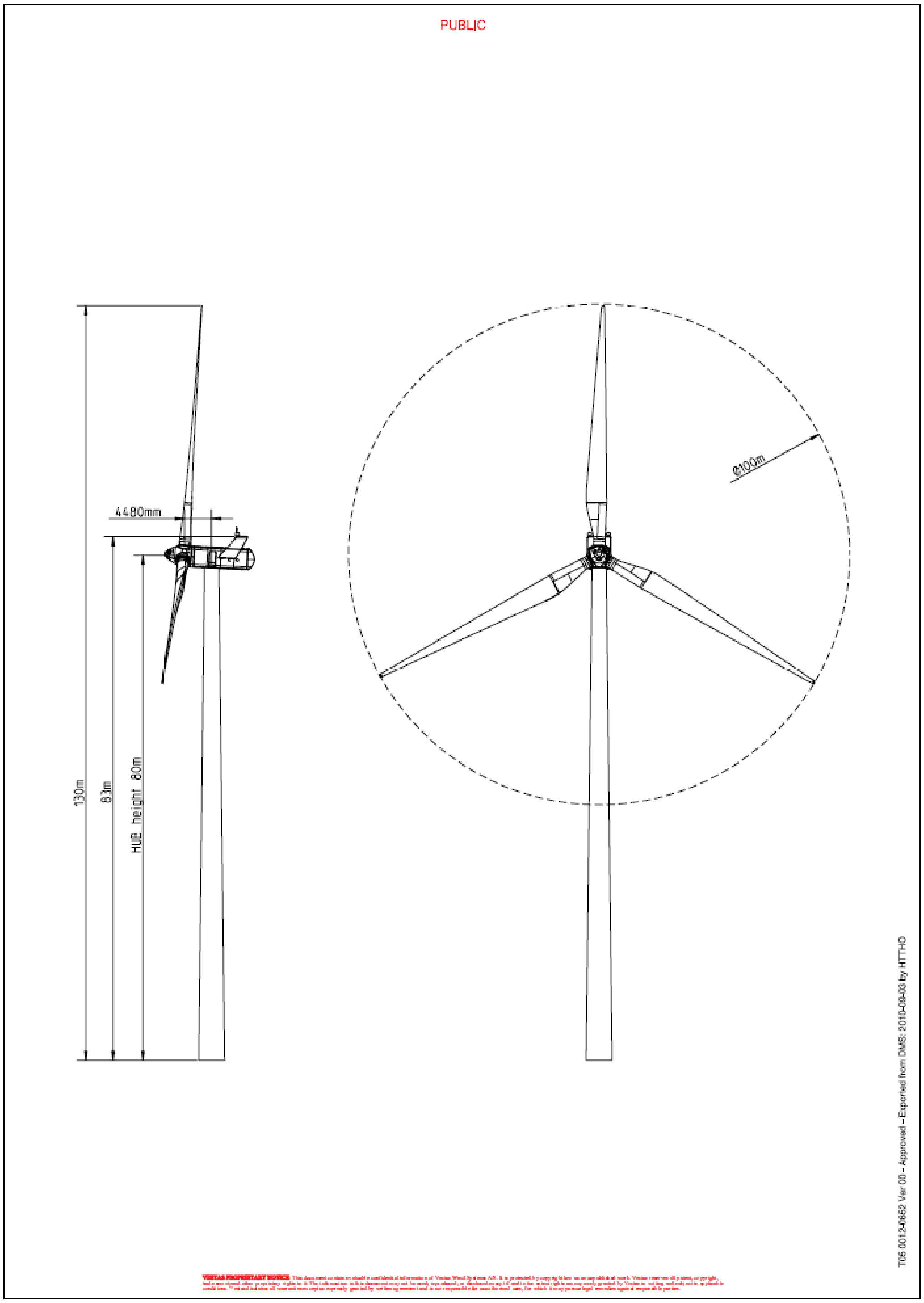

Figure D-1. Turbine Drawing Showing Rotor Plane Offset

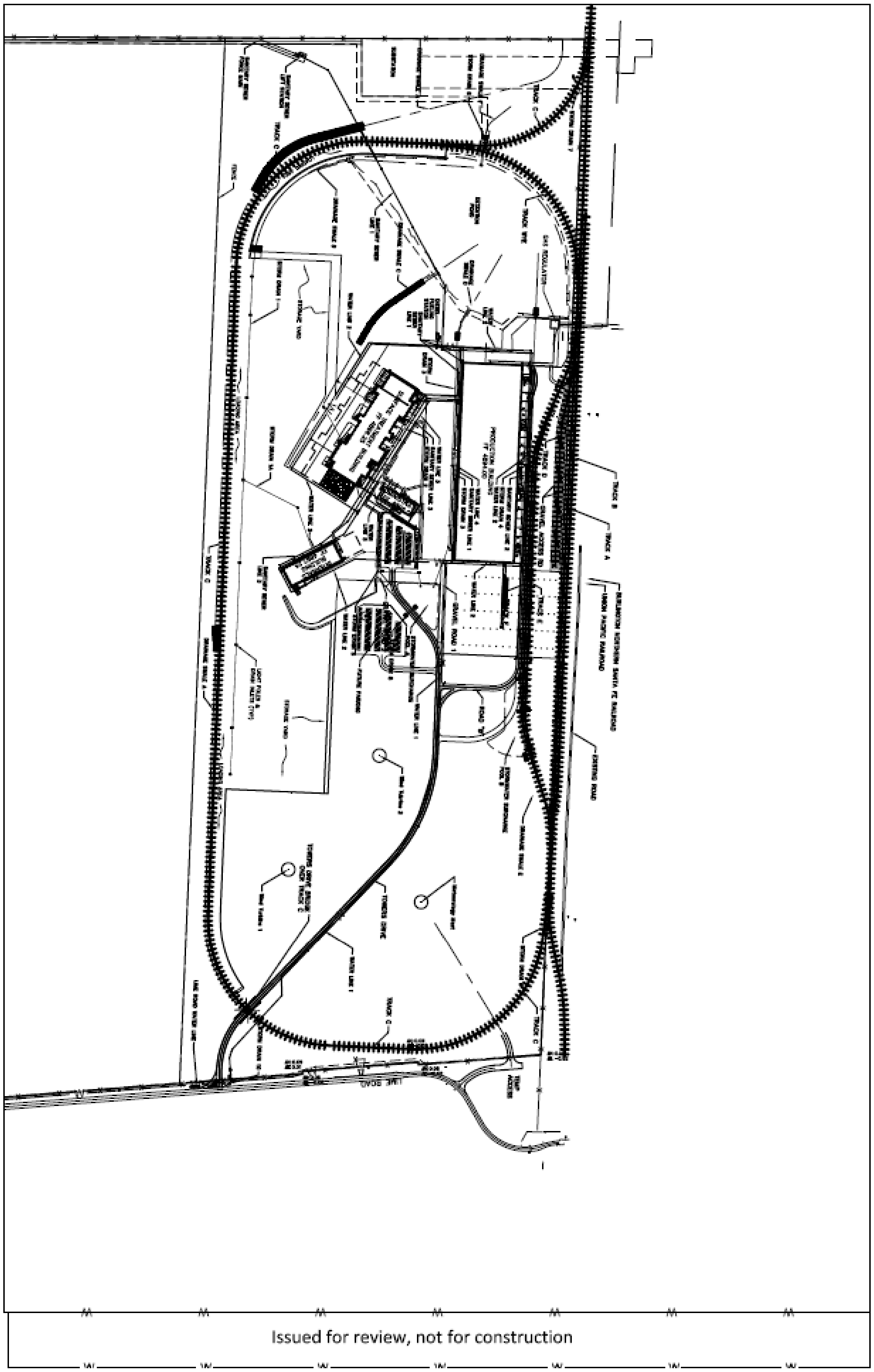

Figure D-2. Plant Map

APPENDIX E
RESULTS GRAPHS

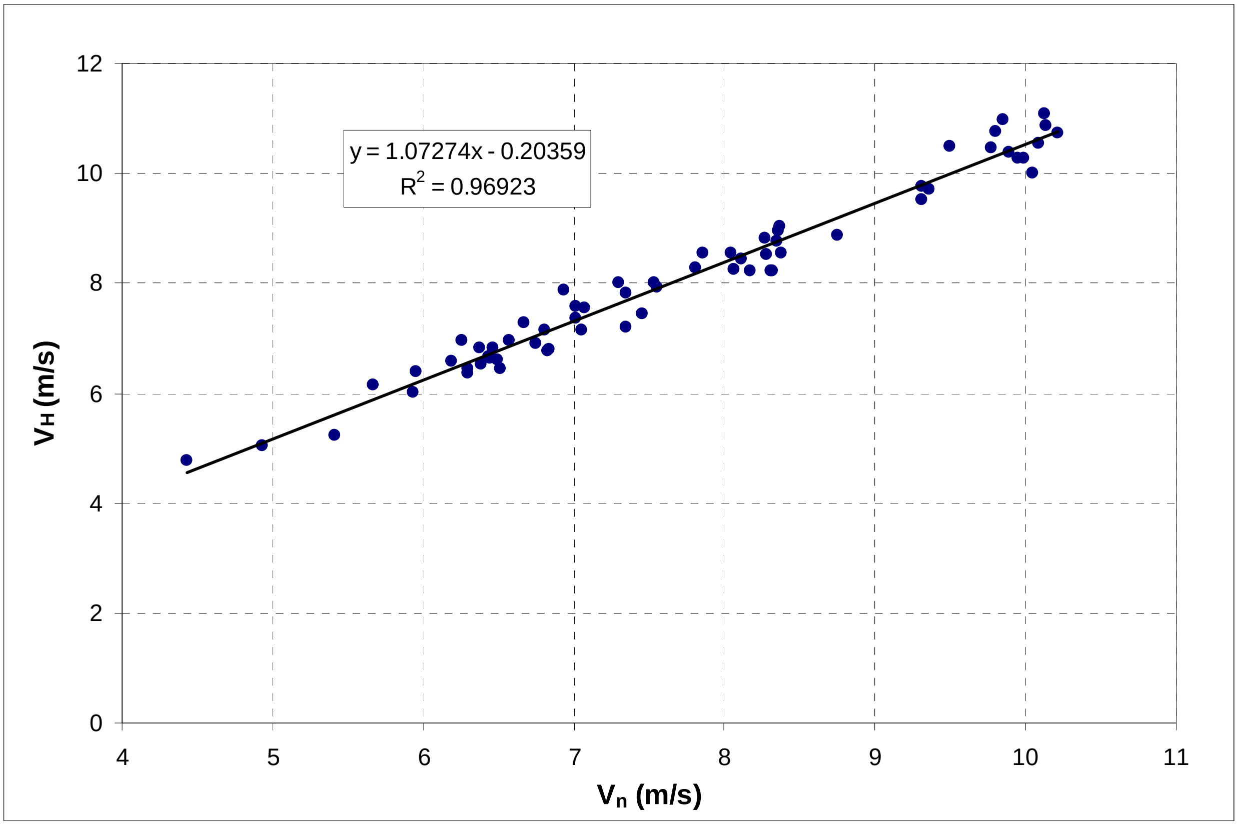

Figure E-1. Hub-Height Derived Wind Speed vs. Nacelle Wind Speed

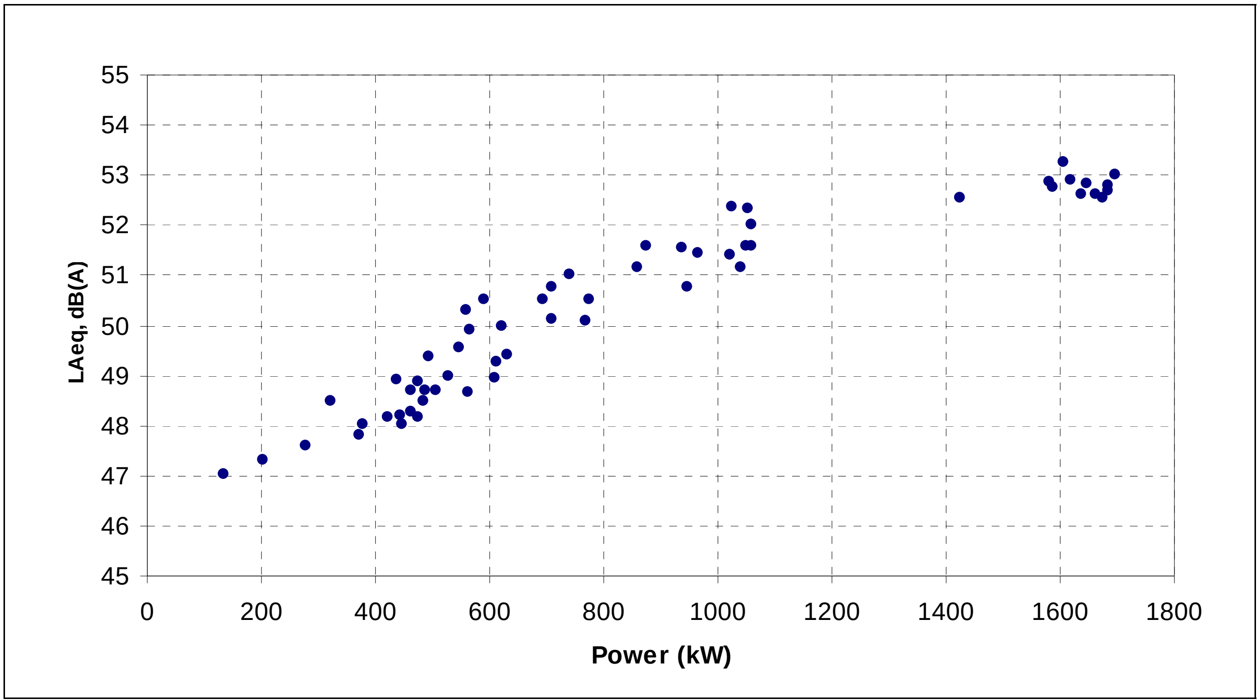

