U.S. DEPARTMENT OF ENERGY

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Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Acoustic Modeling for Aqua Ventus I off Monhegan Island, ME

Jonathan Whiting
Luke Hanna
Nicole Dechello
Andrea Copping

October 2013

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Acoustic Modeling for Aqua Ventus I off Monhegan Island, ME

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Pacific Northwest National Laboratory
Seattle Washington 98109

Table of Contents

1.0 Introduction and Purpose

The DeepCwind consortium, led by the University of Maine, was awarded funding under the US Department of Energy's Offshore Wind Advanced Technology Demonstration Program to develop two floating offshore wind turbines in the Gulf of Maine equipped with Goldwind 6 MW direct drive turbines, as the Aqua Ventus I project. The Goldwind turbines have a hub height of 100 m. The turbines will be deployed in Maine State waters, approximately 2.9 miles off Monhegan Island; Monhegan Island is located roughly 10 miles off the coast of Maine.

In order to site and permit the offshore turbines, the acoustic output must be evaluated to ensure that the sound will not exceed regulatory or other established thresholds of disturbance for residents on Monhegan Island. This initial assessment of the acoustic output focuses on the sound of the turbines in air by assuming a sound source level appropriate to the proposed direct drive turbines and applying a sound propagation model to estimate sound pressure levels on Monhegan Island.

2.0 Methods

Pacific Northwest National Laboratory (PNNL) used WindPRO Decibel software to estimate the source term and propagation for sound expected to be emitted by the proposed turbines. Using several standard sound propagation models, and drawing from an international database of turbines, the WindPRO software enables the modeler to predict the outcome. Acoustic information for the Goldwind direct drive 6 MW turbines proposed for the Aqua Ventus I project is limited and is not currently in the WindPRO database; however source level information from the turbine manufacturer (and provided to PNNL by the University of Maine) was available for the Goldwind 6 MW direct drive turbine.

For this analysis, three large offshore wind turbines contained in the WindPRO database were used to assess the potential acoustic fields of the Goldwind 6 MW direct drive turbines. The first two turbines used to simulate the Goldwind turbines were taken directly from the WindPRO database (a RePower 5 MW geared turbine with a hub height of 100 m and an ENERCON 7.5 MW direct drive turbine with a hub height of 135 m. The third turbine was a copy of the ENERCON 7.5 MW direct drive turbine but was manually edited so that it had the same hub height (100 m) and source level (115dB(A)) as the Goldwind 6 MW direct drive turbine.

The WindPRO model analyzes sound propagation for a fixed wind speed of 8 m/s using a Swedish overwater propagation model developed in 2009. This model assumes that the sound propagates spherically for the first 700 m and cylindrically for the remaining distance over water. It should be noted that PNNL carried out earlier acoustic modeling efforts for a different set of turbines for DeepCwind using an older Swedish water propagation model from 2002 (Naturvårdsverket 2001), which assumes spherical spreading of sound for the first 200 m from the source and cylindrical for the remaining distance. The older model (2002) generates higher sound pressure levels at distance greater than 200 m versus the 2009 model, due to the smaller radius of spherical propagation. The results from both the 2009 and 2002 Swedish sound propagation models are provided in Table 1 below for the three turbines that are the subject of this study. Water is assumed to be an acoustically hard surface with no attenuation or energy absorption by the ocean. Although this assumption is not realistic, it produces an overestimate of the received sound pressure level as it reaches Monhegan Island (i.e., is a conservative assumption). Octave band values are set at 63 Hz – 4000 Hz and calm weather conditions are assumed. This latter assumption is important because the turbine noise is likely to be to be overpowered by wind and wave sounds in rough weather.

3.0 Model Results

The acoustic model outputs (Figures 1, 2, and 3) display the sound pressure levels as a function of distance for the three representative wind turbine sources using the 2009 Swedish propagation model, relative to Monhegan Island. The source terms and estimated values for sound pressure levels for the three representative turbines using both the 2002 and 2009 Swedish sound propagation models are shown in Table 1, using the southern tip of the island as a receptor point. The WindPRO model outputs are provided in Appendix A.

Table 1. Model Inputs and Results for Three Wind Turbines used as surrogates for the Goldwind 6MW direct drive turbines proposed at Monhegan Island. Sound Pressure Level Outputs are shown for the 2002 and 2009 Swedish sound propagation models. All sound levels are recorded in an A-weighted sound pressure level in dB(A) units.

Wind Turbine	Drive Train	Hub Height	Source Level	Sound Pressure Level at Monhegan Island (2002 model)	**Sound Pressure Level at Monhegan Island (2009 model)**
5 MW REpower	Gear box	100 m	106.0 dB(A)	35.1 dB(A)	**20.4 dB(A)**
7.5 MW ENERCON	Direct drive	135 m	107.5 dB(A)	36.5 dB(A)	**21.9 dB(A)**
7.5 MW ENERCON V.2 (edited)	Direct Drive	100 m	115 dB(A)	44.1 dB(A)	**29.4 dB(A)**

4.0 Discussion

By comparing the acoustic output from the three turbines, it is likely that the 6MW Goldwind direct drive turbines planned for the Aqua Ventus I project will contribute approximately 20 to 29 dB(A) to background noise at the southern tip of Monhegan Island. The sound received at the south end of Monhegan Island will decrease as it travels further over the land. It should be noted that the predicted sound pressure levels for all the modeled turbines fall below the World Health Organization's recommendation for maximum night time noise levels in Europe (40 dB(A)) (World Health Organization 2009). To put these sound pressure levels in perspective, 30 dB is the background noise level of a recording studio and 40 dB is the level of a bedroom at night (US Department of Labor 2013); or the equivalent of a whisper.

Using the WindPRO model outputs, the use of the surrogate turbines, and taking into account the probable overestimation of acoustic propagation from the offshore sources, it is probable that the sound of the turbines reaching Monhegan Island will be very low and will almost certainly be masked at the shoreline by wave action and by ambient noise on land.

5.0 Conclusion

As the Aqua Ventus 1 project moves forward, the sound model prediction should be validated with acoustic output data from the 6MW Goldwind direct drive turbines over additional wind speeds and octaves. If such data are not available and integrated with acoustic databases such as that of WindPRO prior to deployment, additional modeling efforts for 6 MW direct drive turbines should be undertaken to ensure that the model continues to accurately reflect the sound source levels at the turbines.

