Appendix BSA-1

Atmospheric Baseline Study

PROJECT NUJIO'QONIK
Environmental Impact Statement

PROJECT NUJIO'QONIK
Atmospheric Environment Baseline Study

August 2023

Prepared for:

Prepared by:

Stantec Consulting Ltd.

File: 121417575

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Abbreviations

%HA	percent highly annoyed
Δ %HA	change in percent highly annoyed
dB	decibel
dBA	A-weighted decibel
kHz	kilohertz
Hz	Hertz
L_{Aeg}	weighted continuous sound level
L_d	daytime equivalent sound levels
L_{dn}	day-night average sound level
L_n	nighttime equivalent sound levels
NL	Newfoundland and Labrador
µg	microgram
µm	micrometre
ºC	degrees Celsius
AAQM	ambient air quality monitoring
AAQS	ambient air quality standards
AEP	Alberta Environment and Parks
AML	Atlantic Minerals Limited
CAAQS	Canadian Ambient Air Quality Standards
CAMS	Copernicus Atmosphere Monitoring Service
CCME	Canadian Council of Ministers of the Environment
cd	candela
CH_4	methane

CIE	Commission Internationale de L'Éclairage
cm	centimetre
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
EAC4	CAMS global re-analysis model, fourth generation
ECCC	Environment and Climate Change Canada
EIS	Environmental Impact Statement
EOG	Earth Observation Group
GHG	greenhouse gas
GW	gigawatt
HFC	hydrofluorocarbons
hr	hour
IDA	International Dark Sky Association
IDF	Intensity-Duration-Frequency
IESNA	Illuminating Engineering Society of North America
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
km	kilometre
lux	lumen/m^2
m	metre
m^2	square metre
m^3	cubic metre
mag/$arcsec^2$	magnitudes per square arcsecond
mg	milligram

mm	millimetre
Mt	megatonne
MUN	Memorial University of Newfoundland
MW	megawatt
N_2O	nitrous oxide
NAPS	National Air Pollutant Surveillance Program
NF_3	nitrogen trifluoride
NH_3	ammonia
NIR	National Inventory Report
NL	Newfoundland and Labrador
NL AAQS	Newfoundland and Labrador Ambient Air Quality Standards
NLDECC	Newfoundland and Labrador Department of Environment and Climate Change
NO	nitric oxide
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NPRI	National Pollutant Release Inventory
O_3	ozone
PCB	polychlorinated biphenyl
PFC	perfluorocarbons
PM_{10}	Particulate matter with an aerodynamic diameter less than 10 µm
$PM_{2.5}$	Particulate matter with an aerodynamic diameter less than 2.5 µm
ppb	parts per billion
RCP	representative concentration pathway
ROW	right-of-way

SF_6	sulfur hexafluoride
SO_2	sulphur dioxide
t	tonne
the Project	Project Nujio'qonik
TPM	Total particulate matter made up of particles with an aerodynamic diameter less than 30 µm
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VOC	volatile organic compounds
WEGH2	World Energy GH2
WHO	World Health Organization

Glossary

Ambient Sound Level or Ambient Noise	All-encompassing sound that is associated with a given environment, usually a composite of sounds from many sources near and far. Includes noise from all sources other than the sound of interest (i.e., sound other than that being measured), such as sound from other industrial noise, transportation sources, animals and nature.
A-Weighting	The weighting network used to account for changes in level sensitivity as a function of frequency. The A-weighting network de-emphasizes the high (i.e., 6.3 kHz and above) and low (i.e., below 1 kHz) frequencies, and emphasizes the frequencies between 1 kHz and 6.3 kHz, in an effort to simulate the relative response of the human ear. See also frequency weighting.
Background Sound Level or Background Noise	Same as the ambient sound level.
Decibel	A logarithmic measure of any measured physical quantity and commonly used in the measurement of sound. The decibel (dB) provides the possibility of representing a large span of signal levels in a simple manner. The difference between the sound pressure for silence versus a loud sound is a factor of 1,000,000:1 or more, therefore it is less cumbersome to use a small range of equivalent values: 0 to 130 dB. A tenfold increase in sound power is equal to +10 dB.
Decibel, A-weighted	A-weighted decibels (dBA). Most common units for expressing sound levels since they approximate the response of the human ear.
Decibel, Linear	Unweighted decibels (dBL). Logarithmic units associated with a sound pressure level, where the sound pressure signal is unfiltered and represents the full spectrum of incoming noise.
Frequency	The number of times per second that the sine wave of sound repeats itself. It can be expressed in cycles per second, or Hertz (Hz). Frequency equals Speed of Sound / Wavelength.

Noise	Any unwanted sound. "Noise" and "sound" are used interchangeably in this document.
Noise level	Same as sound level.
Octave	The interval between two frequencies having a ratio of two to one. For acoustic measurements, the octaves start a 1,000 Hz centre frequency and go up or down from that point, at the 2:1 ratio. From 1,000 Hz, the next filter's centre frequency is 2,000 Hz, the next is 4,000 Hz, or 500 Hz, 250 Hz, etc. Octave filtering is usually referred to as the class of octave filters typically 1, 3 or 12, thus creating full octaves, one-third octaves, or one-twelfth octaves.
Receptor	A representative point considered for the purpose of assessment within noise-sensitive receptor such as a residence, campground, daycare, school, church, or hospital.
Sound	A wave motion in air, water, or other media. It is the rapid oscillatory compression changes in a medium that propagate to distant points. It is characterized by changes in density, pressure, motion, and temperature as well as other physical properties. Not all rapid changes in the medium are due to sound (e.g., wind distortion on a microphone diaphragm).
Sound Level	Generally, sound level refers to the weighted sound pressure level obtained by frequency weighting, usually A- or C-weighted, and expressed in decibels
Sound Power Level	The total sound energy radiated by a source per unit time. The unit of measurement is the Watt. The acoustic power radiated from a given sound source as related to a reference power level (i.e., typically 1E-12 watts, or 1 picowatt) and expressed as decibels. A sound power level of 1 watt = 120 decibels relative to a reference level of 1 picowatt.
Sound Pressure	The root-mean-square of the instantaneous sound pressures during a specified time interval in a stated frequency band.

Sound Pressure Level	Logarithmic ratio of the root mean square sound pressure to the sound pressure at the threshold of human hearing (i.e., 20 micropascals).
Weighting	Adjustment of sound level data to achieve a desired measurement. A-weighting is used to account for changes in human hearing sensitivity as a function of frequency. The A-weighting network de-emphasizes the high (i.e., 6,300 Hz and above) and low (i.e., below 1,000 Hz) frequencies, and emphasizes the frequencies between 1,000 Hz and 6,300 Hz, in an effort to simulate the relative response of human hearing. C-Weighting is linear over the mid frequency range from 200 Hz to 1,600 Hz, and de-emphasizes the low (i.e., below 200 Hz) and high (i.e., above 1,600 Hz) frequencies.

1.0 Introduction

World Energy GH2 (WEGH2) is proposing Project Nujio'qonik (the Project). The Project involves the development, construction, operation and maintenance, and eventual decommissioning and rehabilitation of one of the first Canadian, commercial-scale, "green hydrogen"[1] and ammonia production plants powered by renewable wind energy. Located on the western coast of the island of Newfoundland, Newfoundland and Labrador (NL), the Project will have a maximum production of up to approximately 206,000 t of green hydrogen (equivalent to approximately 1.17 megatonnes (Mt) of ammonia) per year. The hydrogen produced by the Project will be converted into ammonia and exported to international markets by ship. The hydrogen / ammonia plant and associated storage and export facilities will be located at the Port of Stephenville (in the Town of Stephenville, NL) on a privately-owned brownfield site and at an adjacent existing marine terminal, both of which are zoned for industrial purposes.

The electricity demand for hydrogen production is anticipated to be 600 megawatt (MW) to 1.8 gigawatt (GW), depending on Project development. Renewable energy from two approximately 1 GW onshore wind farms on the western coast of Newfoundland will be used to power the hydrogen and ammonia production processes. These wind farms (referred to herein as the "Port au Port wind farm" and the "Codroy wind farm") will include up to 328 turbines and collectively produce approximately 2 GW of renewable electricity. The Port au Port wind farm will include up to 164 wind turbines, with up to 171 sites that are being studied for the Environmental Impact Statement (EIS), on the Port au Port Peninsula, NL and adjacently on the Newfoundland "mainland" (i.e., northeast of the isthmus at Port au Port). The Codroy wind farm will also consist of up to 164 wind turbines located on Crown land in the Anguille Mountains of the Codroy Valley, NL. The modelling and assessment work is based on preliminary layouts for both wind farm sites (i.e., 171 potential turbine locations at the Port au Port wind farm and 143 potential turbine locations at Codroy wind farm). Final wind farm layouts will be dependent on results of the wind campaign and more detailed field investigations. Once the layout and number of turbines are finalized, the results of models will be reviewed and updated as required.

The Project is subject to provincial environmental assessment (EA) requirements under the NL *Environmental Protection Act* and associated Environmental Assessment Regulations (EA Regulations). This document is the Atmospheric Baseline Study, prepared in support of an Environmental Impact Statement (EIS) and required under section 4.3.2 of the EIS Guidelines.

1.1 Project Overview and Location

The Project includes the construction, operation and maintenance, and decommissioning of the Port au Port wind farm, the Codroy wind farm, and a hydrogen / ammonia plant in Stephenville, as well as upgrades to the existing port at Stephenville (Figure 1.1).

The Project Area shown on Figure 1.1 is a conservative representation of the spatial extent of potential Project-related direct physical disturbance (i.e., the Project footprint). In addition to encompassing the immediate area in which Project components and activities will occur, the Project Area also includes up to a 175 metre (m) buffer (350 m right-of-way [ROW]) around key Project components. This buffer allows some flexibility for the micro-siting of certain Project components (e.g., wind turbines) during detailed design, based on technical considerations as well as the avoidance of environmentally sensitive areas, where practicable.

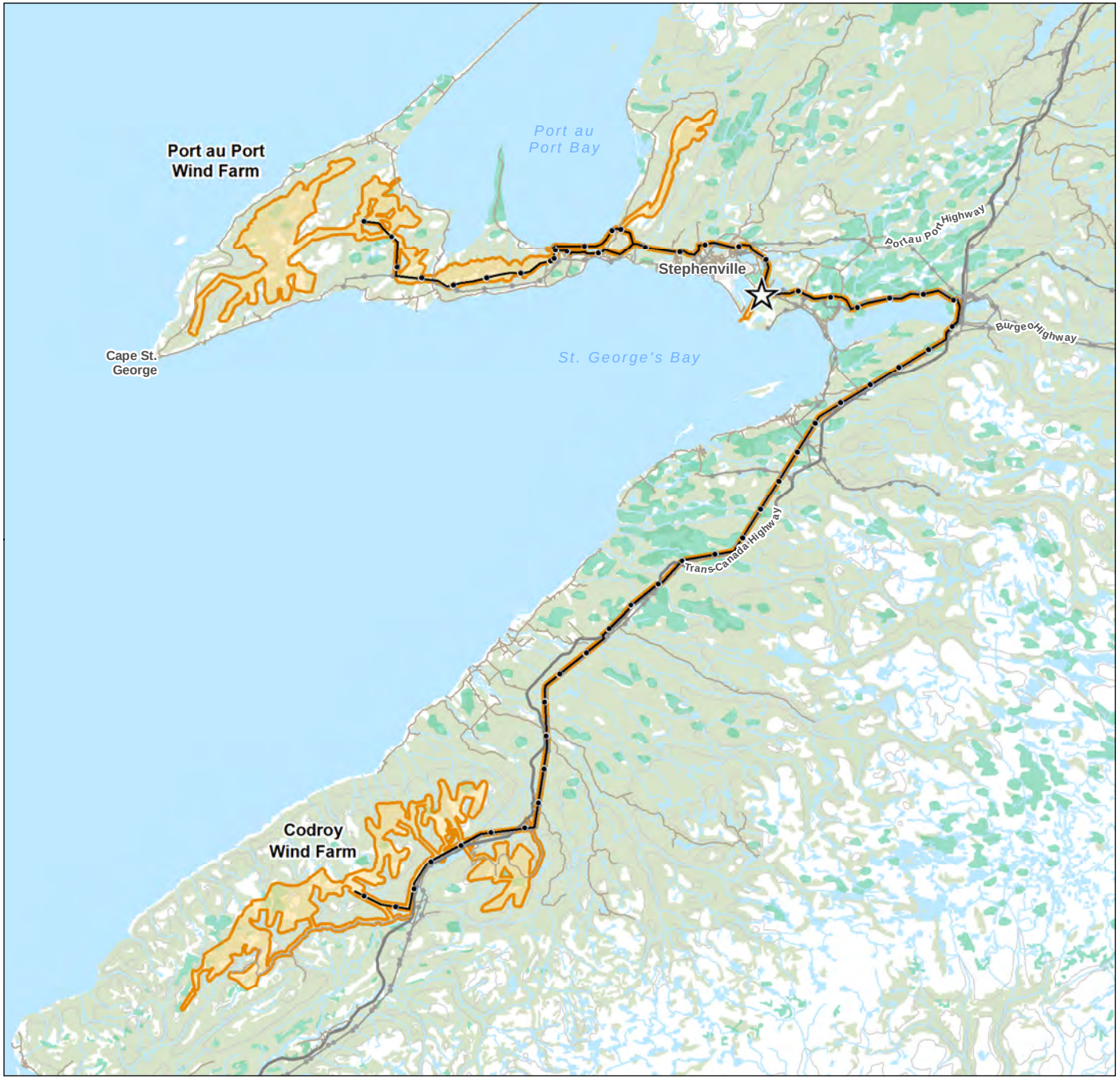
The proposed hydrogen / ammonia plant and export facilities at the Port of Stephenville are located approximately 5 kilometres (km) west of the Town of Stephenville, NL. The Port au Port wind farm (comprised of Port au Port West and Port au Port East) is located west and north of Stephenville and the Codroy wind farm is located 75 km south of Stephenville; both are connected to the hydrogen / ammonia plant by a collector system and transmission lines.