Figure E-2. Measured Sound Pressure Levels (Operating) vs. Turbine Power, not Background Corrected

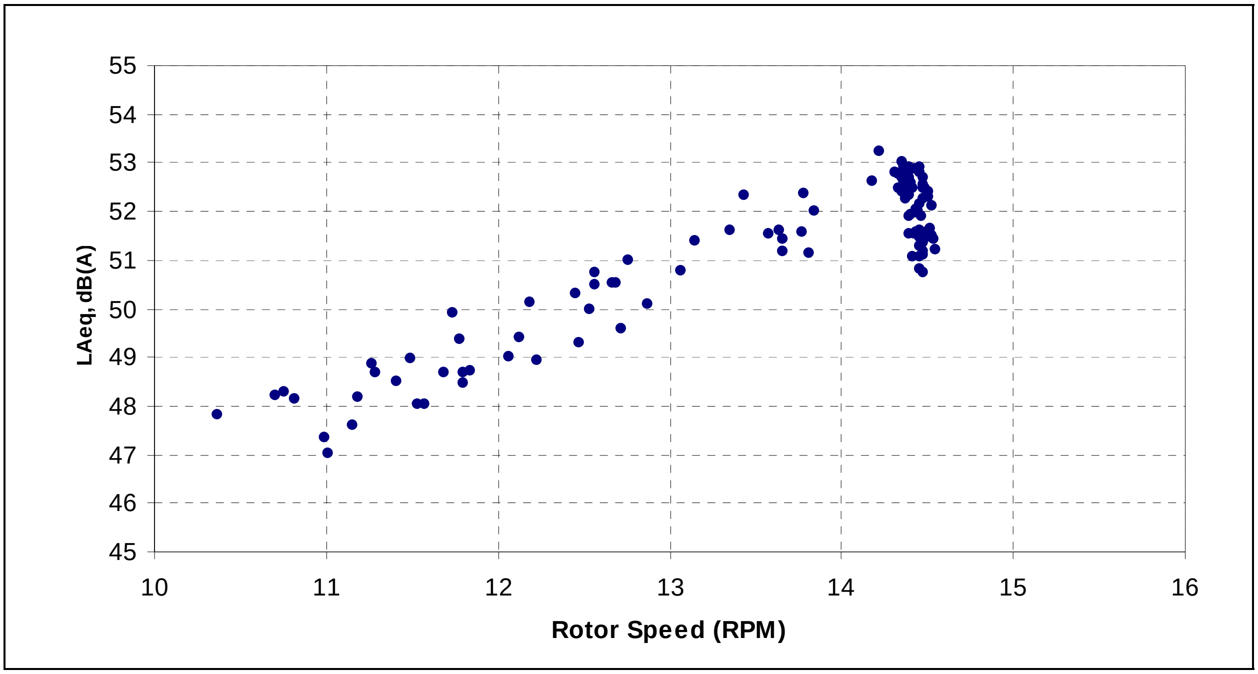

Figure E-3. Operating Sound Pressure Levels vs. Rotor Speed

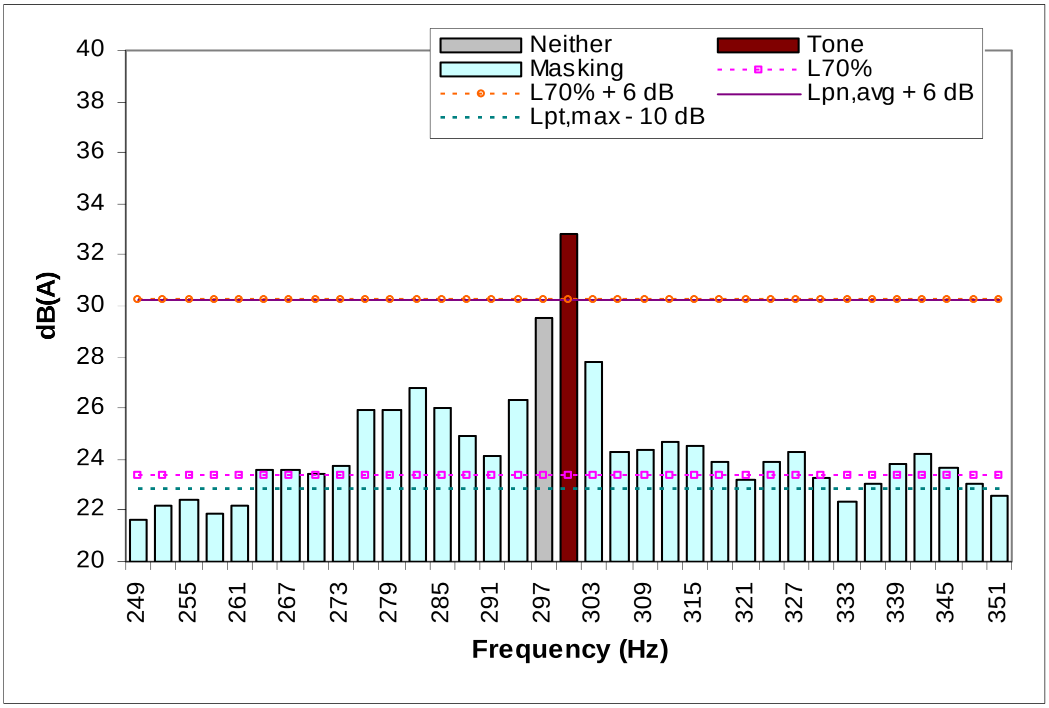

Figure E-5. Tone at 300 Hz in the 4 m/s Bin (graphed data from 02:30, V_S =4.44 m/s)