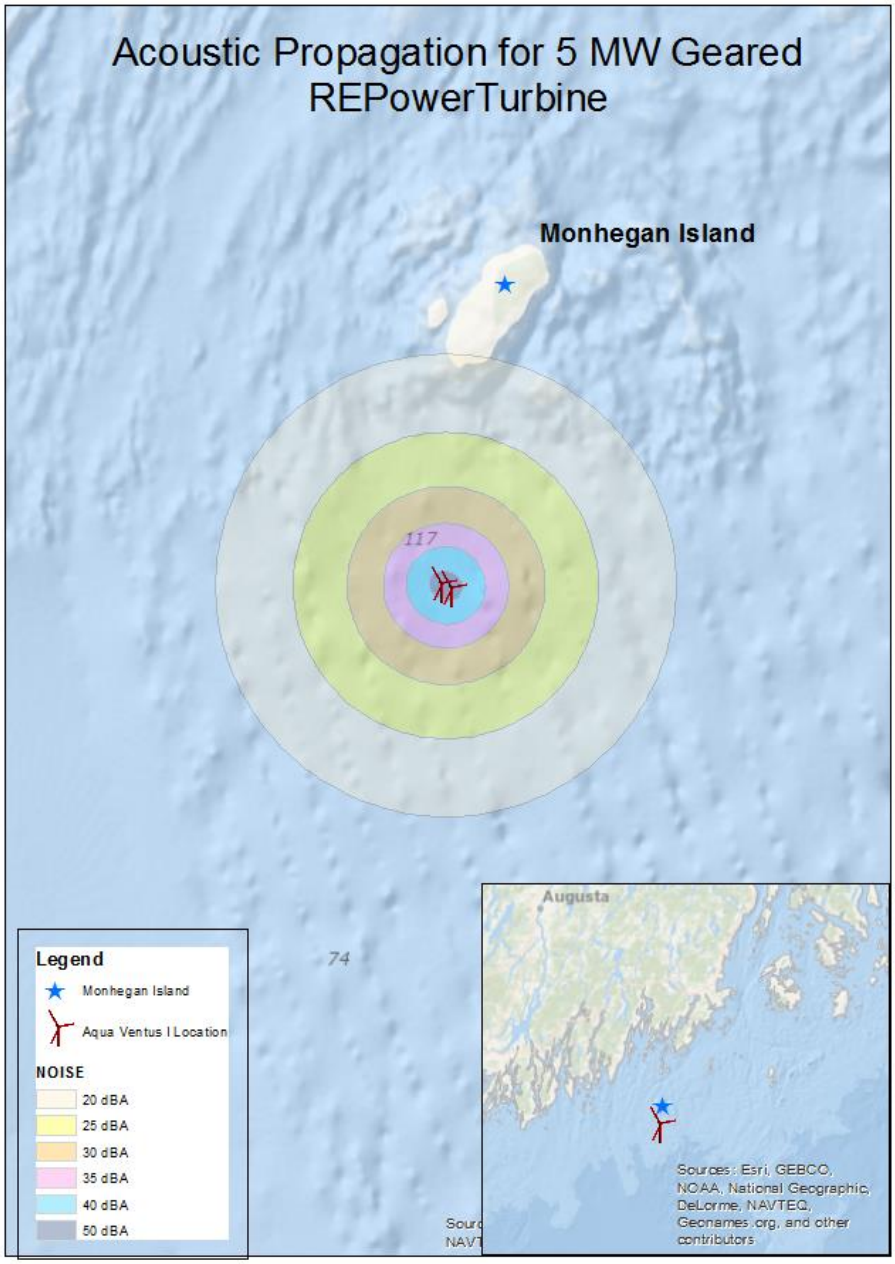

Figure 1. Model output for two 5 MW REPower geared turbines offshore of Monhegan Island ME. The wind turbines are represented by the red figures at the center of the circles. The concentric circles represent received sound levels at a distance from the source.

