Updated Technical Assessment of Valued Ecosystem Components - Environmental Impact Assessment

TCDPO App. No. 3262/11/2004C

Lamberts East Wind Farm

St. Lucy, Barbados

TC150811A

Prepared for:

The Barbados Light and Power Company Limited

Garrison Hill, St. Michael, Barbados

November 2019

Wood Environment & Infrastructure Solutions
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November 22, 2019
TC150811A

Ms. Charmaine Gill-Evans
Generation Engineer
The Barbados Light and Power Company Limited
Garrison Hill, St. Michael, Barbados

Dear Ms. Gill-Evans:

Wood Environment & Infrastructure Solutions a Division of Wood Canada Limited (hereinafter referred to as "Wood"), is pleased to provide this assessment of changes study to the impact study report for the Lamberts East Wind Farm (the Project).

We greatly appreciate the opportunity to provide support for the development and operation of Lamberts East Wind Farm. Should you have any questions regarding this study, please do not hesitate to contact us.

Sincerely,
Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

Prepared by:

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cc: Alfredo Rodrigues

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Executive Summary

Project Proposal

The Barbados Light and Power Company Limited (BLPC) proposes to amend the quantity, size and layout of wind turbines that form part of an existing Planning Permission for the Lamberts East Wind Farm and is submitting this updated technical assessment of Valued Ecosystem Components (VEC) in support of the Environmental Impact Assessment to facilitate the review by the Town and Country Development Planning Office (TCDPO).

The Lamberts East Wind Farm Environmental Impact Assessment (the EIA) was completed in 2007 and updated in 2010 to meet the requirements as set out in the Environmental Impact Assessment Guidelines and Procedures for Barbados (1998). The EIA emphasized the use of Valued Ecosystem Components (VECs) as the focal points for impact assessment, and potential interactions between project components and activities.

The Lamberts East Wind Farm EIA was approved through the Prime Minister's Office Letter Planning Permission issued on December 2010 (LPP) by the Town and Country Development Planning Office (TCDPO), titled *Re: Application No. 3262/11/2004C – Construction of a wind electrical generating station to operate 24 years and consisting of eleven (11) turbines and associated equipment at Lamberts East, Lamberts Plantation, St. Lucy*. Since that time, advancements in WEC technologies have resulted in a revised Project layout consisting of five (5) ENERCON E-70 E4 WECs (reduced from eleven in total), with an approximate output of 10 MW (unchanged).

The proposed project revision includes the construction of a 10 MW wind farm comprised of five (5) Wind Energy Converters (WECs), associated control building, and access roads on land at Lamberts East in the parish of St. Lucy, Barbados. Each WEC will have a tubular tower of approximately 57 m, and three rotor blades with a rotor diameter of approximately 71 m. A new transmission line will connect the site to the existing Trents substation.

Project Schedule

BLPC originally planned to commence development of the project during 2007 with early completion in 2009. However, the schedule has been delayed due to requirements related to additional testing and assessment of new WEC technologies. It is estimated that the construction period will take approximately 6 months.

Approach

Wood (and its predecessors – i.e. AMEC Earth & Environmental and Amec Foster Wheeler) have been involved in supporting BLPC in the environmental work conducted for the Lamberts East Wind Farm Generating Station. This includes the preparation of technical reports and the EIA prepared in 2010. In accordance with the LPP provided in 2010 which granted the approval of the EIA, BLPC has undertaken works on site which maintains the validity of the LPP.

The Project Team met separately with TCDPO and the Environmental Protection Department (EPD) in June 2017 and July 2019 to review the status of the Project and any required changes as a result of the changes to WEC technology and Project layout. In order to capture the change in the number, size of the WECs and Project layout, it was determined that amended technical documents would be prepared to support the existing planning permit, along with an assessment of the environmental effects.

To identify potential impact variations between the two proposed layouts, a Gap Analysis was prepared based on a comparison of the currently approved Project layout assessed in the EIA and the proposed revised Project layout. The focus of the Gap Analysis was centered on the Valued Ecosystem Components (VEC) model, to determine if the new Project layout would have a direct impact on the VEC technical studies presented in the EIA.

The Gap Analysis identified four (4) VECs that were deemed to necessitate further assessment due to the direct relationship between the studies conducted for the VECs and the revised Project layout, type and number of WECs. As agreed upon with EPD, the VECs which have been re-assessed as part of this updated technical assessment are:

- Shadow flicker assessment;
- Visual assessment - Zone of visual influence analysis;
- Visual assessment – Photomontage; and
- Noise impact assessment.

Assessment of Environmental Effects

An assessment of environmental effects related to the four VECs previously noted has been completed for the operational phase of the proposed wind farm. Recommended mitigation methods and significance of environmental effects are discussed for each potentially impacted VEC.

Shadow Flicker Assessment

Shadow flicker occurs when the sunlight and the rotating WEC blades interact in such a way that a moving shadow is cast onto the ground or stationary objects. Within the range of the shadow at any specified location, a flickering effect is evident when the shadow passes. It is generally recognized that shadow flicker impacts reduce with distance, and that shadow flicker usually occurs in the morning or evening when the sun is low in the sky and shadows are long. When the sun is obscured by clouds, fog, or by intervening objects, no shadow flicker will be present. There will also be no shadow flicker from a WEC when the WEC is not operating.

A shadow flicker analysis was conducted using the Shadow Flicker module of the ReSoft WindFarm software. With respect to each of the potential shadow flicker receptors, a total number of shadow flicker hours in a year were modelled. It was found that a number of SFRs would experience varying amounts of shadow flicker in a year.

The SFRs are largely located to the east and west of the WEC and in line with the predominant wind direction and reflective of the rising and setting sun when sun angles are low. It can be seen that:

- Four (4) SFRs to the east are expected to have over 80 hrs/year of shadow flicker;

- Thirty-two (32) SFRs to the east are located within effects zones between approximately 30 hrs/year and 80 hrs/year of shadow flicker; and
- Thirty (30) SFRs to the east and the north-west are located within effects zones between approximately 10 hrs/year and 30 hrs/year of shadow flicker;
- Twenty-five (25) SFRs (the remaining SFRs still within the 710 m zone of influence used as the general limit of observable effects) located to the east and the north-west are expected to have less than 10 hrs/year of shadow flicker.

In comparison of the 80 hrs/yr isolines of the original and revised Project layout, the updated layout of five (5) WECs has resulted in a reduction of the number of SFRs that are located within the 80 hrs/yr isoline by eight (8), representing a reduction of 67% of potentially affected residences.

In review of technical consistency of findings with the EIA (2010), this technical assessment has confirmed that the current Project layout does not exacerbate the effects related to shadow flicker, and in fact has demonstrated a reduction in effects.

Visual Assessment - Zone of Visual Influence Analysis

A zone of visual influence (ZVI) analysis was conducted using the Zone of Visual Impact module of the OpenWind software. Based on the applied assessment model, the following is concluded regarding the visibility of the five (5) WECs:

- Within an area of approximately 1.5 km of the centre of the WECs, all five WECs are generally visible;
- Between approximately 1.5 km and 3 km, visibility for all WECs is restricted to areas along the east coast between Pie Corner and Sea View, and south of the Project along the Mount Stepney to Cherry Tree Hill alignment. All other areas have sporadic visibility of some of the WECs; and
- Beyond 3 km visibility of WECs is predicted to be scattered in areas located in the northern regions of the island.

The reduction in the number of WECs resulted in a corresponding reduction in the general area from which the WECs would be visible. Under the updated Project effects assessment, the areas where WECs are visible have become notably sparser, with many areas now demonstrating no discernable visibility. A significant reduction in visibility is also present in the central and northern areas of the Island, including Church Hill and Mount Gay.

In review of technical consistency of findings with the EIA (2010), this technical assessment has confirmed that the current Project layout does not exacerbate the effects related to visual impacts/ zone of visual influence, and in fact has demonstrated a reduction in effects.

Visual Assessment - Photomontage

Photomontages have been prepared to simulate the windfarm on the landscape from key vantage points at Risk Road, Pie Corner, the existing wind turbine and Josey's Hill.

The number of WECs have been reduced to five (5) for this assessment with a slight increase in nacelle height with the new infrastructure. Consequently, all WEC hubs are predicted to be visible from each of the viewpoints. With the nature of the landscape, there are regions where the WECs are partly obscured by vegetation.

The reduction in the number of WECs from eleven (11) to five (5) results in a direct reduction in the visual impact of the Project, as the maximum number of WECs that have the potential to be seen have been reduced by over half. The intended application of the revised WEC model, reduction in number of WECs and modified Project layout has resulted in a reduction in visual impacts associated with the Project.

In review of technical consistency of findings with the EIA (2010), this technical assessment has confirmed that the current Project layout does not exacerbate the effects related to visual impacts/ photomontage, and appears to have a similar effect as the original turbine layout.

Noise Impact Assessment

An acoustic model of the Project was created by use of a noise prediction software package, CadnaA, published by Datakustik GmbH. As the Government of Barbados does not have specific noise levels standards for wind farm developments, the suggested criteria are based on the guidelines used in Ontario Canada, and applied in the EIA.

Based on preliminary information from the updated Noise Impact Study[1], including the baseline measured on site (NMT1 and NMT2), and continuous monitoring covering the period from October 2017 to February 2019, it can be concluded that for more than 90% of the sample period, the metric L_{Aeq} was measured to be above 45 dBA.

In terms of cumulative sound levels at receivers – i.e., adding the sound levels from the operation of the facility to the measured on-site baseline sound levels, and based on preliminary information from the updated Noise Impact Study, the average A-weighted equivalent sound pressure level will remain unchanged.

The noise assessment was expanded from the assessment in the EIA (2010) to further assess the upper and lower wind speed limits. The technical assessment[2] modeled the 45 dBA contour lines associated with wind speeds of 4 m/s, 8 m/s and 10 m/s, and demonstrated that the 45 dBA contour line at 8 m/s from the EIA (2010) has been significantly reduced as a result of the revised Project layout. The reduction in the number of WECs has resulted in the 45 dBA at 10 m/s contour line extending to the approximate location of the 45 dBA at 8 m/s contour line from the EIA (2010). Furthermore, no noise sensitive receptors are located within the 10 m/s contour line.

In review of technical consistency of findings with the EIA (2010), this technical assessment has confirmed that the current Project layout does not exacerbate the effects related to noise levels, and in fact has demonstrated a reduction in effects.

1 The noise impact study is currently under review by the EPD
2 Based on preliminary information from the updated Noise Impact Study, currently under review by the EPD

Conclusions

As a result of proposed changes to the Project layout, updated technical assessments were undertaken in support of the EIA to confirm that no additional environmental effects were anticipated as a result of the Project. The results of the technical assessments which focused on noise, shadow flicker and visual impacts, determined that the revised Project layout not only does not result in an increase in environmental effects on VECs, but rather results in a reduction in effects associated with the Project. This can largely be attributed to the advancements in WEC technology and the reduction in the number of WECs from eleven (11) to five (5).

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List of Acronyms

BLPC	The Barbados Light and Power Company Limited
CIC	Charge Induced Calibration
CEE	Cumulative environmental effect
EA	Environmental Assessment
ECCs	Environmental components of concern
EIA	Environmental impact assessment
ESAs	Environmentally sensitive areas
kWh	Kilowatt hour
L_{Aeq}	A-weighted Equivalent Sound Level
LPP	Letter Planning Permission
NMT	Noise Monitoring Terminal
MW	Megawatt
NCC	National Conservation Commission
RES	Renewable Energy Systems
SFRs	Shadow Flicker Receptors
SO2	Sulphur dioxide
TCDPO	Town and Country Development Planning Office
TCPA	Town and Country Planning Act
TOR	Terms of reference
UN	United Nations
VECs	Valued ecosystem components
VSCs	Valued socio-economic components
WEC	Wind Energy Converter
WHO	World Health Organization
ZVI	Zone of visual influence

1.0 Introduction

The Barbados Light and Power Company Limited (BLPC) is the primary supplier of electrical energy in Barbados. BLPC has a developed infrastructure network, comprising of generation stations, transmission and distribution systems, maintenance facilities and offices. To provide for future power demands and system reliability, BLPC is embarking on the development of an additional generation site, consisting of a 10 MW wind farm proposed on the land at Lambert's Plantation in the parish of St Lucy, known as the Lamberts East Wind Farm (Figure 1-1 - Project Site Plan).

1.1 Project Process

The Lamberts East Wind Farm Environmental Impact Assessment (the EIA) was completed in 2007 and updated in 2010 to meet the requirements as set out in the Environmental Impact Assessment Guidelines and Procedures for Barbados (1998). The EIA provided a description of the project and establishment of baseline conditions, assessment of potential environmental effects, and identified potential mitigation measures. The assessment emphasized the use of Valued Ecosystem Components (VECs) as the focal points for impact assessment, and potential interactions between project components and activities. The EIA can be found on BLPC's website (https://www.blpc.com.bb/images/pdf/environmment/APP%20H%20-%20Addendum%20to%20Final%20Report.pdf).

The Lamberts East Wind Farm EIA was approved through the Prime Minister's Office Letter Planning Permission issued on December 2010 (LPP) by the Town and Country Development Planning Office (TCDPO), titled *Re: Application No. 3262/11/2004C – Construction of a wind electrical generating station to operate 24 years and consisting of eleven (11) turbines and associated equipment at Lamberts East, Lamberts Plantation, St. Lucy*. The approved project was to consist of eleven (11) Vestas 850 kW Wind Energy Converters (WECs), a control building, and associated access roads and transmission infrastructure.

Since that time, continuous improvements in WEC technologies have resulted in the development of quieter, safer, and more efficient WECs. The WECs originally envisioned for the project are no longer commercially available, nor are they a recommended technology. BLPC, through a review of current available WEC technology, logistics, and constructability, have determined that an alternative WEC would be better suited to the Project. As a result, a revised WEC layout has been developed, consisting of five (5) WECs with an approximate output of 10 MW.

Wood (and its predecessors – i.e., AMEC Earth & Environmental and Amec Foster Wheeler) have been involved in supporting BLPC in the environmental work conducted for the Lamberts East Wind Farm Generating Station. This includes the preparation of technical reports and the EIA prepared in 2010.

The Project Team met with TCDPO and the Environmental Protection Department (EPD) in June 2017 and again in July 2019 to review the status of the Project and any required changes as a result of the changes to WEC technology and Project layout. In accordance with the LPP provided in 2010, which granted the approval of the EIA, BLPC has undertaken works on site which maintains the validity of the LPP. In order to capture any impacts in the change of the number, size of the WECs and Project layout, it was determined that amended technical documents would be prepared to support the existing planning permit, along with an assessment of the environmental effects.

To identify potential impact variation between the two proposed layouts, a Gap Analysis was prepared based on a comparison of the currently approved Project layout assessed in the EIA and the proposed revised Project layout. The focus of the Gap Analysis was centered on the Valued Ecosystem Components (VEC) model, to determine if the new Project layout would have a direct impact on the VEC technical studies presented in the EIA.

The Gap Analysis identified four (4) VECs that were deemed to necessitate further assessment due to the direct relationship between the studies conducted for the VECs and the revised Project layout, type and number of WECs. As agreed upon with EPD, the VECs which have been re-assessed are:

- Shadow flicker assessment;
- Visual assessment - Zone of visual influence analysis;
- Visual assessment – Photomontage; and
- Noise impact assessment.

1.2 Project Proposal

Following the discontinuation of the Vestas V52, BLPC developed evaluation criteria to assess available WEC models and identify the preferred alternative to meet the Project needs. The evaluation process (Ref. Section 2.1) resulted in the selection of the ENERCON E-70 E4 WEC, a direct-drive wind energy converter with a three-bladed rotor, active pitch control, variable speed operation, and a nominal power output of 2300kW. The increased output capacity allowed for a reduction in the number of WECs, resulting in a Project layout of five (5) WECs as opposed to eleven (11).

The principal changes to the Project layout as a result of the change in WEC technology are summarized in Table 1-1.

