Appendix C – Noise Study

Noise Impact Assessment
for the
Proposed Eastern Kings Wind Plant – Phase 2

Revision 1

Prepared for:

PEI Energy Corporation

Prepared by:

Frontier Power Systems Inc.
PO Box 22068 Parkdale
Charlottetown, PE
C1A 9J2

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1.0 Introduction

Frontier Power Systems Inc has been engaged by the PEI Energy Corporation to conduct a noise impact assessment of the proposed Eastern Kings Wind Plant – Phase 2, located in Kings County, Prince Edward Island.

The project will consist of 7 wind turbines and have a total generating capacity of 29.4MW. The proposed turbines have a 138m rotor diameter, a hub height of 108m, and generating capacity of 4.2MW each.

This report outlines the following activities which were required to complete the noise impact assessment:

- Acquisition and review of noise data for the proposed wind turbine generator.
- Identification of all noise sensitive areas (noise receptors) within 1500 meters of the existing and proposed turbine sites.
- Noise propagation modeling using the ISO 9613-2 calculation method.
- Prediction of noise levels at each noise receptor, mapping of noise contours, and comparison to regulatory limits.

2.0 Site Description

The proposed East Kings Wind Plant – Phase 2 (EKWP2) is located on the northeastern tip of the Province of PEI between Elmira and East Point, Kings County. It is within the Rural Municipality of Eastern Kings, approximately 20 kilometers east of the Town of Souris. The project is located to the south of an existing 30 MW wind plant that was installed in 2006. Electrical connection of the EKWP2 project will be made through the existing substation.

The project footprint represents approximately 140 hectares (ha). The project area is composed of forested land that is predominantly mixed and the general surrounding land use is agriculture.

A number of residential properties are located in the vicinity of the project area, along the Elmira Road, to the east of the project, the Northside Road to the north and the East Point Road to the south and east.

3.0 Noise Sources

3.*1* *Turbine Description*

The Enercon E138/4.2 is the proposed wind turbine for the EKWP2 project. The E138/4.2 is a 3 bladed, up-wind, pitch regulated turbine, mounted on a tubular steel tower. The proposed configuration has a 138m rotor diameter, a generating capacity of

4.2MW, and a hub height of 108m. The cut-in wind speed is 3m/s and cut-out wind speed is 25m/s. Rated power is reached at a wind speed of approximately 14m/s. The rotational speed of the rotor ranges from 5.0 RPM to 11.1 RPM. These general specifications are summarized in table 1.

E138 EP3-108-4.2 General Specifications	
Rotor Diameter (m)	138
Hub Height (m)	108
Generating Capacity (MW)	4.2
Cut-in Wind Speed (m/s)	2
Cut-out Wind Speed (m/s)	28
Wind Speed for Rated Power (m/s)	14
Rotor Speed (RPM)	5.0 – 11.1

Table 1: Turbine General Specifications

3.2 *Turbine Noise Data*

Noise emission data for the E-138 EP3-108,4.2 MW turbine was obtained from the turbine manufacturer in accordance with the IEC 61400-11 standard for wind turbine noise measurement.

The Enercon document "Annex 03-04 Power Curve, Sound Power Level and Thrust Coefficient" provides overall and octave band sound power levels at various wind speeds and hub heights for the E138 EP3-108/4.2 The highest expected sound power level is 106.0 dB(A).

3.2.1 Octave Sound Power Levels

The ISO 9613-2 noise model calculates atmospheric attenuation by octave band and therefore, octave sound power levels are required as input to the model. Octave sound power levels were provided by the turbine manufacturer and are summarized in Table 2 below.

E138 EP3-108/4.2 Octave Sound Power Data	
Octave Band	L_{wa}
Hz	dB(A)
31.5	75.5
63	87.2
125	93.0

250	95.7
500	98.2
1000	100
2000	100.9
4000	96.4
8000	81.5

Table 2: Octave Sound Power Data

3.2.2 Tonality

Tonality is a characteristic of noise which is caused by high sound power levels at a narrow band of frequencies, when compared to the rest of the frequency spectrum. Generally, noise containing tones is more perceptible to the human ear and increases the likelihood of annoyance. Most wind turbine noise is broadband and distributed across the audible frequency spectrum. However, mechanical noise from the gearbox, generator, and other ancillary equipment in the nacelle has the potential to contain tones.