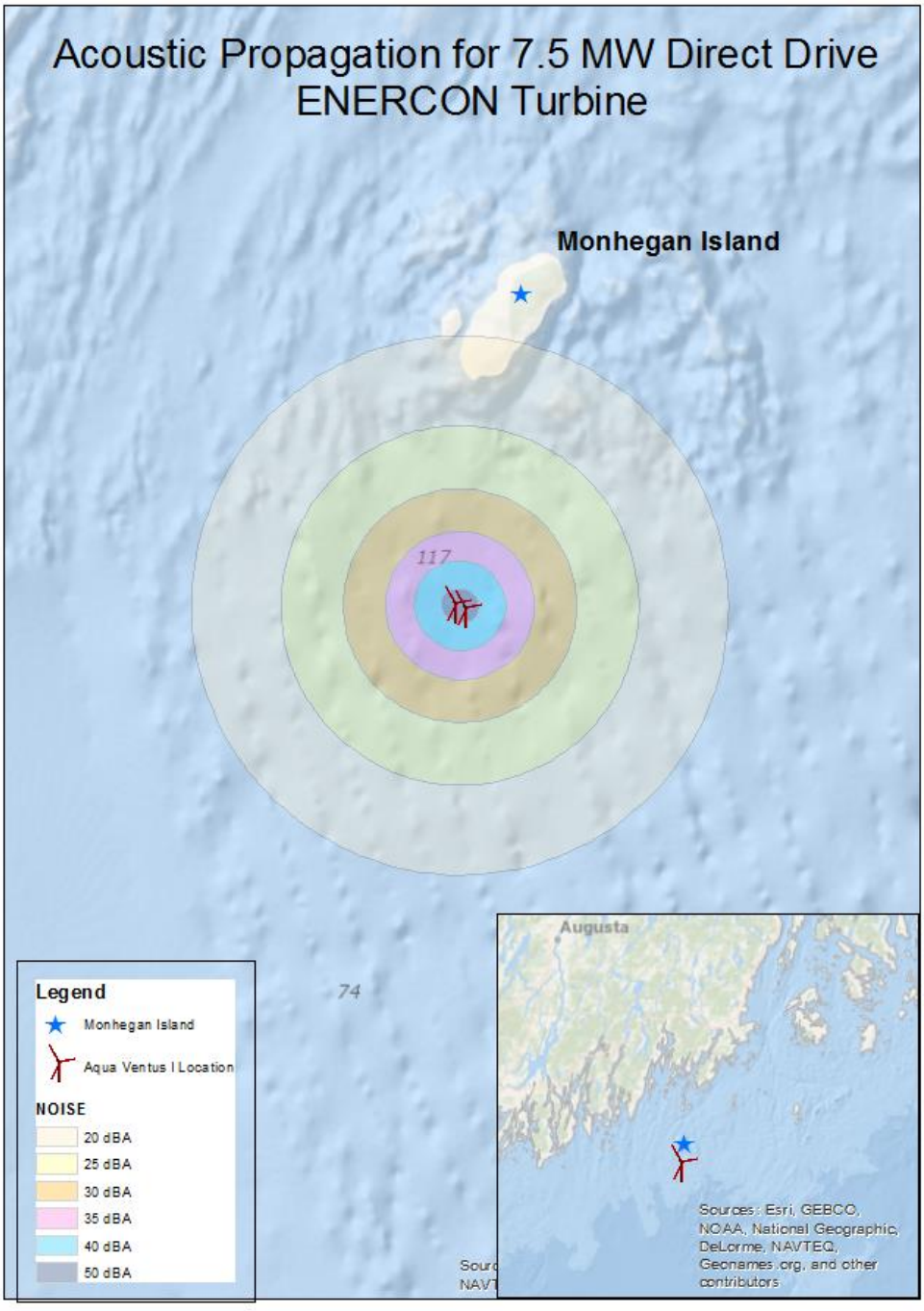

Figure 2. Model output for two 7.5 MW ENERCON direct drive turbines offshore of Monhegan Island ME. The wind turbines are represented by the red figures at the center of the circles. The concentric circles represent received sound levels at a distance from the source.

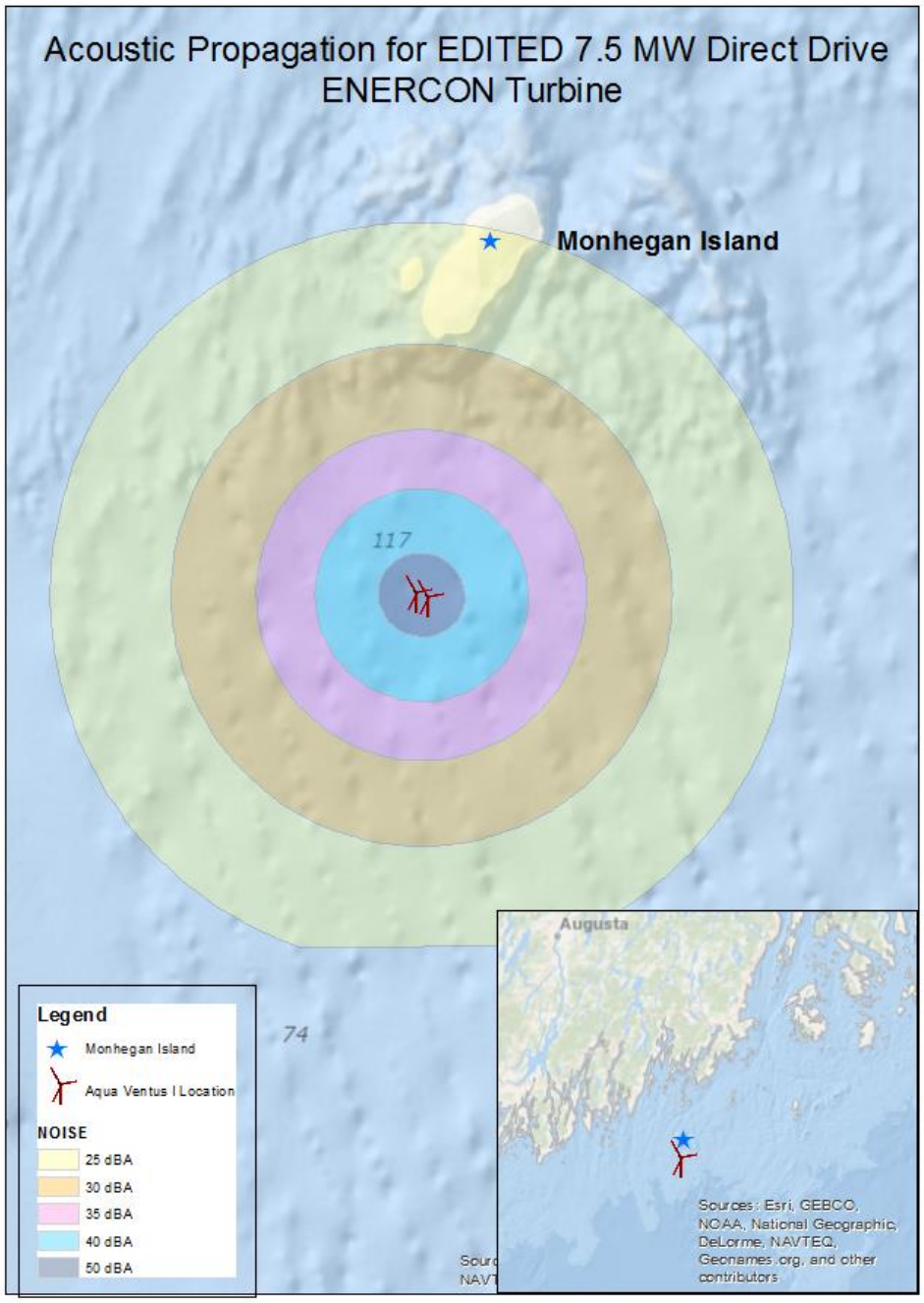

Figure 3. Model output for two adapted 7.5 MW ENERCON direct drive turbines offshore of Monhegan Island ME (hub height = 100 m and source level = 115 dB(A)). The wind turbines are represented by the red figures at the center of the circles. The concentric circles represent received sound levels at a distance from the source.