Table 1-1: Project Description Changes

Item Changed	At EIA Stage	Current Project
Proposed Project Output	10 MW	10 MW
Number of WEC	11	5
Maximum Output per WEC	850 kW	2 MW
Cut-in Speed	3 m/s	2.5 m/s
Cut-out Speed	22 m/s	34 m/s
Hub Height	49 m	57 m
Rotor Diameter	52 m	71 m
Extension of Project 1	~ 1.1 km	~ 700 m

Note:
1 Extension of the project indicates the approximate distance between the two WEC at the end of the project

1.3 Regulatory Framework

The updated technical assessments in support of the EIA are subject to the same regulatory framework applied in 2010, or where applicable by conditions imposed in the LPP, as continuation of the EIA processes previously applied. No legislative guidelines exist specifically for wind farms in Barbados; however, other Acts and guidelines apply, as provided in Section 2.0 of the EIA.

1.4 Report Organization

This report consists of the following sections:

Section 1 - Introduction. Provides a brief Project overview and purpose, and explains the context under which the updated technical assessments of the EIA are being submitted.

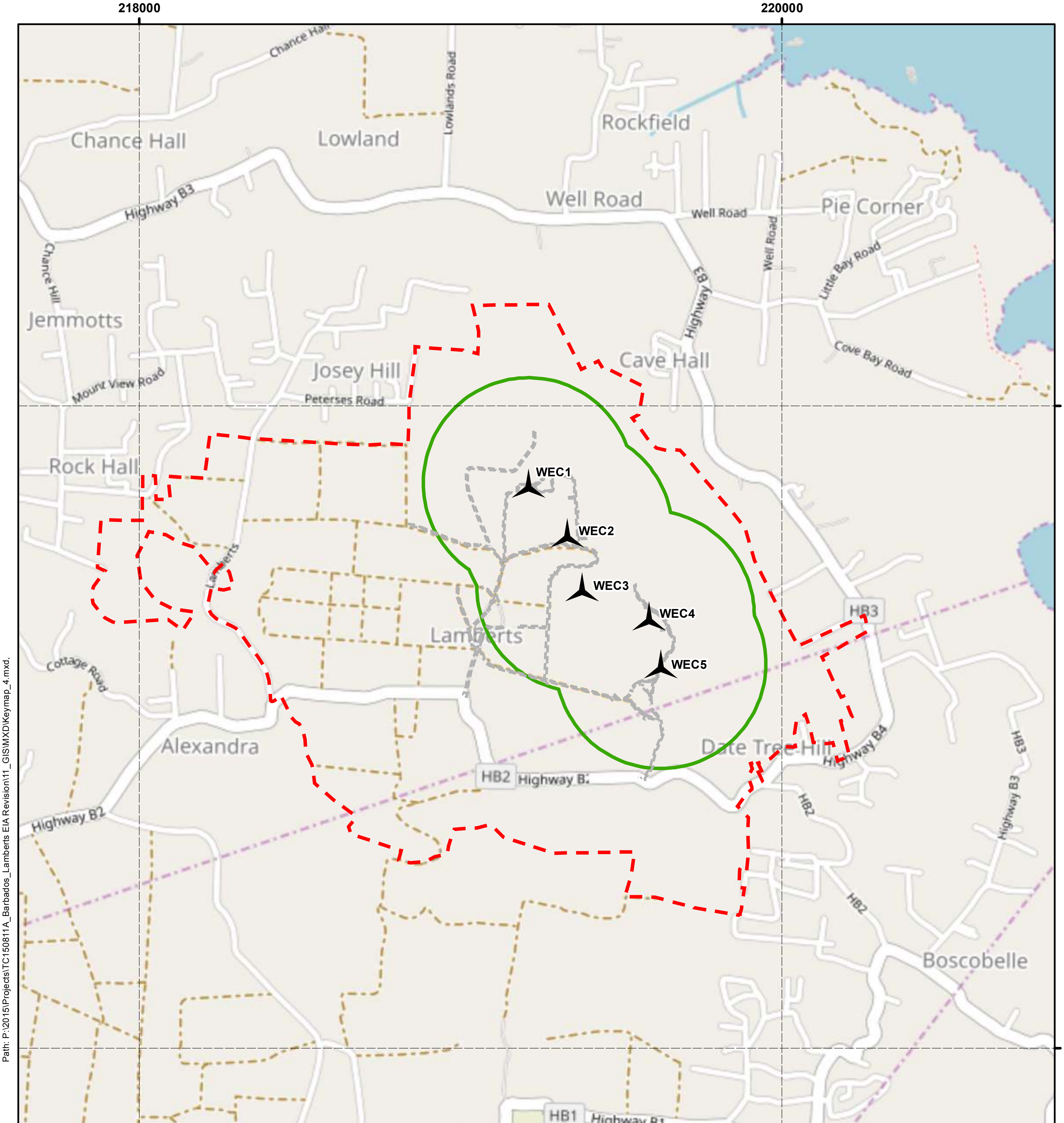
Section 2 - Project Description. Provides a more detailed summary of the facilities and activities that are encompassed in the Project to help identify possible interactions with the environment.

Section 3 - Environmental Assessment Methodology. Describes how the assessment has been conducted.

Section 4 - Environmental Effects Assessment. Specifies the potential effects and significance of these effects during the operational phases, comparing the assessment of impacts and methodology applied in the original and updated technical assessments for the identified VECs.

Section 5 – Summary of Mitigation Measures and Recommendations. Summary of mitigation measures to be implemented into the Project activities and design, including additional recommendations.

Section 6 - Conclusions. Summary of conclusions.



LEGEND

- WEC
- Project Site
- Lamberts Plantation Property Boundary
- Access Route

NOTES:
- WEC: Wind Energy Converter
- Topography from ESRI

Datum: WGS 1984
Projection: UTM Zone 21N

0 0.175 0.35 0.7 1.05 1.4 Kilometres

N S E W

wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Project Site Plan

PROJECT N°: 6.19.203573.CAN	**FIGURE: 1.1**
SCALE: 1:16,000	DATE: July 2019

2.0 Project Description

2.1 WEC Type and Location

WEC manufacturers have been investing heavily in research and development work to continuously improve on their designs and product platforms in an effort to increase yield and lower the cost of energy. Because of design evolution and natural product attrition, the Vestas V52 WEC that was originally contemplated for the Project is no longer being produced. The Vestas V52 WEC was initially produced starting in 2000 and was eventually phased out of production by 2010. Accordingly, BLPC was required to revisit the selection of the WEC for this Project to determine what technology is currently available that would meet the needs of the Project, within the defined permissions.

The main criteria for WECs considered for the Project included (but were not limited to):

- 50 Hz Noise System Frequency (suitable for island grid application);
- 50 m Hub Height (or as close as possible to this without exceeding 60 m);
- 10 MW total facility nameplate;
- Hot climate package optionality;
- Additional corrosion resistance for coastal applications; and
- Designed for IEC Class IA (Class IA models are preferred for hurricane / storm resilience).

The ENERCON E-70 E4 WEC is a direct-drive wind energy converter with a three-bladed rotor, active pitch control, variable speed operation, and a nominal power output of 2300 kW. It has a rotor diameter of 70 m and a hub height of 57 m. All assessments within this technical assessment have been based on this specification. Contract negotiation with Enercon for their model E-70 is ongoing, with a view to being finalized by December 2019.

The WECs begin generating automatically at a cut-in wind speed of 2.5 m/s, and have a shutdown wind speed of 34.0 m/s. They will generate their full rated power output when the wind speed reaches 15.0 m/s, and thereafter perform close to this level up to shut down. A perspective view of a typical 2.0 MW WEC is illustrated in Figure 2-1.

A significant amount of research has been undertaken into WEC colour and finish to minimize visual impact, with off white or pale grey being the most appropriate. The Enercon units are typically painted pale grey, with gradations of green rings on the portions of the tower closest to the ground, to help them blend in with the surrounding landscape. The foundation is the link between the tower and the subsoil and bears all the static and dynamic loads of the WEC. ENERCON foundations are always circular. A cylindrical structural element is set on the blinding layer and precisely aligned with adjusting bolts. Once the foundation is completed, the tower is flanged together with the foundation section. Covering the foundation with backfill soil is not only calculated as a load but also taken into account when calculating the weight required to reduce buoyancy caused by ground or strata water.

During the erection period, a hardstand will be provided alongside each WEC upon which the crane will stand when lifting components into place. The load bearing capacities stated in the ENERCON specifications for access roads and crane platforms, shall be verified with the help of static plate load tests to DIN 18134:2012-04.

2.2 Project Site Description and Infrastructure

The Project's ancillary infrastructure in support of the new WEC technology and Project layout will largely remain consistent with the original design in the EIA. Changes have occurred with the reduction of WECs from eleven (11) to five (5), which generally have resulted in a notable reduction (proportional to the number of WECs) in requirements (i.e., reductions in access roads).

2.2.1 Access Road

The access roads would be a maximum of 4.5 m wide with a total length of approximately 1.5 km. This translates to an estimated land take of the access roads of 6750 m^2 (less than 1 hectare).

2.2.2 Control Building

The control / substation building would take up an area of approximately 30 m x 15 m. The main construction compound layout would initially require an area of approximately 60 m x 40 m. This temporary area would be reinstated after construction.

2.2.3 Transformer

A transformer unit is located within the base of each WEC. There is therefore no additional footprint required for transformers outside the WEC base.

2.2.4 Transmission Lines

The grid connection was also examined for the Project since this can be a limiting factor in the development of wind farms either due to the distance to a single connection point, or whether the transmission line is capable of accepting new capacity.

BLPC had embarked on an upgrade of the transmission line capacity in anticipation of future development in the northern section of the island including the Lamberts windfarm.

The high voltage 132 kV underground transmission double circuit (currently operated at 24 kV) connects BLPC's transmission network in the central part (St. Thomas) of the island to generation assets in the North of the island. The route follows the corridor of the main Ronald Mapp Highway that runs from the St Thomas substation to Trents Substation (in St Lucy). The recently built Trents substation exports power from the Trents Solar PV plant, and the substation bus will also be the point of inter-connection for the Lamberts facility.

The wind farm will have an underground collector system connecting the high voltage terminals of the WEC transformers in a ring. A radial 24 kV overhead transmission line from the Lamberts Wind Farm will connect the wind farm to the existing Trents substation.

2.3 Project Schedule

BLPC plans to commence development of the Project during 2020 with completion in late 2021. Additional site studies, such as geotechnical testing, are required to complete the detailed design.

Commencement of construction will depend on the delivery of WECs and overall planning approvals. It is estimated that the construction period will take approximately 6 months. A detailed schedule will be prepared upon completion of the Project design.

2.4 Project Activities

The construction phase of the wind farm is expected to last approximately 6 months. This period is somewhat weather dependent and can be affected by ground conditions found at the site. Generally, all elements associated with the implementation and operation of the wind farm remain consistent with the EIA, save for the reduction in the number of WEC's. The key Project equipment and buildings that will be constructed or erected on site remain will include:

- Towers;
- WEC generators;
- Rotors;
- Transformers (within the tower base);
- Control building / substation;
- Anemometry mast; and
- Transmission lines.

The proposed sequence of events for the construction program would be as follows:

- Complete any necessary improvements to the road network which is being used as the access route to the site;
- If required, upgrade the site entrance and existing farm tracks to the site and install temporary compound;
- Construct the site access roads with field gates and temporary fencing (if required);
- Excavate the foundations;
- Construct the WEC foundations;
- Install transformers and install the grid connection and earths;
- Construct the control building;

- Erect and connect the towers and WEC;
- Raise the anemometry mast;
- Commission the WEC;
- Carry out land reinstatement; and
- Remove temporary compounds and clear the site.

The construction will normally be completed in daylight hours; however, there will be requirements for extended hours during major concrete pours or other activities that cannot be interrupted once started. The following sections provide a description of the construction activities that will occur during development of the proposed wind farm, that are typical for a project of this nature.

2.4.1 Site Access Roads

Site access roads would permit access by construction vehicles and would be required throughout the life of the project for maintenance purposes. The route of the site access roads will be chosen in order to minimize environmental disturbance while working within technical constraints. The roads would be constructed to the specifications of the WEC manufacturer, with a clearance width of 5.5 m, with some local widening on bends and at passing bays. The design will allow drainage of rain water using lateral drains where appropriate and ditches with culverts.

2.4.2 Foundations

The basic foundation design for each tower would comprise approximately 380 m^3 of concrete with approximately 31 tonnes (T) of concrete reinforced with steel by weight, in a tapered cylindrical block of 18.5 m and 2.5 m height.

The foundation surface lies up to 2.0 m below the normal ground surface and is backfilled with soil and reinstated. Approximately 625 m^3 of soil would be excavated per WEC base.

Alternative foundation designs may be considered depending on the findings of the geotechnical studies.

2.4.3 Site Cabling and Transformer

The current WEC design contains the transformer within the base of the WEC tower. All power and control cabling on site from the transformers and between WECs would be laid in trenches approximately 0.5 m wide by 0.75 m deep, located adjacent to the access tracks. These trenches would be back filled with quarter mix around cables (in conduit for protection) and then further backfilled with adjacent topsoil that has been sieved / graded to remove stones where applicable. Clay plugs would be placed in the trenches at intervals to prevent water flow through or into the cable trenches. The top 100 mm of soil would be stripped and laid beside the trench and used to reinstate to original ground level immediately after installation of the cables.

Between the WECs, a 24 kV underground cable will be used to connect the individual WEC transformers within the tower bases. The SCADA cabling would be laid in the same trenches and the underground cabling between the WEC would follow the routes of the access tracks wherever possible. All cables would be buried according to current best practice, and well below cultivation depth.

2.4.4 Control building

A new control building would be required to house the main wind farm switchgear, metering and associated equipment. This control building would be constructed with local materials and house switchgear, protection and computer control equipment as well as small spares.

2.4.5 Site Civil Work

After initial site preparation, construction of foundations for the WECs and installation of the underground cables will be performed. This involves trenching, burying of underground cables and backfilling.

2.4.6 Anemometry Mast

The anemometry mast will be a free standing or guyed tower approximately 57 m tall (hub height), fabricated of galvanized steel tube. It will be located centrally in the wind farm and will carry instrumentation at the top and at an intermediate height.

2.4.7 Grid Connection Line

A 24 kV overhead line to connect from the control building to the existing transmission grid will also be constructed. It will be approximately 5 km long and consist of four (4) wires mounted on class 3 wooden poles. Class 3 poles offer increased resilience to natural disasters.

Typical 24 kV line construction used in Barbados is shown in Figure 2-3.

2.4.8 Equipment Delivery and Installation

Major equipment will be offloaded at the Bridgetown Port and moved via road transport. As the blades are approximately 35 m in length, these will require coordination of shipments to minimize disruption of traffic. The towers and WEC generators will be erected using mobile cranes.

2.4.9 Commissioning and testing

Prior to plant start up, all systems will be commissioned to ensure correct operation and to adjust the operating parameters to optimize performance. Acceptance testing will be completed on equipment to ensure that it meets all the safety and engineering design specifications. Operating staff will be trained on equipment control, operation and maintenance.

This phase usually takes four (4) to six (6) weeks to complete, and is conducted in the presence of engineers and technical specialists representing the owner, contractor and major equipment suppliers.

2.4.10 Clean-up and landscaping

The clean-up of the construction site is the final construction activity to be conducted. The clean-up crew will pick up debris, remove surplus materials and equipment, and clean or repair any soiled areas.

Temporary buildings will be removed from site, and laydown areas restored. Landscaping will be installed in accordance with the landscape plan.

2.5 Operations and Maintenance

The Project will be designed to run continuously (24 hours per day, seven (7) days per week) to supplement baseload power generation. The wind farm will be unattended and remotely operated from BLPC's central control room at Spring Garden, using a supervisory control system that continually interrogates each of the WECs and the high voltage (HV) connection as well associated protection equipment. In normal operation, this system operates the wind farm. If a fault were to develop, requiring an operator to intervene, the supervisory control system would alert the permanently manned control centre.

The operators would then take the appropriate action required depending on the nature of the fault and if necessary remotely shutdown one or all of the WECs or disconnect the wind farm from the grid if this has not already automatically occurred.

Signs would also be permanently located around the site to provide contact details of BLPC and relevant emergency personnel in the event of an emergency. The contact details of BLPC personnel would also be made available to the local emergency response agencies.