1.2 Scope of the Study

An Atmospheric Environment Baseline Study has been developed in consideration of section 4.3.1 of the final EIS Guidelines. The study is focused on the following three components:

- Noise
- Vibration
- Air Quality
- Climate and Greenhouse Gases (GHGs)
- Light

As detailed below, the approach to the baseline studies has been developed based on both field data and publicly available information. Information on spatial boundaries, study scope, methods and the results are provided in the following sections.



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Proposed Project Features

- Hydrogen / Ammonia Plant Location
- Transmission Line 230 kV
- Project Area

Other Features

- Transmission Line, Existing
- Trans-Canada Highway
- Road
- Contour (100 m)
- Watercourse
- Waterbody
- Wetland
- Forested Area

N

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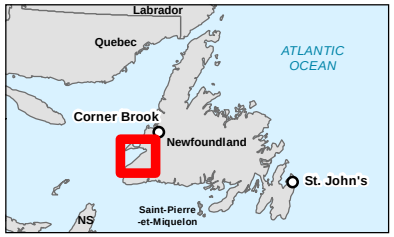
(At original document size of 8.5x11)
1:550,000

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 21N
2. Data Sources: World Energy GH2, NRCan CanVec, OpenStreetMap
3. Background: NRCan CanVec



Project Location
Stephenville
NL

Prepared by MB on 2023-07-28
QR by AW on 2023-07-28

Client/Project
World Energy GH2
Project Nujio'qonik

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Figure No.
1.1

Project Area

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2.0 Noise

2.1 Scope And Objectives of the Noise Study

The objective of this noise baseline study is to characterize the baseline conditions (i.e., the existing conditions) within the Project Area. As per the Provincial EIS Guidelines, this study includes an assessment on ambient noise conditions at each of the wind energy generation sites, and at the hydrogen and ammonia production facility. The assessment includes baseline ambient noise surveys, information on typical sound sources, decibel levels, geographic extent and temporal variations.

Provincially, there are no regulations regarding noise. Health Canada provides guidance for assessing noise impacts in their "Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise" document (Health Canada 2017), as well as Guidelines for Wind Turbine Noise (FPT CHE 2012). Heath Canada's approach to acoustic assessments is based on internationally recognized standards for acoustics, including the World Health Organization's (WHO) Guidelines for Community Noise (1999) and Night Noise Guidelines for Europe (2009).

Health Canada recommends using a guideline level related to annoyance called percent highly annoyed or %HA. The %HA is an estimate of the percentage of people who are potentially annoyed by noise emissions and is based on research conducted by the United States Environmental Protection Agency (US EPA). To calculate the %HA, the daytime equivalent sound levels (or L_d, a 15-hour time average of sound levels over the daytime period from 7:00 AM to 10:00 PM) and nighttime equivalent sound levels (or L_n, a 9-hour time average over the nighttime period from 10:00 PM to 7:00 AM) are combined to calculate an adjusted day-night average sound level (or L_{dn}). In the L_{dn} calculation, the L_n value is increased by 10 dB to account for higher sensitivity to noise emissions at night. The L_{dn} value is used to calculate the %HA value due to project-related noise emissions.

A %HA value is calculated for the existing environmental sound emissions (i.e., the baseline conditions). A second %HA is calculated for the total sound levels from baseline conditions and project-related sound emissions. The difference between the values of %HA is then compared with guideline criteria. Health Canada recommends that the maximum change in %HA due to project activities be no more than 6.5%. If the change in %HA threshold is exceeded, the effects are considered to be of concern and may require mitigation.

The noise guidance from Health Canada (2017) references the WHO guidelines and recommendations for community noise and night noise (WHO 1999 and 2009). The WHO guideline recommends a target for sleep disturbance as being an indoor sound level of no more than 30 dBA L_{eq} for continuous noise during the sleep period (WHO 1999). Health Canada recommends that an outdoor-to-indoor transmission loss with windows at least partially open is 15 dBA and fully closed windows are assumed to reduce outdoor sound levels by approximately 27 dBA (Health Canada 2017). The corresponding outdoor sound level targets for sleep disturbance is 45 dBA and 57 dBA for partially open windows and fully closed windows, respectively.

A summary of sound level criteria developed by Health Canada used for this assessment is provided in Table 2.1.

Table 2.1 Summary of Guideline Criteria Developed by Health Canada used for Noise Assessment

Criteria	Threshold
Change in Percent Highly Annoyed (Δ %HA)	6.5%
Sleep Disturbance	45 dBA

An overview of the methods and the results of the baseline study are provided in the following sections.

2.2 Baseline Study Methods

The exiting conditions for noise are characterized using data collected from baseline field studies. A description of the site selection, field methods, data analysis, and quality assurance/quality control (QA/QC) for the baseline noise field studies is provided in the following subsections.

2.2.1 Site Selection

The baseline ambient sound levels within the Project Area were characterized by conducting a baseline sound quality monitoring survey. The baseline sound quality monitoring survey was conducted between May 16 and 26, 2023 at 16 locations, shown in Figure 2.1. The baseline sound quality monitoring locations were chosen based on the presence of residential receptors near project components.

2.2.2 Field Methods

The baseline sound quality monitoring survey was conducted in accordance with ISO 1996-2:2007 ("Acoustics –Description, measurement and assessment of environmental noise – Part 2L Determination of environmental noise levels"), as recommended by Health Canada (Health Canada 2017).

Ambient sound levels were measured using Type 1 Sound Pressure Level Meters, including three Larson Davis LxT meters and three 01dB Cube meters. The microphone was positioned on a tripod approximately 1.5 meters above grade. The microphone was equipped with a wind screen to reduce extraneous noise due to the wind. Digital audio recordings were also logged so that the recordings could be reviewed afterward and any abnormalities in the data checked. The sound pressure level meter was set up to log one-minute equivalent sound pressure level (L_{eq}) values. Measurements were taken continuously over a period of between 2 to 4 days at each location. Each meter has been factory calibrated, and daily calibration checks were undertaken throughout the monitoring survey.

Sound pressure levels are measured in decibels (dB). For environmental assessments where the effect of sound on humans is the focus, an A-weighted dB scale (dBA) is used to report sound pressure levels as the A-weighting accounts for the sensitivity of the human ear to different frequencies.

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- Vibration Monitoring Location
- Noise Monitoring Location

Proposed Project Features

- Hydrogen / Ammonia Plant Location
- Project Area

Other Features

- Quarry
- Trans Canada Highway
- Road
- Watercourse
- Waterbody
- Wetland
- Forested Area

N

0 10 Kilometres
(At original document size of 8.5x11)
1:500,000

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 21N
2. Data Sources: World Energy GH2, NRCan CanVec, OpenStreetMap
3. Background: NRCan CanVec

Project Location
Stephenville
NL

Prepared by MGS on 2023-07-19
QR by AW on 2023-07-19

Client/Project
World Energy GH2
Project Nujio'qonik

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Figure No.
2.1

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Noise and Vibration Monitoring Locations

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2.2.3 Data Analysis

Upon completion of the sound monitoring, the baseline measurements were downloaded from the sound pressure level meter and analyzed in consideration of meteorological conditions during the time of monitoring, potential nearby sources of sound (both natural and anthropogenic) and the audio recordings. Further calculations were performed on the raw data to obtain the daytime sound pressure level (L_d), the nighttime sound pressure level (L_n), and the day-night average sound pressure level (L_{dn}) (Health Canada 2017).

2.3 Results

The sound pressure levels measured during the baseline sound quality survey are presented below in Table 2.2, including daytime sound level (L_d), nighttime sound level (L_n), the day-night average sound level (L_{dn}) values.

Table 2.2 Measured Sound Pressure Levels within the Project Area, May 2023

Monitoring Location	UTM Coordinates		7:00 to 22:00 L_d (dBA)	22:00 to 07:00 L_n (dBA)	Day-Night Average Sound Level (L_{dn}) (dBA)
	Latitude	Longitude			
1N	378611	5390284	43	36	44
2N	376211	5384199	41	41	48
3N	376130	5379651	40	38	45
4N	382717	5379268	53	49	56
1E	393057	5374322	48	43	51
Campground	386413	5375265	41	39	45
1S	361324	5325755	47	41	49
3S	355443	5335205	42	41	48
1W	338315	5372291	49	43	51
2W	347891	5375812	45	41	48
3W	358157	5376412	44	38	46
4W	354948	5386770	39	40	47
5W	338648	5380467	45	42	49
6W	345901	5387190	40	37	44
7W	370228	5379901	43	43	50
8W	367078	5376977	46	43	50

Noise levels were found to be highest for locations close to major roadways or nearer to urban areas close to Stephenville, such as 1E, 1W, 1S, and 4N. Rural areas experienced less noise, including 4W, 2N, 3N, 6W, and the campground across Port Harmon. Daytime sound levels ranged from 39 dBA at 4W to 53 dBA at 4N. Night time sound levels were lower, ranging from 36 dBA at 1N to 49 dBA at 4N.

2.4 References

Health Canada. 2017. Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise. Available online: https://www.ceaa.gc.ca/050/documents/p80054/119378E.pdf (last accessed April 6, 2023).

World Health Organization. 1999. Guidelines for Community Noise. Occupational and Environmental Health Team: Berglund, B.,Lindvall, T., Schwela, D. Available online: https://www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf (last accessed April 6, 2023).

World Health Organization. 2009. Night Noise Guidelines for Europe. Available online: https://www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf (last accessed April 6, 2023).

FPT CHE (FPT Committee on Health and the Environment). 2012. Guidelines for Wind Turbine Noise. Secretariat: Health Canada, Environmental and Radiation Health Sciences Directorate, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.

3.0 Vibration

3.1 Scope And Objectives of the Vibration Study

The objective of this vibration baseline study is to characterize the baseline conditions (i.e., the existing conditions) within the Project Area. As per the Provincial EIS Guidelines issued for this project, the baseline vibration study includes an assessment of ambient vibration near the wind energy generation sites.

3.2 Methods

Ground-borne vibration is the measure of ground oscillations, usually due to industrial activities such as construction, earthworks, pile driving, or even highway traffic. The most common approach to vibration measurement is by measuring velocity at ground level, where higher velocities correspond to higher levels of vibration. For effects on structures, it is common to measure and report the maximum vibration level at any given time, also known as the peak particle velocity (PPV). Humans are more sensitive to vibrations that occur over a period of time more so than a more sudden exposure to vibrations for a short amount of time (Caltran 2020). Therefore, a common measure of vibration for human exposure is the root-mean-square (RMS) of the vibrations. The RMS approach calculates an average vibration value for a given time period (usually one second). Since the RMS value is an average of the instantaneous vibration velocity measurements, it is always a lower value than the PPV value. The PPV and RMS can be related by a crest factor, or the ratio of the PPV and the RMS values. The crest factor can be as low as 1.4, but can be as high as 8 depending on the nature of the vibration source (US FTA 2018).