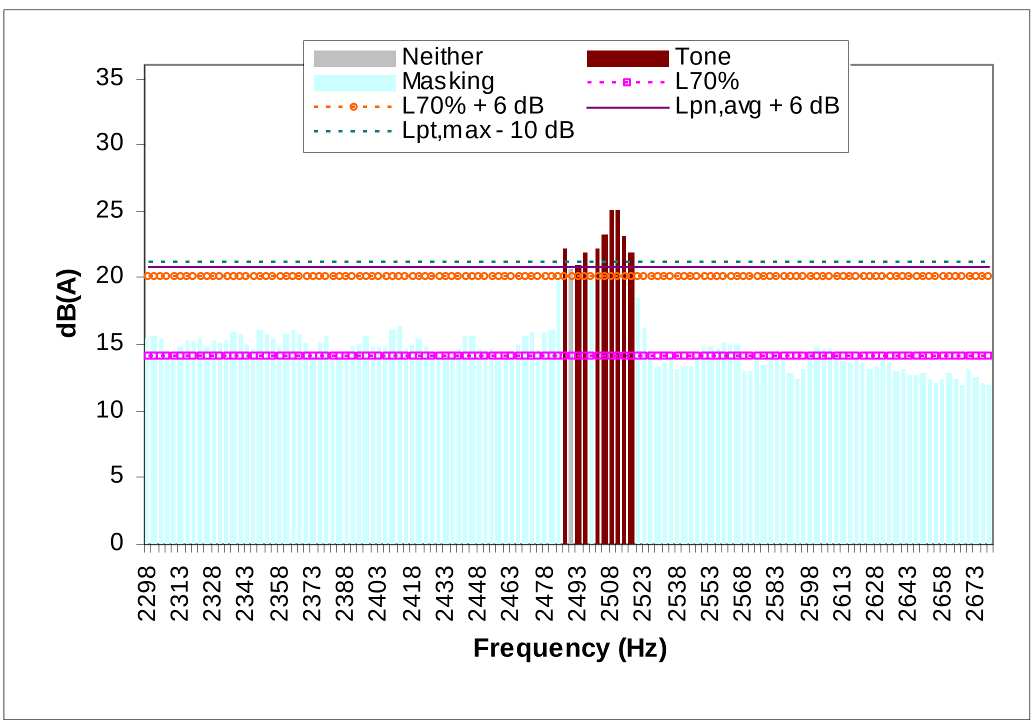

Figure E-6. Tone at 2490 Hz in the 4 m/s Bin (graphed data from 02:23, V_S = 4.07 m/s)

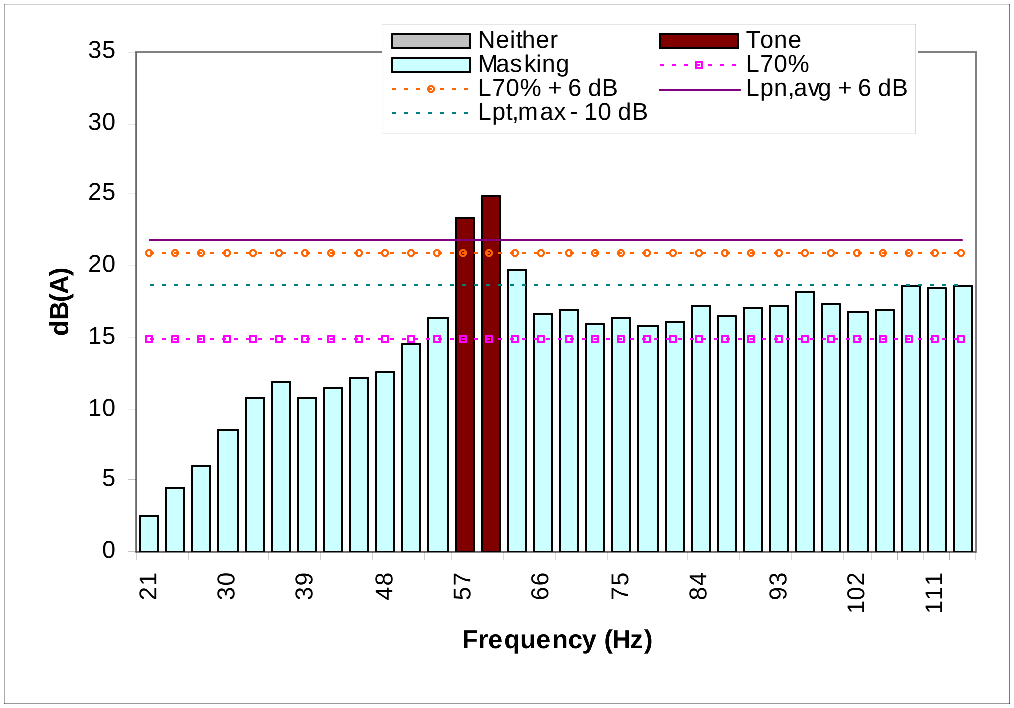

Figure E-7. Tone at 60 Hz in the 5 m/s Bin (graphed data from 04:06, V_S = 5.04 m/s)

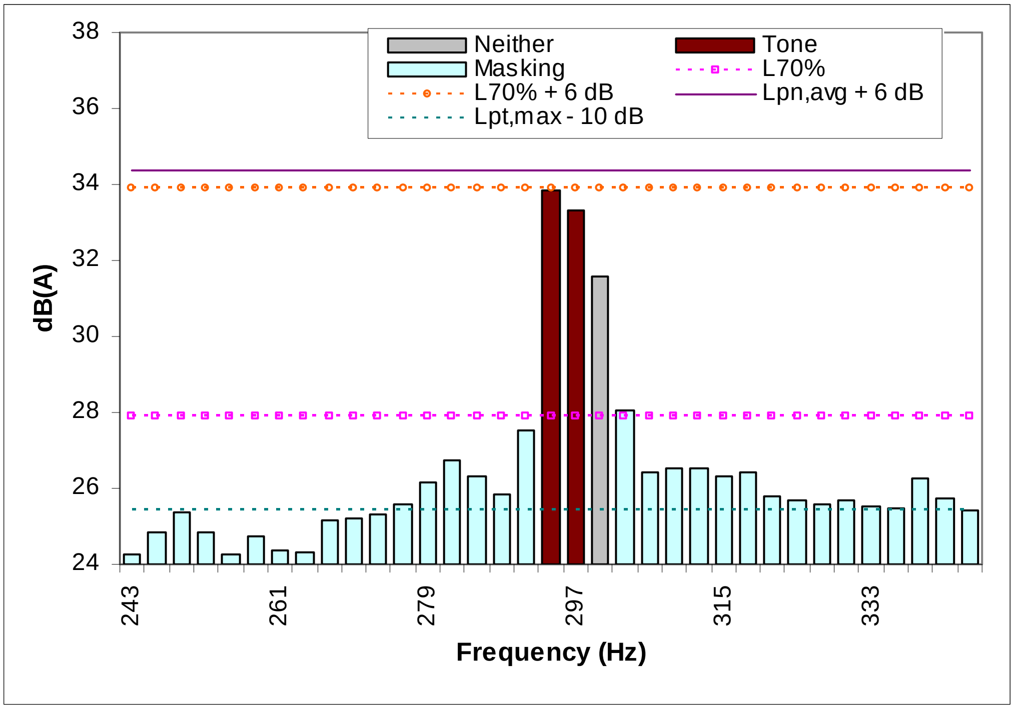

Figure E-8. Tone at 300 Hz in the 5 m/s Bin (graphed data from 04:06, V_S = 5.04 m/s)