The measurement of tonality is a requirement under the IEC 61400-11 standard. The noise specification document for the E138 EP3108/4.2 (Annex 03-04 Power Curve, Sound Power Level and Thrust Coefficient) indicates that tonal audibility will be less than 1 dB over the entire operational range. Tonal audibility lower than 4 dB is not considered significant under ISO 1996-2, Annex C, "Objective method for assessing the audibility of tones in noise". This is consistent with reduced mechanical noise from the direct drive design and indicates tonality should not be an issue.

3.2.3 Low Frequency Noise

Low frequency noise or 'infrasound' has not been considered in this noise impact assessment. Low frequency noise testing is not required under IEC 61400-11. In general, modern wind turbines do not exhibit significant low frequency noise emissions.

3.3 Wind Farm Layout

The turbine layout was determined using a wind farm design software package to optimize the turbine sites for energy generation. The software includes a noise propagation model, which prevents the optimization process from placing turbines where they will exceed the specified noise limit at nearby receptor locations. The proposed wind farm layout is shown in figure 1 and UTM coordinates for the 7 turbines are summarized in table 3.

Turbine Coordinates (UTM Zone 20 NAD83)			
Turbine ID	Easting (m)	Northing (m)	Elevation (m asl.)
1	572895	5143987	28
2	573410	5144075	26
3	573969	5144214	18
4	574571	5144208	18
5	575015	5144142	18
6	573486	5142950	28
7	573866	5143231	23

Table 3: Turbine Coordinates

3.4 Existing Wind Farm

The proposed project is located to the south of ten (10) existing wind turbines. These are Vestas V90 3MW turbines on 80m towers. The existing turbines were included as noise sources in the noise propagation model. The predicted sound pressure level at all receptor locations is the cumulative result from both proposed and existing wind turbines.

4 Noise Receptors

The project area was assessed to identify all noise sensitive areas (receptors) within 1500m of the proposed and existing turbine sites. In most cases receptors up to 2000m or more were also included. A total 132 receptors were identified, consisting primarily of permanent residences, seasonal residences, and several buildings which appear to be uninhabited. Figure 1 shows the receptor database in relation to the proposed turbine sites. The receptor coordinates are summarized in table 4.

Noise Receptor Coordinates (UTM Zone 20 NAD83)									
Receptor ID	Easting (m)	Northing (m)	Elevation (m asl.)	Distance to Nearest Turbine (m)	Receptor ID	Easting (m)	Northing (m)	Elevation (m asl.)	Distance to Nearest Turbine (m)
1	571319	5145149	23	1958	67	573790	5141850	30	1142
2	571472	5145214	22	1879	68	573700	5141935	34	1037
3	571550	5145281	21	1867	69	573575	5141873	34	1081
4	571636	5145356	20	1860	70	573508	5141852	34	1099
5	571448	5145478	16	2078	71	573476	5141615	33	1335
6	571673	5145527	16	1966	72	573403	5141644	33	1308
7	571791	5145657	14	2002	73	573348	5141606	35	1351
8	571888	5145662	15	1955	74	573224	5141632	36	1343
9	571894	5145753	14	2030	75	573158	5141559	38	1429
10	572494	5145991	6	2043	76	573232	5141526	36	1447
11	572668	5145406	15	1437	77	573103	5141443	37	1555

