Appendix 13 Noise and Shadow Flicker Modelling

February 20, 2015

Mr. Trent MacDonald
EON WIndElectric
#200 - 300 Prince Albert Road
Dartmouth, NS B2Y 4J2

Dear Mr. MacDonald,

Re: Sound and Shadow Flicker Modeling Results
Harrietsfield - Williamswood Wind Power Project, Halifax County, NS

INTRODUCTION

Watts Wind Energy Inc. (WWEI) is proposing the development of the Harrietsfield - Williamswood Wind Power Project (the Project) near the communities of Harrietsfield and Williamswood in Halifax County, NS. The Project consists of three General Electric (GE) 1.6 MW turbines.

To support Project planning and the Nova Scotia Environmental Assessment (EA) process, Strum completed the following sound and shadow flicker modelling assessments.

BACKGROUND

Wind Turbines and Noise

Wind turbines generate sound both through the movement of mechanical equipment inside the nacelle and through the interaction of the blades with the air as they rotate around the nacelle. In modern turbine designs, much of the mechanical noise is mitigated through the use of noise insulating materials. Aerodynamic sound resulting from blade rotation is an unavoidable by-product of wind energy generation, although advances in blade engineering have greatly reduced the sound power level emitted from operating turbines. The sound pressure level at a given point in the landscape surrounding the wind turbine is influenced by propagation distance, local topography, atmospheric conditions, and vegetative cover (Hau 2006).

Nova Scotia has no specific sound guidelines for wind farms; however, through the EA process, Nova Scotia Environment (NSE) requires that predicted noise levels at identified residential receptors (as well as daycares, hospitals, and schools) not exceed 40 dBA. As this guideline is intended to be protective of human sleep disturbance, 40 dBA does not apply to commercial or vacant lot receptors. This guideline was used in the current sound assessment for the Project.

Wind Turbines and Shadow Flicker

The rotating blades of a wind turbine can cast a moving shadow on locations within a certain distance of the turbine. This intermittent shadow, perceived as a change in light intensity to an observer, is referred to as shadow flicker. The potential impact area depends on the time of year and day and the wind turbine's physical characteristics (height, rotor diameter, blade width, and orientation of the rotor blades).

For shadow flicker to occur, the following criteria must be met:

- The sun must be shining and not be obscured by clouds/fog.
- The source turbine must be operating.
- The wind turbine must be situated between the sun and the shadow receptor.
- The wind turbine must be facing directly towards, or away from, the sun such that the rotational plane of the blades (rotor plane) is perpendicular to the azimuth of incident sun rays. For this to occur, the wind direction would have to be parallel to the azimuth of the incident sun rays throughout the day.
- The line of sight between the turbine and the shadow receptor must be clear. Light-impermeable obstacles, such as vegetation, tall structures, etc., will prevent shadow flicker from occurring at the receptor.
- The shadow receptor has to be close enough to the turbine to be in the shadow.

There are no municipal, provincial, or federal guidelines related to shadow flicker, but many jurisdictions (including NSE) have adopted the industry standard of no more than 30 hours of shadow flicker per year, or no more than 30 minutes of shadow flicker on the worst day of the year. These guidelines were developed in Germany to prevent excessive annoyance to neighbours of wind energy developments and are now included under that country's *Federal Emission Control Act* (as cited in Haugen 2011). These guidelines were used in the current shadow flicker assessment for the Project.

ASSESSMENT METHODOLOGY AND RESULTS

Project Layout and Turbine Characteristics

All modelling was based on the Project layout and the GE 1.6-82.5 turbine model. The precise coordinates and locations of each turbine are:

- **T1:** 44° 32' 22.58" N, 63° 36' 40.41" W
- **T2:** 44° 32' 12.69" N, 63° 36' 35.92" W
- **T3:** 44° 31' 59.14" N, 63° 36' 40.28" W

The GE 1.6-82.5 turbine model has the following structural characteristics (GE 2012):

- Hub height – 80 m;
- Rotor diameter – 82.5 m.

Sound Assessment

Sound Methodology

An acoustic assessment was conducted for the Project to predict sound pressure levels at identified receptors within a 2 km radius of the proposed turbine locations. The assessment was completed using the "Decibel" module of the WindPro v. 3.0 software package. For the purposes of this model, receptors included all structures identified in the provincial topographic mapping, as well as any additional identifiable structures based on aerial imagery. No attempt to distinguish sheds and outbuildings from dwellings or cottages was made.