6.0 References

Naturvårdsverket. 2001. Ljud från Vindkraftverk. Swedish EPA. ISBN 91-620-6241-7

U.S. Department of Labor: Occupational Noise Exposure. U.S. Department of Labor. <https://www.osha.gov/SLTC/noisehearingconservation/index.html > Last accessed: 9/25/2013

World Health Organization, 2009. Night Noise Guidelines for Europe. Copenhagen, Denmark. World Health Organization. < http://www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf > Last Accessed: 10/21/2013

Appendix A: WindPRO Generated Outputs

Model output for sound propagation generated by the 7.5 MW direct drive ENERCON turbine, the 5 MW REPower geared turbine, and the edited version of the 7.5 MW direct drive ENERCON turbine offshore of Monhegan Island, ME. The wind turbines are represented by the red figures at the center of the circles. The concentric circles represent received sound levels at a distance from the source. Note: point A represents the entire Island of Monhegan; recoded sound pressure levels were taken from the closest point to the turbines on the Island.

Project:
Monhegan Island Turbine Noise 2013

Description:
Two 6.0 MW Goldwind floating offshore wind turbines are planned approximately 3 nautical miles offshore from Monhegan Island, Maine. Inhabitats have expressed concern with the noise levels, prompting this study.
The 2009 Swedish code is a revision of the Swedish 2002 code. A roughness coefficient is replaced with a standard IEC profile of 0.05 m. The distance at which geometric spreading changes from spherical to cylindrical changed from 200 m to 700 m.

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DECIBEL - Main Result

Calculation: RE 5 MW Standard

SWEDISH RULES FOR NOISE CALCULATION.

The calculation is based on the "Ljud frånvindkraftverk", 2010 (NV dnr 382-6897-07 Rv)

Scale 1:200,000
New WTG
Noise sensitive area

WTGs

	Geo [deg]-WGS84				WTG type						Noise data						
	Longitude	Latitude	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Creator	Name	Wind speed	Status	LwA,ref	Pure tones	
			[m]					[kW]	[m]	[m]			[m/s]		[dB(A)]		
1	-69.325371° East	43.718239° North	0.0	REpower 5 M 5000 126.0 !O! hu...	Yes	REpower	5 M-5,000	5,000	126.0	100.0	EMD	Level 0 - guaranteed - 108,0dB(A) - 11/2008	8.0	From slope	106.0	No	g
2	-69.323052° East	43.717498° North	0.0	REpower 5 M 5000 126.0 !O! hu...	Yes	REpower	5 M-5,000	5,000	126.0	100.0	EMD	Level 0 - guaranteed - 108,0dB(A) - 11/2008	8.0	From slope	106.0	No	g

g) Data calculated from data for other wind speed (uncertain)

Calculation Results

Sound Level

Noise sensitive area		Geo [deg]-WGS84				Demands	Sound Level		Demands fulfilled ?
No.	Name	Longitude	Latitude	Z	Imission height	Noise	From WTGs	Distance to noise demand	Noise
				[m]	[m]	[dB(A)]	[dB(A)]	[m]	
A	Noise sensitive area: Main Island	-69.321328° East	43.755586° North	39.5	1.5	44.0	20.4	3,684	Yes

Distances (m)

WTG	A
1	4161
2	4232

Project:
Monhegan Island Turbine Noise 2013

Description:
Two 6.0 MW Goldwind floating offshore wind turbines are planned approximately 3 nautical miles offshore from Monhegan Island, Maine. Inhabitats have expressed concern with the noise levels, prompting this study.
The 2009 Swedish code is a revision of the Swedish 2002 code. A roughness coefficient is replaced with a standard IEC profile of 0.05 m. The distance at which geometric spreading changes from spherical to cylindrical changed from 200 m to 700 m.

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DECIBEL - Detailed results

Calculation: RE 5 MW Standard**Noise calculation model:** Swedish 2009 8.0 m/s

Assumptions

Calculated L(DW) = LWA,ref + K + Dc - (Adiv + Aatm + Agr + Abar + Amisc) - Cmet
(when calculated with ground attenuation, then Dc = Domega)

LWA,ref:	Sound pressure level at WTG
K:	Pure tone
Dc:	Directivity correction
Adiv:	the attenuation due to geometrical divergence
Aatm:	the attenuation due to atmospheric absorption
Agr:	the attenuation due to ground effect
Abar:	the attenuation due to a barrier
Amisc:	the attenuation due to miscellaneous other effects
Cmet:	Meteorological correction

Calculation Results

Noise sensitive area: A Noise sensitive area: Main Island

WTG **Wind speed: 8.0 m/s**

No.	Distance [m]	Sound distance [m]	Land distance [m]	Calculated [dB(A)]	LwA,ref [dB(A)]	Dc [dB]	Adiv [dB]	Aatm [dB]	Agr [dB]	Abar [dB]	Amisc [dB]	A [dB]	Cmet [dB]
1	4,161	4,162	4,161	**17.52**	106.0	0.00	0.00	-	0.00	0.00	0.00	-	0.00
2	4,232	4,234	4,232	**17.31**	106.0	0.00	0.00	-	0.00	0.00	0.00	-	0.00
Sum	20.42												

- Data undefined due to calculation with octave data

Project:
Monhegan Island Turbine Noise 2013

Description:
Two 6.0 MW Goldwind floating offshore wind turbines are planned approximately 3 nautical miles offshore from Monhegan Island, Maine. Inhabitats have expressed concern with the noise levels, prompting this study.
The 2009 Swedish code is a revision of the Swedish 2002 code. A roughness coefficient is replaced with a standard IEC profile of 0.05 m. The distance at which geometric spreading changes from spherical to cylindrical changed from 200 m to 700 m.

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DECIBEL - Assumptions for noise calculation

Calculation: RE 5 MW Standard**Noise calculation model:** Swedish 2009 8.0 m/s

Noise calculation model:
Swedish 2009
Wind speed:
8.0 m/s
Ground attenuation:
None
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Pure tones:
Pure tone penalty are added to demand: 5.0 dB(A)
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)
Octave data required
Air absorption

63 [db/km]	125 [db/km]	250 [db/km]	500 [db/km]	1,000 [db/km]	2,000 [db/km]	4,000 [db/km]	8,000 [db/km]
0.1	0.3	0.6	1.4	3.2	7.9	22.0	50.0

WTG: REpower 5 M 5000 126.0 !O!
Noise: Level 0 - guaranteed - 108,0dB(A) - 11/2008

Source	Source/Date	Creator	Edited
REpower	11/4/2008	EMD	9/8/2009 3:17 PM

Based on documents SD-5.1_WT.SL.00-A-A-DE and SD-5.1-WT SL.01-A-B-EN.