12	572726	5146112	6	2131	78	573077	5141542	38	1466
13	572786	5146167	6	2183	79	573032	5141486	38	1533
14	573097	5145972	9	1923	80	572857	5141466	38	1611
15	573141	5146014	11	1958	81	572827	5141453	37	1635
16	573139	5146091	12	2034	82	572806	5141350	31	1738
17	573262	5146118	13	2031	83	572754	5141331	30	1777
18	573361	5146015	14	1901	84	572572	5141389	34	1809
19	572943	5146223	9	2198	85	572610	5141175	22	1979
20	573180	5146177	12	2114	86	573032	5141648	38	1379
21	573106	5146311	6	2257	87	572942	5141687	36	1375
22	573232	5146299	7	2212	88	572883	5142049	33	1084
23	573303	5146206	12	2101	89	572838	5142134	32	1042
24	573496	5146296	8	2135	90	572734	5142135	32	1108
25	573509	5146323	8	2159	91	572494	5142530	33	1077
26	574367	5146236	10	2038	92	572520	5142671	34	1005
27	574640	5145982	14	1775	93	572481	5142725	35	1030
28	574644	5145909	16	1702	94	572367	5142802	39	1129
29	574725	5145949	14	1748	95	572259	5142883	40	1229
30	575150	5145912	9	1775	96	572327	5142922	39	1160
31	575016	5145614	13	1472	97	572363	5142978	38	1123
32	576236	5145564	10	1874	98	572264	5143018	37	1157
33	576349	5145541	12	1934	99	572204	5142972	38	1228
34	576380	5145322	14	1804	100	572154	5143006	38	1230
35	576463	5145367	14	1896	101	572235	5143054	37	1143
36	576502	5145318	15	1896	102	572222	5143177	36	1053
37	576540	5145338	15	1938	103	572063	5143106	37	1212
38	576539	5145522	13	2056	104	572029	5143131	37	1218
39	576605	5145570	12	2137	105	571956	5143220	37	1213
40	576649	5145588	12	2181	106	572099	5143264	36	1075
41	576730	5145595	11	2247	107	572206	5143259	36	1002
42	576753	5145648	10	2299	108	571988	5143321	36	1125
43	577007	5145119	15	2218	109	571903	5143283	37	1216
44	577151	5145129	14	2353	110	571945	5143339	36	1150
45	577130	5144542	16	2153	111	572037	5143381	36	1051
46	577072	5144355	16	2068	112	571931	5143398	36	1130
47	577171	5144289	13	2161	113	571795	5143338	37	1278
48	577447	5144367	14	2442	114	571735	5143404	36	1298
49	577549	5144291	14	2538	115	571733	5143436	36	1286
50	576921	5144254	12	1909	116	571697	5143470	35	1305
51	576816	5144180	9	1802	117	571740	5143525	35	1244
52	576605	5144048	8	1593	118	571800	5143531	35	1186
53	576229	5143656	14	1308	119	571654	5143532	34	1322
54	576607	5143536	7	1703	120	571212	5143645	34	1718
55	577280	5143205	6	2451	121	571050	5143617	41	1882
56	576578	5142851	10	2027	122	571328	5143788	33	1579
57	576589	5142741	8	2107	123	571178	5143909	37	1719
58	575603	5143138	22	1163	124	571094	5143847	40	1806

59	575501	5143151	23	1103	125	571165	5144123	35	1735
60	575200	5143007	28	1150	126	571165	5144362	37	1770
61	575062	5142943	30	1200	127	571322	5144397	34	1626
62	574681	5142641	29	1006	128	570970	5144822	30	2098
63	575246	5142361	6	1632	129	570923	5144883	28	2166
64	575148	5142285	5	1593	130	570768	5144695	37	2242
65	574700	5142249	17	1288	131	570574	5144737	36	2439
66	573822	5141941	32	1063	132	570495	5144924	28	2577