2.6 Decommissioning

The expected operational life of the wind farm is in excess of twenty years from the date of commissioning. Planning permission has been granted for 24 years of operations. At the end of this period a decision would be made as to whether to refurbish, remove, or replace the WECs. If a decision was taken to remove the WECs, this would entail the removal of all the WEC components, transformers, substation, roads and associated buildings. The site will be restored to an acceptable condition for its intended use, in accordance with the requirements of the existing land Lease.

Prior to decommissioning, BLPC will review the work plan with the appropriate government agencies to ensure that it meets the regulatory requirements in effect at that time.

Major pieces of equipment are recyclable or reusable, with the exception of the WEC blades. The steel towers can be sold for scrap. Electrical equipment can either be salvaged for reuse or sold for recycling. Some parts such as the generators and cabling will have a high resale value. The exposed concrete foundation would be removed to approximately one metre below grade and the remaining foundation buried. Local labour is readily available to contribute to the decommissioning and this phase will provide economic benefits to the community. The cost of decommissioning a wind farm can usually be balanced against its scrap value.

As there is no industrial processing or fuel or chemical handling during the operations phase, the potential for site contamination is very low. The wind farm project will not, therefore, result in any residual long-term decommissioning issues that would be detrimental to future use of the site.

Figure 2-1: Perspective View of ENERCON E-70 E4 WEC [3]

3 Figure presented above is for reference only, color shades may vary from those depicted

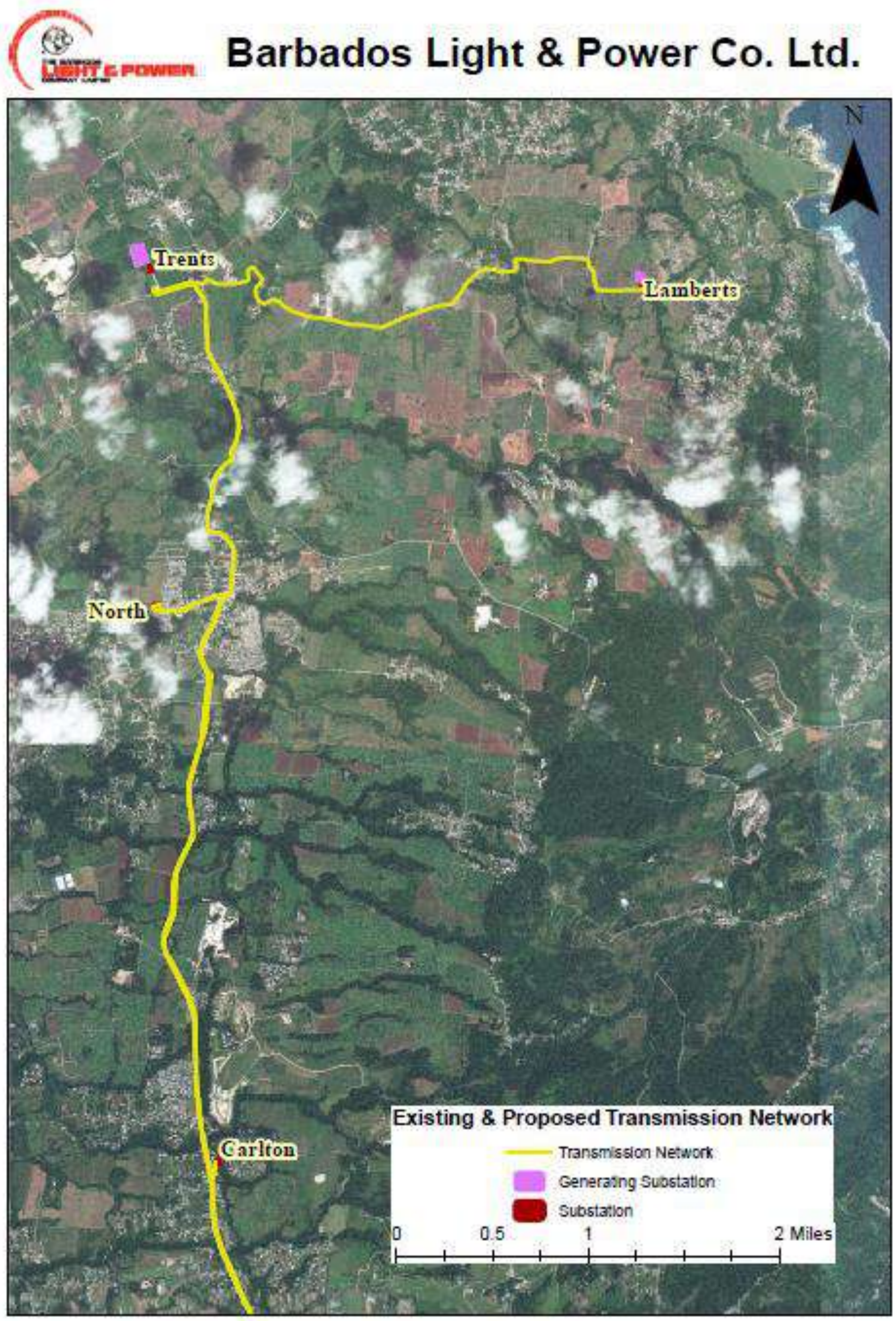


Figure 2-2: Existing & Proposed Transmission Network

Figure 2-3: Standard Overhead 24 kV Power Line used in Barbados

3.0 Environmental Assessment Methodology

3.1 Environmental Assessment Approach

The EIA and updated technical assessments have been completed to meet the requirements as set out in the Environmental Impact Assessment Guidelines and Procedures for Barbados (1998). An Environmental Assessment (EA) is a complete process, emphasizing the use of Valued Ecosystem Components (VECs) as the focal points for impact assessment and potential interactions between project components and activities.

The EIA is based on scientific, engineering, environmental and economic parameters, professional judgment, and consultation with the public, applicable government agencies, communities, interest groups and other stakeholders directly affected by the project. The approach includes the following steps:

- Step 1 – Assembling Project Baseline Information;
- Step 2 – Issue Scoping;
- Step 3 – Identification of Valued Ecosystem Components;
- Step 4 – Effects Assessment; and
- Step 5 – Environmental Protection Measures.

These five (5) steps have been undertaken and are documented in detail in the EIA.

Considerations that were incorporated into the EIA and the updated technical assessments include:

- Spatial and Temporal Boundaries – The determination of study boundaries in both space and time, to determine the effect a specific project activity may have on a VEC.
- Methodology to Predict Environmental Effects – Methodologies used in the identification and assessment of effects may vary for each VEC, and include a variety of primary and secondary data sources, such as literature review and model development.
- Determination of Significance – Significance criteria have been based on scientific determinations, social values, public concerns, and economic judgements. A significant adverse environmental effect is defined as an effect that is adverse **and** significant **and** likely.

These considerations have been expanded upon in detail in Section 3.0 of the EIA.

3.2 Valued Ecosystem Components (VECs)

3.2.1 Scope Determination and VEC Selection

This part of the environmental assessment serves to identify those environmental components that are likely to be affected by the Project.

3.2.1.1 EIA (2010)

The potential interactions between Project components or Project activities and environmental components of concern (ECCs), specifically VECs, were identified during an issue scoping process. Environmental components include the biological, physical and socio-economic environment. As a result of this process, the actual assessment focused (only) on issues / components of concern.

Consultation with stakeholders (e.g., regulators and the public), as well as the scientific community, was part of the issues scoping process and the identification of VECs. The selection of VECs was also based on experience gained during other comparable environmental assessments, available information on the environment surrounding the proposed project, and the technical and professional expertise of Wood (formerly AMEC).

The evaluation of the environmental issues resulted in the following Project VECs:

- Shadow Flicker
- Aesthetics
- Noise
- Air quality
- Traffic
- Waste Disposal
- Accidents and Malfunctions
- Electromagnetic Interference
- Groundwater
- Ecological Effects
- Environmentally Sensitive Areas

3.2.1.2 Updated Assessment (2019)

The changes in WEC technology and the Project layout were presented to EPD and TCDPO at a meeting in June 2017. In order to identify potential impact variation between the two proposed Project layouts, BLPC proactively prepared and presented a Gap Analysis based on a comparison of the currently approved Project layout assessed in the EIA and the proposed revised Project layout. The Gap Analysis was focused on the Valued Ecosystem Components (VEC) model, to determine if the new Project layout would have a direct impact on the VEC technical studies presented in the EIA. The results of the Gap Analysis of VECs are presented in Table 3-1.

Table 3-1: Gap Analysis of VECs

Valued Ecosystem Component	Main Changes	Impact
Shadow Flicker	Number and size of WECs	Additional study recommended
Aesthetics (Visual Assessment): Zone of Influence	Number and size of WECs	Additional study recommended
Aesthetics (Visual Assessment): Photomontage	Number and size of WECs	Additional study recommended
Noise	Number of WECs	Additional study recommended
Air Quality	Number of WECs (construction)	No change
Traffic	Number and size of WEC components	No change
Waste Disposal	Size of WECs (construction)	No change
Accidents and Malfunctions	Size of WECs (construction)	No change

Valued Ecosystem Component	Main Changes	Impact
Electromagnetic Interference	Number of WECs	No change
Hydrogeology and Groundwater Quality	Number of WECs	No change
Ecological Effects: Flora	Number of WECs	No change
Ecological Effects: Fauna	Number of WECs	No change
Environmentally Sensitive Areas	No new environmentally sensitive areas	No Change

The Gap Analysis identified four (4) technical components that were deemed to necessitate further effects assessment due to the direct interaction between the VECs and the revised Project layout, type and number of WECs. EPD and TCDPO reviewed the selection process with the Project Team and acknowledged the scoped recommendations for additional study. On the basis of that agreement in principle, BLPC proceeded with the execution of the effects assessment of selected VECs.

Accordingly, the VECs which have been recommended for the technical effects assessment under the new project configuration are:

- Shadow flicker assessment;
- Aesthetics: visual assessment - Zone of visual influence analysis;
- Aesthetics: visual assessment – Photomontage; and
- Noise impact assessment.

The findings of these four (4) technical assessments are presented in Section 4.0, to support EPD's and TCDPO's review of the Lamberts East Wind Farm.

3.2.2 Temporal and Spatial Assessment Boundaries

The spatial boundaries for WEC construction include the actual footprint of each individual WEC, the entire Project site, as well as the spatial distribution of those VECs which the assessment has determined are potentially affected.

The updated technical studies undertaken as part of this assessment have focused on the operational phase of the Project, as the change in WEC technologies and revised Project layout do not translate to significant changes in construction methods. Potential impacts related to construction and temporal and spatial bounds applicable to the construction phase are expected to remain consistent with the EIA.

3.2.2.1 Original Assessment (2010)

The temporal bounding envelope for the operational phase of the proposed Project reflects the long-term operation of the wind energy facility (WEC design lifetime is 20 years). There is some temporal variability, since a refurbishment of the WECs at the end of their regular lifetime is possible. This refurbishment will likely double the lifetime of the wind generator facility, but a new planning application and approval will be required to extend generation beyond the 24-year approval duration.

The spatial boundaries for assessing potential effects will typically be established by determining the spatial extent of an effect of a project component or a project activity. The physical boundaries of the site are as shown on Figure 3-1.

Both the duration of the effects (temporal boundary) and physical (spatial) boundary may vary depending on the individual VEC and Project activity.

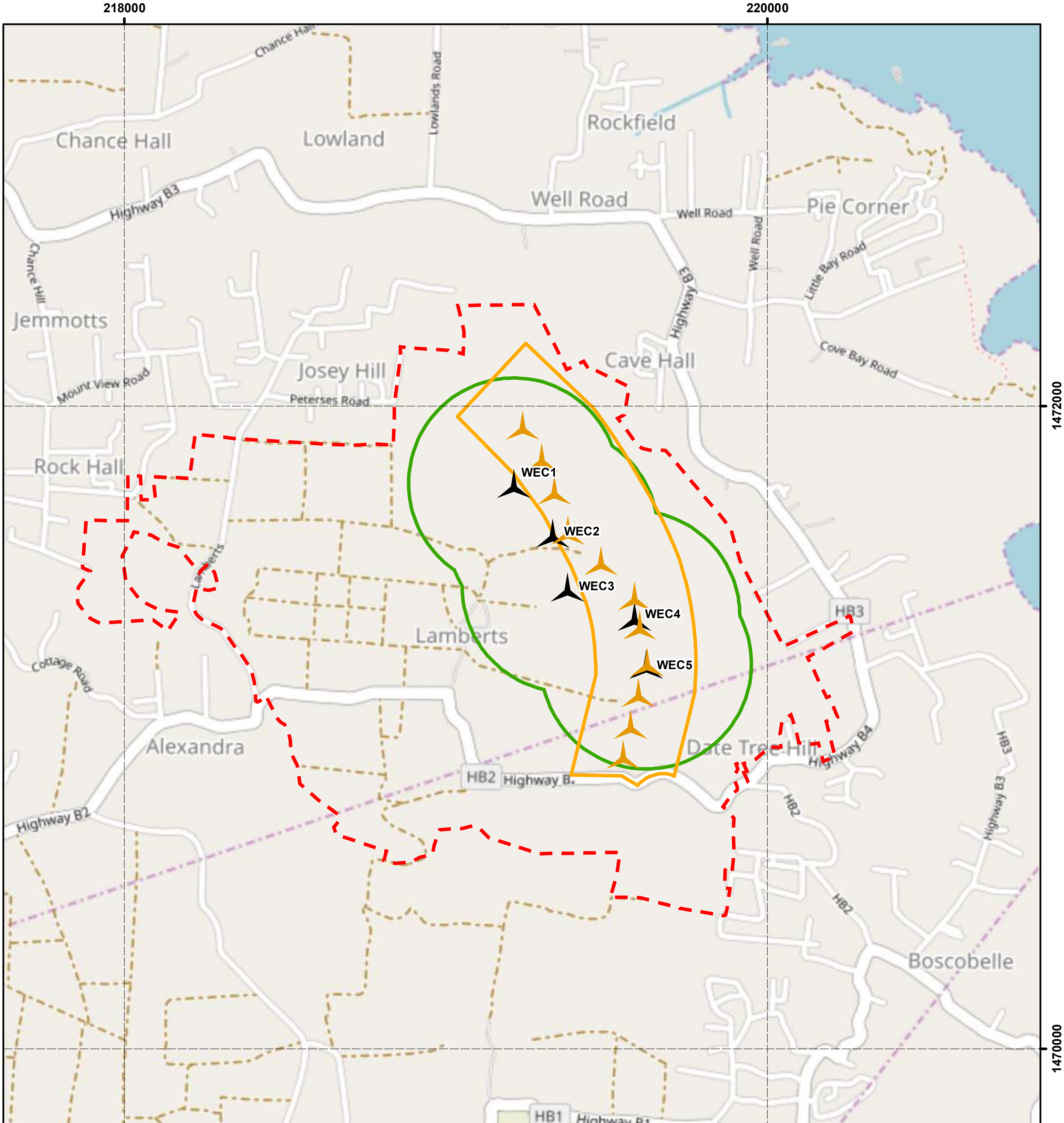
3.2.2.2 Updated Assessment (2019)

The updated technical assessment revaluated the temporal and spatial assessment boundaries based on the revised Project layout, to confirm the boundaries established in the EIA remain accurate or are updated accordingly.

Since approval in 2010, BLPC has secured via long-term lease lands of Lamberts Plantation, and has also purchased the private property at Lamberts Yard for non-residential use. The agreement will allow BLPC to properly control which areas are enclosed and secured for purposes of the project with the remaining of the estate to be used for agriculture purposes., The buildings within the yard are no longer considered residential receptors, and this allows added flexibility in positioning the turbines.

For the operational phase, the temporal bounding envelope extends 20 years subsequent to completion of construction and remains consistent with the Project temporal bounding envelope defined in the EIA. The expected operational life of the ENERCON E-70 E4 WEC is twenty (20) years, which is equivalent with the expected operational life of the Vestas 850 kW WEC.