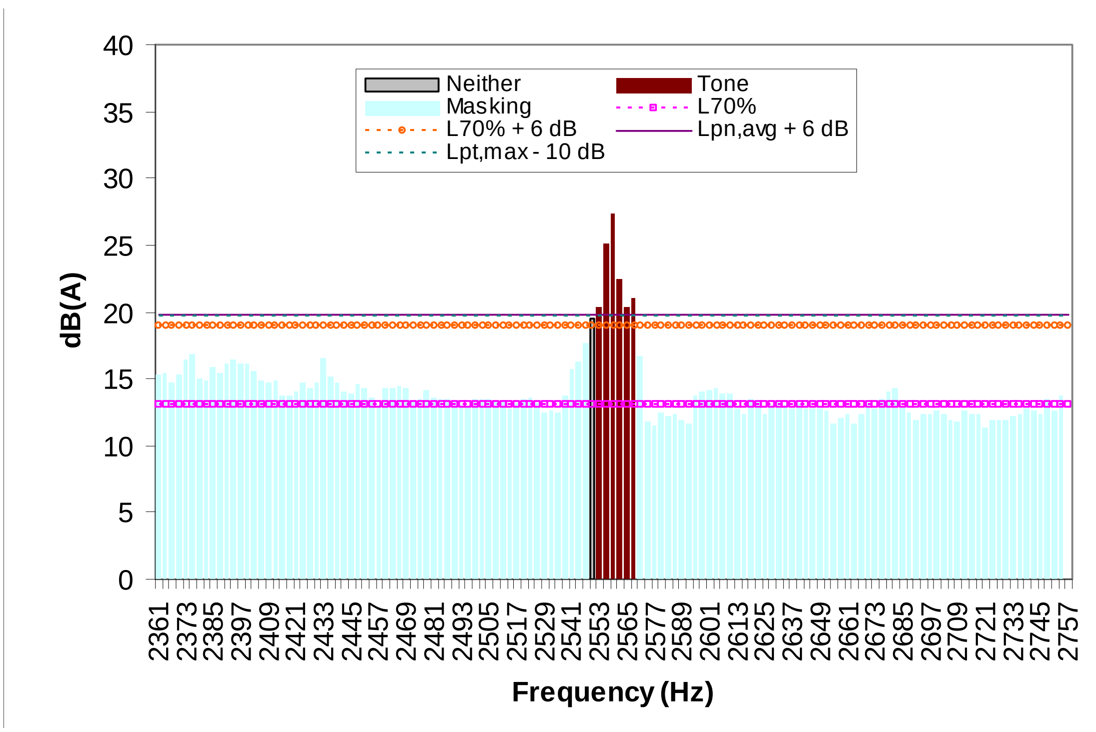

Figure E-9. Tone at 2553 Hz in the 5 m/s Bin (graphed data from 03:55, V_S = 4.98 m/s)

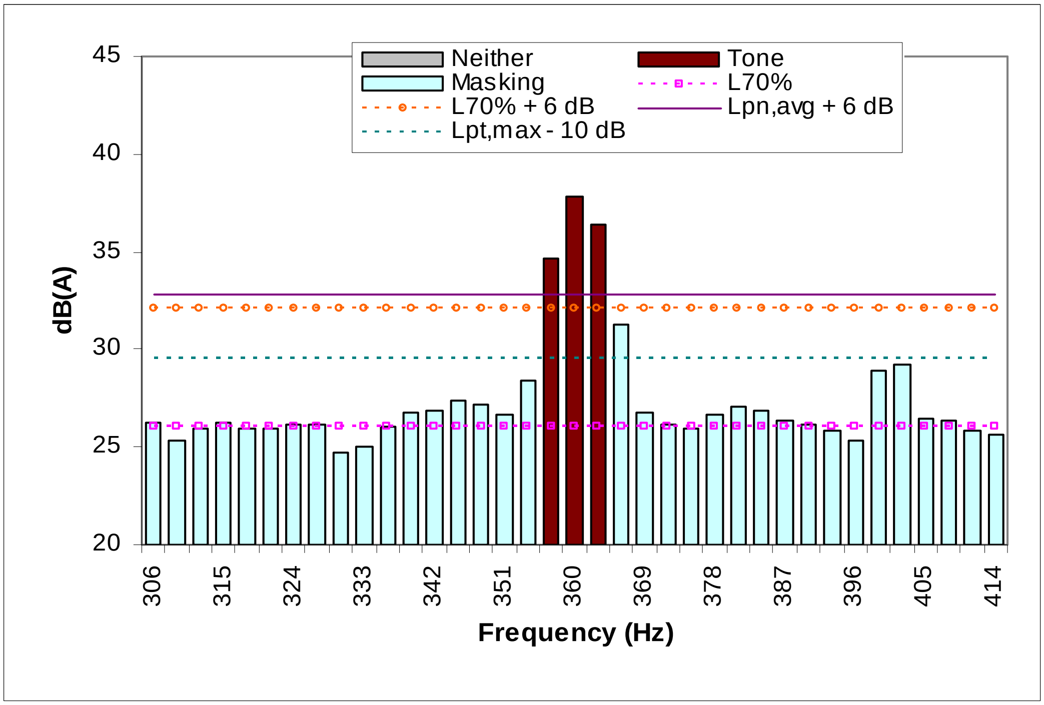

Figure E-10. Tone at 360 Hz in the 9 m/s Bin (graphed data from 05:59, V_S = 8.99 m/s)

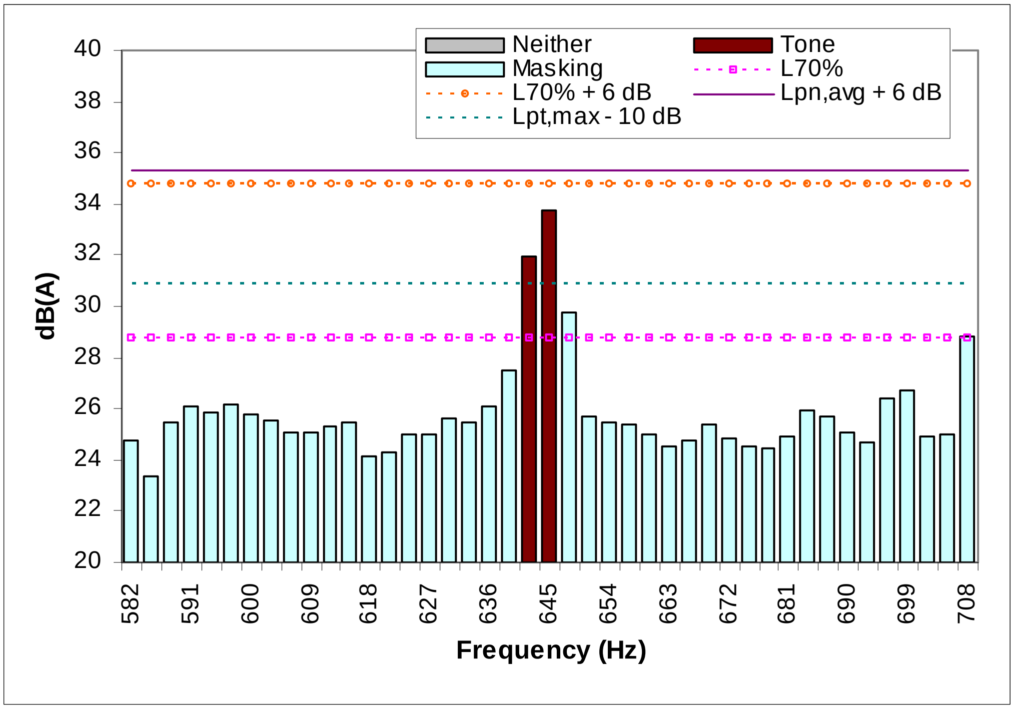

Figure E-11. Tone at 645 Hz in the 9 m/s Bin (graphed data from 06:02, V_S = 8.97 m/s)

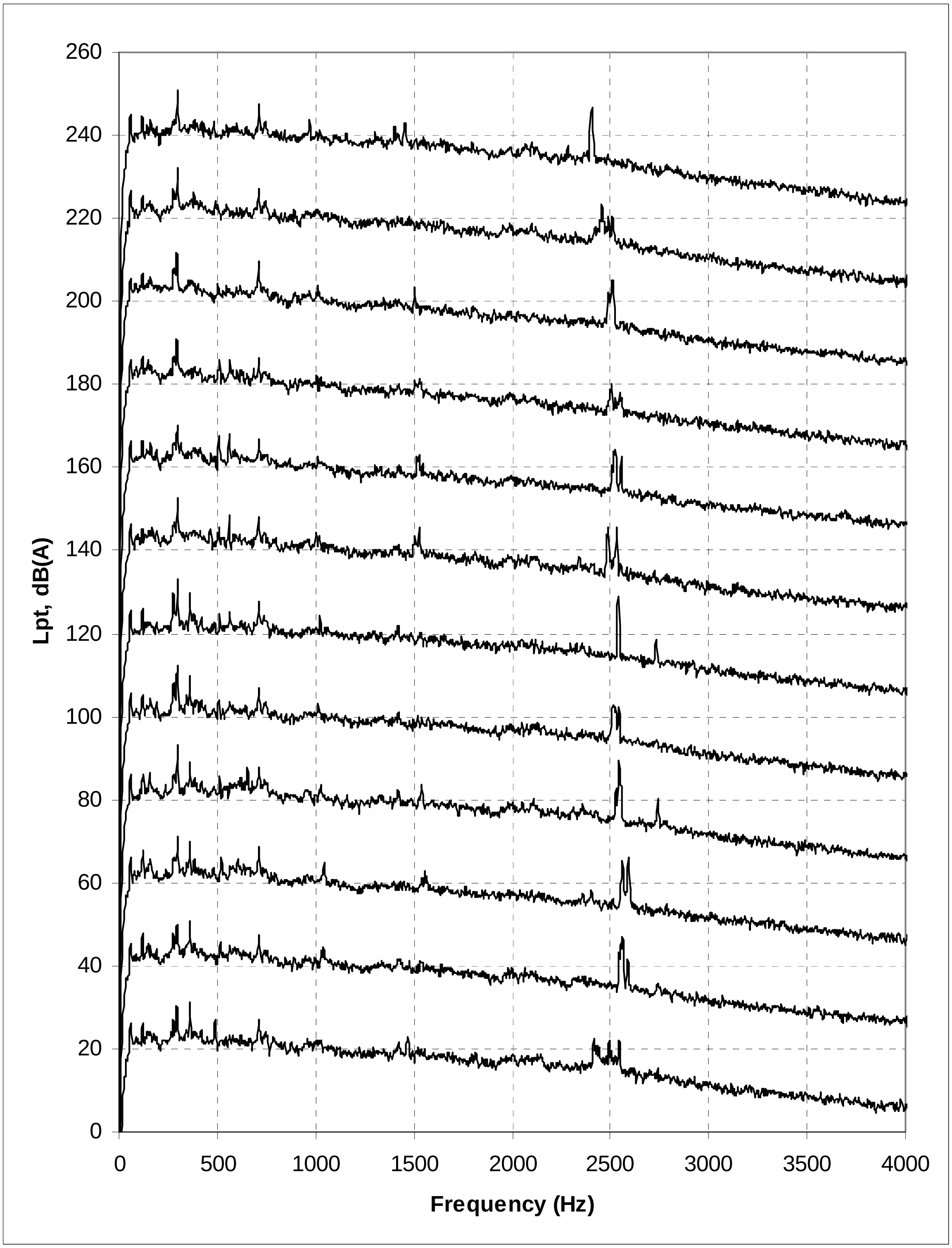

Figure E-12. Total Noise FFTs used for 4 m/s Tonality Analysis, Upper Spectra Shifted by 20 dB each (V_S = 4.06 and 4.07 m/s)