						Octave data							
Status	Hub height [m]	Wind speed [m/s]	LwA,ref [dB(A)]	Pure tones		63 [dB]	125 [dB]	250 [dB]	500 [dB]	1000 [dB]	2000 [dB]	4000 [dB]	8000 [dB]
From slope	100.0	8.0	106.0	No	Generic data	87.6	94.6	98.0	100.6	100.4	97.5	92.7	83.2

NSA: Noise sensitive area: Main Island-A
Predefined calculation standard:
Imission height(a.g.l.): 1.5 m

Noise demand: 44.0 dB(A)
Distance demand:

Project:
Monhegan Island Turbine Noise 2013

Description:
Two 6.0 MW Goldwind floating offshore wind turbines are planned approximately 3 nautical miles offshore from Monhegan Island, Maine. Inhabitats have expressed concern with the noise levels, prompting this study.
The 2009 Swedish code is a revision of the Swedish 2002 code. A roughness coefficient is replaced with a standard IEC profile of 0.05 m. The distance at which geometric spreading changes from spherical to cylindrical changed from 200 m to 700 m.

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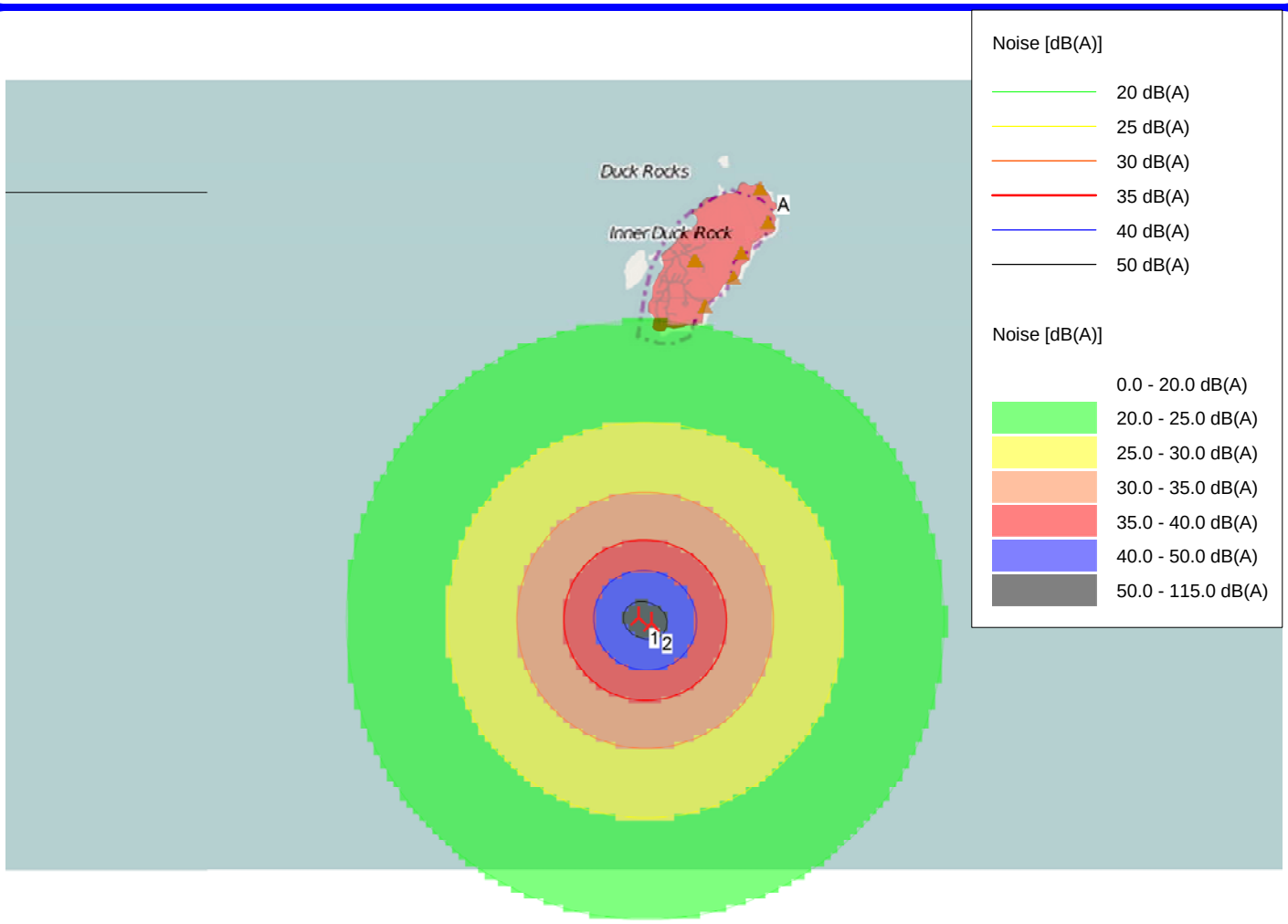
DECIBEL - Map 8.0 m/s

Calculation: RE 5 MW Standard**Noise calculation model:** Swedish 2009 8.0 m/s



0 1 2 3 4 km

Map: WindPRO map , Print scale 1:100,000, Map center Geo WGS84 East: -69.324144° East North: 43.719168° North

New WTG Noise sensitive area

Noise calculation model: Swedish 2009. Wind speed: 8.0 m/s
Height above sea level from active line object

Project:
Monhegan Island Turbine Noise 2013

Description:
Two 6.0 MW Goldwind floating offshore wind turbines are planned approximately 3 nautical miles offshore from Monhegan Island, Maine. Inhabitats have expressed concern with the noise levels, prompting this study.
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DECIBEL - Main Result

Calculation: ENERCON 7.5 MW Standard

SWEDISH RULES FOR NOISE CALCULATION.