The sound assessment model followed ISO 9613-2 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method and calculations, and was based on the following input information:

- UTM coordinates for the wind turbines;
- UTM coordinates for existing receptors (12) within a 2 km radius of the Project site;
- A wind speed of 7 m/s, the speed at which the highest sound power level output is achieved (based on test data from the manufacturer);
- Overall sound emission data for the GE 1.6-82.5, provided by the manufacturer in the document "Technical Documentation Wind Turbine Generator Systems 1.6-82.5 - 50 Hz and 60 Hz 1.68-82.5 - 60 Hz" (GE 2012);
- Topographic data for the surrounding area; and
- 1/1 octave level data provided by the manufacturer.

The ISO 9613-2 calculation method assumes meteorological conditions that are ideal for noise propagation, including a ground temperature of 10^{o}C and 70% relative humidity. A conservative ground factor of 0.7 was applied to the model, although the forested nature of the landscape (e.g. predominantly porous ground which is capable of supporting vegetative growth) could support a higher value.

Sound Modelling Results

Modelling results are provided in Table 1 (attached) and indicate that predicted sound pressure levels will not exceed 40 dBA at any existing receptor (Drawing 1, attached).

Shadow Flicker Assessment

Shadow Flicker Methodology

A shadow flicker assessment was completed for the Project to assess the potential impact of shadows at identified receptors within a 2 km radius of the proposed turbine locations. Receptors were identified using the same methodology as described in the previous section for the sound assessment. The assessment was completed using the "Shadow" module of the WindPro v. 3.0 software package using worst case scenario conditions, including:

- Constant sunshine during daylight hours;
- Turbines are always operational;
- Turbine blades are oriented perpendicular to the line between the sun and all receptors;
- No obstructions are present that may obscure shadows; and
- Receptor windows are oriented towards the turbine(s).

The extent of the shadow zone of each turbine was calculated in consideration of the structural characteristics of the turbine, according to guidelines used in Germany (WindPro 2012).

Shadow Flicker Results
Modelling results are provided in Table 2 (attached) and indicate that all existing receptors are predicted to comply with the industry standard of no more than 30 minutes of shadow on the worst day and no more than 30 hours of shadow flicker per year (Drawing 2, attached).

CONCLUSIONS

An evaluation of potential sound and shadow flicker levels of the Harrietsfield – Williamswood Wind Power Project was completed. Based on predictive modelling, sound and shadow flicker levels are not expected to exceed NSE guidelines or accepted industry standards at any existing receptor.

Once you have had an opportunity to review this correspondence, please contact us to address any questions you may have.