The reconfiguration of the Project layout has resulted in a westerly shift of the Project spatial boundary. The reconfiguration of the WECs could have also resulted in a compression of the north and south limits due to the reduction of WECs and concentration in the centre of the property. However, rather than a compression, the spatial boundary was maintained to provide a more conservative assessment of effects. Consistent with the EIA, the spatial boundaries continue to remain within the property limits of the Lamberts Plantation (Figure 3-1).



LEGEND

- WEC (Original Project Layout)
- WEC (Revised Project Layout)
- Original Project Site Boundary
- Revised Project Site Boundary
- Lamberts Plantation Property Boundary

0 0.175 0.35 0.7 1.05 1.4 Kilometres

NOTES:
- WEC: Wind Energy Converter
- Topography from ESRI

Datum: WGS 1984
Projection: UTM Zone 21N

N S E W

wood.

LAMBERTS EAST WIND FARM ENVIRONMENTAL IMPACT ASSESSMENT

Project Spatial Boundaries

PROJECT N°: 6.19.203573.CAN	**FIGURE: 3.1**
SCALE: 1:16,000	DATE: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Project_Spatial_Boundaries_2.mxd

4.0 Environmental Effects Assessment

4.1 Shadow Flicker

Shadow flicker occurs when the sunlight and the rotating WEC blades interact in such a way that a moving shadow is cast onto the ground or stationary objects. Within the range of the shadow at any specified location, a flickering effect is evident when the shadow passes. It is generally recognized that shadow flicker impacts reduce with distance, and that shadow flicker usually occurs in the morning or evening when the sun is low in the sky and shadows are long. When the sun is obscured by clouds, fog, or by intervening objects, no shadow flicker will be present. There will also be no shadow flicker from a WEC when the WEC is not operating due to controlled stoppage by the operator, or under no wind conditions to very slow wind conditions that compromise WEC operation.

The EIA (2010) did not apply any specific assessment procedures as it followed the International Finance Corporation (IFC) Environmental Health and Safety Guidelines for Wind Energy (IFC 2006), which does not include any specific limits for acceptable exposure to shadow flicker.

According to current industry standards and planning guidance[4,5], shadow flicker impact is likely to be negligible beyond a distance of 10 RotorDiameters (RDs). It was therefore determined for the purpose of this updated technical effects assessment, to apply an estimated conservative zone of potential shadow flicker effect to establish the study limits at a distance of up to 10 RDs, which equates to 710 m based on the RD of the Enercon E-70 E4-2.3MW WEC. The assessment will be conducted in order to review the EIA (2010) exposure and the current Project configuration exposure to shadow flicker.

4.1.1 Original Assessment (2010)

4.1.1.1 Methodology

The potential shadow flicker for the wind farm was modeled and is demonstrated in Figures 4-1 to 4-4 (as shown in the EIA, Figures 7-10 to 7-13), which show shadow flicker contours.

Demonstrated on the figures are the possible maximum number of hours per year of shadow flicker on a 1 m x 1 m (vertical) house window situated 2 m above the ground and facing north, east, south or west, and facing perpendicular to the WECs.

The modeling was very conservative and assumes full sunshine throughout the year (i.e., no cloudy periods). It did not take into account the following:

- Periods when the sun is obscured by cloud – no shadow flicker generated;
- Wind direction – shadow flicker is not an issue when the rotor is pointing in a direction perpendicular to the direction of the sun from the window (the rotor is not positioned perpendicular to the sun and sensitive receptor);

4 Scottish Executive, 2001, Planning Advice Note (PAN) 45: Renewable Energy Technologies, section 64
5 Department for Business Innovation and Skills, 2009, Onshore Wind: Shadow Flicker , data accessed at: www.berr.gov.uk/energy/sources/renewables/planning/onshore-wind/shadow-flicker/page18736.html

- WEC operating hours – there is no shadow flicker when a WEC is shutdown, as would be the case for low or very high wind, maintenance or repair;
- Shading due to terrain, vegetation, or buildings – these will block the shadow; and
- Hours estimated when the property is actually used by people (who are awake / active) and they are situated at a spot where flicker could be an annoyance (at other times there is no receptor exposure to the shadow flicker and consequent annoyance).

4.1.1.2 Effects Assessment

The areas most affected by shadow flicker, that is with the longest durations and longest shadows, occur in the northwest to southwest and in the northeast to southeast of a WEC. The intensity is highest closer to the WEC; with intensity and duration both diminishing with distance from the WEC.

For dwellings closest to the wind farm, the theoretical maximum amount of shadow flicker could be as much as 80 hours per year, or an average of less than 15 minutes per day. The effects of shadow flicker diminish with distance from the WEC. When taking into account all of the additional factors that were not included in the analysis to maintain conservative estimates of effect, it is anticipated that the period that shadow flicker could potentially be an annoyance would be reduced to a few minutes per day.

4.1.2 Updated Assessment (2019)

4.1.2.1 Methodology

The shadow flicker analysis was conducted using the Shadow Flicker module of the ReSoft WindFarm software.

The results generated by the WindFarm model are considered to be consistent with the definition of the 'astronomic worst case' in the German Guidance (WEA- Schattenwurf-Hinweise, 2002)[6] which assumes that:

- Buildings each have a single window of 2 m x 2 m facing the wind farm;
- Calculated at an eye level of 2 m above ground;
- The sun is always shining;
- The WEC blades are always turning;
- The WEC rotor tracks the movement of the sun; and
- That there is no screening from vegetation or buildings.

The minimum angle of the sun above the horizon also has an effect on the results. As the sun approaches the horizon, the light becomes less intense and therefore the shadow influence is reduced. The analysis

6 WEA-Schattenwurf-Hinweise (2002). Hinweise zur Ermittlung und Beurteilung der optischen Immissionen von Windenergianlagen (Notes on the identification and assessment of the optical pollutions of Wind Turbines).

was conducted using a 2˚ minimum angle above the horizon. This value is considered to be conservative as the lower the sun is in the sky, the longer the shadow cast by WEC would be, thus potentially impacting a greater area. However, at below 2˚ it is generally considered that the intensity of the light decreases such that shadow flicker is unlikely to occur to any significant extent.

According to current industry standards and planning guidance[7,8], shadow flicker impact is likely to be negligible beyond a distance of 10 RDs, which equates to 710 m based on the RD of the Enercon E-70 E4-2.3MW WEC. BLPC provided the identification of the Shadow Flicker Receptors (SFRs) located within the 710 m zone, and accordingly all these receptors were included in the model for effects assessment.

4.1.2.2 Effects Assessment

With respect to each of the potential shadow flicker receptors, a total number of shadow flicker hours in a year were modelled. It was found that a number of SFRs would experience varying amounts of shadow flicker in a year.

To visualize the worst-case shadow flicker likely to occur over the wind farm area, a shadow flicker map is presented in Figure 4-5. This map shows areas where shadow flicker visibility is possible under specific atmospheric conditions at eye level of 2 m above ground.

The SFRs are largely located to the east and west of the WEC and in line with the predominant wind direction and reflective of the rising and setting sun when sun angles are low. It can be seen that:

- Four (4) SFRs to the east are expected to have over 80 hrs/year of shadow flicker;
- Thirty-two (32) SFRs to the east are located within effects zones between approximately 30 hrs/year and 80 hrs/year of shadow flicker; and
- Thirty (30) SFRs to the east and the north-west are located within effects zones between approximately 10 hrs/year and 30 hrs/year of shadow flicker;
- Twenty-five (25) SFRs (the remaining SFRs still within the 710 m zone of influence used as the general limit of observable effects) located to the east and the north-west are expected to have less than 10 hrs/year of shadow flicker.

4.1.3 Comparison of Effects

The methodologies applied in the EIA (2010) and the updated technical assessment vary as the present technical effects assessment takes advantage of up to date standards in modeling software and industry practice. To graphically summarize the study findings, the EIA (2010) included individual figures that represented an assumed selection of four (4) general directional views (i.e., north, south, east, west). The updated technical effects assessment analysis has accounted for multiple facing directions summarized and represented in one comprehensive effects delineation figure.

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7 Scottish Executive, 2001, Planning Advice Note (PAN) 45: Renewable Energy Technologies, section 64
8 Department for Business Innovation and Skills, 2009, Onshore Wind: Shadow Flicker , data accessed at: www.berr.gov.uk/energy/sources/renewables/planning/onshore-wind/shadow-flicker/page18736.html

In order to compare the findings of the original and updated technical effect assessment, the 80 hrs/yr, isoline, representative of the theoretical maximum amount of shadow flicker experienced by receptors, was combined from each of the four (4) EIA figures to generate one representative isoline for the overall Project (Figure 4-5). In comparison of the 80 hrs/yr isolines of the original and revised Project layout, the updated layout of five WECs has resulted in a reduction in the number of SFRs that are located within the 80 hrs/yr isoline by eight (8), representing a reduction of 67% of potentially affected residences.

Conclusion of Consistency with EIA Findings

In review of technical consistency of findings with the EIA (2010), this technical assessment has confirmed that the current Project layout does not exacerbate the effects related to shadow flicker, and in fact has demonstrated a reduction in effects.

4.1.4 Mitigation Measures

Based on the EIA (2010) several optional mitigation measures were identified to potentially reduce concerns with shadow flicker. Although the shadow flicker effects are considered minor, consideration of mitigation measures will be evaluated in consultation with stakeholders, when and where practical and feasible. These include planting screening vegetation (trees and bushes that exceed 2 m in height) in specified locations, installing curtains and/or shutters to block shadow flicker into SFR buildings or constructing screens, trellis structures or fences strategically placed to block effects of shadow flicker at SFRs. The WECs could potentially enter a limited state of operation, when sunlight, wind speed and the angle and position of the sun combine to cause a flicker nuisance.

No new mitigation measures have been considered in this report.

4.2 Visual Assessment

A key environmental effect associated with a wind farm is related to aesthetic considerations and visual effect. The revised Project layout consists of a reduction in the number of WEC from eleven (11) to five (5), reducing an extent of visual interactions with the Project. The Project revision has introduced a technology that increases WEC hub height from 49 m to 58 m, a potential for increased visual interaction.

To update the Aesthetics VEC effect assessment, a Zone of Visual Influence (ZVI) assessment and photomontage were completed consistent with recommendations of the Gap Analysis. This assessment was intended to identify any potential changes to effects upon both the landscape resource and the visual environment arising from the introduction of the revised Lambert's East Wind Farm.

4.2.1 Zone of Visual Influence

4.2.1.1 Original Assessment (2010)

Methodology

The ZVI as depicted in the EIA (Figure 4-6), demonstrates areas from which the WEC or parts of the WEC would be visually discernable. It should be noted that the assessment is based on the partial visibility of components of a WEC (nacelles – turbine housing) in relation to the general topography of the surrounding area, rather than the complete WEC structure from ground to vertical extent of the rotor blades. This approach was considered to provide a more conservative assessment of the aesthetic interaction and associated effect. It should be noted, that the effect zone colours in Figure 4-6 reflect the number of nacelles that are visible from any spot within 6 km of the site accounting for terrain, and that the mapping does not account for the screening due to vegetation or existing infrastructure.

Effects Assessment

Based on the applied assessment model, the following was concluded regarding the visibility of the eleven (11) WECs:

- Within an area of approximately 1.5 km of the centre of the WECs, all eleven (11) are generally visible;
- Between approximately 1.5 km and 3 km, all eleven (11) WECs are generally visible along the northeast coast between Grape Hall and Boscobelle, with a partial distribution of visibility in areas south-west of the Project form Mount Stepney to Mount Gay;
- Between approximately 3 km and 5 km, visibility is limited to between one (1) and (5) WECs along the west coast from Mount Royer to Bromfield; and
- Beyond 3 km to the south and east, and 5 km to the north and west, WECs are generally no longer visible.

4.2.1.2 Updated Assessment (2019)

Methodology

A ZVI analysis (Figure 4-7) was conducted using the Zone of Visual Impact module of the OpenWind software. The same methodology used in the ZVI assessment completed in 2010 was applied, representing the worst-case scenario, where:

- The number of nacelles that are visible from any location within approximately 6 km of the Project site to establish representative zones of visual influence;
- The analysis considers changes in terrain elevation but does not account for potential visual obstruction due to vegetation and structures / infrastructure (e.g., buildings and/or other structures); and
- The height of point of assessment at any location is 1.75 m above ground level.

Effects Assessment

Based on the applied assessment model, the following is concluded regarding the visibility of the five (5) WECs:

- Within an area of approximately 1.5 km of the centre of the WECs, all five WECs are generally visible;

- Between approximately 1.5 km and 3 km, visibility for all WECs is restricted to areas along the east coast between Pie Corner and Sea View, and south of the Project along the Mount Stepney to Cherry Tree Hill alignment. All other areas have sporadic visibility of some of the WECs; and
- Between approximately 3 km and 5 km, visibility of WECs is predicted to be scattered in areas located in the northern regions of the island.
- Beyond 3 km to the south one to three WECs have limited visibility, and beyond 3km to the east and west there is zero visibility of any WECs.

4.2.1.3 Comparison of Effects

The reduction in the number of WECs resulted in a corresponding reduction in the general area from which the WECs would be visible. As graphically demonstrated on Figure 4-6, where the EIA (2010) AVI assessment is depicted, a large part of the north-west portion of the Island included visibility of between one (1) and eleven (11) WECs.

Under the updated Project effects assessment, the areas where WECs are visible have become notably sparser, with many areas now demonstrating no discernable visibility (Figure 4-7). A significant reduction in visibility is also present in the central and northern areas of the Island, including Church Hill and Mount Gay.

Conclusion of Consistency with EIA Findings

In review of technical consistency of findings with the EIA (2010), this technical assessment has confirmed that the current Project layout does not exacerbate the effects related to visual impacts/ zone of visual influence, and in fact has demonstrated a reduction in effects.

4.2.2 Photomontage

4.2.2.1 Original Assessment (2010)

Methodology

The view points indicated on Figure 4-8, and listed below in Table 4-1, were chosen for the photomontages (Figure 4-9 to Figure 4-11) applied in the assessment. To produce the photomontages, photographs were taken from the view points using a digital camera mounted on a tripod. Multiple shots were “stitched” together using Canon® camera software to form a panoramic view. The grid coordinates of various reference points in the photographs were obtained using a portable GPS. A digitized map of the area was used to generate a wireline projection of the site from each viewpoint with the WECs incorporated.

Table 4-1: Locations of Photomontage Viewpoints (2010)

Location of Viewpoint		BN Grid Reference	Distance from Site
Viewpoint	Description		
Viewpoint 1	From the Pie Corner Mission	E25255, N88150	1.5 km
Viewpoint 2	From Risk Road	E26310, N87895	0.4 km
Viewpoint 3	From the existing WEC	E27660, N87780	1.0 km

Effects Assessment

The nature of the landscape of this part of Barbados is such that it reduces the number of areas from which the whole of the wind farm can be seen primarily to the north-east coast. The design of the WECs allow for them to moderately blend in with the scenery. From these simulations, it was concluded that the Project will not impose a significant visual impairment of the scenery of the area under the eleven (11) WEC configuration.

4.2.2.2 Updated Assessment (2019)

Methodology

The view points indicated on Figure 4-12, and listed below in Table 4-2, were chosen for the photomontages (Figure 4-13 to Figure 4-17). To produce the photomontages, photographs were taken from the selected view points using a digital camera mounted on a tripod. The camera maker was FUJIFILM with model X30, taken at a 7 mm focal length. Multiple shots were “stitched” together using ReSoft WindFarm to form a panoramic view. The grid coordinates of various reference points in the photographs were obtained using a portable GPS. A digitized map of the area was used to generate a wireline projection of the site from each viewpoint with the WECs incorporated. The study was structured to include the same vantage points as the EIA (2010). The assessment was further expanded at the request of EPD to provide a better overview of the viewpoints from different locations, through two additional viewpoints that were captured from Josey Hill (Figure 4-16 and Figure 4-17).