The calculation is based on the "Ljud frånvindkraftverk", 2010 (NV dnr 382-6897-07 Rv)

Scale 1:200,000
New WTG
Noise sensitive area

WTGs

	Geo [deg]-WGS84					WTG type							Noise data				
	Longitude	Latitude	Z [m]	Row data/Description	Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Creator	Name	Wind speed [m/s]	LwA,ref [dB(A)]	Pure tones	
1	-69.325371° East	43.718239° North	0.0	ENERCON E-126 7500 127.0 ...	Yes	ENERCON	E-126-7,500	7,500	127.0	135.0	EMD	Level 0 - calculated - Op.Mode I - 12/2010	8.0	107.5	No	h
2	-69.323052° East	43.717498° North	0.0	ENERCON E-126 7500 127.0 ...	Yes	ENERCON	E-126-7,500	7,500	127.0	135.0	EMD	Level 0 - calculated - Op.Mode I - 12/2010	8.0	107.5	No	h

h) Generic octave distribution used

Calculation Results

Sound Level

Noise sensitive area		Geo [deg]-WGS84				Demands	Sound Level		Demands fulfilled ?
No.	Name	Longitude	Latitude	Z	Imission height	Noise	From WTGs	Distance to noise demand	Noise
				[m]	[m]	[dB(A)]	[dB(A)]	[m]	
A	Noise sensitive area: Main Island	-69.321328° East	43.755586° North	39.5	1.5	44.0	21.9	3,616	Yes

Distances (m)

WTG	A
1	4161
2	4232

Project:
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DECIBEL - Detailed results

Calculation: ENERCON 7.5 MW Standard **Noise calculation model:** Swedish 2009 8.0 m/s

Assumptions

Calculated L(DW) = LWA,ref + K + Dc - (Adiv + Aatm + Agr + Abar + Amisc) - Cmet
(when calculated with ground attenuation, then Dc = Domega)

LWA,ref:	Sound pressure level at WTG
K:	Pure tone
Dc:	Directivity correction
Adiv:	the attenuation due to geometrical divergence
Aatm:	the attenuation due to atmospheric absorption
Agr:	the attenuation due to ground effect
Abar:	the attenuation due to a barrier
Amisc:	the attenuation due to miscellaneous other effects
Cmet:	Meteorological correction

Calculation Results

Noise sensitive area: A Noise sensitive area: Main Island

WTG **Wind speed: 8.0 m/s**

No.	Distance [m]	Sound distance [m]	Land distance [m]	Calculated [dB(A)]	LwA,ref [dB(A)]	Dc [dB]	Adiv [dB]	Aatm [dB]	Agr [dB]	Abar [dB]	Amisc [dB]	A [dB]	Cmet [dB]
1	4,161	4,163	4,161	**19.01**	107.5	0.00	0.00	-	0.00	0.00	0.00	-	0.00
2	4,232	4,235	4,232	**18.80**	107.5	0.00	0.00	-	0.00	0.00	0.00	-	0.00

Sum 21.92

- Data undefined due to calculation with octave data

Project:
Monhegan Island Turbine Noise 2013

Description:
Two 6.0 MW Goldwind floating offshore wind turbines are planned approximately 3 nautical miles offshore from Monhegan Island, Maine. Inhabitats have expressed concern with the noise levels, prompting this study.
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DECIBEL - Assumptions for noise calculation

Calculation: ENERCON 7.5 MW Standard**Noise calculation model:** Swedish 2009 8.0 m/s

Noise calculation model:
Swedish 2009
Wind speed:
8.0 m/s
Ground attenuation:
None
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Pure tones:
Pure tone penalty are added to demand: 5.0 dB(A)
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)
Octave data required
Air absorption

63 [db/km]	125 [db/km]	250 [db/km]	500 [db/km]	1,000 [db/km]	2,000 [db/km]	4,000 [db/km]	8,000 [db/km]
0.1	0.3	0.6	1.4	3.2	7.9	22.0	50.0

WTG: ENERCON E-126 7500 127.0 !O!
Noise: Level 0 - calculated - Op.Mode I - 12/2010

Source	Source/Date	Creator	Edited
Manufacturer	12/8/2010	EMD	1/7/2013 9:34 AM

According to manufacturer specification document "SIAS-04-SPL E-126 7_5 Est Rev1_0-ger-ger.pdf" dated 12/2010

						Octave data							
Status	Hub height [m]	Wind speed [m/s]	LwA,ref [dB(A)]	Pure tones		63 [dB]	125 [dB]	250 [dB]	500 [dB]	1000 [dB]	2000 [dB]	4000 [dB]	8000 [dB]
From Windcat	135.0	8.0	107.5	No	Generic data	89.1	96.1	99.5	102.1	101.9	99.0	94.2	84.7

NSA: Noise sensitive area: Main Island-A
Predefined calculation standard:
Imission height(a.g.l.): 1.5 m

Noise demand: 44.0 dB(A)
Distance demand:

Project:
Monhegan Island Turbine Noise 2013

Description:
Two 6.0 MW Goldwind floating offshore wind turbines are planned approximately 3 nautical miles offshore from Monhegan Island, Maine. Inhabitats have expressed concern with the noise levels, prompting this study.
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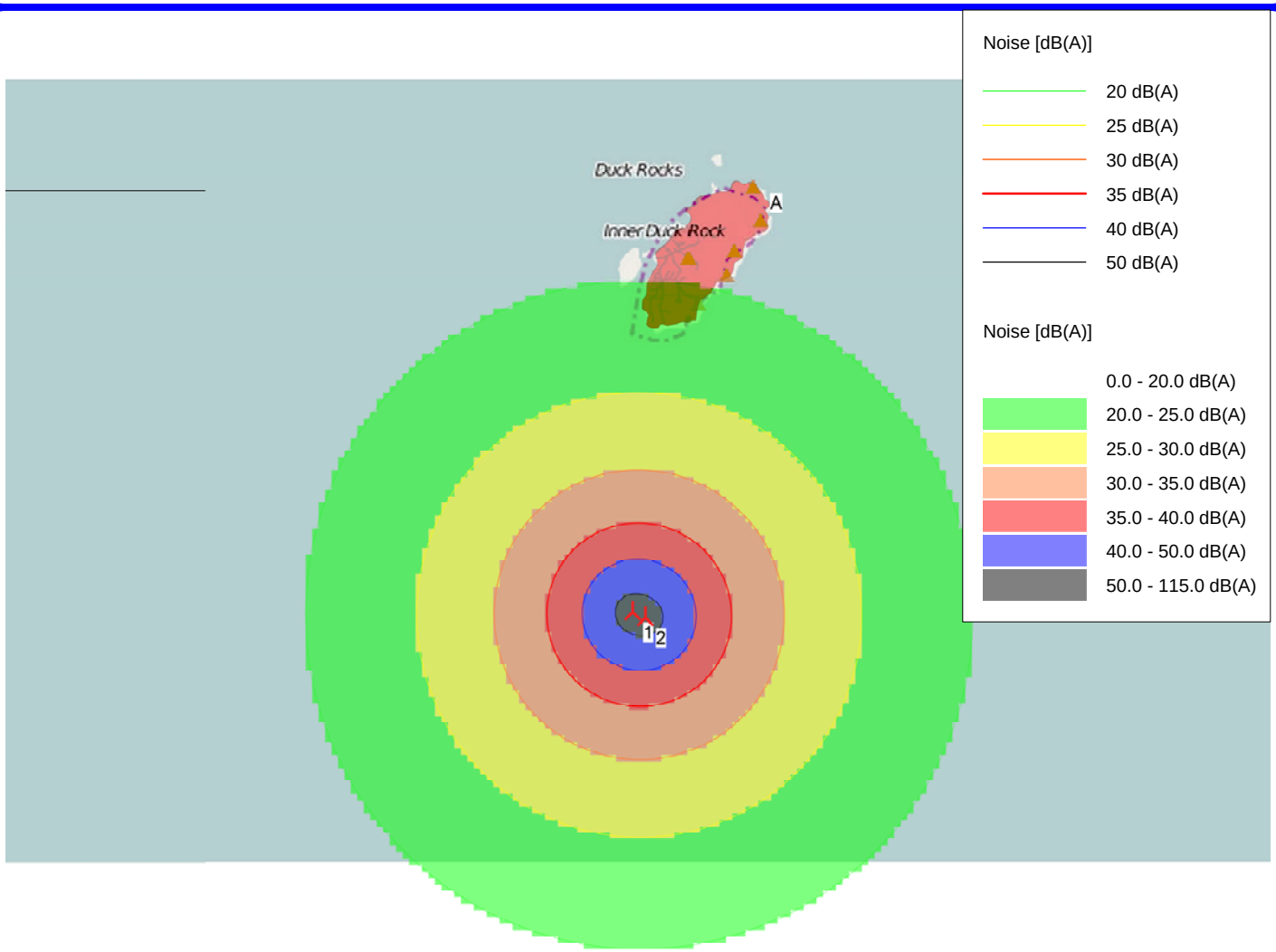
DECIBEL - Map 8.0 m/s

Calculation: ENERCON 7.5 MW Standard **Noise calculation model:** Swedish 2009 8.0 m/s



0 1 2 3 4 km

Map: WindPRO map , Print scale 1:100,000, Map center Geo WGS84 East: -69.324144° East North: 43.719168° North

New WTG Noise sensitive area

Noise calculation model: Swedish 2009. Wind speed: 8.0 m/s
Height above sea level from active line object

Project:
Monhegan Island Turbine Noise 2013

Description:
Two 6.0 MW Goldwind floating offshore wind turbines are planned approximately 3 nautical miles offshore from Monhegan Island, Maine. Inhabitats have expressed concern with the noise levels, prompting this study.
The 2009 Swedish code is a revision of the Swedish 2002 code. A roughness coefficient is replaced with a standard IEC profile of 0.05 m. The distance at which geometric spreading changes from spherical to cylindrical changed from 200 m to 700 m.

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Calculated:
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DECIBEL - Main Result

Calculation: Goldwind 6 MW Custom

SWEDISH RULES FOR NOISE CALCULATION.

The calculation is based on the "Ljud frånvindkraftverk", 2010 (NV dnr 382-6897-07 Rv)

Scale 1:200,000

New WTG Noise sensitive area

WTGs

	Geo [deg]-WGS84				WTG type						Noise data				
	Longitude	Latitude	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Creator	Name	Wind speed	LwA,ref	Pure tones
			[m]					[kW]	[m]	[m]			[m/s]	[dB(A)]	
1	-69.325371° East	43.718239° North	0.0	Goldwind GW6.0-152 6000 1...	Yes	Goldwind	GW6.0-152-6,000	6,000	152.2	100.0	USER	Level 0 - Estimated - 115 dB - 09-2013	8.0	115.0	No h
2	-69.323052° East	43.717498° North	0.0	Goldwind GW6.0-152 6000 1...	Yes	Goldwind	GW6.0-152-6,000	6,000	152.2	100.0	USER	Level 0 - Estimated - 115 dB - 09-2013	8.0	115.0	No h

h) Generic octave distribution used

Calculation Results

Sound Level

Noise sensitive area		Geo [deg]-WGS84				Demands	Sound Level		Demands fulfilled ?
No.	Name	Longitude	Latitude	Z	Imission height	Noise	From WTGs	Distance to noise demand	Noise
				[m]	[m]	[dB(A)]	[dB(A)]	[m]	
A	Noise sensitive area: Main Island	-69.321328° East	43.755586° North	39.5	1.5	44.0	29.4	3,027	Yes

Distances (m)

WTG	A
1	4161
2	4232

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DECIBEL - Detailed results

Calculation: Goldwind 6 MW Custom**Noise calculation model:** Swedish 2009 8.0 m/s

Assumptions

Calculated L(DW) = LWA,ref + K + Dc - (Adiv + Aatm + Agr + Abar + Amisc) - Cmet
(when calculated with ground attenuation, then Dc = Domega)

LWA,ref:	Sound pressure level at WTG
K:	Pure tone
Dc:	Directivity correction
Adiv:	the attenuation due to geometrical divergence
Aatm:	the attenuation due to atmospheric absorption
Agr:	the attenuation due to ground effect
Abar:	the attenuation due to a barrier
Amisc:	the attenuation due to miscellaneous other effects
Cmet:	Meteorological correction