Table 4: Noise Receptor Coordinates

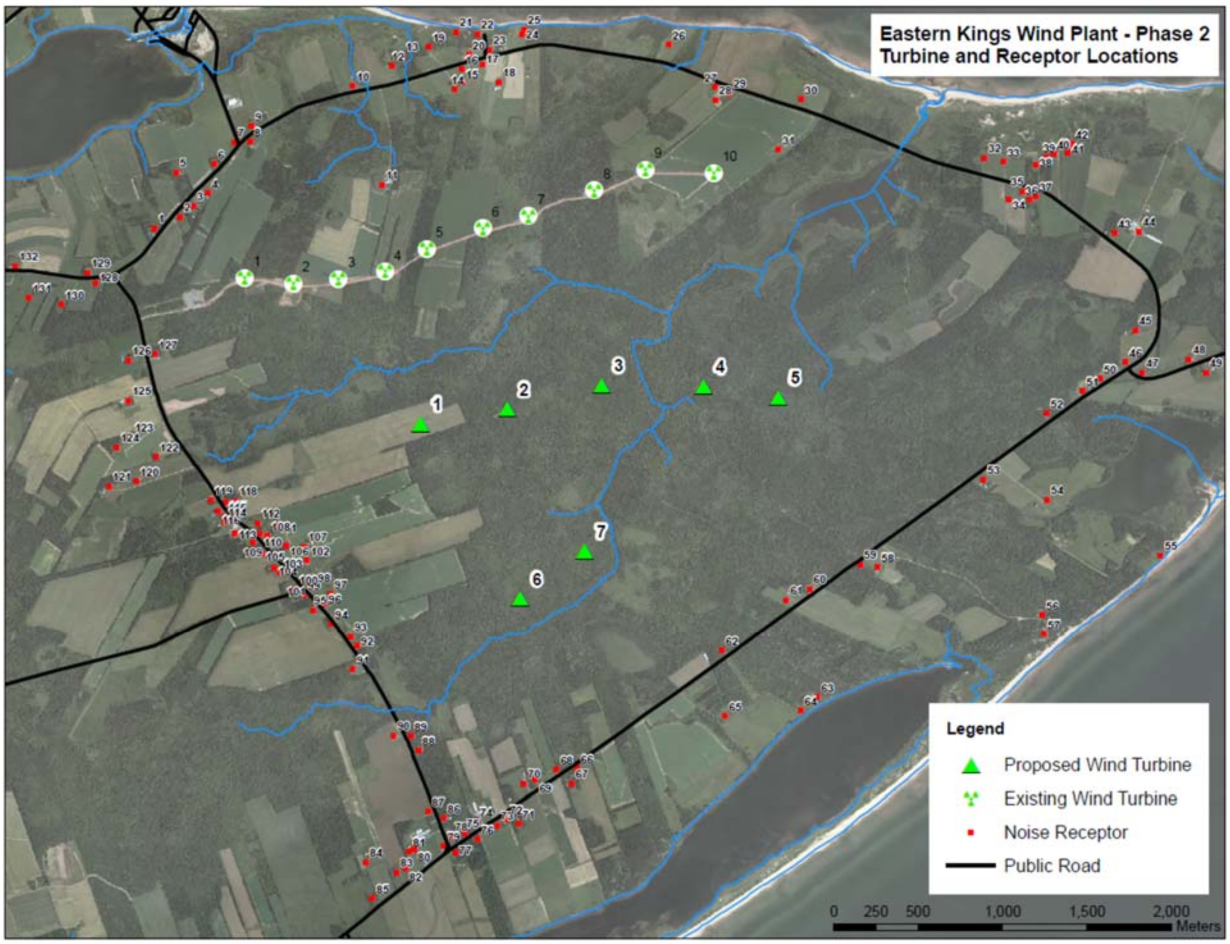

Figure 1: Turbine Sites and Noise Receptors

5 Noise Impact Assessment

5.1 Methodology

The noise impact assessment was conducted by predicting the sound pressure level (noise) from the wind turbines at each receptor location, and comparing to a specified noise limit. The receptor noise levels were predicted using a 3 dimensional noise propagation model based on ISO 9613-2 “Acoustics - Attenuation of sound during propagation outdoors”. The noise model considers frequency dependant attenuation due to geometric divergence, atmospheric absorption, and ground effect. The model is valid for downwind propagation under a well-developed moderate ground based temperature inversion, which are conditions favorable to noise propagation from source to receiver. The parameters for the noise model are explained in more detail below. The noise model does not consider building acoustics, and therefore the predicted noise levels are valid at the exterior of a receptor building.

5.2 Allowable Noise Limits

Currently there is no provincially or federally regulated noise limit for wind farms on Prince Edward Island. A noise limit of 45 dB(A) is a commonly used guideline for this jurisdiction. The World Health Organization’s “Guidelines for Community Noise” identifies the main health risks associated with noise and derives acceptable environmental noise limits for various activities and environments. These noise limits identify 50 dB(A) as the point at which moderate annoyance can begin in outdoor living areas. 45 dB(A) is identified as the noise limit outside of a bedroom with the window open, before sleep disturbance can become an issue. The noise limit used for this noise impact assessment is 45 dB(A).