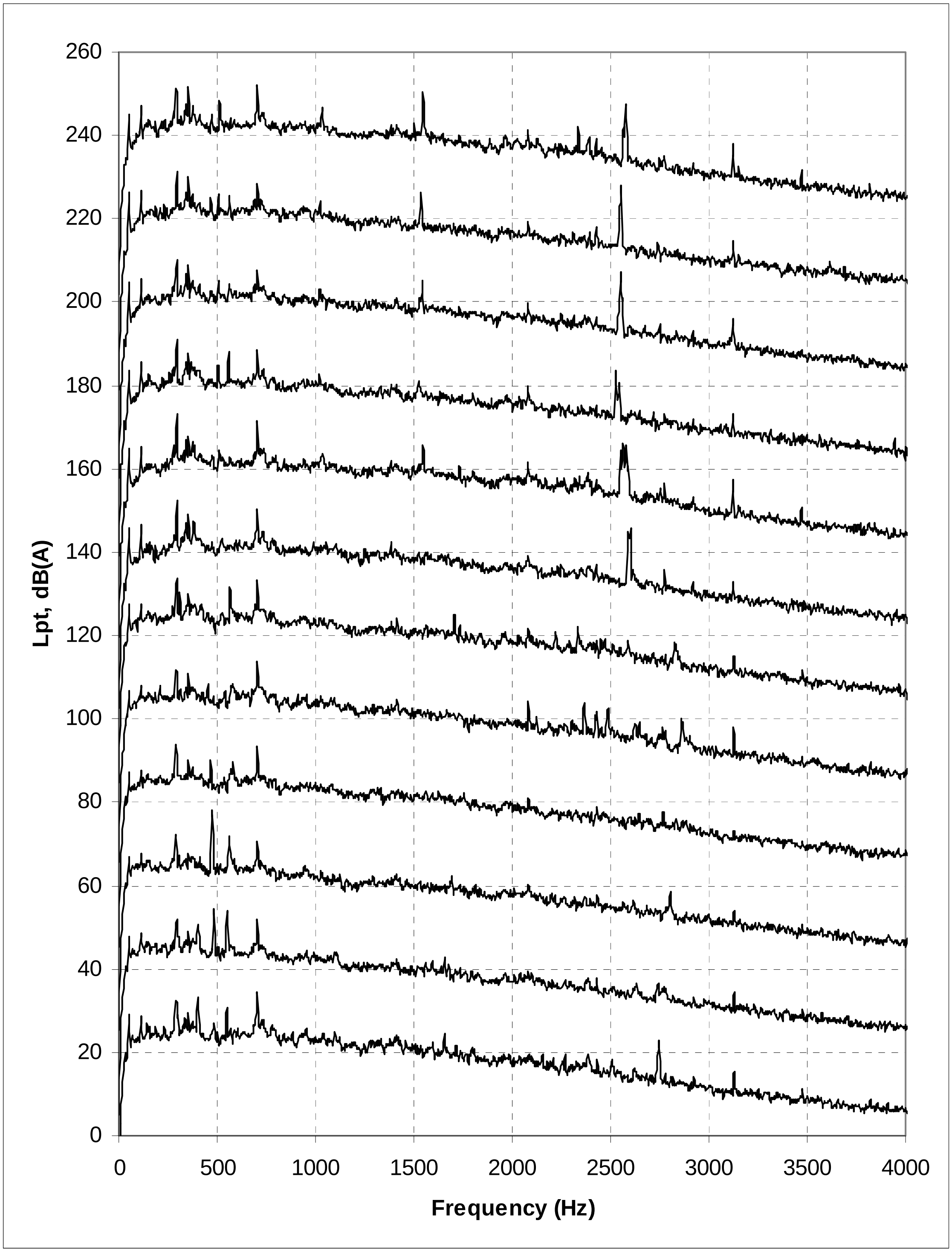

Figure E-13. Total Noise FFTs used for 5 m/s Tonality Analysis, Upper Spectra Shifted by 20 dB each (V_S = 4.98 and 5.04 m/s)

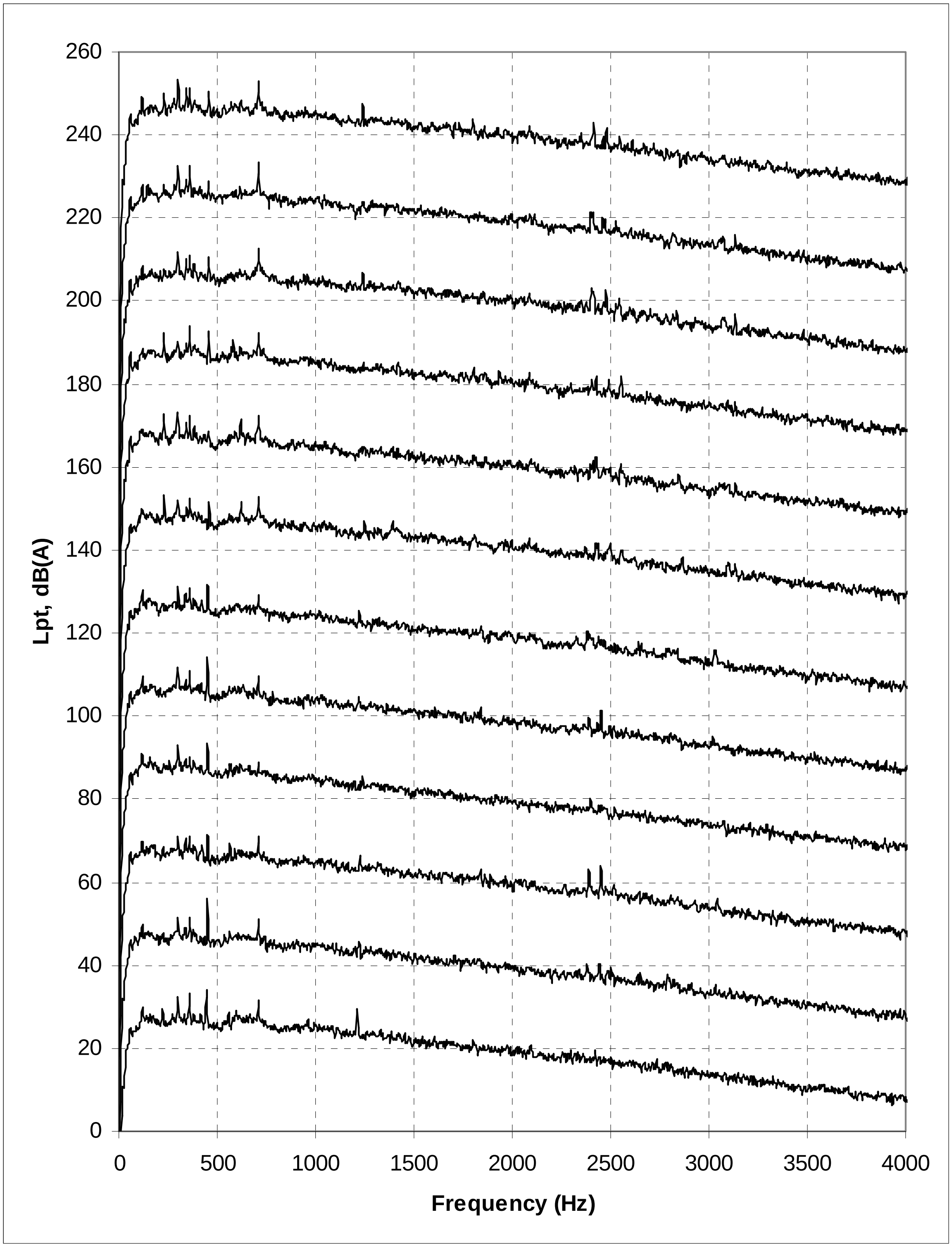

Figure E-14. Total Noise FFTs used for 6 m/s Tonality Analysis, Upper Spectra Shifted by 20 dB each (V_S = 6.00 and 6.01 m/s)