Thank you,

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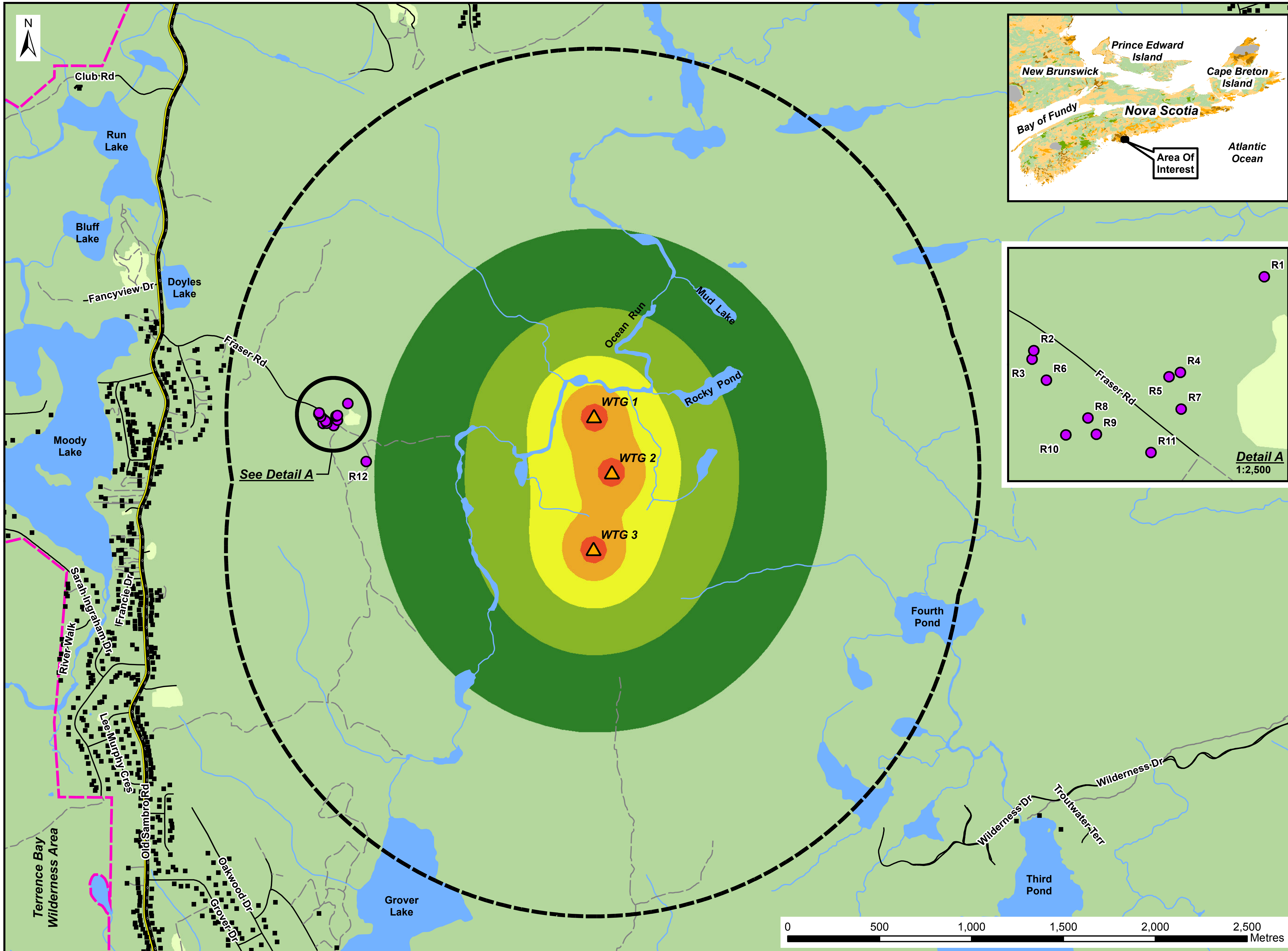
REFERENCES

General Electric. 2012. Technical Documentation Wind Turbine Generator Systems 1.6-82.5 - 50 Hz and 60 Hz 1.68-82.5 - 60 Hz. 7 pp.

Haugen K.M.B. 2011. International review of policies and recommendations for wind turbine setbacks from residences: setbacks, noise, shadow flicker, and other concerns. Minnesota Department of Commerce: Energy Facility Permitting. 43 pp.

WindPRO. 2012. Environment Manual Section 4.2.1



Notes:

1. Reference: Digital Topographic Mapping & Property Management Unit MU0802 by Nova Scotia Geomatics Centre. Nova Scotia Property Records.
2. Projection: NAD83(CSRS), UTM Zone 20 North.
3. Noise Calculation Model was Done in Accorddance with ISO 9613-2 General Guidelines and Using Wind Turbine Data Supplied by Client

Legend:

- Proposed Turbine
- Existing Receptors
- 2km Buffer
- Building
- Wilderness Area
- Major Roads and Highways
- Public Roads
- Access Roads / Trails
- Mapped Stream
- Mapped Indefinite Stream
- Water Bodies
- Cleared Area