5.3 Model Parameters

5.3.1 Atmospheric Attenuation Coefficients

Atmospheric attenuation coefficients depend strongly on the frequency of the sound, ambient temperature, and the relative humidity of the air. The atmospheric attenuation coefficients used for this analysis are valid for 10ºC and 70% relative humidity. These values are commonly used and represent a conservative choice. Table 5 summarizes the atmospheric attenuation coefficients.

Atmospheric Attenuation Coefficients	
Octave Band	Attenuation Coefficient
(Hz)	(dB/km)
31.5	0.0
63	0.1
125	0.4
250	1.0
500	1.9
1000	3.7
2000	9.7
4000	32.8

8000	117.0

Table 5: Atmospheric Attenuation Coefficients

5.3.2 Ground Factor

Ground attenuation is mainly the result of sound reflected by the ground surface interfering with the sound propagating directly from the source to the receiver. Ground attenuation is included in the noise propagation model and requires specification of a ground factor (G). Hard ground, such as pavement, rock, concrete, water, ice, and tamped ground, has a ground factor G = 0. Hard ground results in higher noise levels at the receiver. Porous ground, such as ground covered by grass, trees, or suitable for the growth of vegetation, including farmland, has a ground factor G = 1. Porous ground results in lower noise levels at the receiver. Mixed ground is a combination of both hard and porous ground, and has a ground factor between 0 and 1, the value being the fraction of the ground that is porous.

A ground factor of 0.7 was used in this noise model. This value is conservative in that more than 70% of the ground within the modeling area could be considered suitable for the growth of vegetation.

5.3.3 Meteorological Correction Factor

The ISO 9613-2 method considers downwind meteorological conditions favorable to noise propagation from source to receiver. In the case of a wind farm this results in the conservative assumption that all receivers are always downwind from every turbine. In reality this would require an omni-directional wind, or wind blowing from all directions simultaneously. A meteorological correction factor can be applied to predict the long term average sound pressure levels encompassing a wider variety of meteorological conditions.

To maintain a conservative noise analysis, no meteorological correction factor was applied.

5.4 Results

5.4.1 Predicted Noise Levels

The predicted noise level for each receptor is presented in table 6. The predicted noise level is below 45 dB(A) for all receptors, with the exception of receptor 11, which is a participating landowner. It is also important to note that the predicted noise levels for receptors directly north of the phase 1 turbines (receptors 1 through 31) are essentially unchanged by the addition of the proposed phase 2 turbines. The maximum increase in predicted noise level is less than 0.5 dB(A) at any of these receptors.

Predicted Noise Levels

Receptor ID	Sound Pressure Level (dB(A)	Receptor ID	Sound Pressure Level (dB(A)
1	42.92	67	35.52
2	44.25	68	36.15
3	44.51	69	35.79
4	44.56	70	35.65
5	42.06	71	34.28
6	43.23	72	34.42
7	42.78	73	34.2
8	43.2	74	34.25
9	42.48	75	33.84
10	42.57	76	33.74
11	48.91	77	33.27
12	42.2	78	33.69
13	41.91	79	33.4
14	44.14	80	33.14
15	43.85	81	33.05
16	43.18	82	32.62
17	43.15	83	32.49
18	44.23	84	32.51
19	41.79	85	31.78
20	42.53	86	34.15
21	41.38	87	34.22
22	41.64	88	35.98
23	42.46	89	36.33
24	41.92	90	36.04
25	41.71	91	37.14
26	41.99	92	37.88
27	43.77	93	37.97
28	44.73	94	37.9
29	43.7	95	37.9
30	40.53	96	38.3
31	44.05	97	38.68
32	34.51	98	38.54
33	34.03	99	38.13
34	34.11	100	38.13
35	33.71	101	38.61
36	33.59	102	39.17
37	33.41	103	38.31
38	33.25	104	38.32
39	32.94	105	38.51
40	32.75	106	39.21
41	32.44	107	39.55
42	32.31	108	39.12
43	31.76	109	38.65
44	31.26	110	39.07
45	31.42	111	39.61