Table 4-2: Locations of Photomontage Viewpoints (2019)

Location of Viewpoint		UTM Zone 21 (WGS 84) Reference	Distance from Site
Viewpoint	Description		
Viewpoint 1	From the Pie Corner Mission	E219815, N1472317	1.2 km
Viewpoint 2	From Risk Road	E220361, N1471238	0.8 km
Viewpoint 3	From existing WEC	E218113, N1471564	1.5 km
Viewpoint 4	From Josey Hill (at Church)	E218470, N1471992	1.4 km
Viewpoint 5	From Josey Hill (alternative location)	E219893, N1470619	0.6 km

Effects Assessment

The number of WECs have been reduced to five (5) for this assessment with a slight increase in nacelle height with the new infrastructure. Consequently, all WEC hubs are predicted to be visible from each of the viewpoints. With the nature of the landscape, there are regions where the WECs are partly obscured by vegetation.

4.2.2.3 Comparison of Effects

The reduction in the number of WECs from eleven (11) to five (5) results in a direct reduction in the visual impact of the Project, as the maximum number of WECs that have the potential to be seen have been reduced by over half. The intended application of the revised WEC model, reduction in number of WECs and modified Project layout has resulted in a reduction in visual impacts associated with the Project.

Conclusion of Consistency with EIA Findings

In review of technical consistency of findings with the EIA (2010), this technical assessment has confirmed that the current Project layout does not exacerbate the effects related to visual impacts/ photomontage, and appears to have a similar effect.

4.2.3 Mitigation Measures

Based on the EIA (2010) several specific mitigation options have been presented and are still applicable. The options have been included in the plans for the site as follows:

- The route of the access road to the site will be chosen to reduce the visibility for the dwellings to the east of the site.
- The tower height of the WEC has been kept to a minimum reasonable dimension to allow for decreased / minimized visual impact.
- The number of WECs has been reduced from earlier studies while still retaining the same total energy output.

Additional research that has been undertaken into WEC colour and finish further promotes a reduction of visual impacts. The ENERCON E-70 E4 WEC, with typically painted pale grey units and gradations of green rings on the portions of the tower closest to the ground, help them blend in with surrounding grassy regions.

4.3 Noise Assessment

WECs generate sound through a variety of different mechanisms, which can be grouped into two separate groups: mechanical sources and aerodynamic sources. The major mechanical components include the gearbox, generator, and yaw motors, each of which produce their own characteristic sounds. Other mechanical systems, such as fans and hydraulic motors, can also contribute to the overall acoustic emissions. Mechanical noise is radiated by the surface of the WEC and by openings in the nacelle housing.

The interaction of air and the WEC blades produces aerodynamic noise through a variety of processes as air passes over and past the blades. [9 10]

4.3.1 Original Assessment (2010)

4.3.1.1 Methodology

As the Government of Barbados does not have specific noise levels standards for wind farm developments, the suggested criteria were based on the guidelines used in Ontario Canada. Under those guidelines, the maximum noise levels at the closest residence would be 45 dBA at up to 8 m/s wind speed and would be allowed to increase at higher wind speeds due to the wind-induced increased background sound levels. This also compares with the guidelines for the World Health Organization (WHO) and World Bank which each recommend 45 dBA at sensitive receptors such as houses during the night time.

The sound levels were based on worst-case noise levels at maximum power output for the Vestas V-52 850 kW WEC. Reduced noise levels can be achieved for the same wind speeds but with lower power outputs.

Sound contours were developed for the wind farm at different wind speeds using the ReSoft WindFarm software noise module. This was based on the "Description of Noise Propagation Model Specified by Danish Statutory Order on Noise from Windmills (Nr. 304, Dated 14 May 1991)" as produced by the Danish Ministry of the Environment National Agency for Environmental Protection. The DSO 304 model attenuation coefficient was adjusted to match the 40, 43 and 45 dBA noise level predicted by an ISO 9613-2 model as referenced by the Ontario noise guideline. The ISO 9613-2 model was used to check the results from the DSO 304 model with the adjusted attenuation coefficient.

4.3.1.2 Effects Assessment

Sound level contours in the vicinity of the closest receptors for given wind speeds of 6 m/s (40 dBA contour), 7 m/s (43 dBA contour) and 8 m/s (45 dBA contour), are shown on Figures 4-18 to 4-20, respectively.

Based on maximum power output, the predicted noise level at the Lambert’s Plantation house, which is the closest receptor, meets the WHO guideline of 45 dBA at a wind speed of 8 m/s (Figure 4.20). At higher wind speeds the background sound levels will increase at a greater rate than the turbine noise. The WHO guidelines are acceptable levels of sound for sleeping but do not require inaudibility. Wind turbines have an amplitude modulation at low frequency producing the characteristic “swoosh”, which should not be confused with low frequency sound or infrasound.

9 World Bank Group, ENVIRONMENTAL, HEALTH, AND SAFETY GUIDELINES WIND ENERGY (2015)
10 B. Howe et al., Wind Turbines and Sound: Review and Best Practice Guidelines (2007)

4.3.2 Updated Assessment (2019)

4.3.2.1 Methodology

As the Government of Barbados does not have specific noise levels standards for wind farm developments, the suggested criteria are based on the guidelines used in Ontario Canada, as was applied in the EIA.

Noise data was obtained for the Enercon E-70 E4 WEC (Operational Mode II) which is proposed for the Project. The sound levels are based on sound power level, as a function of the wind speed, of the identified WECs at a hub height of 57 m and in Operational Mode II, for wind speeds between 4 m/s and 10 m/s.

An acoustic model of the Project was created by use of a noise prediction software package, CadnaA, published by Datakustik GmbH. This software package implements the ISO 9613-2 [11] environmental sound propagation algorithms for assessment of stationary sources. It allows for the creation of complex acoustical models and predictions of noise levels at specific receptors due to sound emissions from a specific source(s). The modelling takes into account the following factors:

- Source sound power level and directivity;
- Distance attenuation;
- Source-receptor geometry, including heights and elevations;
- Barrier effects of the building and surrounding topography; and
- Ground and air (atmospheric) attenuation.

Based on the sound power data collected from the manufacturer, noise levels induced from the WECs under different wind speed conditions were calculated at the selected receptors. Topographical data for the site and surrounding area was provided and used to create a terrain model for the calculation of sound levels. 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 20 degree Celsius (°C) and 70%, respectively.

4.3.2.2 Effects Assessment

Based on preliminary information from the updated Noise Impact Study[12] , including the baseline measured on site (NMT1 and NMT2), and continuous monitoring covering the period from October 2017 to February 2019, it can be concluded that for more than 90% of the sample period, the baseline metric L_{Aeq} was measured to be above 45 dBA.

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11 International Organization for Standardization, "ISO-9613-2. Acoustics – Attenuation of Sound during propagation outdoors. Part 2 – General method of calculation," (1996).
12 The noise impact study is currently under discussion with the EPD

In terms of cumulative sound levels at receivers – i.e., adding the sound levels from the operation of the facility to the measured on-site baseline sound levels, and based on preliminary information from the updated Noise Impact Study[13], the average A-weighted equivalent sound pressure level will remain unchanged.

In summary, the operation of the WECs do not result in an average increase in noise levels at the site, as the effects of the existing background noise levels are higher and are expected to remain to be a significant source in the sound environment.

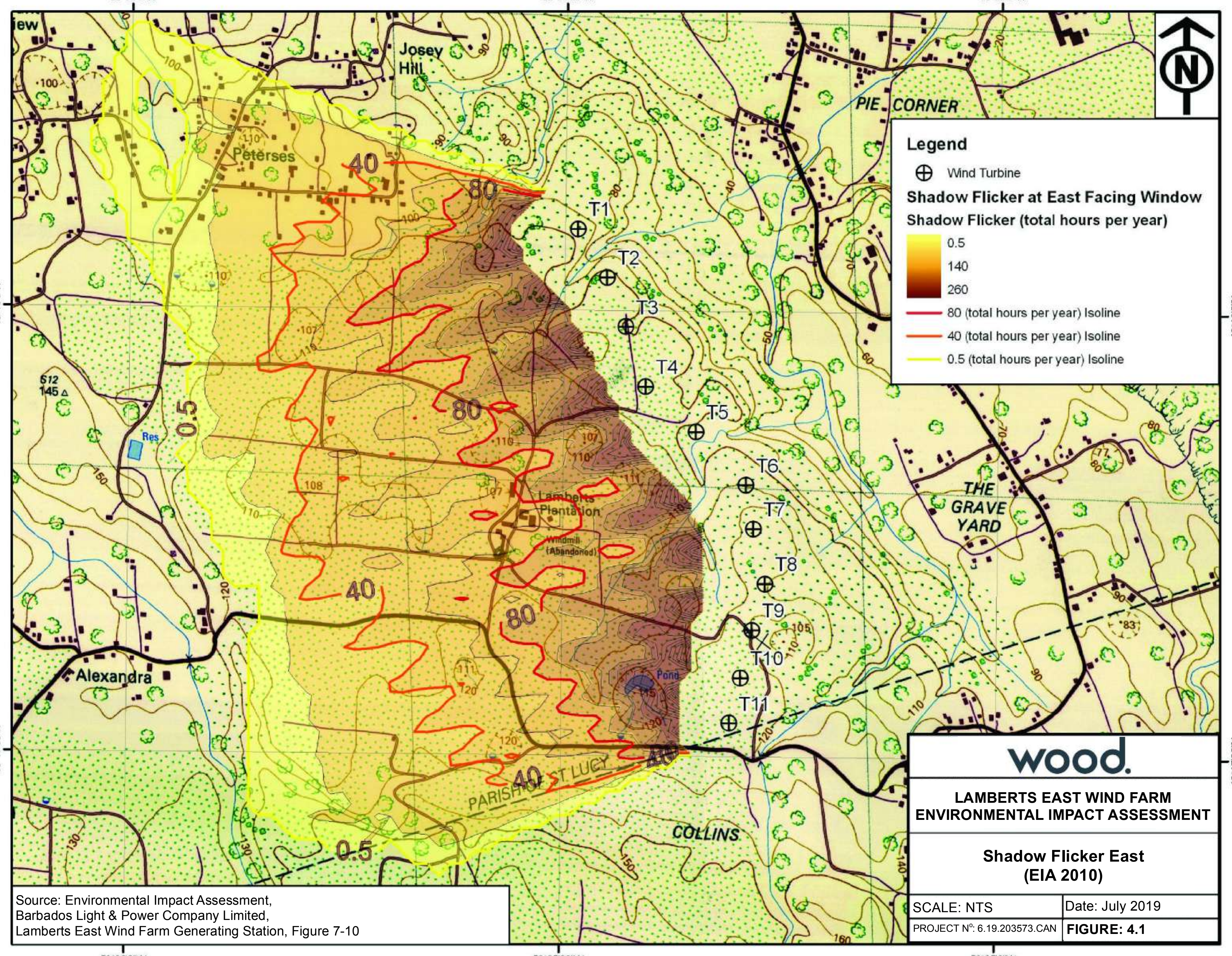
4.3.3 Comparison of Effects

As presented in Figure 4-21, the 45 dBA contour lines associated with wind speeds 4 m/s, 8 m/s and 10 m/s were modeled. The noise assessment was expanded from the assessment in the EIA (2010), which assessed 6 m/s, 7 m/s and 8 m/s, to further assess the upper and lower wind speed limits, at the request of EPD. As shown on Figure 4-21, the 45 dBA contour line at 8 m/s from the EIA (2010) has been significantly reduced as a result of the revised Project layout. The reduction in the number of WECs has resulted in the 45 dBA at 10 m/s contour line extending to the approximate location of the 45 dBA at 8 m/s contour line from the EIA (2010). Furthermore, no noise sensitive receptors are located within the 10 m/s contour line.

Conclusion of Consistency with EIA Findings

In review of technical consistency of findings with the EIA (2010), this technical assessment has confirmed that the current Project layout does not exacerbate the effects related to noise levels, and in fact has demonstrated a reduction in effects.

13 The noise impact study is currently under discussion with the EPD



Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Original_EIA_Shadow_Flicker_East_2.mxd.

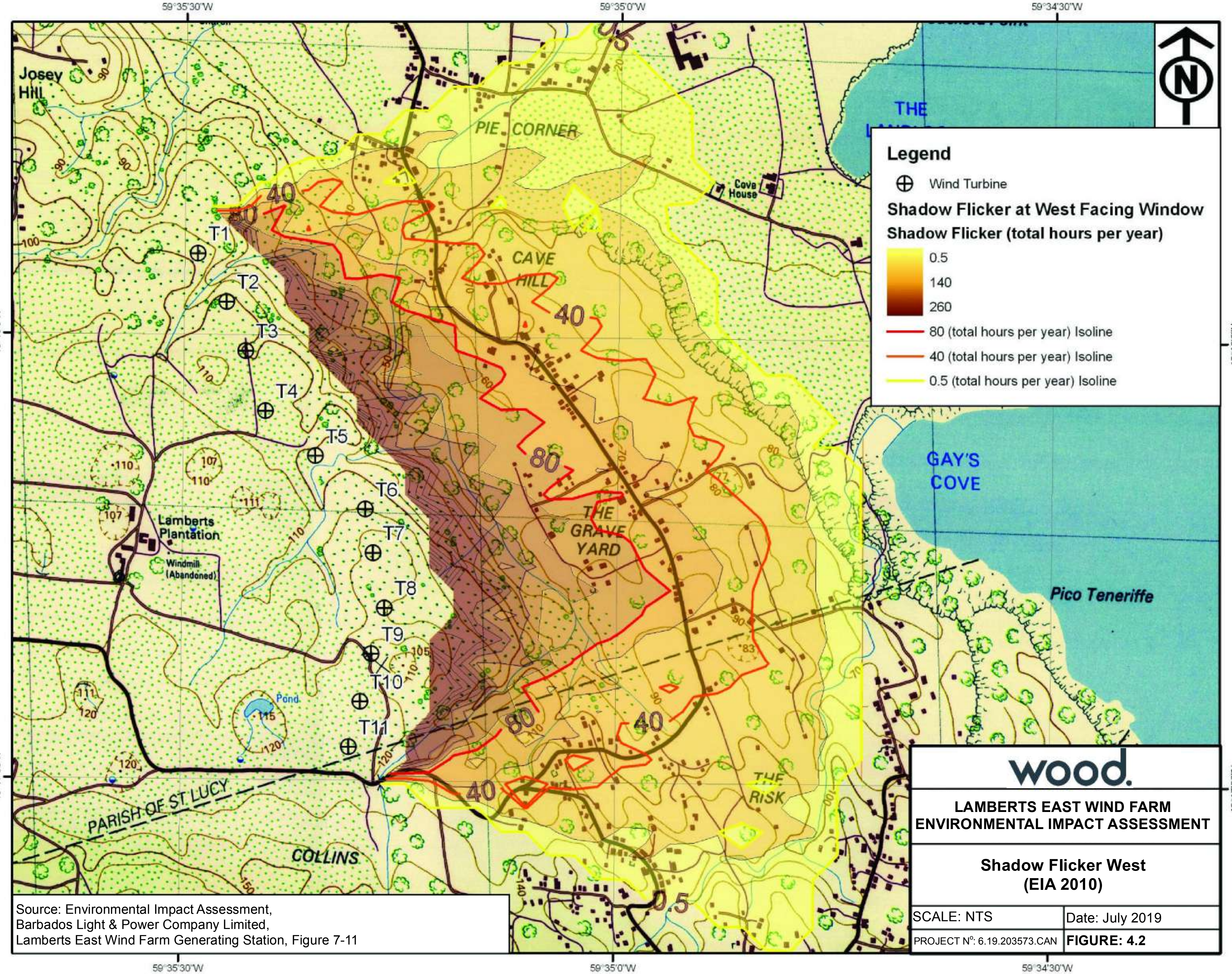
Source: Environmental Impact Assessment,
Barbados Light & Power Company Limited,
Lamberts East Wind Farm Generating Station, Figure 7-10

wood.

LAMBERTS EAST WIND FARM ENVIRONMENTAL IMPACT ASSESSMENT

Shadow Flicker East (EIA 2010)

SCALE: NTS	Date: July 2019
PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.1**



wood.