Sound Modeling Results

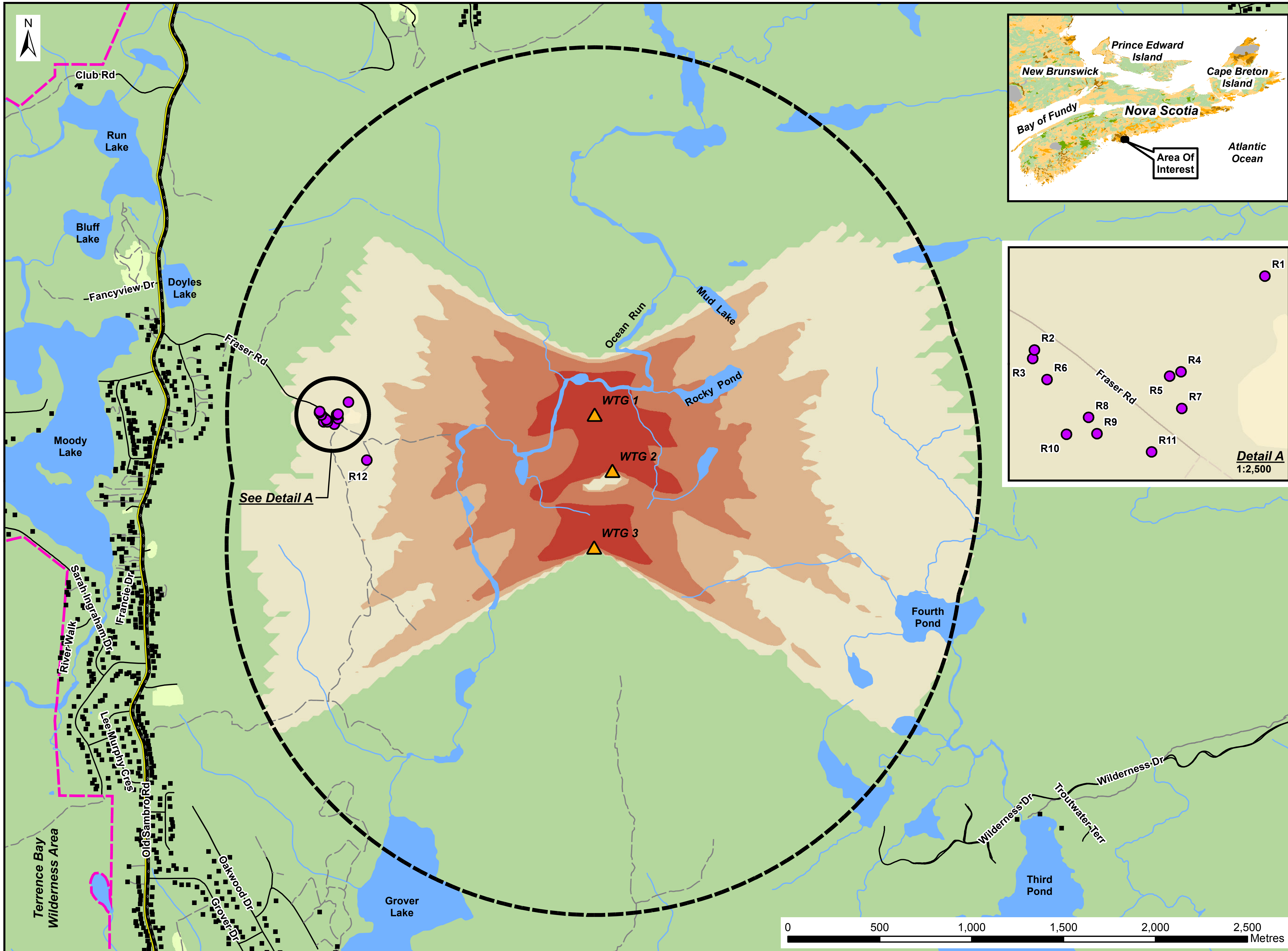
Predicted Sound Level (dBA)

- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 55.0
- 55.0 - 100.0

Harrietsfield Williamswood Wind Project - Sound Modeling Results

Strum CONSULTING

Date: February 2015	Project #: 15-5274
Scale: 1:20,000	Drawing #: 1
Drawn By: H. Serhan	
Checked By: S. Dickey	



Notes:

1. Reference: Digital Topographic Mapping & Property Management Unit MU0802 by Nova Scotia Geomatics Centre. Nova Scotia Property Records.
2. Projection: NAD83(CSRS), UTM Zone 20 North.
3. Shadow Calculation Model Using Wind Turbine Data Supplied by Client.