There are no regulations or guideline exposure limits for vibration in Newfoundland and Labrador. Guidelines related to public nuisance from vibration have been developed by the American National Standards Institute through ANSI/ASA S.39-1983. These guidelines have been adopted by regulatory agencies such as the United States Federal Transit Administration and are often used in jurisdictions across Canada for assessing vibration. The ANSI guidance gives threshold values for different types of land use. For land uses associated with residential areas or in areas where sleeping occurs, the recommended ANSI threshold is 0.1 mm/s RMS. This guideline level was used for the vibration assessment.

3.2.1 Site Selection

The baseline vibration levels within the Project Area were measured at 7 locations during a field survey campaign between May 16 and 26, 2023. The measurement locations are shown in Figure 2.1. These locations were chosen to capture potential existing vibration emissions from nearby roadways and an active aggregate quarry in Port au Port that are near the project location. These locations are also near populated areas closest to the project and so are most likely to experience changes in vibration due to project activities.

3.2.2 Field Methods

Instatel Micromate seismographs were used to measure peak particle velocity (PPV) at each monitoring location. Monitoring occurred over a 24-hour period at each of the 7 locations.

The seismograph sensors were buried approximately one foot below ground and were covered with a sandbag to ensure the sensors remained stationary during measurements. Checks were completed prior to measurement that the sensors were level. The level check was also completed after the monitoring event was completed.

3.2.3 Data Analysis

The baseline measurements were downloaded from the seismographs and a summary of the PPV values were calculated for each location. A crest factor of 1.4 was applied to the PPV values to estimate the RMS vibration levels. This approach is expected to conservatively overestimate the RMS values for these locations.

3.3 Results

A summary of the RMS vibration levels for the 7 monitoring locations is provided in Table 3.1. Baseline vibration levels were found to be low at most locations. Location 5 was closest to the existing quarry, and had one occurrence of vibration levels above 0.1 mm/s RMS. Location 7 also experienced one event with an RMS level above 0.1 mm/s. In both cases, the elevated vibration levels were likely due to a vehicle pass-by. The remaining measurements at each location were well below 0.1 mm/s.

Table 3.1 Results of the Baseline Vibration Monitoring Study

Monitoring Location	Location Coordinates (UTM 21)		RMS Value (mm/s) [1]
	Easting (m)	Northing (m)	
V1	361780	5326284	0.056
V2	355814	5335463	0.056
V3	370197	5379930	0.045
V4	338620	5380439	0.062
V5	349109	5376753	0.209
V6	338496	5372380	0.090
V7	393062	5374298	0.101

Note:
[1] RMS values are based on PPV measurements combined with a crest factor of 1.4

3.4 References

Caltrans (California Department of Transportation). 2020. Transportation and Construction Vibration Guidance Manual.

US FTA (United States Federal Transit Administration). 2018. Transit Noise and Vibration Impact Assessment Manual. FTA Report No. 0123.

4.0 Air Quality

4.1 Scope And Objectives of the Air Quality Study

The objective of this baseline study on air quality is to characterize the baseline conditions regarding ambient (i.e., outdoor) air quality (i.e., current, existing conditions) within the Project Area. As per the provincial EIS Guidelines, this report includes a review of ambient air quality data, including particulate matter. The air quality study considers the following air contaminants:

- Nitrogen dioxide (NO_2)
- Carbon monoxide (CO)
- Ozone (O_3)
- Sulphur dioxide (SO_2)
- Ammonia (NH_3)
- Total particulate matter (TPM) with particles having an aerodynamic diameter less than 30 micrometre (µm)
- Particulate matter (PM_{10}) with particles having an aerodynamic diameter less than 10 µm
- Particulate matter ($PM_{2.5}$) with particles having an aerodynamic diameter less than 2.5 µm

Exposure to air contaminants, including those listed above, can lead to adverse health effects (World Health Organization [WHO] 2023). There are provincial and federal ambient air quality standards (AAQS) which have been developed to help track, regulate, and reduce exposure to air contaminants. The federal and NL AAQS apply to the Project and are presented below.

Provincially, the Newfoundland and Labrador Ambient Air Quality Standards (NL AAQS), as per Schedule A of the Air Pollution Control Regulations, 2022 were updated recently and are provided in Table 4.1.

Hydrogen sulphide, arsenic, asbestos, cadmium, copper, lead, mercury, nickel, polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (dioxins) and polychlorinated dibenzo furans, vanadium, and zinc are also regulated by the NL AAQS. These compounds are not expected to be released in substantive quantities and are not typically the primary air contaminants of concern from the operation of hydrogen facilities and wind turbines due to the sources of air contaminants expected from Project activities.

Federally, the applicable air quality criteria are the Canadian Ambient Air Quality Standards (CAAQS), founded by the Canadian Council of Ministers of the Environment (CCME) for SO_2, $PM_{2.5}$, O_3, and NO_2. The CAAQS are presented in Table 4.2.

Table 4.1 NL Ambient Air Quality Standards

Contaminant	Units(1)	1-hour	3-hour	8-hour	24-hour	1 year
Nitrogen dioxide	Parts per billion (ppb)	213	-	-	106	53
Carbon monoxide	ppb	30,582	-	13,107	-	-
Ozone	ppb	82	-	44	-	-
Sulphur dioxide	ppb	344	229	-	115	23(2)
Ammonia	ppb	-	-	-	144	-
Particulate matter Total	micrograms per cubic meter (µg/m^3)	-	-	-	120	60(3)
Particulate matter < 10 microns	µg/m^3	-	-	-	50	-
Particulate matter < 2.5 microns	µg/m^3	-	-	-	25(4)	8.8(2)(4)

Notes:
(1) Units are presented as those provided in the Regulations
(2) The arithmetic average over a single calendar year of all 1-hour average concentrations in the year.
(3) The geometric average over a single calendar year of all 1-hour average concentrations in the year.
(4) At reference conditions, a dry gas temperature of 25 °Celsius and a gas pressure of 101.325 kilopascals
Source: NL Air Pollution Control Regulations 2022

Table 4.2 Canadian Ambient Air Quality Standards

Air Contaminant	Averaging Period	µg/m^3	
		2020–2024	2025+
Ozone (O_3)	8-hour (1)	122	118
Nitrogen Dioxide (NO_2)	1-hour (2)	113	79
	1-year (3)	32	23
Sulphur Dioxide (SO_2)	1-hour (4)	183	170
	1-year (5)	13	10
Particulate Matter ($PM_{2.5}$)	24-hour (6)	27	27
	1-year (7)	8.8	8.8

Notes:
(1) The 3-year average of the annual 4th highest of the daily maximum 8-hour average ozone concentrations
(2) The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations
(3) The average over a single calendar year of all 1-hour average concentrations
(4) The 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations
(5) The average over a single calendar year of all 1-hour average SO_2 concentrations
(6) The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
(7) The 3-year average of the annual average of the daily 24-hour average concentrations
Source: CCME 2023

An overview of the methods and the results of the air quality baseline study are provided in the following sections.

4.2 Methods

The existing conditions for air quality are characterized using a combination of publicly available data and literature. The most recently available ambient air quality data from the Environment and Climate Change Canada (ECCC) National Air Pollutant Surveillance (NAPS) Program (2019–2021), the provincial air quality annual report (2022), and air contaminant release information from the National Pollutant Release Inventory (NPRI) were obtained and used in the assessment herein. The data was processed to the statistical metrics required by the CAAQS, which are presented in the footnotes of Table 4.2. In addition, the 90th percentile hourly ambient monitoring data was presented as this is the metric that is often used to estimate existing 1-hour background ambient concentrations used in dispersion modelling for short-term averaging periods. The 90th percentile is used as it provides a conservative estimate of ambient levels, while at the same time providing some consideration for the fact that the location and time for the occurrence of maximum ground level concentrations from background sources varies from that for the source(s) being considered in the modelling assessment. Similarly, the maximum 24-hour concentrations excluding the hourly values >90th percentile was included as this is used to estimate the existing 24-hour baseline ambient concentrations used in dispersion modelling. Establishing background concentrations to use in dispersion modelling following these methods is consistent with the approach that is recommended in Alberta and has been applied for this assessment due to the absence of province specific guidance (Alberta Environment and Parks [AEP] 2021).

The European Centre for Medium-Range Weather Forecasts (ECMWF) publishes atmospheric data that is generated through modelled results assimilated with observational data. The dataset is known as the Copernicus Atmosphere Monitoring Service global re-analysis (CAMS EAC4) is also summarized below as requested by the Newfoundland and Labrador Department of Environment and Climate Change (NLDECC; Lawrence 2023, pers. comm.). The CAMS EAC4 combines model data with observations (satellite data) for a complete and consistent global dataset of atmospheric composition, including the concentrations of many air contaminants (Inness et al. 2019). The CAMS EAC4 data are instantaneous concentration values on 3-hour intervals, and the data are not representative of an hourly average. The annual averages estimated using this data are annual averages of the 3-hour values in the year, whereas the 24-hour averages are estimated using the average of the eight 3-hour values within a 24-hour period, i.e., these averages are not continuous averages over the specified period. This data being on a 3-hour basis results in loss of time series resolution when compared to hourly data.

Field data are being collected in the summer and fall of 2023, and into 2024, to supplement the desktop assessment. There are three field data monitoring locations, one near each of the two wind farms and one in Stephenville. In June, August and November, 2023, three 24-hour samples will be collected at the Stephenville and Port au Port sites for $PM_{2.5}$ and PM_{10}, for a total of six samples. The Codroy wind farm sampling will also have three 24-hour samples for $PM_{2.5}$ and $PM_{10;}$ this monitoring will occur in 2024. There will also be three passive samples collected for SO_2 and NO_2 in the three sampling locations. In Stephenville, three passive NH_3 samples will also be collected. The data will be collected and presented in a supplementary report.

4.3 Results

There are no large industrial emissions sources in the Project Area. Based on a review of the ECCC NPRI reporting data for the Island of Newfoundland, the nearest emissions sources to the Project Area include the Atlantic Minerals Limited (AML) Lower Cove Quarry, the Corner Brook Pulp and Paper Mill, and the Newfoundland and Labrador Hydro Ramea Diesel Generating Station. The AML quarry is located approximately 45 km west of Stephenville and that facility has reported releases of particulate matter to the atmosphere. The Corner Brook Pulp and Paper Mill is located approximately 60 km northeast of Stephenville. The air contaminants released from the pulp and paper mill consist of combustion gases (NO_X, CO, and SO_2), PM, volatile organic compounds (VOCs) and selected trace metals. The generating station is located 140 km southeast of Stephenville. Based on recent NPRI reporting data, air contaminants that are released in substantive quantities from these facilities include combustion gases (nitrogen oxides) and particulate matter (PM_{10} and $PM_{2.5}$) (ECCC 2023a). NPRI defines "substantive quantities" as the masses of air contaminants released to the atmosphere that may impact air quality within a 5 km radius of the source.

The nearest and most representative NAPS ambient air quality monitoring (AAQM) station is at Grand Falls-Windsor, approximately 220 km east-northeast from proposed Project. There is a NAPS station located at Corner Brook, which is closer to the Project; however, this station is adjacent to the Corner Brook Pulp and Paper Mill which would be expected to contribute to NO_2 and SO_2 levels that would not be representative to the background of the Project Area. The Grand Falls-Windsor station measures the following air contaminants: SO_2, nitric oxide (NO), NO_2, NO_X, CO, $PM_{2.5}$, PM_{10}, and O_3.

An overview of the 2019–2021 NAPS monitoring results for the Grand Falls-Windsor station (ECCC 2023b), for those air contaminants relevant to the Project, is presented in Table 4.3. The data for the NL 2022 Ambient Air Monitoring Report are not yet publicly available, as such, the 2022 data was not able to be analyzed in this assessment. For PM10, no valid data at the Grand Falls-Windsor station was available for 2019 or 2021, with only approximately 3 months of data in 2020 (from September 17, 2020, to December 31, 2020).