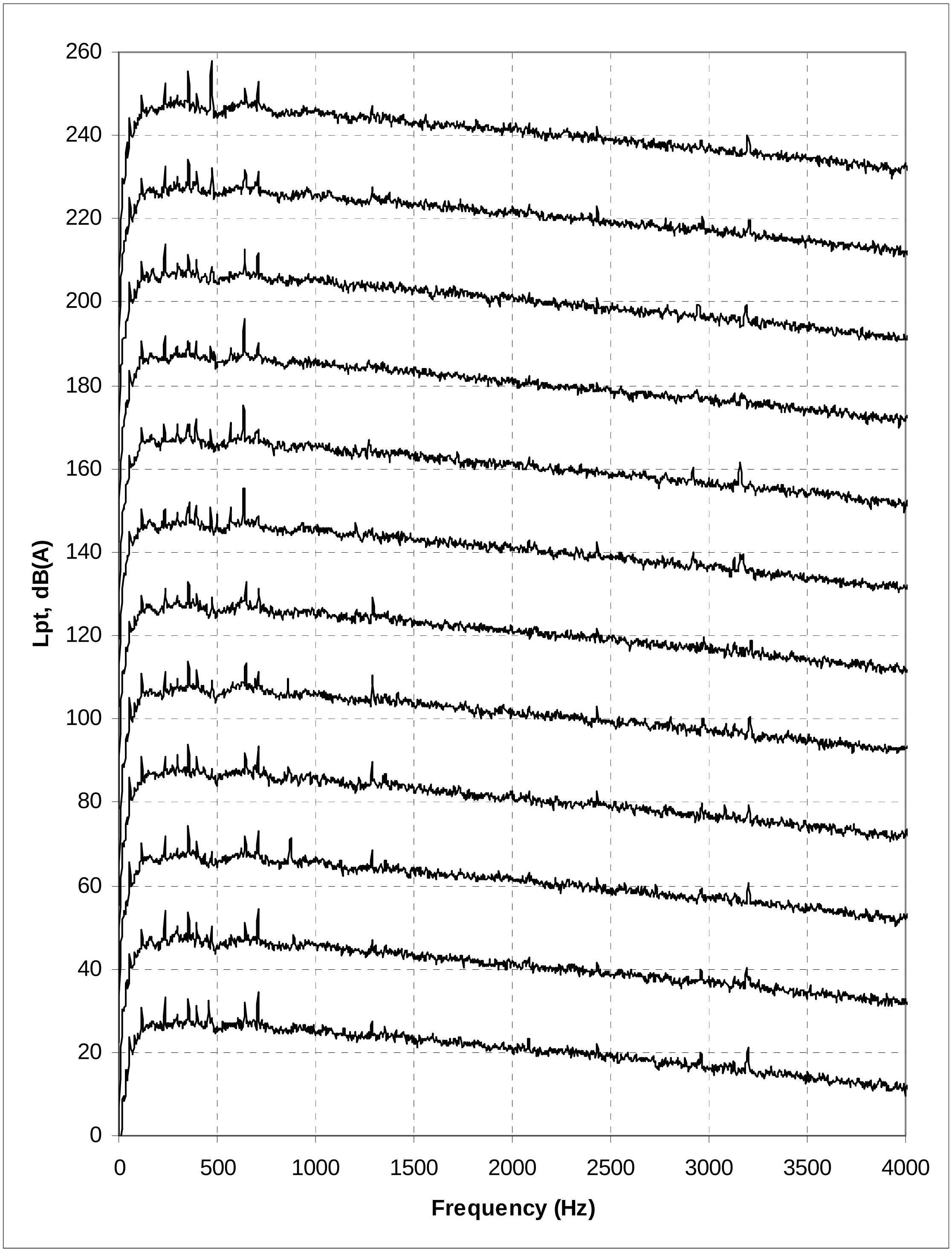

Figure E-15. Total Noise FFTs used for 7 m/s Tonality Analysis, Upper Spectra Shifted by 20 dB each (V_S = 7.02 and 7.04 m/s)

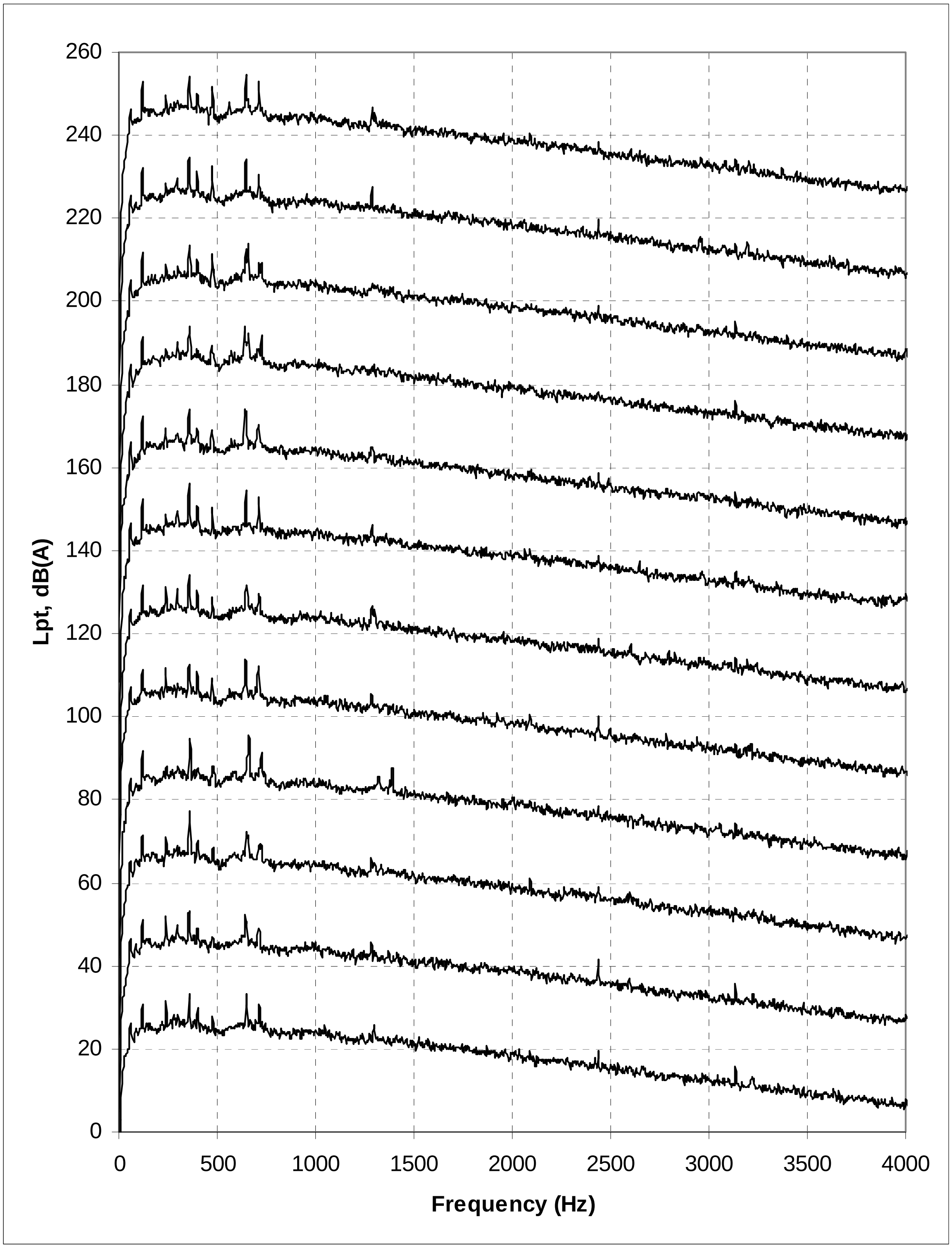

Figure E-16. Total Noise FFTs used for 8 m/s Tonality Analysis, Upper Spectra Shifted by 20 dB each (V_S = 8.00 and 8.02 m/s)