Legend:

- Proposed Turbine
- Existing Receptors
- 2km Buffer
- Building
- Wilderness Area
- Major Roads and Highways
- Public Roads
- Access Roads / Trails
- Mapped Stream
- Mapped Indefinite Stream
- Water Bodies
- Cleared Area

Shadow Flicker Modeling Results

Predicted Shadow Hours/Year

- 0.0 - 10.0
- 10.0 - 30.0
- 30.0 - 100.0
- 100.0+

Harrietsfield Williamswood Wind Project - Shadow Modeling Results

Strum CONSULTING

Date: February 2015	Project #: 15-5274
Scale: 20,000	Drawing #: 2
Drawn By: H. Serhan	
Checked By: S. Dickey	

Table 1: Sound Modeling Results, Harrietsfield - Williamswood Wind Power Project *Project #15-5274*

Receptor ID	Easting	Northing	Predicted Noise Level (dBA)
R1	450102	4932058	33.44
R2	449945	4932008	32.37
R3	449944	4932002	32.37
R4	450045	4931993	33.12
R5	450037	4931990	33.06
R6	449954	4931988	32.46
R7	450046	4931968	33.16
R8	449982	4931962	32.70
R9	449988	4931951	32.76
R10	449967	4931950	32.60
R11	450025	4931938	33.04
R12	450202	4931742	34.60

Table 2: Shadow Flicker Modeling Results, Harrietsfield - Williamswood Wind Power Project *Project #15-5274*

Receptor ID	Easting	Northing	Predicted Shadow Hours/Year	Predicted Maximum Shadow Hours/Day
R1	450102	4932058	2:32	0:06
R2	449945	4932008	1:24	0:04
R3	449944	4932002	1:16	0:04
R4	450045	4931993	1:50	0:05
R5	450037	4931990	1:43	0:05
R6	449954	4931988	1:20	0:04
R7	450046	4931968	1:52	0:05
R8	449982	4931962	1:32	0:04
R9	449988	4931951	1:30	0:05
R10	449967	4931950	1:27	0:04
R11	450025	4931938	1:44	0:05
R12	450202	4931742	1:57	0:07

Appendix 14 Visual Impact Assessment

February 17, 2015

Mr. Trent MacDonald
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Dear Mr. MacDonald,

Re: Visual Assessment
Harrietsfield-Williamswood Community Wind Project

INTRODUCTION

Watts Wind Energy Inc. (WWEI) is proposing the development of the Harrietsfield-Williamswood Wind Power Project (the Project). The Project consists of three General Electric (GE) 1.6 MW turbines located near the communities of Harrietsfield and Williamswood in Halifax County, NS.

To support Project planning and the Nova Scotia Environmental Assessment (EA) process, Strum completed the following visual assessment.

PREDICTED VIEW PLANE

The predicted view plane was established by collecting representative photos from vantage points within the community to represent the existing and future visual landscape.

Photographs were collected with magnetic bearings and a GPS waypoint recorded at each photo location. Geographical Information System (GIS) software was used to plot the photo locations and construct bearing lines to assist in the construction of a 3D view, generated using the GIS. A 3D surface was then constructed using the provincial Digital Elevation Model (DEM) points from the Nova Scotia Topographic Database, which supports 5 m contour intervals. The proposed turbine locations and specifics regarding the height of the turbines were used to develop the view plane. Each selected viewing site was created using the viewer location (photo GPS point, elevation, and bearing line) resulting in an accurate 3D view. The resulting computer generated view was then merged with the digital photographs using a scaled image of the proposed turbine.

Photos were taken from three locations as shown in Drawing 1. Simulated results are provided in Figures 1-3.

Actual View:

Predicted View:

Figure 1. Roadside from Jacqueline Purcell Drive, Portuguese Cove: View to the northwest, towards the Project site.

Actual View:

Predicted View:

Figure 2. Roadside from Highway 349, Ketch Harbour. View to the northwest, towards the Project site.

Actual View:

Predicted View:

Figure 3. Roadside from Oakwood Drive, Williamswood. View to the northeast, towards the Project site.

Once you have had an opportunity to review this correspondence, please contact us to address any questions you may have.