Table 4.3 NAPS Monitoring Results – Grand Falls-Windsor

Contaminant	Averaging Period	Measured Concentrations (µg/m^3)	Air Quality Criteria/Objectives		
			NL AAQS	CAAQS 2020–2024	CAAQS 2025+
SO_2	Maximum Hourly	12.3	900	-	-
	98th Percentile Hourly Concentrations	3.41	-	-	-
	90th Percentile Hourly Concentrations	2.36	-	-	-
	3-hour Rolling Average 90th Percentile Hourly Concentrations	2.45	-	-	-
	Maximum 24-hour Average	4.40	300 µg/m^3 24-hour averaging period	-	-
	Maximum 24-hour (Excluding Hourly Values >90th Percentile)	2.10			
	3-Year Average of 99th Percentile of the Daily Maximum Hour	3.93	-	183 (1)	170 (1)
	Maximum Annual Average	1.72	60 µg/m^3 (7) Annual averaging period	13 (2)	10 (2)
NO_2	Maximum Hourly	52.7	400	-	-
	98th Percentile Hourly Concentrations	11.3	-	-	-
	90th Percentile Hourly Concentrations	5.65	-	-	-
	Maximum 24-hour Average	14.3	200 µg/m^3 24-hour averaging period	-	-
	Maximum 24-hour (Excluding Hourly Values >90th Percentile)	3.76	-	-	-
	3-Year Average of 98th Percentile of the Daily Maximum Hour	23.2	-	113 (3)	79 (3)
	3-Year Average of 24-hour 98th Percentile	-	-	-	-
	Maximum Annual Average	3.83	100 µg/m^3 Annual averaging period	32 (4)	23 (4)

Table 4.3 NAPS Monitoring Results – Grand Falls-Windsor

Contaminant	Averaging Period	Measured Concentrations (µg/m^3)	Air Quality Criteria/Objectives		
			NL AAQS	CAAQS 2020–2024	CAAQS 2025+
$PM_{2.5}$	Maximum Hourly	90.0	-	-	-
	98th Percentile Hourly Concentrations	13.0	-	-	-
	90th Percentile Hourly Concentrations	7.00	-	-	-
	Maximum 24-hour Average	20.5	25 µg/m^3 24-hour averaging period	-	-
	Maximum 24-hour (Excluding Hourly Values >90th Percentile)	6.00	-	-	-
	3-Year Average of 24-hour 98th Percentile	9.19	-	27[5]	27[5]
	Maximum Annual Average	4.51	8.8 µg/m^3 [7][8] Annual averaging period	8.8[6]	8.8[6]
PM_{10} [9]	Maximum Hourly	129	-	-	-
	98th Percentile Hourly Concentrations	29	-	-	-
	90th Percentile Hourly Concentrations	17	-	-	-
	Maximum 24-hour Average	27	50 µg/m^3 24-hour averaging period	-	-
	Maximum 24-hour (Excluding Hourly Values >90th Percentile)	14	-	-	-
	Maximum Annual Average	9.9	-	-	-

Table 4.3 NAPS Monitoring Results – Grand Falls-Windsor

Contaminant	Averaging Period	Measured Concentrations (µg/m^3)	Air Quality Criteria/Objectives		
			NL AAQS	CAAQS 2020–2024	CAAQS 2025+
CO	Maximum Hourly	1,031	35,000	-	-
	98th Percentile Hourly Concentrations	298	-	-	-
	90th Percentile Hourly Concentrations	206	-	-	-
	Maximum 8-hour Rolling Average	784	15,000	-	-
	8-hour Rolling Average (Excluding hourly values >90th Percentile)	206	-	-	-

Notes:

(1) The 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations

(2) The average over a single calendar year of all 1-hour average SO_2 concentrations

(3) The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations

(4) The average over a single calendar year of all 1-hour average concentrations

(5) The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations

(6) The 3-year average of the annual average of the daily 24-hour average concentrations

(7) The arithmetic average over a single calendar year of all 1-hour average concentrations in the year.

(8) At reference conditions, a dry gas temperature of 25 °Celsius and a gas pressure of 101.325 kilopascals

(9) Only PM_{10} data that was available from 2019-2021 were from September 17, 2020 to December 31, 2020

Source of measured concentrations: ECCC 2023b

The ambient air quality monitoring data collected at the NAPS monitoring location at Grand Falls-Windsor measured over the 2019–2021 period were below the NL AAQS and CAAQS.

The NL Annual Ambient Air Monitoring Reports include results from the industrial monitoring network across the province. The industrial monitoring network includes six facilities located across NL, including Atlantic Minerals Limited or AML. The monitoring station at the AML site collects $PM_{2.5}$ and TPM data from continuous monitors located at the western side of their Port au Port facility (NLDECC 2023). In 2022, there were no $PM_{2.5}$ exceedances of the NL AAQS or the CAAQS. The NL AAQS for TPM were exceeded five times over a six-month period, in May (1), June (1), August (2) and October (1). The exceedances were associated with stockpiling and port activities at the AML facility (NLDECC 2023).

The CAMS EAC4 dataset (Inness et al. 2019) was used to obtain air quality data in the vicinity of the Project. The CAMS EAC4 can provide gridded global data for every 3 hours from 2003 to 2022, at a 0.75º by 0.75º horizontal resolution. Data can be obtained from the earth's surface to the top of the atmosphere. Stantec selected the following data input variables from the CAMS EAC4:

- Data from 2019–2021 (2021 is the most recent year with complete annual data available)
- Concentrations of particulate matter and contaminants ($PM_{2.5}$, PM_{10}, NO_2, CO, and SO_2)
- Level 60 (data from the earth's surface to 10 m)

A total of 9 data point locations were selected for analysis that captured the Project Area and surrounding area. The coordinates of the sample locations are presented in Table 4.4 and displayed in Figure 4.1.

Table 4.4 Longitude and Latitude of Data Points Selected for Analysis with Copernicus Atmosphere Monitoring Service Global Re-analysis

Location	Latitude	Longitude
1	47.299	-59.599
2	47.299	-58.849
3	47.299	-58.099
4	48.049	-58.099
5	48.049	-58.849
6	48.049	-59.599
7	48.799	-59.599
8	48.799	-58.849
9	48.799	-58.099

An overview of the CAMS EAC4 results is provided herein. The full set of results for all 9 locations are presented in Appendix A. Table 4.5 shown here provides the 90th percentile 3-hour results from CAMS EAC4 for all locations for PM_{10}, $PM_{2.5}$, CO, NO_2 and SO_2.

Table 4.6 presents the maximum 24-hour average results, excluding the values >90th percentile, over 2019-2021 from CAMS EAC4 for all locations for PM_{10}, $PM_{2.5}$, CO, NO_2 and SO_2. Table 4.7 presents the three-year average of the 3-hour results from CAMS EAC4 for all locations for PM_{10}, $PM_{2.5}$, CO, NO_2 and SO_2.

Table 4.5 Air Quality Results from CAMS EAC4 – 90th Percentile (2019–2021)

Location	Concentrations (µg/m^3)				
	PM_{10}	**$PM_{2.5}$**	**CO**	**NO_2**	**SO_2**
1	21.40	13.80	173.08	17.22	3.03
2	22.80	14.50	170.66	12.08	2.00
3	22.43	14.30	168.75	5.72	1.02
4	19.80	13.20	171.47	9.99	1.68
5	20.20	13.40	170.65	6.69	1.22
6	23.40	14.70	169.09	2.75	0.68
7	29.30	17.60	169.44	3.74	0.85
8	21.60	14.03	169.90	3.31	0.76
9	19.50	13.00	170.75	2.68	0.65
Maximum Across Locations	29.3	17.6	173.08	17.22	3.03

Table 4.6 Air Quality Results from CAMS EAC4 – Maximum 24-hour Average (excluding values >90th percentile) (2019–2021)

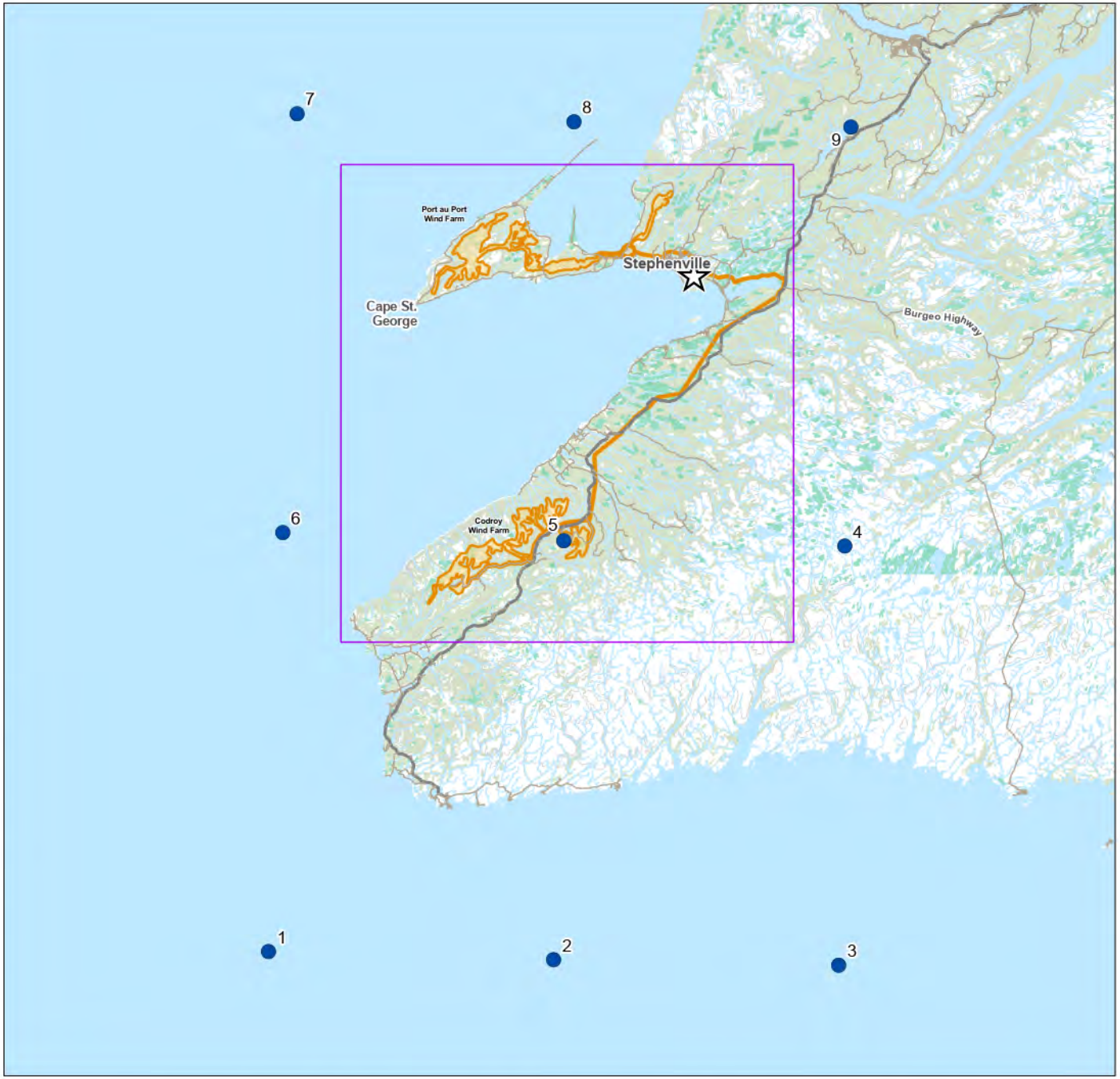
Location	Concentrations (µg/m^3)				
	PM_{10}	**$PM_{2.5}$**	**CO**	**NO_2**	**SO_2**
1	18.94	12.34	171.59	16.83	2.84
2	20.49	13.05	168.83	11.49	1.88
3	19.75	12.74	166.98	5.84	0.92
4	17.10	11.44	169.33	9.77	1.61
5	17.51	11.55	168.85	6.44	1.13
6	20.52	12.96	167.25	2.42	0.63
7	25.84	15.67	166.81	3.46	0.76
8	19.40	12.59	167.49	3.08	0.68
9	17.23	11.43	168.43	2.25	0.56
Maximum Across Locations	25.84	15.67	171.59	16.83	2.84

Table 4.7 Air Quality Results from CAMS EAC4 – 3-Year Average (2019–2021)

Location	Concentrations (µg/m³)				
	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2
1	10.91	6.99	146.53	6.98	1.48
2	11.55	7.25	145.30	4.83	0.98
3	11.33	7.08	144.47	2.34	0.50
4	9.53	6.22	145.85	3.90	0.80
5	9.93	6.47	145.89	2.74	0.58
6	11.90	7.45	145.08	1.19	0.30
7	14.37	8.64	144.88	1.42	0.36
8	10.76	6.88	145.87	1.36	0.34
9	9.41	6.22	146.32	1.16	0.31
Maximum Across Locations	14.37	8.64	146.53	6.98	1.48

The CAMS EAC4 Location 9 is located approximately 20 km away from the Corner Brook NAPS station (refer to Figure 4.1). The Corner Brook NAPS station summary concentration data that is reported in the annual Newfoundland and Labrador Ambient Air Monitoring Reports (NLDECC, 2020, 2021, 2022) were pulled for 2019-2021 and are presented below in Table 4.8, alongside CAMS EAC4 data for comparison. The CAMS EAC4 data presented in Table 4.8 were calculated against the same metrics as the NAPS data, but this data does not represent the averages over the respective periods. The CAMS EAC4 data are instantaneous values taken on 3-hour intervals, instead of an hourly average. As such, the annual values are not the annual average of 1-hour averages, but instead the annual average of instantaneous data taken every three hours. The 1-hour CAMS EAC4 values are representative of a single reading, while the 24-hour are an average of the eight readings taken over a 24-hour period.