46	31.59	112	39.33
47	31.22	113	38.55
48	30.35	114	38.68
49	30.02	115	38.83
50	32.1	116	38.87
51	32.47	117	39.32
52	33.26	118	39.58
53	34.53	119	39.03
54	32.67	120	37.73
55	30.03	121	36.91
56	31.58	122	38.93
57	31.34	123	38.73
58	35.96	124	38.02
59	36.45	125	39.61
60	37.01	126	40.65
61	37.24	127	42.2
62	37.48	128	39.93
63	34.32	129	39.52
64	34.34	130	38.24
65	35.57	131	36.94
66	36.07	132	36.46

Table 6: Predicted Noise Levels

5.4.2 Noise Contour Map

A noise contour map was produced to show the predicted noise levels throughout the project area. The noise contour map is shown in figure 2.

Figure 2: Noise Contour Map

5.5 *Model Qualifications*

The accuracy of the ISO 9613-2 method is limited to approximately +/- 3 dB. Due to the uncertainty associated with noise propagation modeling, it important to use conservative input data and parameters for the model. The noise model and input data used for this analysis contain the following conservative input data:

- Worst case turbine sound power level of 106.0 dB(A) under all operating conditions.
- A ground factor of 0.7 when the actual fraction of porous ground is actually in excess of 0.9.
- Modeling favorable downwind propagation conditions for all turbine sites simultaneously.

Given the conservativeness of the noise model inputs and parameters, the predicted noise levels at the receptors should be somewhat 'worst case' compared to the long term average noise levels that are actually encountered. However, there may be certain conditions under which the noise level at a receptor is higher than, or is perceived to be higher than, what is predicted. These conditions could include periods of high atmospheric stability and high wind shear, leading to low background noise levels at ground level. Temperature inversions may also periodically increase the sound pressure level at a receptor.

6.0 Conclusions and Recommendations

The noise impact from the proposed Eastern Kings Wind Project- Phase 2 has been assessed by modeling the noise propagation from the wind turbines and comparing the predicted noise levels to an established noise limit. The noise limit used for this assessment was 45 dB(A). The predicted noise levels do not exceed 45 dB(A) at any of the receptors surrounding the project area, with the exception of receptor 11, which is a participating landowner. It is important to note that the predicted noise levels for receptors directly north of the phase 1 turbines (receptors 1 through 31) are essentially unchanged by the addition of the proposed phase 2 turbines. The maximum increase in predicted noise level is less than 0.5 dB(A) at each of these receptors. No adverse impact related to noise is expected during normal operation of the proposed wind farm. It is also important to add that Phase 2 of the development has a very modest impact on those receptors that were previously unaffected by the original wind plant installed in 2006. Those receptors, particularly along the southern sections of the Elmira Road and along the East Point Road to the south are predicted to have noise levels less than 40 dB(A)

Due to the variability in human perception of noise and the potential occurrence of higher noise levels during some meteorological conditions, certain noise complaint mitigation measures may be required. It is recommended that wind farm operator establish a noise complaint mitigation protocol to receive, assess, and respond to potential noise complaints. An adaptive management approach may be appropriate. This could include upgrades to houses for improved noise impedance or installation of noise screens to provide additional noise attenuation. This could also include noise reduced operation (reduced power output) of certain turbines under certain conditions if they are identified as problematic.

7.0 References

Enercon (2019). Annex 03-04 Power Curve, Sound Power Level and Thrust Coefficient.

IEC 61400-11 (2006). Wind turbine generator systems – Part 11: Acoustic noise measurement techniques. Edition 2.1

ISO 1996-2 (1997). Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels. Second edition.

ISO 9613-2 (1996). Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation. First edition.

Ontario Ministry of Environment (2008). Noise guidelines for wind farms. Interpretation for applying MOE NPC publications to wind power generation facilities. MOE PIBS 4709e

World Health Organization (1999). Guidelines for Community Noise. http://www.who.int/docstore/peh/noise/guidelines2.html