Thank you,

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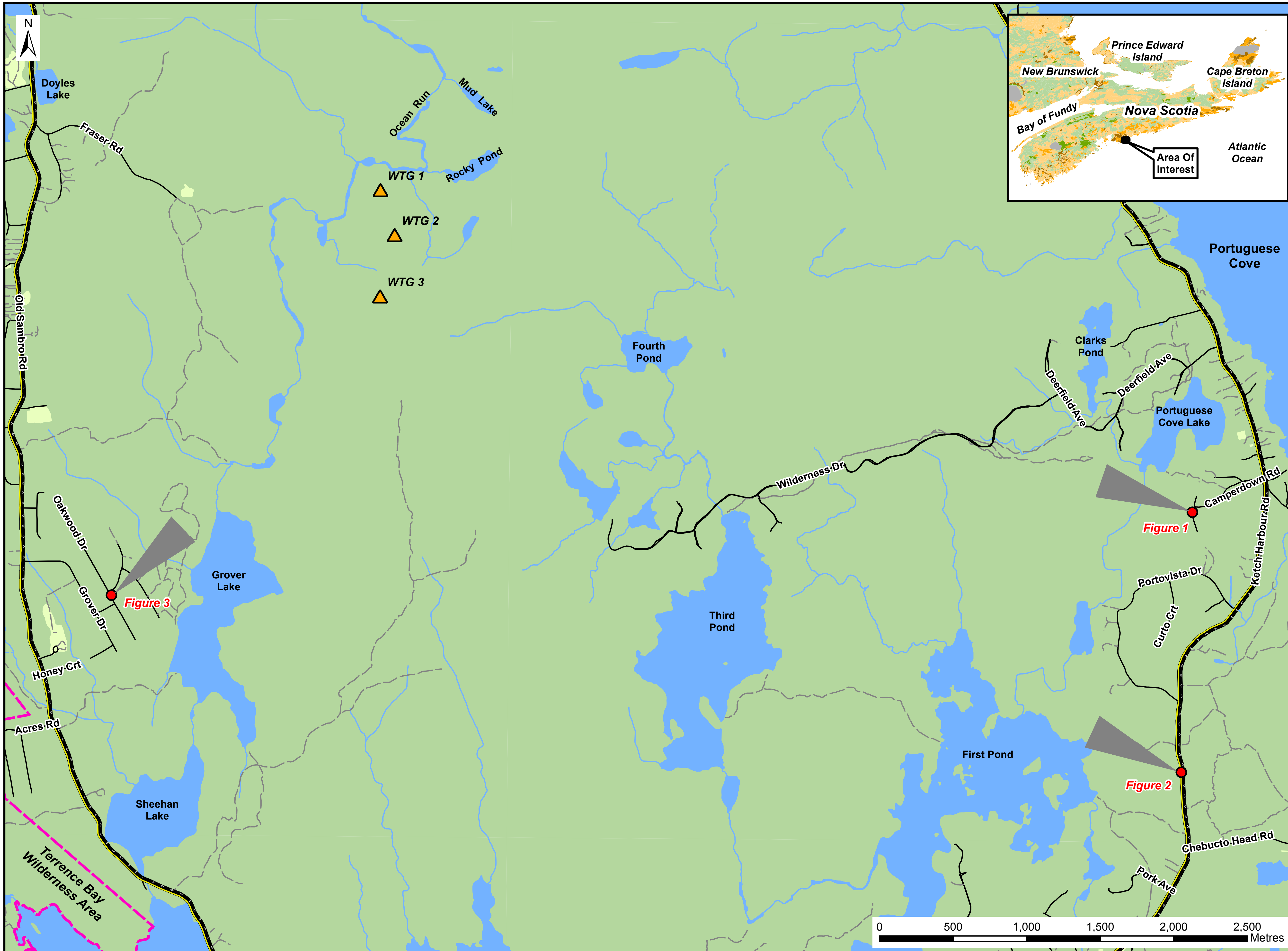

Notes:

1. Reference: Digital Topographic Mapping & Property Management Unit MU0802 by Nova Scotia Geomatics Centre. Nova Scotia Property Records.
2. Projection: NAD83(CSRS), UTM Zone 20 North.

Legend:

Name

- Visual Assessment Locations
- Proposed Turbine
- Wlderness Area
- Major Roads and Highways
- Public Roads
- Access Roads / Trails
- Mapped Stream
- Mapped Indefinite Stream
- Water Bodies
- Cleared Area

Harrietsfield Williamswood Wind Project - Visual Assessment Locations

Strum CONSULTING

Date: February 2015	Project #: 15-5274
Scale: 1:20,000	Drawing #: 1
Drawn By: H. Serhan	
Checked By: A. Walter	