The 1-hour, 24-hour, and 8-hour data did not compare well between any of the species in the two datasets. The annual results for particulates showed better correlation between the two sources, but did not correlate well for the gases.



Stantec

CAMS EAC4 Data Location

Local Assessment Area/Regional Assessment Area

Proposed Project Features

Hydrogen / Ammonia Plant Location

Project Area

Other Features

Trans Canada Highway

Road

Watercourse

Waterbody

Wetland

Forested Area

N

0 12 24 Kilometres

(At original document size of 8.5x11)

1:1,200,000

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 21N

2. Data Sources: World Energy GH2, NRCan CanVec, OpenStreetMap

3. Background: NRCan CanVec

Project Location
Stephenville
NL

Prepared by MER on 2023-07-06
QR by AW on 2023-07-19

Client/Project
World Energy GH2
Project Nujio'qonik

121417233 _202

Figure No.
4.1

Page 1 of 1

Location of Selected CAMS EAC4 Data Points

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Table 4.8 Concentration Data from Corner Brook NAPS Station and the CAMS EAC4 Location 9

Species	Averaging Period*	Units	Corner Brook NAPS Station			CAMS EAC4 Location 9		
			2019	2020	2021	2019	2020	2021
SO_2	Max 1- hour	($\mu g/m^3$)	39.7	10.7	16.0	1.60	1.74	1.38
	Max 24-hour	($\mu g/m^3$)	6.1	3.6	2.3	0.97	0.96	0.95
	Annual	($\mu g/m^3$)	1.4	1.4	0.5	0.30	0.32	0.30
$PM_{2.5}$	Max 24-hour	($\mu g/m^3$)	15.8	14.7	13.5	22.4	23.6	22.2
	Annual	($\mu g/m^3$)	6.1	5.4	4.3	6.7	5.9	6.1
NO_2	Max 1- hour	($\mu g/m^3$)	72.7	58.6	51.7	10.2	9.6	8.0
	Max 24-hour	($\mu g/m^3$)	20.5	20.5	17.1	5.3	4.8	4.0
	Annual	($\mu g/m^3$)	5.7	4.5	3.9	1.2	1.2	1.1
PM_{10}	Max 24-hour	($\mu g/m^3$)	-	39.9	50.4	31.5	36.1	31.2
CO	Max 1-hour	(mg/m^3)	0.5	0.7	1.1	0.22	0.21	0.30
	Max 8-hour	(mg/m^3)	0.4	0.4	0.7	0.22	0.20	0.29

4.4 Discussion

Based on a review of NPRI reporting data for NL, there are no large industrial emissions sources in the area surrounding the ammonia / hydrogen plant (the nearest industrial facility, the AML quarry, is 45 km west of the plant). However, the AML quarry is close to the Project Area (< 1 km away) on the Port au Port Peninsula where the Port au Port wind farm will be located. The AML industrial monitoring data for TPM exceeded the NL AAQS five times in 2022. Given that the AML facility is near the Project Area , it is expected that air contaminant releases from AML would on occasion contribute materially to reduced air quality within the Project Area near the quarry and the LAA.

The NAPS AAQM station to the Project site is at Grand Falls-Windsor, located approximately 220 km east-east from the Project. In 2022, there were no measured concentrations that exceeded the NL AAQS or CAAQS for SO2, NOX, NO2, or CO at the Grand Falls-Windsor station; however, there were some concentrations that exceeded the ambient standards for $PM_{2.5}$, O_3 and PM_{10} (NLDECC 2023).

The CAMS EAC4 data in the vicinity of the Project Area were also reviewed. This data represents concentration values on 3-hour intervals, not as hourly averages. As such, the concentrations associated with the AAQS averaging periods cannot directly be estimated. As a compromise, it was assumed that the 3-hour values could be compared against the 1-hour limit, that the average of eight 3-hour values could be compared against the 24-hour, and that the average of all 3-hour values within a year could be compared against the annual. It is recognized there is some inaccuracy in using these assumptions and the limitations should be considered when directly comparing the data. Of the nine locations that were assessed, the concentrations of CO, NO_2, and SO_2 did not exceed the NL AAQS or CAAQS when the metrics were calculated as described. At the same time, concentrations for maximum 24-hour averages

for PM_{10} and $PM_{2.5}$ at several locations exceeded the NL AAQS and CAAQS, including Location 1, Location 2, Location 3, Location 5 ($PM_{2.5}$ only), Location 7, and Location 8.

The CAMS EAC4 data collected from the location closest to the Corner Brook NAPS station (Location 9) had results that did not correlate with those measured at the NAPS station. While CAMS EAC4 data for Location 9 are not consistent with those measured at the NAPS station, results taken from other locations were closer to concentrations that would be expected in the area.

Both the NAPS and the CAMS EAC4 datasets provide valuable insight when assessing the baseline conditions. The CAMS EAC4 dataset allows for data with more spatial coverage, however, it also contains the inherent uncertainties that arise with any modelled data set due to assumptions in atmospheric processes. Where the NAPS data has been collected using United States Environmental Protection Agency (US EPA) Federal Reference Methods, and the data has been quality assured prior to publication, it is the data that will be used in future studies (e.g., the operational phase dispersion modelling) when establishing background concentrations.

4.5 References

4.5.1 Literature Cited

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4.5.2 Personal Communication

Lawrence, Barrie. 2023. Senior Environmental Scientist, Newfoundland and Labrador Department of Environment and Climate Change. Email communication to Stantec dated April 6, 2023.

5.0 Climate and Greenhouse Gases

5.1 Scope And Objectives of the Climate and Greenhouse Gases Study

The objective of this baseline study on climate and GHG is to characterize the baseline conditions (i.e., current, existing conditions) within the Project Area. As per the EIS Guidelines, this assessment includes a review of the following:

- Climate information, including monthly and annual minimum, maximum, and mean values for precipitation, temperature and wind speed, prevailing wind direction, and storm events
- Provincial climate change projections for Stephenville and coastal sea level rise projections for western Newfoundland
- Indications of recent climate change observations and trends
- Historical and current provincial GHG emissions including emissions specifically from the industrial sector
- Existing weather radar monitoring in and near the study area of the Project

In this assessment, the emissions of GHGs are expressed in the form of tonnes (t) of carbon dioxide equivalent (CO_2e), as explained in more detail below. The climate and GHG assessment includes the following GHGs that will be emitted by Project activities:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)

Greenhouse gases also include perfluorocarbons (PFC), hydrofluorocarbons (HFC), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). These gases are expected to be released in nominal or very small quantities, or not at all, and are, therefore, not considered further in the GHG assessment.

The management of GHG emissions occurs at provincial, national, and international scales. The existing legislation is mostly related to reporting industrial emissions above specified thresholds and promoting emission reductions at industrial operations.

Federally, under the Canadian Environmental Protection Act, 1999, industrial facilities that emit more than 10,000 t of CO_2e per year are required to quantify and report GHG emissions to Environment and Climate Change Canada's Greenhouse Gas Reporting Program. Provincially, under the Management of Greenhouse Gas Act and the Management of Greenhouse Gas Reporting Regulations, there are provincial GHG emission reporting requirements. There are three levels of GHG reporting as follows:

- Facilities emitting 15,000 t of CO_2e or more annually must report their emissions to the provincial government

- Facilities emitting between 15,000 and 25,000 t of CO2e annually may apply to be designated as opted-in facilities, in which the facility opts to performing a third-party verification of emissions
- By opting in, facilities may apply to become exempt from the application of the federal Greenhouse Gas Pollution Pricing Act for fuels those emissions are included in their reporting
- Facilities emitting more than 25,000 t of CO_2e annually are subject to annual GHG reduction targets and require third-party verification of emissions

Depending on the annual quantity of GHG emissions released to the atmosphere, the Project may be required to report annual GHG emissions to both the provincial and federal government.

In the 2015 submission to the United Nations Framework Convention on Climate Change, the Government of Canada agreed to reduce GHG emissions by 30% below 2005 levels by 2030 as part of the Paris Agreement (ECCC 2019). More recently, Canada's 2030 Emissions Reduction Plan includes the following updated targets (ECCC 2022):

- 40–45% reduction in national GHG emissions below 2005 levels by 2030
- Achieve net zero emissions by 2050

The Government of NL has set the following emission reduction targets in the provincial Climate Change Action Plan (Government of NL 2019):

- A 35% to 45% reduction in regional GHG emissions below 1990 levels by 2030
- A 30% reduction in provincial GHG emissions below 2005 levels by 2030

An overview of the methods and the results of the baseline study are provided in the following sections.

5.2 Methods

The existing climate in the Project Area is characterized using ECCC climate normals data from representative meteorological stations located nearest to the Project with sufficient available data (ECCC 2023c). Climate normals data for the 30-year period from 1981 to 2010 are presented below, including temperature and precipitation data. Climate normals data refer to arithmetic calculations based on observed climate values for a given location over a specified period of time (ECCC 2020). Wind data from 2018 to 2022 are presented below. Information about historical storm events in NL, from literature and published data, is also presented below.

Climate change projections (temperature, precipitation, and sea level rise) in the Project Area are characterized by summarizing data published by Memorial University in their Climate Projections Study for the province of NL (Memorial University of Newfoundland [MUN] 2018), Climate Data (2023c), and a sea level rise study commissioned by the province of NL (Batterson 2020).

Provincial and national GHG emissions are characterized by summarizing provincial and national GHG emissions inventory data from ECCC's National Inventory Report (NIR) (ECCC 2023e). Data published for the 2021 reporting year were used (most recently available information).

5.3 Results

5.3.1 Climate

Climate is defined by the long-term average, seasonal, and extreme meteorological conditions, which includes measurable parameters such as temperature, precipitation, and winds, among others. ECCC has developed statistical summaries of data collected from weather stations located across Canada, known as climate normals. As of June 2023, the most recent data available are for the period of 1981 to 2010.

5.3.1.1 Temperature, Precipitation, Fog and Wind

The nearest weather station to the Project is located adjacent to the Stephenville airport, which is less than 5 km northwest from the hydrogen / ammonia plant. The daily average temperatures at the Stephenville meteorological station range between -6.7°C to 16.7°C, with the lowest average temperatures occurring in February and the highest occurring in August. Extreme daily maximum and minimum temperatures range between -29.5°C (February) to 30.6°C (July). Total annual average precipitation (snow and rain) at Stephenville meteorological station is 1,340.4 millimetres (mm), with 393 centimetres (cm) of snow and 995 mm of rain. Monthly average precipitation ranges between 78 to 130 mm, with the least occurring in April and the most occurring in August.

There is a measured increase in the hours of reduced visibility/fog (less than 1 km) in winter relative to the other months. The Stephenville meteorological station has experienced, on average, 129.8 hours (5.4 days) per year when visibility is less than 1 km (ECCC 2023c). The 1981 to 2010 climate normals for the Stephenville meteorological station are shown in Table 5.1.

Wind rose plots of the annual and seasonal winds at Stephenville meteorological station are shown in Table 5.1 and Figure 5.2. Winds prevail from the west, northwest, and east directions. The highest wind speeds occur most frequently from the northwest direction and the lowest wind speeds occur most frequently from the northeast direction. Generally, the seasonal winds are consistent, with winds prevailing predominantly from the west and east. The wind speed is generally lower in the summer months.