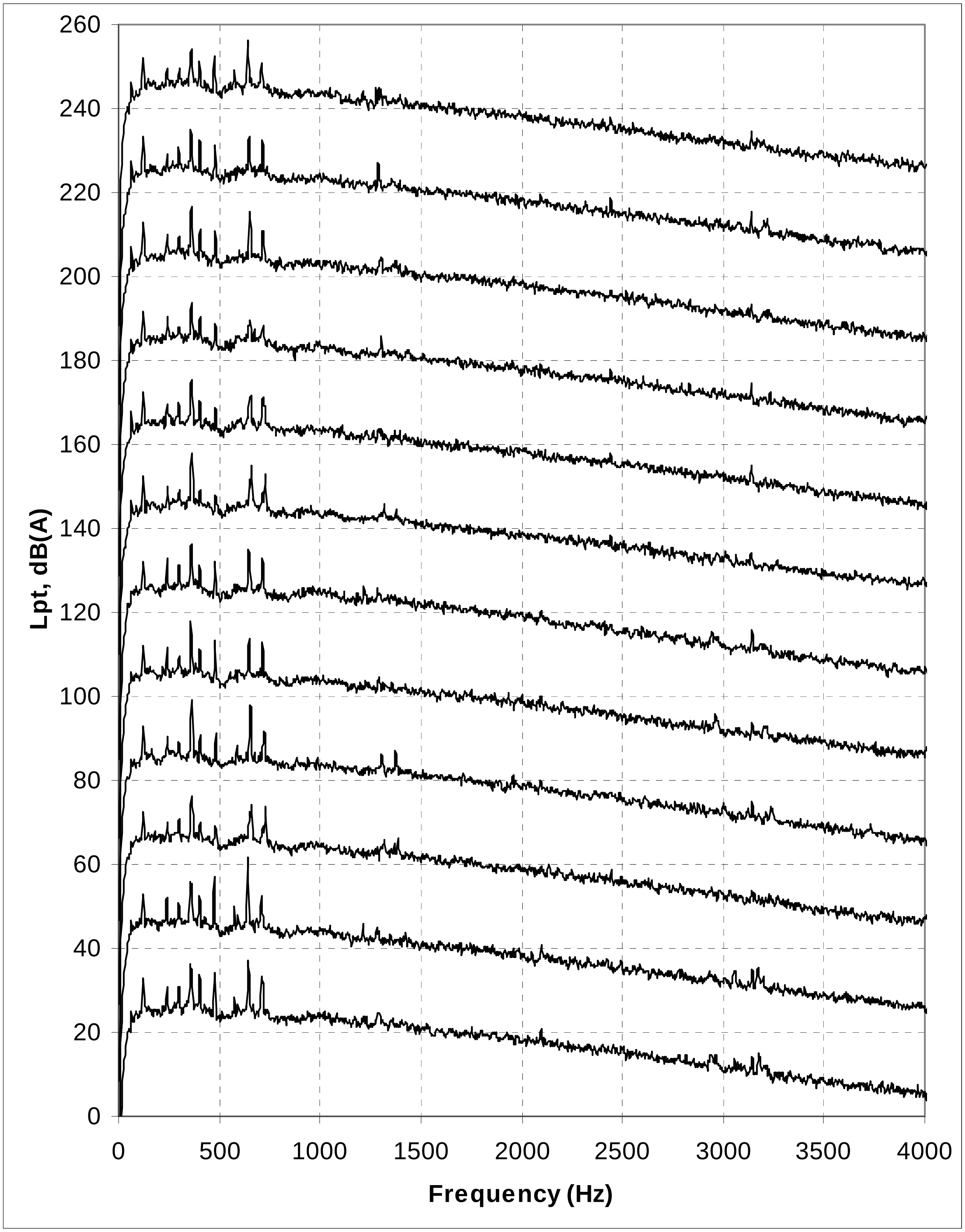

Figure E-17. Total Noise FFTs used for 9 m/s Tonality Analysis, Upper Spectra Shifted by 20 dB each (V_S = 8.99 and 8.97 m/s)

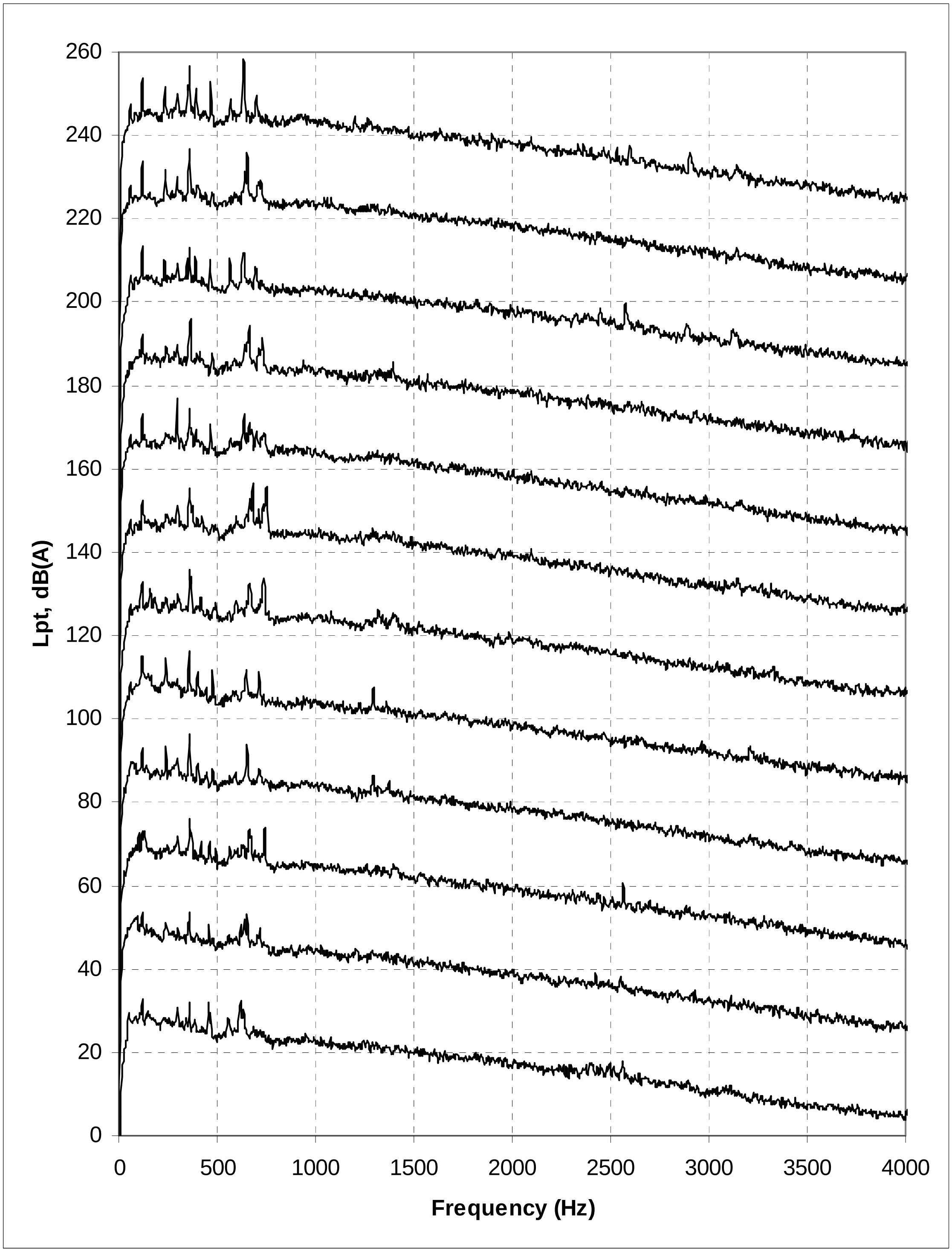

Figure E-18. Total Noise FFTs used for 10 m/s Tonality Analysis, Upper Spectra Shifted by 20 dB each (V_S = 9.82 and 10.04 m/s)

APPENDIX E:
CALCULATION DETAILS

Summary of Calculations - Condensed Overall, dBA Format

R001	Non-Participating Receptor	605650	4773240	209.5												
Src ID	Src Name	X	Y	Z	Lx	Adiv	K0	Dc	Agnd	Abar	Aatm	Afol	Ahous	Cmet	Refl	Lr
WTG1	Vestas V100	604718	4775553	295.0	105	78.9	0	0.0	-0.5	0.0	7.1	0.0	0.0	0.0	0.0	19
WTG2	Vestas V100	604889	4775173	295.0	105	77.4	0	0.0	-0.5	0.0	6.4	0.0	0.0	0.0	0.0	22
WTG3	Vestas V100	606291	4774905	290.0	105	76.0	0	0.0	-0.5	0.0	5.8	0.0	0.0	0.0	0.0	24
WTG4	Vestas V100	604359	4774308	297.1	105	75.5	0	0.0	-0.5	0.0	5.6	0.0	0.0	0.0	0.0	24
WTG5	Vestas V100	606233	4773420	296.5	105	66.8	0	0.0	-0.7	0.0	3.0	0.0	0.0	0.0	0.0	36

R060	Non-Participating Receptor	605060	4774364	204.5												
Src ID	Src Name	X	Y	Z	Lx	Adiv	K0	Dc	Agnd	Abar	Aatm	Afol	Ahous	Cmet	Refl	Lr
WTG1	Vestas V100	604718	4775553	295.0	105	72.9	0	0.0	-0.6	0.0	4.7	0.0	0.0	0.0	0.0	28
WTG2	Vestas V100	604889	4775173	295.0	105	69.4	0	0.0	-0.6	0.0	3.7	0.0	0.0	0.0	0.0	33
WTG3	Vestas V100	606291	4774905	290.0	105	73.6	0	0.0	-0.6	0.0	4.9	0.0	0.0	0.0	0.0	27
WTG4	Vestas V100	604359	4774308	297.1	105	68.0	0	0.0	-0.7	0.0	3.3	0.0	0.0	0.0	0.0	34
WTG5	Vestas V100	606233	4773420	296.5	105	74.6	0	0.0	-0.6	0.0	5.3	0.0	0.0	0.0	0.0	26

R120	Non-Participating Receptor	606031	4774379	202.8												
Src ID	Src Name	X	Y	Z	Lx	Adiv	K0	Dc	Agnd	Abar	Aatm	Afol	Ahous	Cmet	Refl	Lr
WTG1	Vestas V100	604718	4775553	295.0	105	75.9	0	0.0	-0.5	0.0	5.8	0.0	0.0	0.0	0.0	24
WTG2	Vestas V100	604889	4775173	295.0	105	73.9	0	0.0	-0.6	0.0	5.0	0.0	0.0	0.0	0.0	27
WTG3	Vestas V100	606291	4774905	290.0	105	66.5	0	0.0	-0.7	0.0	3.0	0.0	0.0	0.0	0.0	36
WTG4	Vestas V100	604359	4774308	297.1	105	75.5	0	0.0	-0.5	0.0	5.6	0.0	0.0	0.0	0.0	24
WTG5	Vestas V100	606233	4773420	296.5	105	70.9	0	0.0	-0.6	0.0	4.1	0.0	0.0	0.0	0.0	31