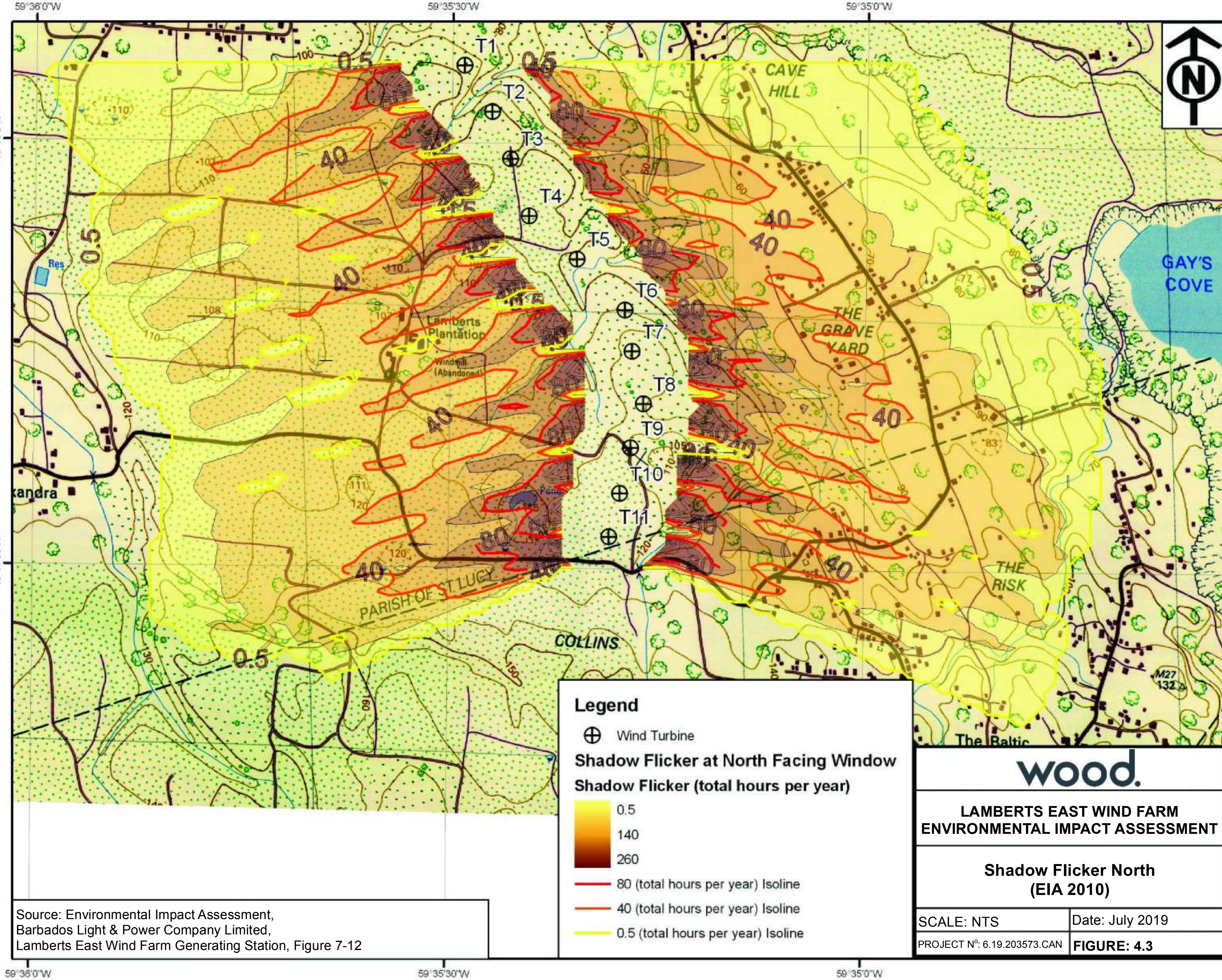
LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Shadow Flicker West
(EIA 2010)

SCALE: NTS	Date: July 2019
PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.2**

Source: Environmental Impact Assessment,
Barbados Light & Power Company Limited,
Lamberts East Wind Farm Generating Station, Figure 7-11

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Original_EIA_Shadow_Flicker_West_2.mxd.



Legend

⊕ Wind Turbine

Shadow Flicker at North Facing Window

Shadow Flicker (total hours per year)

0.5

140

260

80 (total hours per year) Isoline

40 (total hours per year) Isoline

0.5 (total hours per year) Isoline

Source: Environmental Impact Assessment,
Barbados Light & Power Company Limited,
Lamberts East Wind Farm Generating Station, Figure 7-12

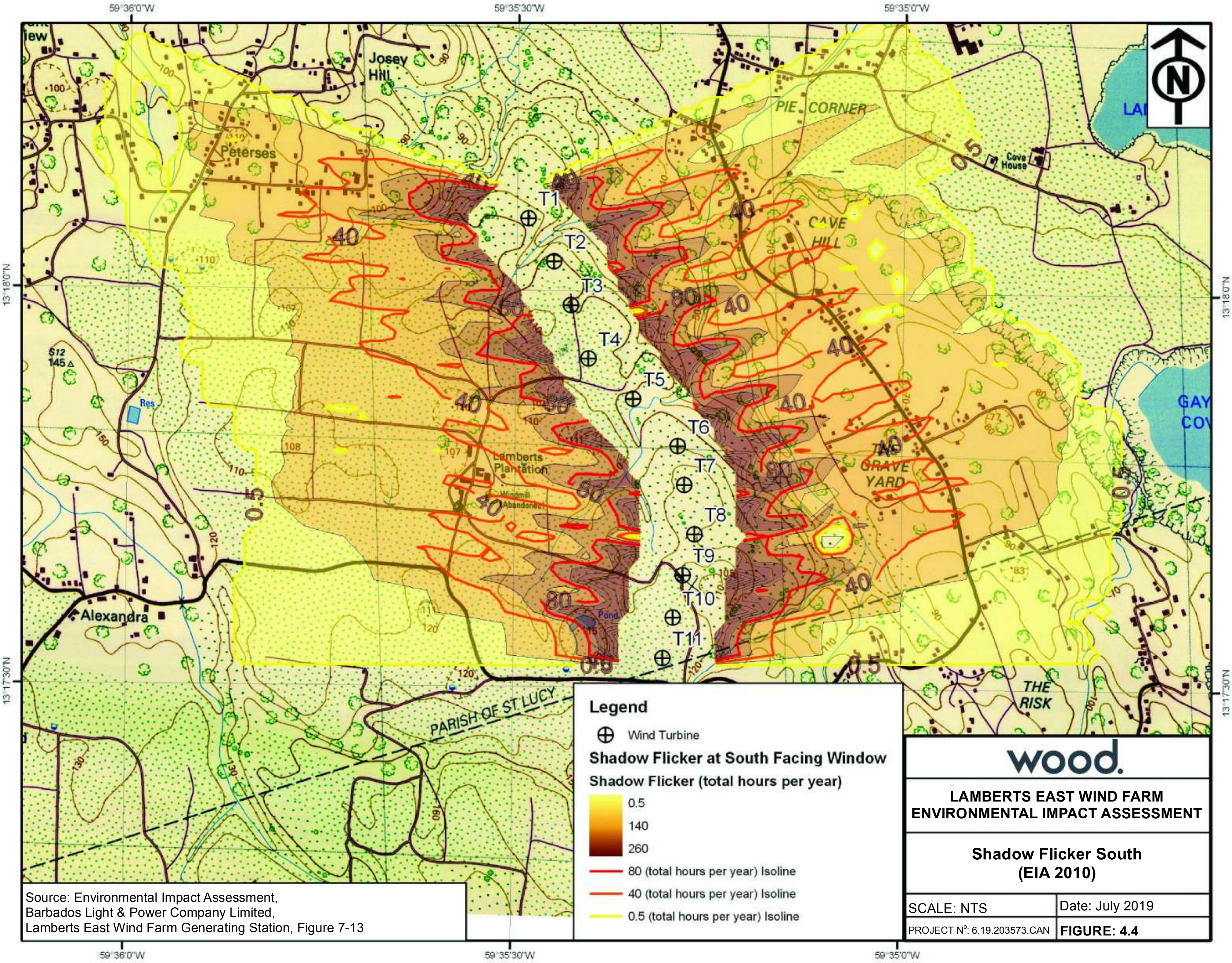
wood.

LAMBERTS EAST WIND FARM ENVIRONMENTAL IMPACT ASSESSMENT

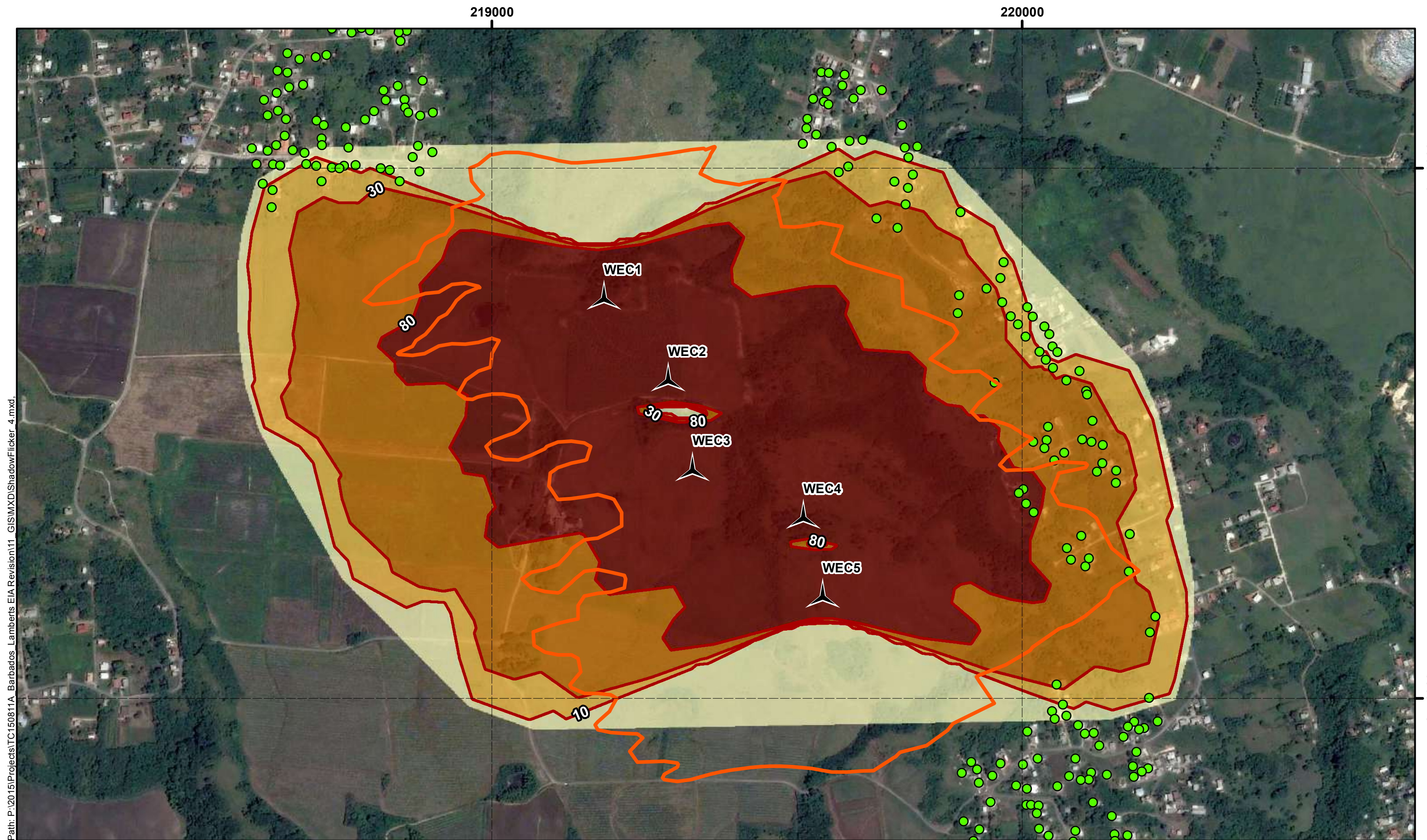
Shadow Flicker North (EIA 2010)

SCALE: NTS	Date: July 2019
PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.3**

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Original_EIA_Shadow_Flicker_North_2.mxd,



Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Original_EIA_Shadow_Flicker_South_2.mxd.



LEGEND

- WEC
- Sensitve Receptor
- Isoline
- 80 Hr Isoline (total hours per year) (the EIA)

Shadow Flicker (hrs/year)

- <10
- 10 - 30
- 30 - 80
- >80

0 100 200 400 600 800 Metres

NOTES:
- WEC: Wind Energy Converter
- Imagery from ESRI

Datum & Projection:
WGS 1984 UTM Zone 21N

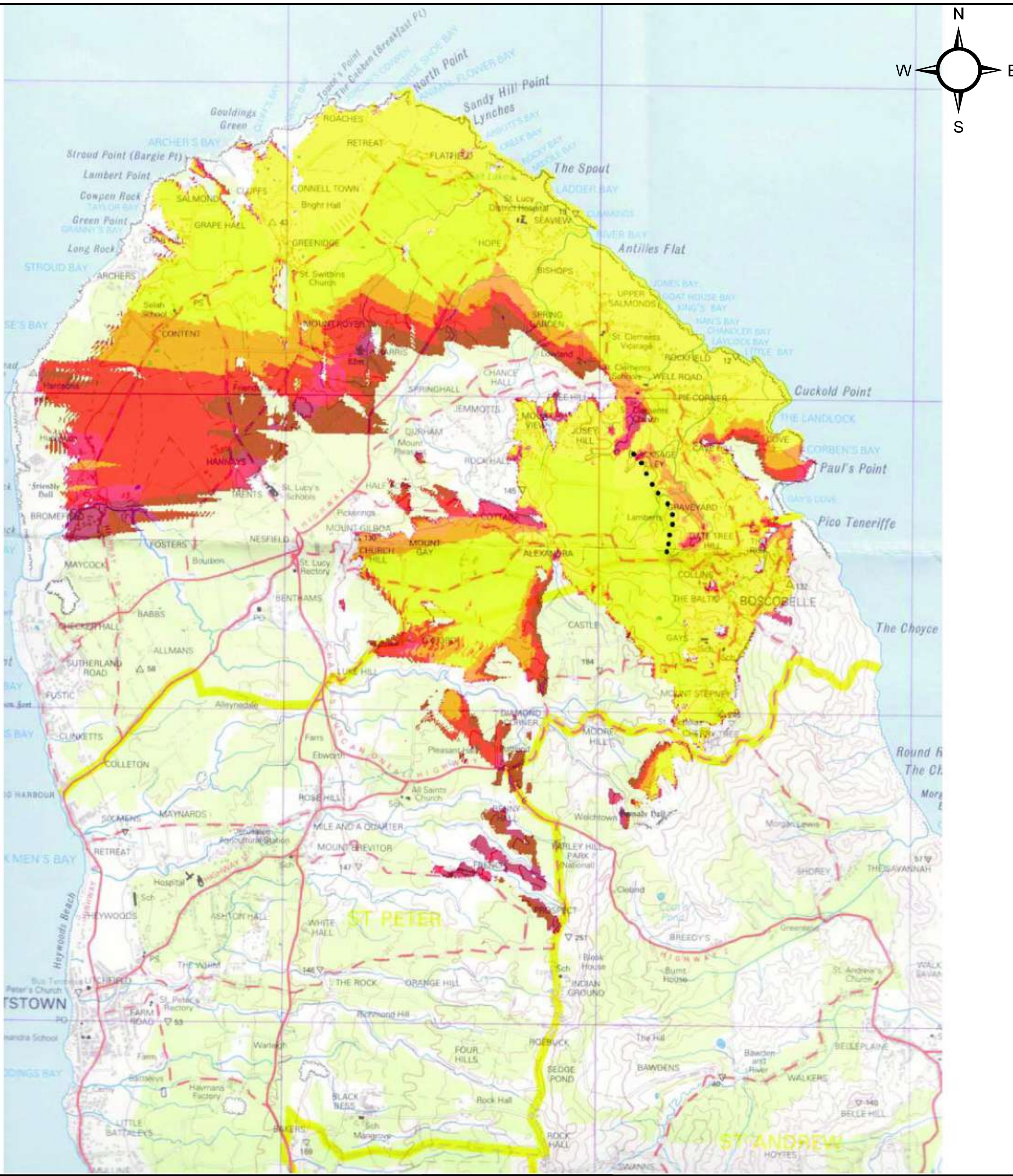
wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