Table 5.1 Climate Normals, Stephenville, NL (1981–2010)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature													
Daily Average (°C)	-6	-6.7	-3.5	2.6	7.6	12.1	16.4	16.7	12.8	7.4	2.7	-2.4	5
Daily Maximum (°C)	-2.4	-2.6	0.6	6.4	11.9	16.4	20.2	20.6	16.7	10.8	5.6	0.7	8.7
Daily Minimum (°C)	-9.4	-10.7	-7.6	-1.3	3.2	7.8	12.6	12.8	8.9	4	-0.2	-5.3	1.2
Extreme Daily Maximum (°C)	14.6	12.7	19.7	23.8	27.2	30	30.6	29.9	29.1	22.4	20.6	16.1	-
Date (yyyy/dd)	2006/15	1996/17	1999/29	1986/26	1950/26	1954/27	1949/31	2001/01	1989/10	2010/01	1967/05	1966/01	-
Extreme Daily Minimum (°C)	-26.1	-29.5	-29.2	-15.6	-7.1	-1.1	3.5	2.2	-0.7	-5.6	-14.9	-20.2	-
Date (yyyy/dd)	1957/29	1990/05	1990/08	1994/02	1993/11	1943/01	2009/08	1975/25	1986/21	1969/31	1992/24	1984/26	-
Precipitation													
Rainfall (mm)	28.9	27.2	36.9	61.5	94	104.1	118.4	130.4	127.5	124	93.8	48.6	995.3
Snowfall (cm)	113.3	90.1	54.4	17	3.3	0	0	0	0.1	2.9	26.2	86	393.2
Precipitation (mm)	124.6	105.3	86.2	77.7	97.4	104.1	118.4	130.4	127.6	126.9	118.4	123.4	1340.4
Extreme Daily Rainfall (mm)	52.8	83.8	50.8	68.8	53.6	130.7	84.1	96	76.4	50.2	63	48.2	-
Date (yyyy/dd)	1979/08	1946/22	1968/20	1994/07	1993/14	1995/08	1979/17	1989/05	2005/27	2000/10	1951/08	1990/08	-
Extreme Daily Snowfall (cm)	56.1	41.7	34	21.1	14	2.5	0	0	2.4	12.7	20.8	35.3	-
Date (yyyy/dd)	1973/31	1964/17	1993/14	1964/02	1963/10	1946/01	1942/01	1942/01	1989/27	1969/23	1997/29	1952/31	-
Extreme Daily Precipitation (mm)	58.8	94	50.8	68.8	58.9	130.7	84.1	96	81	50.2	70.1	48.2	-
Date (yyyy/dd)	1979/08	1946/22	1968/20	1994/07	1954/22	1995/08	1979/17	1989/05	1955/21	2000/10	1958/07	1990/08	-

Table 5.1 Climate Normals, Stephenville, NL (1981–2010)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Visibility (Fog) (hours with)													
< 1 km	29.5	18.5	11.4	8	6.4	12.5	13.2	4	2.7	3	4.7	15.9	129.8
1 to 9 km	207.4	155.5	98.8	61.6	52.2	65.4	82.5	56.6	44.1	37.2	70.8	154	1085.9
> 9 km	507.1	504	633.9	650.4	685.4	642.1	648.3	683.4	673.2	703.8	644.5	574.1	7550.3
Source: ECCC 2023c													

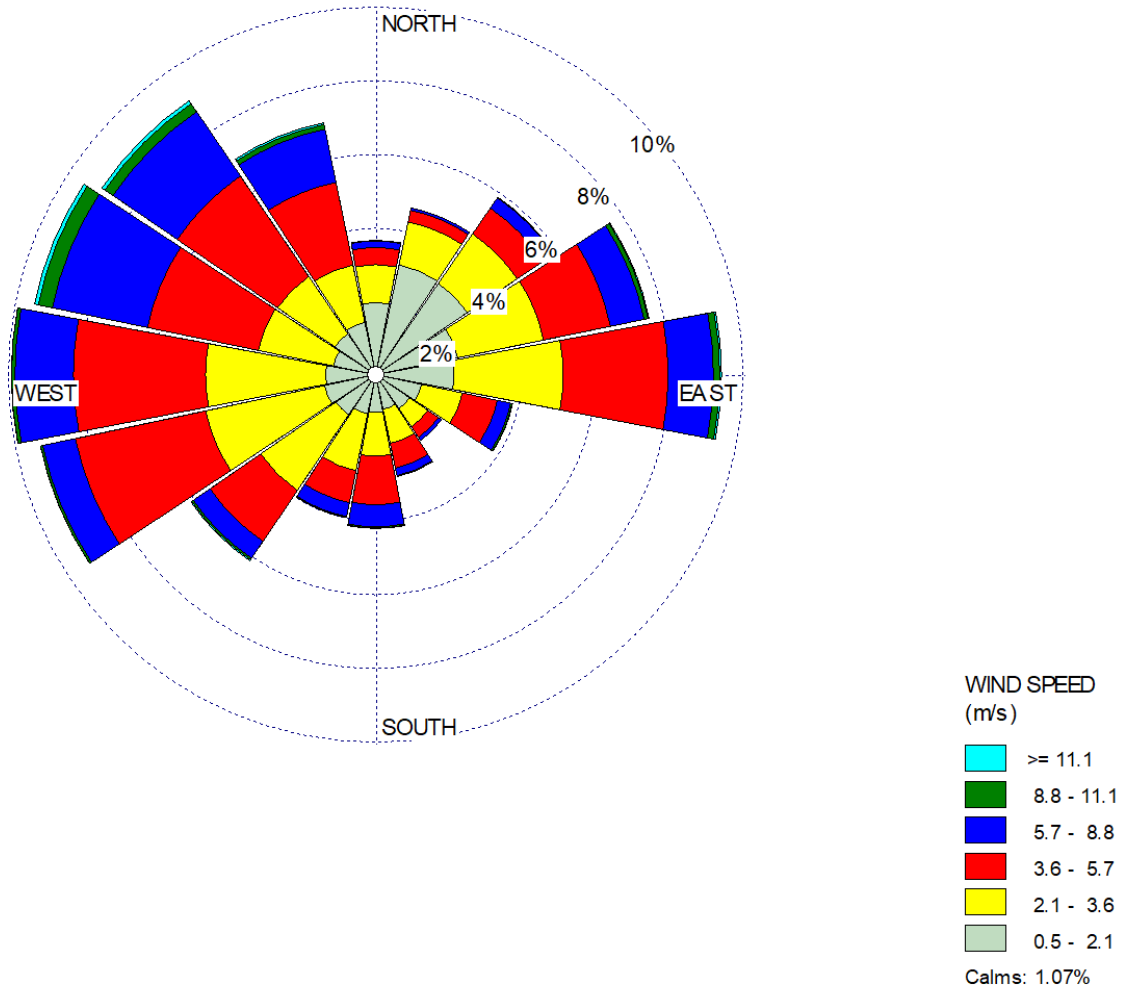

Figure 5.1 Winds at Stephenville, NL (2018 – 2022)

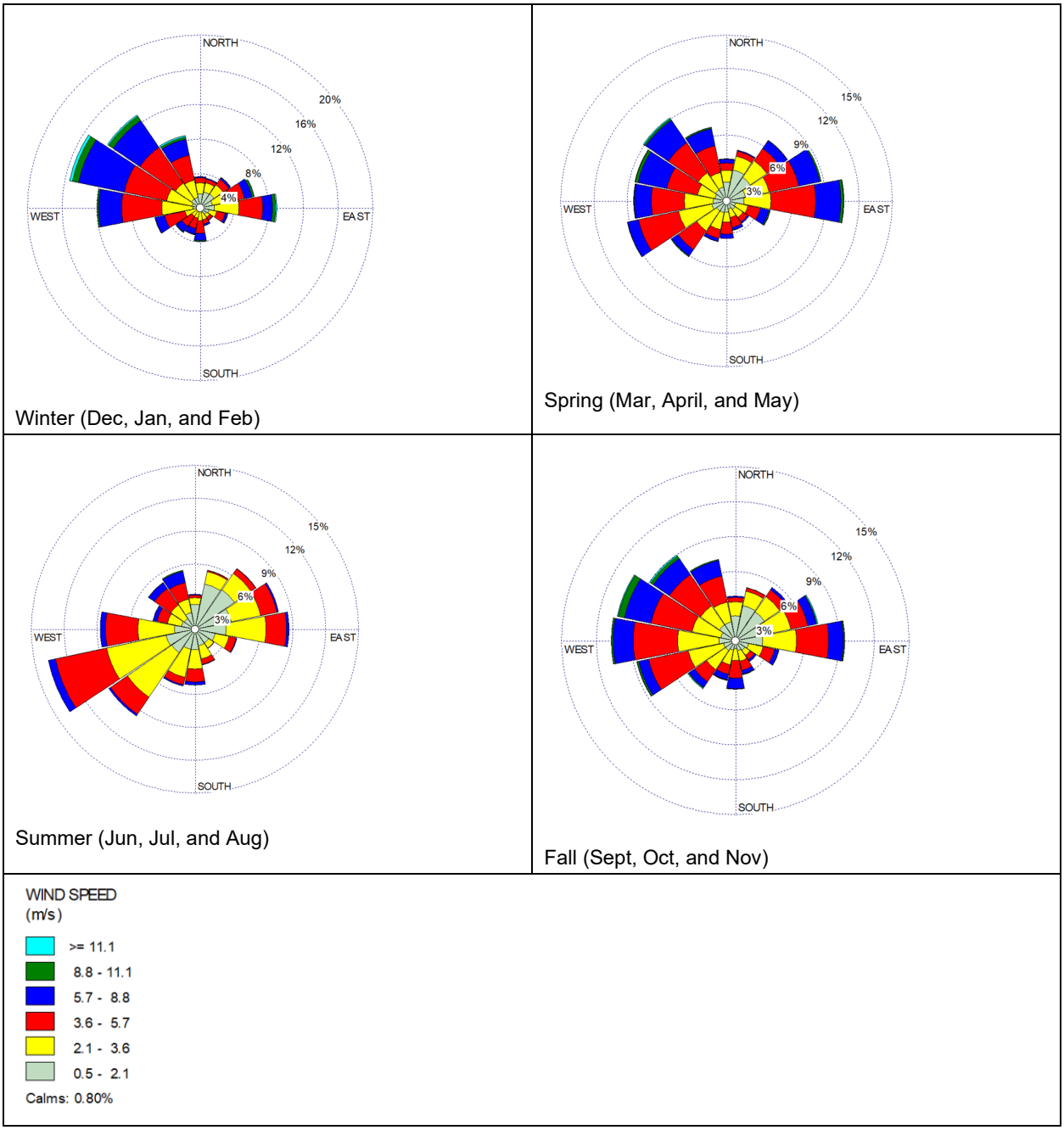

Figure 5.2 Seasonal Winds at Stephenville, NL (2018–2022)

5.3.1.2 Storms

Storm events in NL tend to be more common in the winter (Government of NL 2023), and consist of high winds, snow, rain and ice. A study commissioned by the Government of NL reviewed the documented storm events that occurred from 1950 to 2014. Over this period, a total of 296 storm events occurred (an average of 5 storm events per year); the west coast region of NL experienced 105 storm events during this time or about 2 storm events per year (Government of NL 2023).

Hurricane season occurs between June and November of each year. The aforementioned study found that storm events in September have caused the greatest flooding impacts across NL (Government of NL 2023). One of the worst hurricanes to occur in NL was Hurricane Igor, a Category 1 hurricane that occurred in 2010 and resulted in $200 million in damages in the province (NL Department of Finance n.d.). Hurricane Igor had maximum sustained landfall wind of 140 km/hour (hr) and extreme rainfall as high as 238 mm in the St. Lawrence area, making it a 1-in-100 year storm event (Pasch and Kimberlain 2011).

More recently, in 2022, Hurricane Fiona caused devastation to the Atlantic provinces, including NL. Channel-Port aux Basques, NL declared a state of emergency due to severe winds, storm surges and flooding; several homes and roads were washed away during the storm (CBC News 2022).

5.3.2 Climate Change

When GHGs are released, they absorb and trap heat in the atmosphere, creating a phenomenon called "the greenhouse effect". Releases of GHGs, on a global scale, have increased and continue to increase worldwide concentrations of GHGs in the atmosphere; these changes to the atmosphere are associated with climate change (IPCC 2014).

Climate change is defined by the Intergovernmental Panel on Climate Change (IPCC) as

> "*a change in the state of climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer*" (IPCC 2014).