R165	Non-Participating Receptor	604109	4775818	204.5												
Src ID	Src Name	X	Y	Z	Lx	Adiv	K0	Dc	Agnd	Abar	Aatm	Afol	Ahous	Cmet	Refl	Lr
WTG1	Vestas V100	604718	4775553	295.0	105	67.5	0	0.0	-0.7	0.0	3.2	0.0	0.0	0.0	0.0	35
WTG2	Vestas V100	604889	4775173	295.0	105	71.1	0	0.0	-0.6	0.0	4.1	0.0	0.0	0.0	0.0	30
WTG3	Vestas V100	606291	4774905	290.0	105	78.5	0	0.0	-0.5	0.0	6.9	0.0	0.0	0.0	0.0	20
WTG4	Vestas V100	604359	4774308	297.1	105	74.7	0	0.0	-0.6	0.0	5.3	0.0	0.0	0.0	0.0	26
WTG5	Vestas V100	606233	4773420	296.5	105	81.1	0	0.0	-0.5	0.0	8.1	0.0	0.0	0.0	0.0	16

Where: Lr = Lx - Adiv + K0 + Dc - Agnd - Abar - Aatm - Afol - Ahous + Cmet + Refl

Summary of Calculations - Octave Band Format

R001	Non-Participating Receptor		605650	4773240	209.5													
Src ID	Src Name	Band	X	Y	Z	Lx	Adiv	K0	Dc	Agnd	Abar	Aatm	Afol	Ahous	Cmet	Refl	Lr	Band
WTG1	Vestas V100	63	604718	4775553	295.0	87.4	78.9	0	0.0	-3.0	0.0	0.3	0.0	0.0	0.0	0.0	11.2	63
WTG1	Vestas V100	125	604718	4775553	295.0	92.0	78.9	0	0.0	1.8	0.0	1.0	0.0	0.0	0.0	0.0	10.3	125
WTG1	Vestas V100	250	604718	4775553	295.0	94.7	78.9	0	0.0	0.1	0.0	2.6	0.0	0.0	0.0	0.0	13.1	250
WTG1	Vestas V100	500	604718	4775553	295.0	97.1	78.9	0	0.0	-0.9	0.0	4.8	0.0	0.0	0.0	0.0	14.3	500
WTG1	Vestas V100	1000	604718	4775553	295.0	99.7	78.9	0	0.0	-0.9	0.0	9.1	0.0	0.0	0.0	0.0	12.5	1000
WTG1	Vestas V100	2000	604718	4775553	295.0	98.2	78.9	0	0.0	-0.9	0.0	24.1	0.0	0.0	0.0	0.0	--	2000
WTG1	Vestas V100	4000	604718	4775553	295.0	96.6	78.9	0	0.0	-0.9	0.0	81.8	0.0	0.0	0.0	0.0	--	4000
WTG1	Vestas V100	8000	604718	4775553	295.0	89.8	78.9	0	0.0	-0.9	0.0	291.6	0.0	0.0	0.0	0.0	--	8000
WTG2	Vestas V100	63	604889	4775173	295.0	87.4	77.4	0	0.0	-3.0	0.0	0.3	0.0	0.0	0.0	0.0	12.8	63
WTG2	Vestas V100	125	604889	4775173	295.0	92.0	77.4	0	0.0	1.8	0.0	0.9	0.0	0.0	0.0	0.0	12.0	125
WTG2	Vestas V100	250	604889	4775173	295.0	94.7	77.4	0	0.0	0.1	0.0	2.2	0.0	0.0	0.0	0.0	15.1	250
WTG2	Vestas V100	500	604889	4775173	295.0	97.1	77.4	0	0.0	-0.9	0.0	4.0	0.0	0.0	0.0	0.0	16.6	500
WTG2	Vestas V100	1000	604889	4775173	295.0	99.7	77.4	0	0.0	-0.9	0.0	7.6	0.0	0.0	0.0	0.0	15.6	1000
WTG2	Vestas V100	2000	604889	4775173	295.0	98.2	77.4	0	0.0	-0.9	0.0	20.1	0.0	0.0	0.0	0.0	1.7	2000
WTG2	Vestas V100	4000	604889	4775173	295.0	96.6	77.4	0	0.0	-0.9	0.0	68.1	0.0	0.0	0.0	0.0	--	4000
WTG2	Vestas V100	8000	604889	4775173	295.0	89.8	77.4	0	0.0	-0.9	0.0	243.0	0.0	0.0	0.0	0.0	--	8000
WTG3	Vestas V100	63	606291	4774905	290.0	87.4	76.0	0	0.0	-3.0	0.0	0.2	0.0	0.0	0.0	0.0	14.2	63
WTG3	Vestas V100	125	606291	4774905	290.0	92.0	76.0	0	0.0	1.8	0.0	0.7	0.0	0.0	0.0	0.0	13.5	125
WTG3	Vestas V100	250	606291	4774905	290.0	94.7	76.0	0	0.0	0.1	0.0	1.9	0.0	0.0	0.0	0.0	16.7	250
WTG3	Vestas V100	500	606291	4774905	290.0	97.1	76.0	0	0.0	-0.9	0.0	3.4	0.0	0.0	0.0	0.0	18.5	500
WTG3	Vestas V100	1000	606291	4774905	290.0	99.7	76.0	0	0.0	-0.9	0.0	6.5	0.0	0.0	0.0	0.0	18.0	1000
WTG3	Vestas V100	2000	606291	4774905	290.0	98.2	76.0	0	0.0	-0.9	0.0	17.3	0.0	0.0	0.0	0.0	5.8	2000
WTG3	Vestas V100	4000	606291	4774905	290.0	96.6	76.0	0	0.0	-0.9	0.0	58.5	0.0	0.0	0.0	0.0	--	4000
WTG3	Vestas V100	8000	606291	4774905	290.0	89.8	76.0	0	0.0	-0.9	0.0	208.7	0.0	0.0	0.0	0.0	--	8000
WTG4	Vestas V100	63	604359	4774307	297.1	87.4	75.5	0	0.0	-3.0	0.0	0.2	0.0	0.0	0.0	0.0	14.7	63
WTG4	Vestas V100	125	604359	4774307	297.1	92.0	75.5	0	0.0	1.8	0.0	0.7	0.0	0.0	0.0	0.0	14.0	125
WTG4	Vestas V100	250	604359	4774307	297.1	94.7	75.5	0	0.0	0.1	0.0	1.8	0.0	0.0	0.0	0.0	17.4	250
WTG4	Vestas V100	500	604359	4774307	297.1	97.1	75.5	0	0.0	-0.9	0.0	3.2	0.0	0.0	0.0	0.0	19.3	500
WTG4	Vestas V100	1000	604359	4774307	297.1	99.7	75.5	0	0.0	-0.9	0.0	6.1	0.0	0.0	0.0	0.0	19.0	1000
WTG4	Vestas V100	2000	604359	4774307	297.1	98.2	75.5	0	0.0	-0.9	0.0	16.2	0.0	0.0	0.0	0.0	7.4	2000
WTG4	Vestas V100	4000	604359	4774307	297.1	96.6	75.5	0	0.0	-0.9	0.0	55.0	0.0	0.0	0.0	0.0	--	4000
WTG4	Vestas V100	8000	604359	4774307	297.1	89.8	75.5	0	0.0	-0.9	0.0	196.0	0.0	0.0	0.0	0.0	--	8000
WTG5	Vestas V100	63	606233	4773420	296.5	87.4	66.8	0	0.0	-3.0	0.0	0.1	0.0	0.0	0.0	0.0	23.5	63
WTG5	Vestas V100	125	606233	4773420	296.5	92.0	66.8	0	0.0	1.6	0.0	0.3	0.0	0.0	0.0	0.0	23.4	125
WTG5	Vestas V100	250	606233	4773420	296.5	94.7	66.8	0	0.0	0.1	0.0	0.6	0.0	0.0	0.0	0.0	27.2	250
WTG5	Vestas V100	500	606233	4773420	296.5	97.1	66.8	0	0.0	-0.9	0.0	1.2	0.0	0.0	0.0	0.0	30.0	500
WTG5	Vestas V100	1000	606233	4773420	296.5	99.7	66.8	0	0.0	-0.9	0.0	2.3	0.0	0.0	0.0	0.0	31.6	1000
WTG5	Vestas V100	2000	606233	4773420	296.5	98.2	66.8	0	0.0	-0.9	0.0	6.0	0.0	0.0	0.0	0.0	26.4	2000
WTG5	Vestas V100	4000	606233	4773420	296.5	96.6	66.8	0	0.0	-0.9	0.0	20.2	0.0	0.0	0.0	0.0	10.5	4000
WTG5	Vestas V100	8000	606233	4773420	296.5	89.8	66.8	0	0.0	-0.9	0.0	72.0	0.0	0.0	0.0	0.0	--	8000

Where: Lr = Lx - Adiv + K0 + Dc - Agnd - Abar - Aatm - Afol - Ahous + Cmet + Refl

APPENDIX F:
WIND SHEAR COEFFICIENT SUMMARY

Figure F1: Diurnal Wind Shear, HAF Wind Energy
Calculations based on Wind Speeds Measured Between August 26 and September 9, 2010
at 79 m, 57 m and 39 m Heights