Calculation Results

Noise sensitive area: A Noise sensitive area: Main Island

WTG **Wind speed: 8.0 m/s**

No.	Distance [m]	Sound distance [m]	Land distance [m]	Calculated [dB(A)]	LwA,ref [dB(A)]	Dc [dB]	Adiv [dB]	Aatm [dB]	Agr [dB]	Abar [dB]	Amisc [dB]	A [dB]	Cmet [dB]
1	4,161	4,162	4,161	**26.52**	115.0	0.00	0.00	-	0.00	0.00	0.00	-	0.00
2	4,232	4,234	4,232	**26.31**	115.0	0.00	0.00	-	0.00	0.00	0.00	-	0.00

Sum 29.42

- Data undefined due to calculation with octave data

Project:
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DECIBEL - Assumptions for noise calculation

Calculation: Goldwind 6 MW Custom**Noise calculation model:** Swedish 2009 8.0 m/s

Noise calculation model:
Swedish 2009
Wind speed:
8.0 m/s
Ground attenuation:
None
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Pure tones:
Pure tone penalty are added to demand: 5.0 dB(A)
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)
Octave data required
Air absorption

63 [db/km]	125 [db/km]	250 [db/km]	500 [db/km]	1,000 [db/km]	2,000 [db/km]	4,000 [db/km]	8,000 [db/km]
0.1	0.3	0.6	1.4	3.2	7.9	22.0	50.0

WTG: Goldwind GW6.0-152 6000 152.2 !O!
Noise: Level 0 - Estimated - 115 dB - 09-2013

Source	Source/Date	Creator	Edited
Manufacturer	9/20/2013	USER	10/3/2013 1:08 PM

Based on Goldwind 128/6000 Wind Turbine Specification

						Octave data							
Status	Hub height [m]	Wind speed [m/s]	LwA,ref [dB(A)]	Pure tones		63 [dB]	125 [dB]	250 [dB]	500 [dB]	1000 [dB]	2000 [dB]	4000 [dB]	8000 [dB]
From Windcat	100.0	8.0	115.0	No	Generic data	96.6	103.6	107.0	109.6	109.4	106.5	101.7	92.2

NSA: Noise sensitive area: Main Island-A
Predefined calculation standard:
Imission height(a.g.l.): 1.5 m

Noise demand: 44.0 dB(A)
Distance demand:

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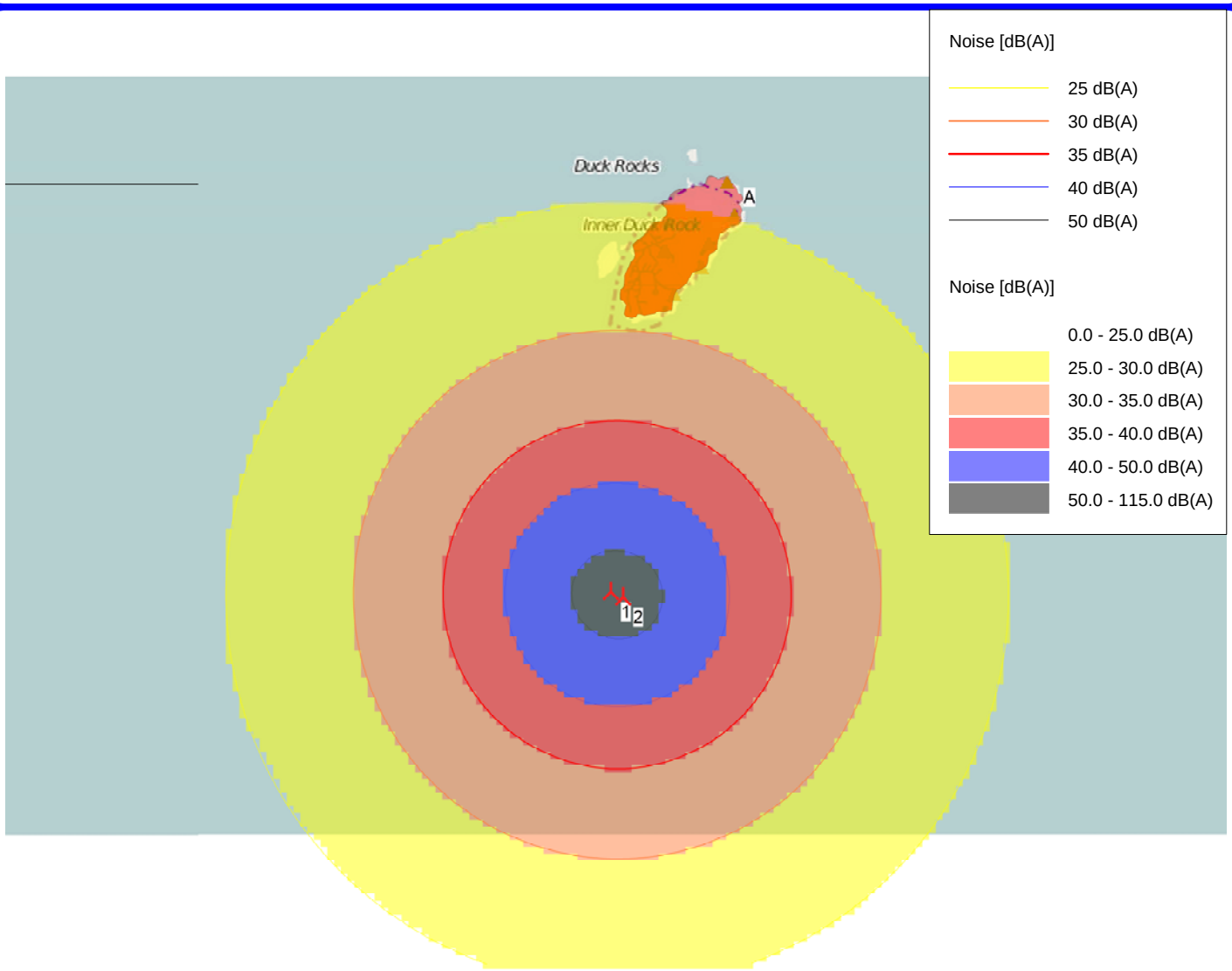

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New WTG Noise sensitive area

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U.S. DEPARTMENT OF
ENERGY

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