Projections of future climate change are derived from mathematical and statistical models. The results can be used to guide project planning, design, and adaptation. Over the next 50 years, Atlantic Canada is predicted to experience warmer temperatures, increased precipitation, more frequent and intense storm events, sea level rise, and increased flooding (Poitras et al. 2022; Dietz and Arnold 2021; Comeau and Nunes 2019).

The subsections below focus on temperature, precipitation, and sea level rise projections.

5.3.2.1 Temperature

In 2018, the government of NL commissioned a Climate Projections Study that identifies how the province's climate, including temperature and precipitation, is projected to change by the year 2100 (MUN 2018). The data on the projected mean (average) temperature from the Climate Projections Study for Stephenville are presented below.

Daily mean temperatures are projected to increase throughout NL, with the largest changes in the winter, at high latitudes, and away from coastlines (MUN 2018). The daily mean winter temperature in Stephenville is projected to increase from -4.5ºC to 1.8ºC by the year 2100. The daily mean summer temperature is projected to increase from 7.7ºC to 13.2ºC by 2100 (MUN 2018) (Table 5.2).

The average daily mean temperature in Stephenville is expected to rise from 5.1ºC in the 20th century to 8.4ºC by 2070 and 10.4ºC by 2100 (Table 5.2) (MUN 2018). This correlates with data published by Climate Data, a collaboration between ECCC, the Computer Research Institute of Montréal, Ouranos, the Pacific Climate Impacts Consortium, the Prairie Climate Centre, and Habitat Seven. According to Climate Data projections, the mean temperature in Stephenville is expected to rise to 8.5ºC between 2041 and 2070, and to 10.7ºC between 2070 and 2100 (Climate Data 2023c).

Daily minimum and maximum temperatures are projected to increase throughout the province as well, with the greatest changes expected to occur in the winter months. In Stephenville, the daily minimum temperature is expected to increase from -7.79ºC in the winter to -0.74ºC by the year 2100 (MUN 2018). The daily maximum temperature in Stephenville is expected to increase from -1.33ºC in the winter to 4.44 ºC by the year 2100 (MUN 2018).

Table 5.2 Projected Daily Mean Temperature (ºC) at Stephenville, NL

Location	Months	20th Century Climate (1970 – 2005)	Projection: 2041–2070	Projection: 2071–2100
			Ensemble Average[1]	Ensemble Average
Stephenville	Winter (December, January, February)	-4.5	-0.4	1.8
	Spring (March, April, May)	2.2	4.9	6.8
	Summer (June, July, August)	15.1	18.0	19.9
	Fall (September, October, November)	7.7	11.1	13.2
	Average	5.1	8.4	10.4

Notes:

[1] Ensemble average refers to a collection of model forecasts for a single period. By including multiple model runs, an ensemble provides a sense of forecast uncertainty; if the runs agree with one another, the ensemble average forecast is considered reliable; if they diverge, the forecast is less reliable. The uncertainty of the data presented above ranges between 1.3 and 1.9.

ºC = degrees Celsius

Source: MUN 2018

5.3.2.2 Precipitation

The projected mean precipitation data from the Climate Projections Study for Stephenville are presented below in Table 5.3.

Table 5.3 Projected Daily (24-hour) Mean Precipitation (mm) at Stephenville, NL

Location	Months	20th Century Climate (1970 – 2005)	Projection: 2041–2070	Projection: 2071–2100
			Ensemble Average[1]	Ensemble Average
Stephenville	Winter (December, January, February)	5.3	4.8	5.2
	Spring (March, April, May)	3.2	3.5	3.8
	Summer (June, July, August)	3.6	4.0	4.2
	Fall (September, October, November)	4.4	4.8	4.8
	Average	4.1	4.3	4.5

Notes:

[1] Ensemble average refers to a collection of model forecasts for a single period. By including multiple model runs, an ensemble provides a sense of forecast uncertainty; if the runs agree with one another, the ensemble average forecast is considered reliable; if they diverge, the forecast is less reliable. The uncertainty of the data presented above ranges between 0.2 and 0.5 .

Source: MUN 2018

Daily mean precipitation is expected to increase slightly throughout the province of NL by mid-century, and larger changes are expected by the end of the century (MUN 2018). At Stephenville, daily mean precipitation by 2100 is expected to be slightly lower in the winter (0.1 mm less) compared to 20th century climate (Table 5.3). Daily mean precipitation in the spring, summer, and fall is expected to increase slightly by an average of 0.6 mm per day (Table 5.3) (MUN 2018). The mean intensity of precipitation events (mm/day) from the Climate Projections Study are presented below in Table 5.4.

Table 5.4 Mean Intensity of Precipitation Events (mm/day) at Stephenville, NL

Location	Months	20th Century Climate (1970 – 2005)	Projection: 2041–2070	Projection: 2071–2100
			Ensemble Average[1]	Ensemble Average
Stephenville	Winter (December, January, February)	7.7	8.1	8.9
	Spring (March, April, May)	7.7	8.5	8.9
	Summer (June, July, August)	9.4	10.5	11.2
	Fall (September, October, November)	9.0	10.3	11.0
	Average	8.5	9.4	10.0

Notes:

[1] Ensemble average refers to a collection of model forecasts for a single period. By including multiple model runs, an ensemble provides a sense of forecast uncertainty; if the runs agree with one another, the ensemble average forecast is considered reliable; if they diverge, the forecast is less reliable. The uncertainty of the data presented above ranges between 0.4 and 1.2.

Source: MUN 2018

The typical precipitation event is expected to become more intense over time (MUN 2018). At Stephenville, the mean intensity of precipitation events in 2100 is expected to increase by as much as 16% (from 8.5 mm to 10.0 mm) (Table 5.4) (MUN 2018). Climate Data estimates the total annual precipitation at Stephenville to increase from 1,214 mm (1991 to 2020) to 1,409 mm (2070 to 2100), which is an increase of approximately 14% (Climate Data 2023c).

The Climate Projections Study includes expected changes to intensity-duration-frequency (IDF) precipitation analyses. IDF curves are graphical tools that describe the likelihood of a range of extreme rainfall events, typically ranging from 5 minutes to 24 hours (Climate Data 2023a). The results of the median of IDF projections at Stephenville, NL are presented in Table 5.5.

Table 5.5 Median of Intensity-Duration-Frequency (IDF) Precipitation Projections at Stephenville, NL

Historical IDF, 2015 Update to Observational Records (mm)						
	Return Interval (years)					
Duration	2	5	10	25	50	100
5 min	4.5	6.2	7.3	8.7	9.7	10.7
10 min	6.7	9.4	11.1	13.4	15.0	16.7
15 min	8.4	11.6	13.7	16.4	18.3	20.3
30 min	12.1	16.7	19.8	23.7	26.6	29.5
1 hour	16.8	22.6	26.5	31.3	34.9	38.5
2 hour	22.8	29.6	34.1	39.8	44.1	48.2
6 hour	38.5	50.1	57.7	67.4	74.6	81.8
12 hour	47.5	61.6	71.0	82.8	91.6	100.3
24 hour	59.8	79.4	92.4	108.8	120.9	133.0

Table 5.5 Median of Intensity-Duration-Frequency (IDF) Precipitation Projections at Stephenville, NL

Projected IDF Data, 2041–2070 (mm)						
	Return Interval (years)					
Duration	**2**	**5**	**10**	**25**	**50**	**100**
5 min	5.4	7.1	8.3	9.8	10.9	12.0
10 min	8.1	10.9	12.8	15.2	16.9	18.7
15 min	10.1	13.4	15.7	18.5	20.6	22.7
30 min	14.5	19.4	22.7	26.9	30.0	33.0
1 hour	19.8	26.0	30.0	35.2	39.1	42.9
2 hour	26.3	33.6	38.4	44.4	48.9	53.4
6 hour	44.4	56.7	64.9	75.2	82.9	90.5
12 hour	54.7	69.7	79.7	92.3	101.6	110.9
24 hour	69.8	90.7	104.5	121.9	134.9	147.7
Projected IDF Data, 2071–2100 (mm)						
	Return Interval (years)					
Duration	**2**	**5**	**10**	**25**	**50**	**100**
5 min	6.2	8.6	10.2	12.1	13.6	15.1
10 min	9.5	13.2	15.7	18.9	21.2	23.6
15 min	11.7	16.2	19.2	22.9	25.7	28.5
30 min	16.9	23.5	27.9	33.4	37.5	41.6
1 hour	22.8	31.0	36.4	43.3	48.4	53.5
2 hour	29.8	39.5	45.9	53.9	59.9	65.8
6 hour	50.4	66.8	77.7	91.5	101.7	111.8
12 hour	62.0	82.0	95.3	112.1	124.5	136.9
24 hour	79.9	107.7	126.1	149.4	166.6	183.7

Notes:

The data presented above is based on representative concentration pathway (RCP) 8.5. RCPs represent climate projection results from different combinations of assumptions about population growth, economic activity, energy intensity, socioeconomic development, land use change, and climate policies; different combinations of assumptions lead to different amounts of GHG emissions in the future. RCP 8.5 is the high emissions scenario, where GHG emissions continue to increase through the century, stabilizing by the year 2250 (Climate Data 2023b).

Source: MUN 2018

The median projected IDF response indicate considerable increases in extreme precipitation can be expected in NL in future (MUN 2018). For example:

- On a 24-hour basis, a 1-in-100 years storm is expected to result in 147.7 mm of precipitation by 2070 and 183.7 mm by 2100, an increase from 133.0 mm expected in the current climate (Table 5.5)
- On a 12-hour basis, a 1-in-100 years storm is expected to result in 110.9 mm of precipitation by 2070 and 136.9 mm by 2100, an increase from 100.3 mm expected in the current climate (Table 5.5)

5.3.2.3 Sea Level Rise

Sea level rise can result in increased height of water levels, waves, and tides. The implication for coastal change in NL includes an increase in the extent and frequency of coastal flooding, increased erosion of the cliff base, and landward migration of beaches and dunes (Batterson 2020). In 2020, the government of NL funded the development of a data portal for information on the implications of sea level rise. The portal includes case studies about coastal changes across the province and a user guide on how to use the data (Government of NL n.d.). According to the study, a relative sea level rise[1] of over 110 cm is expected for eastern parts of NL by the year 2100, with somewhat lesser rise predicted on the west coast (Batterson 2020) where the Project is located. Climate Data predicts that sea level rise on the west coast, near Stephenville, will increase by 38–111 cm by 2100 (assuming an RCP of 8.5) (Climate Data 2023c).

5.3.3 Greenhouse Gases

As noted above, there are no large industrial emission sources located near the Project (the nearest industrial facility is approximately 45 km from the Project).

Current provincial and national GHG emissions were characterized by summarizing provincial and national GHG emissions inventory data. The provincial and national GHG emissions are presented in Table 5.6. Data published for the 2021 reporting year were used, as it presents the most recently available information. The GHG emissions information was obtained from the ECCC NIR (ECCC 2023e).

Table 5.6 Provincial and National GHG Emissions (2021)

Parameter	Units	CO_2	CH_4	N_2O	Other GHGs [a] (CO_2e)	Total (CO_2e)
NL GHG Emissions	kt CO_2e/y	7,314	727	105	190	**8,336**
National GHG Emissions	kt CO_2e/y	537,174	90,510	30,231	12,513	**670,428**
NL contribution to National GHG Emissions	%	1.4	0.8	0.3	1.5	**1.2**

Notes:
kt CO_2e /y kilotonnes of carbon dioxide (CO_2) equivalent per year
[a] Other GHGs include sulphur hexafluoride, hydrofluorocarbons, perfluorocarbons, and nitrogen trifluoride
Source: ECCC 2023e

[1] Relative sea level rise refers to how the height of the ocean rises and falls relative to the land at a specific location. In contrast, absolute sea level change refers to the height of the ocean surface above the centre of the earth (US EPA 2022).

The provincial NL GHG emissions accounted for a small fraction of Canada's national GHG emissions in 2021 (1.2%).

5.4 Discussion

Over time, Atlantic Canada, including NL, is predicted to experience warmer temperatures, increased precipitation, more frequent and intense storm events, sea level rise, and increased flooding (Poitras et al. 2022, Dietz and Arnold 2021, Comeau and Nunes 2019).

Currently, the provincial NL GHG emissions account for a small fraction of Canada's national GHG emissions in 2021 (ECCC 2023e). Depending on the amount of GHG emissions released by the Project, the Project may be subject to legislation requiring GHG emissions quantification, reporting, and third-party verification.