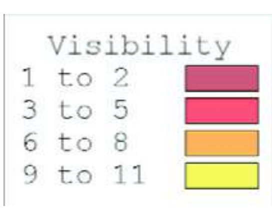
Shadow Flicker
(Updated Assessment)

PROJECT N°: 6.19.203573.CAN | **FIGURE: 4.5**

SCALE: 1:10,000 | Date: July 2019



LEGEND



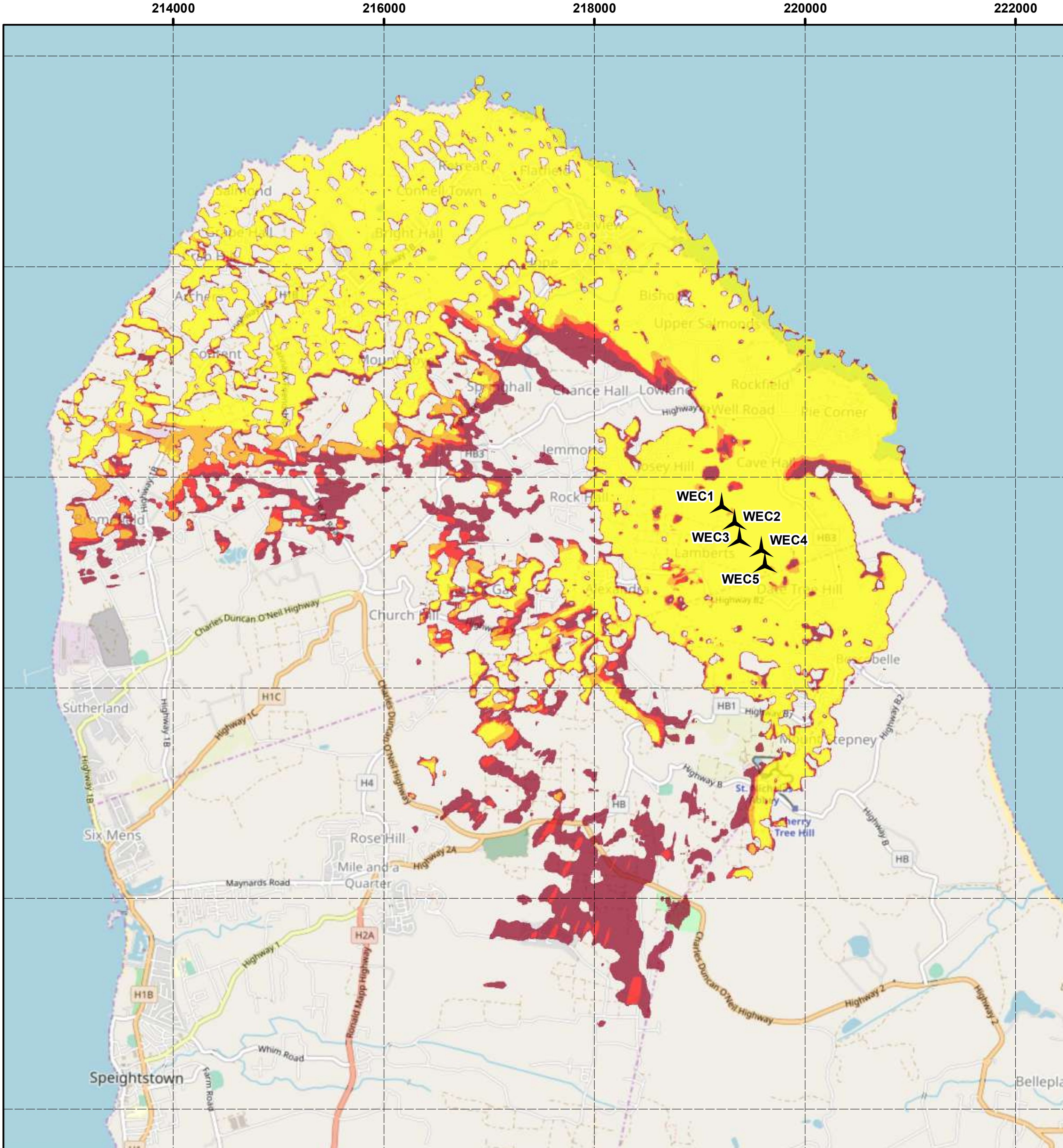
Source:
Environmental Impact Assessment, Barbados Light & Power Company Limited, Lamberts East Wind Farm Generating Station, Figure 7-1

LAMBERTS EAST WIND FARM ENVIRONMENTAL IMPACT ASSESSMENT

Zone of Visual Influence (EIA 2010)

PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.6**
SCALE: NTS	DATE: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Original_EIA_Zone_of_Visual_Influence_2.mxd,



Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\ZoneofVisualInfluence_5.mxd.

LEGEND

WEC

Number of Hubs Visible

- 1 - 2
- 3
- 4
- 5

0 0.5 1 2 3 4 Kilometres

NOTES:
- WEC: Wind Energy Converter
- Topography from ESRI

Datum: WGS 1984
Projection: UTM Zone 21N

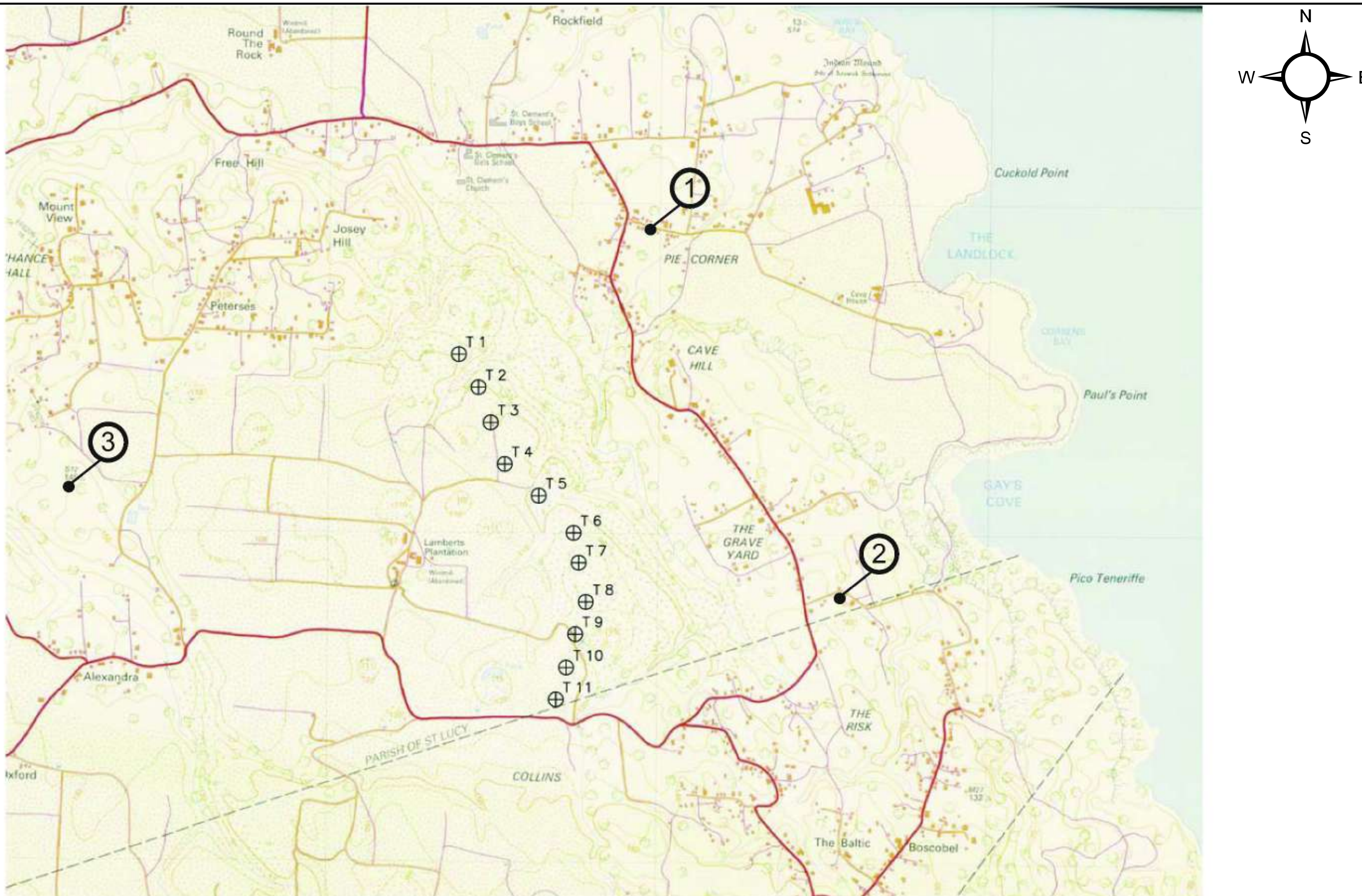
N S W E

wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT FARM

Zone of Visual Influence (Updated Assessment)

PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.7**
SCALE: 1:50,000	DATE: July 2019



Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Original_EIA_Photomontage_Viewpoint_Locations_2.mxd.

LEGEND

③ Approximate viewpoint location

⊕ WEC

WEC: Wind Energy Converter
Source:
Environmental Impact Assessment, Barbados Light & Power Company Limited, Lamberts East Wind Farm Generating Station, Figure 7-2

wood.

LAMBERTS EAST WIND FARM ENVIRONMENTAL IMPACT ASSESSMENT

Photomontage Viewpoint Locations (EIA 2010)

PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.8**
SCALE: NTS	Date: July 2019

NO LEGEND

Source:
Environmental Impact Assessment,
Barbados Light & Power
Company Limited,
Lamberts East Wind Farm
Generating Station, Figure 7-3

wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Photomontage Viewpoint #1
(EIA 2010)

PROJECT N^{o}: 6.19.203573.CAN	**FIGURE: 4.9**
SCALE: NTS	Date: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Original_EIA_Photomontage_ViewpointTwo_2.mxd.

NO LEGEND

Source:
Environmental Impact Assessment,
Barbados Light & Power
Company Limited,
Lamberts East Wind Farm
Generating Station, Figure 7-4

wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Photomontage Viewpoint #2
(EIA 2010)

PROJECT N^{o}: 6.19.203573.CAN	**FIGURE: 4.10**
SCALE: NTS	Date: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Original_EIA_Photomontage_ViewpointThree_2.mxd.

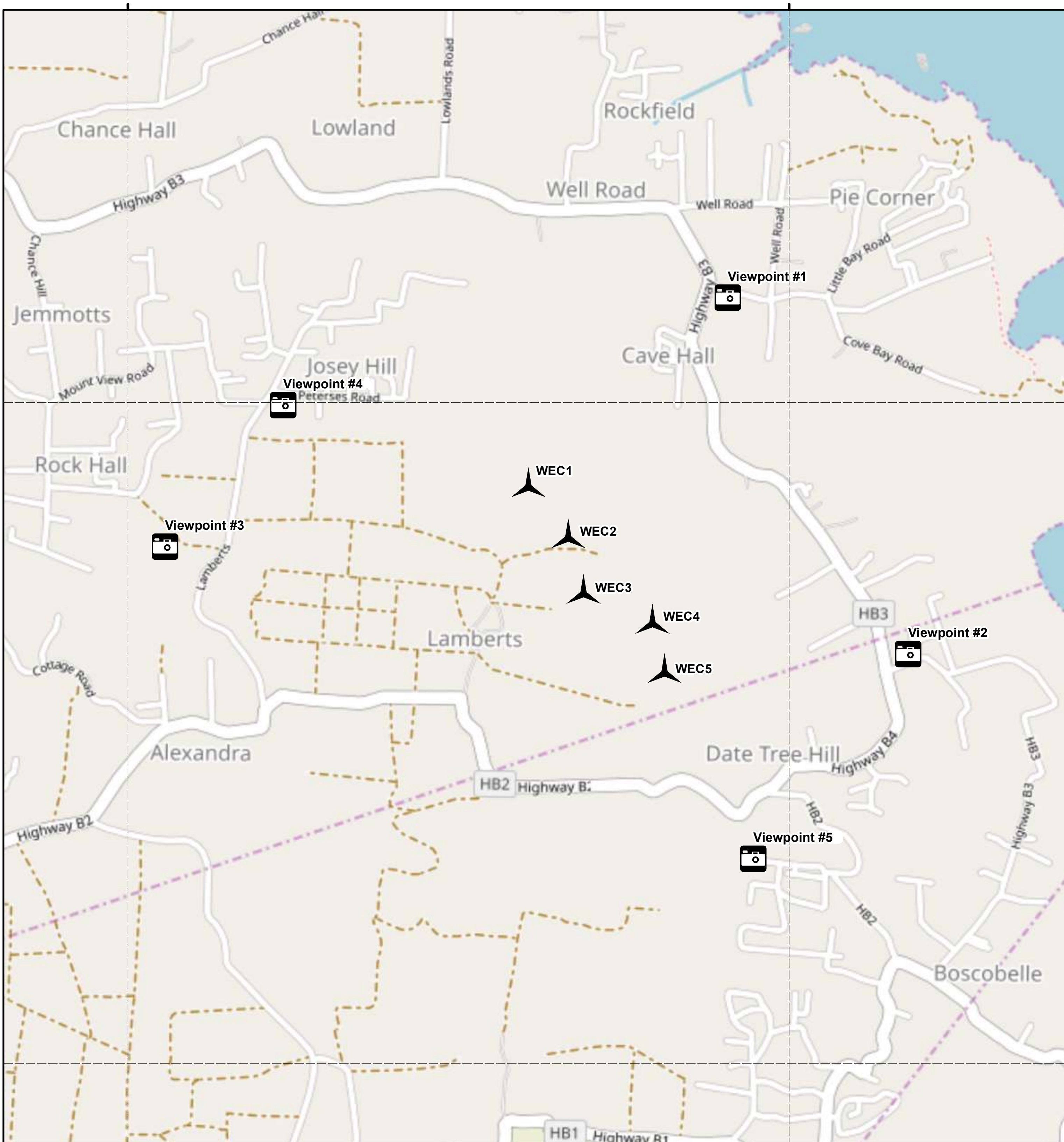
NO LEGEND

Source:
Environmental Impact Assessment, Barbados Light & Power Company Limited, Lamberts East Wind Farm Generating Station, Figure 7-5

LAMBERTS EAST WIND FARM ENVIRONMENTAL IMPACT ASSESSMENT

Photomontage Viewpoint #3 (EIA 2010)

PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.11**
SCALE: NTS	Date: July 2019



Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Photomontage_3.mxd,

LEGEND

WEC

Viewpoint

0 0.175 0.35 0.7 1.05 1.4 Kilometres

NOTES:
- WEC: Wind Energy Converter
- Topography from ESRI

Datum: WGS 1984
Projection: UTM Zone 21N

N S E W

wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Photomontage Viewpoint Locations (Updated Assessment)

PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.12**
SCALE: 1:16,000	DATE: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Photomontage_ViewpointOne_1.mxd.

NO LEGEND

wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Photomontage Viewpoint #1
(Updated Assessment)

PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.13**
SCALE: NTS	Date: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Photomontage_ViewpointTwo_1.mxd.

NO LEGEND

wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Photomontage Viewpoint #2
(Updated Assessment)

PROJECT N°: 6.19.203573.CAN	FIGURE: 4.14
SCALE: NTS	Date: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Photomontage_ViewpointThree_1.mxd.

NO LEGEND

wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Photomontage Viewpoint #3 (Updated Assessment)

PROJECT N^{o}: 6.19.203573.CAN	**FIGURE: 4.15**
SCALE: NTS	Date: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Photomontage_ViewpointFour_1.mxd.

NO LEGEND

wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Photomontage Viewpoint #4
(Updated Assessment)

PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.16**
SCALE: NTS	Date: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Photomontage_ViewpointFive_1.mxd.

NO LEGEND

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Photomontage Viewpoint #5
(Updated Assessment)

PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.17**
SCALE: NTS	Date: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Original_EIA_Sound_Level_Contours_6ms_WindSpeed_2.mxd.

LEGEND

⊕ WEC

45 dBA Contour at 6 m/s

WEC: Wind Energy Converter
Source:
Environmental Impact Assessment,
Barbados Light & Power
Company Limited,
Lamberts East Wind Farm
Generating Station, Figure 7-7

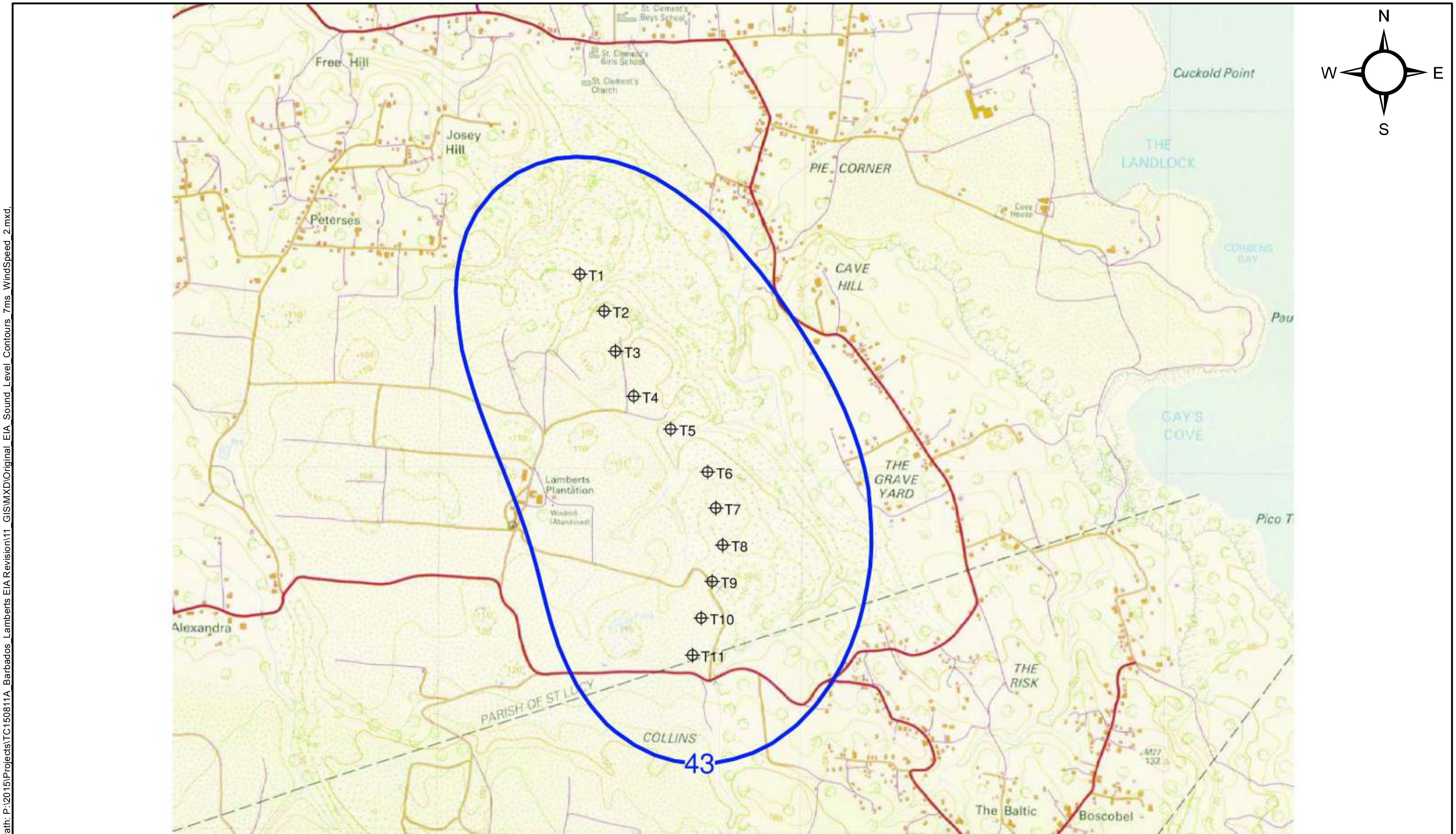
wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Sound Level Contours for
6 m/s Wind Speed (EIA 2010)

PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.18**
SCALE: NTS	Date: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision11_GIS\MXD\Original_EIA_Sound_Level_Contours_7ms_WindSpeed_2.mxd.



LEGEND

WEC

45 dBA Contour at 7 m/s

WEC: Wind Energy Converter
Source:
Environmental Impact Assessment, Barbados Light & Power Company Limited, Lamberts East Wind Farm Generating Station, Figure 7-8

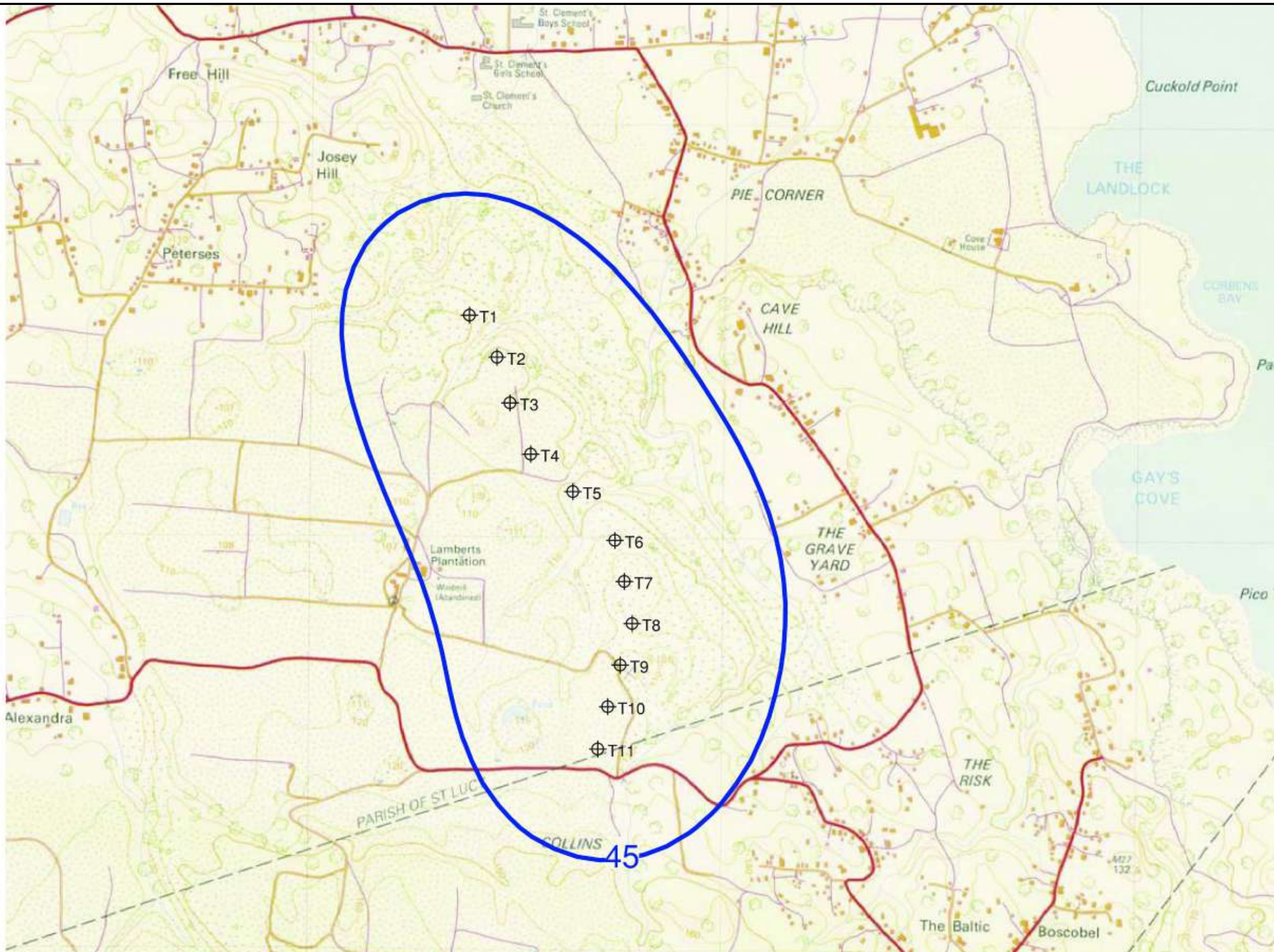
wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Sound Level Contours for 7 m/s Wind Speed (EIA 2010)

PROJECT N^{o}: 6.19.203573.CAN	**FIGURE: 4.19**
SCALE: NTS	Date: July 2019

Path: P:\2015\Projects\TC150811A_Barbados_Lamberts EIA Revision\11_GIS\MXD\Original_EIA_Sound_Level_Contours_8ms_WindSpeed_2.mxd.



LEGEND

WEC

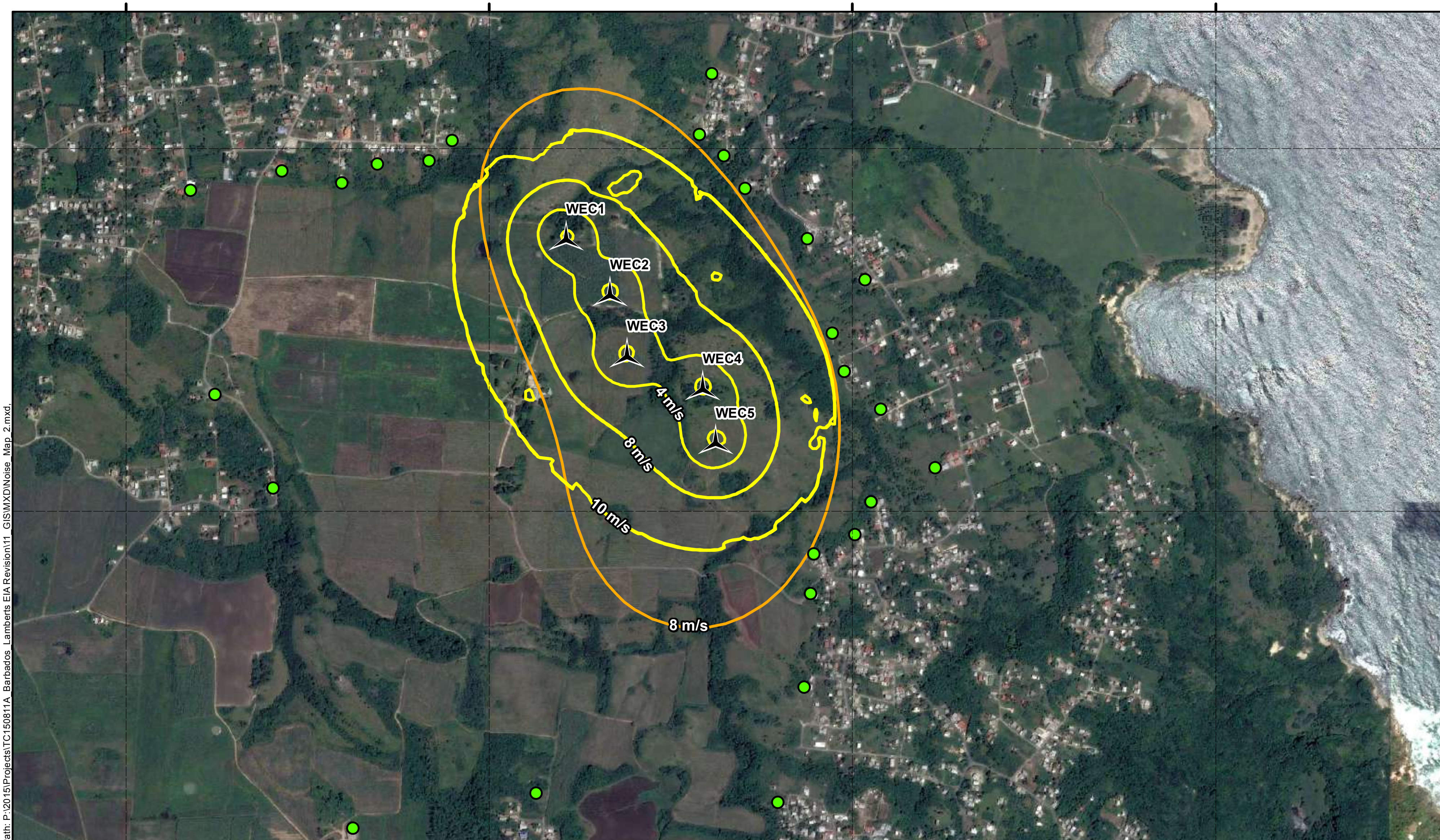
45 dBA Contour at 8 m/s

WEC: Wind Energy Converter
Source:
Environmental Impact Assessment, Barbados Light & Power Company Limited, Lamberts East Wind Farm Generating Station, Figure 7-9

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Sound Level Contours for 8 m/s Wind Speed (EIA 2010)

PROJECT N°: 6.19.203573.CAN	**FIGURE: 4.20**
SCALE: NTS	Date: July 2019



Path: P:\2015\Projects\TC150811A Barbados Lamberts EIA Revision\11 GIS\MXD\Noise Map 2.mxd.

LEGEND

- WEC
- Sensitive Receptor
- 45 dBA Contour Line (Updated Assessment)
- 45 dBA Contour at 8 m/s (the EIA)

0 100 200 400 600 800 Metres

NOTES:
- WEC: Wind Energy Converter
- Imagery from ESRI

Datum & Projection:
WGS 1984 UTM Zone 21N

wood.

LAMBERTS EAST WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT

Comparison of Noise Contours

PROJECT N°: 6.19.203573.CAN

FIGURE: 4.21

SCALE: 1:15,000

Date: July 2019

5.0 Summary of Mitigation Measures and Recommendations

Recommendations regarding optional mitigation measures for respective VECs have been provided in Table 5-1.

Table 5-1: Mitigation Measures and Recommendations

Valued Ecosystem Component	Mitigation Measures and Recommendations
Aesthetics (Visual Assessment) Zone of Visual Influence Photomontage	**Preliminarily discussed in EIA (2010):** • The route of the access road to the site will be chosen to reduce the visibility for the dwellings to the east of the site. • The tower height of the WEC has been kept to a minimum reasonable dimension to allow for decreased / minimized visual impact. • The number of WECs has been reduced from earlier studies while still retaining the same total energy output. **New identified mitigation measure:** • Additional research that has been undertaken into WEC colour and finish further results in a reduction of visual impacts. The ENERCON E-70 E4 WEC, with typically painted pale grey units and gradations of green rings on the portions of the tower closest to the ground, help them blend in with surrounding grassy regions.
Noise	**Preliminarily discussed in EIA (2010):** • Specific mitigative options to reduce noise have been incorporated into the design and structure of the wind WEC and therefore the wind farm will meet the recommended criteria for noise. No additional mitigative measures are required.

Valued Ecosystem Component	Mitigation Measures and Recommendations
Shadow Flicker	**Preliminarily discussed in EIA (2010):** Consideration of mitigation measures will be evaluated in consultation with stakeholders, when and where practical and feasible, including: • Planting screening vegetation (trees and bushes that exceed 2 m in height) in specified locations • Installing curtains and/or shutters to block shadow flicker into SFR buildings or constructing screens, trellis structures or fences strategically placed to block effects of shadow flicker at SFRs. • The WECs could potentially enter a limited state of operation, when sunlight, wind speed and the angle and position of the sun combine to cause a flicker nuisance. No additional mitigative measures are required.

6.0 Conclusions

As a result of changes to the Project layout, updated technical assessments were undertaken in support of the EIA to confirm no additional environmental effects were anticipated as a result of the Project.

The results of the technical assessments, focused on noise, shadow flicker and visual impacts, determined that not only does the revised Project layout not result in an increase in environment effects on VECs, but rather results in a reduction in effects associated with the Project. This can largely be attributed to the advancements in WEC technology and the reduction in the number of WECs from eleven (11) to five (5).