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6.0 Light

6.1 Scope And Objectives of the Light Study

The objective of this baseline study is to characterize the baseline light conditions (i.e., current existing conditions) within the Project Area. As per the EIS Guidelines, this report includes a review of existing light levels in the Project Area. Lighting was selected as a subcomponent of the atmospheric environment because exterior Project lighting can affect nighttime sky views and migrating wildlife, and result in visual aesthetic changes for, and physiological changes in, humans.

Three attributes are used to describe potential environmental effects of light:

- Light trespass refers to the transmission of light from fixtures within a facility to the surrounding environment and receptors outside the facility. The unit of measure for light incidence either in or outside the facility is a lux. A lux is equal to one lumen lighting up an area of 1 square metre (m^2), or 1 lumen/m^2. A 60-watt incandescent light bulb emits approximately 800 lumens. Light trespass reaches problematic levels, for example, when lights (also referred to as luminaires) located on the outside of an industrial facility shine in through the windows of nearby residential homes at levels that could disrupt sleep or cause annoyance.
- Glare refers to intense, harsh or contrasting lighting conditions associated with incoming light that reduces the ability of humans, birds and other organisms to see clearly. The most common example of glare is oncoming high-beam vehicle headlights that provide ample light for the driver in the oncoming vehicle, while at the same time, result in poor visibility, potentially reaching hazardous conditions for the driver meeting the other vehicle. The unit of measure is luminance, which is equal to lumens per steradian, and this is referred to as the candela (cd).
- Sky glow refers to the illumination of the clouds by light sources on the surface of the Earth at night, such as street lighting, and haze in the atmosphere that replaces the natural nighttime sky with a translucent to opaque lighted dome. The sky appears washed out, or brownish-purple and may be devoid of visible stars in the extreme. Sky glow is the cumulative effect of all the lights at the surface either emitting upward or being reflected upward by the surface plus the emission from photochemical activity in the atmosphere. The unit of measure for the brightness of the sky, including sky glow, is magnitudes per square arcsecond (mag/arcsec^2). A sky glow measurement representative of a clear sky in a rural or dark area would be approximately 21 to 22 mag/arcsec^2 and within a city or urban well-lit area would be approximately 18-19 mag/arcsec^2 (Berry 1976).

The three attributes of light (light trespass, glare and sky glow) form the framework for describing the existing environment in the Project Area.

Most lighting guidelines and regulations have been directed toward the provision of suitable lighting for the safe and efficient activities of humans. For example, street lighting, indoor lighting and lighting around industrial plants are subjects of various guidelines to facilitate a safe work environment. Currently there

are no legally binding requirements (e.g., regulations, orders) in NL to regulate obtrusive light from industrial facilities.

Various international organizations, including the International Dark Sky Association (IDA) and the Commission Internationale de L'Éclairage (CIE), also known as the International Commission on Illumination, have developed guidelines and recommendations to limit light pollution and associated effects to humans and wildlife. The Illuminating Engineering Society of North America (IESNA) has adopted these types of guidelines and provide recommendations for use in designing new outdoor lighting systems.

The CIE is an independent non-profit organization serving member countries on a voluntary basis. Since its inception in 1913, the CIE has become a professional organization and is currently recognized by the International Organization for Standardization (ISO) as an international standardization body relating to matters on light and lighting, color and vision, photobiology, and image technology (CIE 2017). The CIE has established guidelines for light trespass and glare for various levels of urbanization. These guidelines have been adopted in Great Britain, in particular by the Scottish Executive in their guidance document *Controlling Light Pollution and Reducing Lighting Energy Consumption* (Scottish Executive 2007) and have been used in this study.

The values represented in the guidelines are based on environmental zones and time of day. Five environmental zones have been established by the CIE (CIE 2017) as a basis for outdoor lighting. The five zones are listed in Table 6.1.

Table 6.1 Environmental Lighting Zones

Zone	Lighting Environment	Examples
E0	Intrinsically Dark	IDA Dark Sky Parks
E1	Dark	Relatively uninhabited rural areas
E2	Low district brightness	Sparsely inhabited rural areas
E3	Medium district brightness	Well inhabited rural and urban settlements
E4	High district brightness	Town and city centres and other commercial areas
Source: CIE 2017		

The maximum values recommended by CIE for light trespass (vertical illuminance) and glare on properties by environmental lighting zone and time of day are presented in Table 6.2 (CIE 2017).

Table 6.2 Recommended Maximum Values of Light Trespass (Illumination) per Environmental Zones

Time of Day	Environmental Zones				
	E0	E1	E2	E3	E4
19:00 – 23:00	n/a	2 lux	5 lux	10 lux	25 lux
23:00 – 6:00	n/a	< 0.1 lux	1 lux	2 lux	5 lux
Source: CIE (2017)					

The maximum values recommended by CIE for glare (intensity of luminaires) in designated directions by environmental zone and time of day are presented in Table 6.3. The recommended values for glare depend not only on the brightness of the luminaire, but also the distance from the observer to the luminaire (*d)* and the size of the luminaire (Ap).

Table 6.3 Recommended Maximum Values for Glare (Intensity of Luminaires)

Light Technical Parameter	Application Conditions	Luminaire group (projected area Ap in m^2)				
		$0<Ap\leq0.002$	**$0.002<Ap\leq0.01$**	**$0.01<Ap\leq0.03$**	**$0.03<Ap\leq0.13$**	**$0.13<Ap\leq0.50$**
Maximum luminous intensity luminaire (*I* in cd)	**Environmental Zone E0**					
	Pre-curfew:	0	0	0	0	0
	Post-curfew:	0	0	0	0	0
	Environmental Zone E1					
	Pre-curfew:	$0.29\cdot d$	$0.63\cdot d$	$1.3\cdot d$	$2.5\cdot d$	$5.1\cdot d$
	Post-curfew:	0	0	0	0	0
	Environmental Zone E2					
	Pre-curfew:	$0.57\cdot d$	$1.3\cdot d$	$2.5\cdot d$	$5.0\cdot d$	$10\cdot d$
	Post-curfew:	$0.29\cdot d$	$0.63\ d$	$1.3\cdot d$	$2.5\cdot d$	$5.1\cdot d$
	Environmental Zone E3					
	Pre-curfew:	$0.86\cdot d$	$1.9\cdot d$	$3.8\cdot d$	$7.5\cdot d$	$15\cdot d$
	Post-curfew:	$0.29\cdot d$	$0.63\cdot d$	$1.3\cdot d$	$2.5\cdot d$	$5.1\cdot d$
	Environmental Zone E4					
	Pre-curfew:	$1.4\cdot$d	$3.1\cdot d$	$6.3\cdot d$	$13\cdot$d	$26\cdot d$
	Post-curfew:	$0.29\cdot d$	$0.63\cdot d$	$1.3\cdot d$	$2.5\cdot d$	$5.1\cdot d$
Source: CIE (2017)						

Reference levels for sky glow are shown in Table 6.4 (Berry 1976). The higher the number, the more the sky is dominated by the natural background (i.e., light from human activities is less), and the lower the number, the greater the degree of sky glow caused by the reflection of lighting from the atmosphere.

Table 6.4 Reference Levels of Sky Glow

Sky Glow (mag/arcsec^2)	Corresponding Appearance of the Sky
21.7 (Rural)	The sky is covered with stars that appear large and close. In the absence of haze, the Milky Way can be seen to the horizon. The clouds appear as black silhouettes against the sky.
21.6	Sky appearance similar to that defined for rural (above) but with a glow in the direction of one or more cities is seen on the horizon. Clouds are bright near the city glow.
21.1	The Milky Way is brilliant overhead but cannot be seen near the horizon. Clouds have a greyish glow at the zenith and appear bright in the direction of one or more prominent city glows.
20.4	The contrast to the Milky Way is reduced and detail is lost. Clouds are bright against the zenith sky. Stars no longer appear large and near.
19.5	Milky Way is marginally visible, only near the zenith. Sky is bright and discoloured near the horizon in the direction of cities. The sky looks dull grey.
(18.5 Urban)	Stars are weak and washed out and reduced to a few hundred. The sky is bright and discoloured everywhere.
Source: Berry (1976)	

6.2 Methods

The existing ambient light levels within the Project Area were characterized by conducting ambient light monitoring, reviewing satellite observations of artificial light (World Atlas 2015), and by making assumptions based on the Project location, nearby communities, nearby sources of light, and Stantec's professional experience.

The following subsections describe specifics of the baseline light study.

6.2.1 Site Selection

The Project Area includes the proposed hydrogen/ammonia plant and the export facilities at the Port of Stephenville, located approximate 5 km west of the Town of Stephenville. The Port au Port wind farm (comprised of Port au Port West and Port au Port East) is located west and north of Stephenville and the Codroy wind farm is located 75 km south of Stephenville; both are connected to the hydrogen / ammonia plant by a collector system of transmission lines. The total population of the town of Stephenville in 2021 was 7,344 (Statistics Canada 2022). The total population of the Port au Port Peninsula in 2021 was 4,734 (Statistics Canada 2022), with the population spread amongst several small communities along Route 460 to the south and Route 463 to the north.

The domain of satellite observations of artificial light reviewed consisted of a 200 x 200 km area around the Project Area as presented in Figure 6.1.

The baseline monitoring for lighting was completed at three locations, two on the Port au Port peninsula, and one near the Port of Stephenville. The monitoring locations are listed in Table 6.5 and presented on Figure 6.1.

Stantec

Light Monitoring Location

Proposed Project Features

Hydrogen / Ammonia Plant Location

Project Area

Other Features

Trans-Canada Highway

Road

Watercourse

Waterbody

Wetland

Forested Area

N

0 11 Kilometres

(At original document size of 8.5x11)

1:550,000

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 21N
2. Data Sources: World Energy GH2, NRCan CanVec, OpenStreetMap
3. Background: NRCan CanVec

Project Location
Stephenville
NL

Prepared by MGS on 2023-07-18
QR by AW on 2023-07-18

Client/Project
World Energy GH2
Project Nujio'qonik

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Figure No.
6.1

Page 1 of 1

Baseline Monitoring Locations for Light

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Table 6.5 Baseline Light Study Monitoring Locations

Location No.	Site Location (UTM Zone 21)		Site Elevation (m)	Site Description
1	358156.99	5376412.12	65.5	Near Abraham's Cove – House Yard
2	354948.07	5386769.97	4.3	West Bay – House Yard
3	386490.71	5375116.39	0	Little Port Harmon – Parking Lot near Beach

Baseline monitoring for lighting in the Codroy wind farm area was considered, however, due to the risks during nighttime driving and high moose activity in the area, it was deemed to be unsafe. The Codroy wind farm area is sparsely populated and rural, and it is expected that the rural samples taken on Port au Port at locations 1 and 2 would be representative of the lighting conditions in the Codroy wind Farm area.

6.2.2 Field Methods

Light monitoring was conducted at the three selected locations (Table 6.4, Figure 6.2). Ambient light monitoring included measurements of illuminance (lux) and sky glow (mag/arcsec^2). Illuminance was measured using a conventional, integrating hemispherical light meter (Extech EA33) with a resolution of 0.01 lux. Sky glow was measured using a Unihedron Sky Quality Meter (SQM-L).

The lighting measurements were conducted on May 22, 2023 (sites 1 and 2) and on May 23, 2023 (site 3), just before midnight (between 11:30 pm and 11:50 pm). The new moon occurred on May 19, 2023, and as such, these measurements were taken when the moon was in a waxing crescent phase.

The baseline light measurements taken in May occurred during clear skies with limited moon interference (moon was set). Incident light levels are not sensitive to seasonal variation, and sky glow typically varies by 0.2 mag/arcsec^2 depending on the season (Patat 2007). Sky glow is usually dominated by factors other than the changing seasons, including anthropogenic light, celestial objects (e.g., the moon) and meteorological conditions (e.g., cloud cover).

Existing ambient light levels within the Project Area were also characterized by reviewing satellite observations of artificial light (Interactive world light pollution map based on the National Oceanic and Atmospheric Administration (NOAA) / Earth Observation Group (EOG) overlay (World Atlas 2015).

6.2.3 Data Analysis

Three measurements were taken for sky glow in units of mag/arcsec^2 at each of the three locations, and the average of the three values were reported. The results were compared against reference levels for sky-glow, as previously presented in Table 6.6, to describe the corresponding appearance of the sky.

For illuminance, the equipment provides a real-time reading in units of lux that was reported for each location. The results were compared to CIE light trespass (vertical illuminance) values based on environmental lighting zones, as previously presented in Table 6.1.

6.3 Results

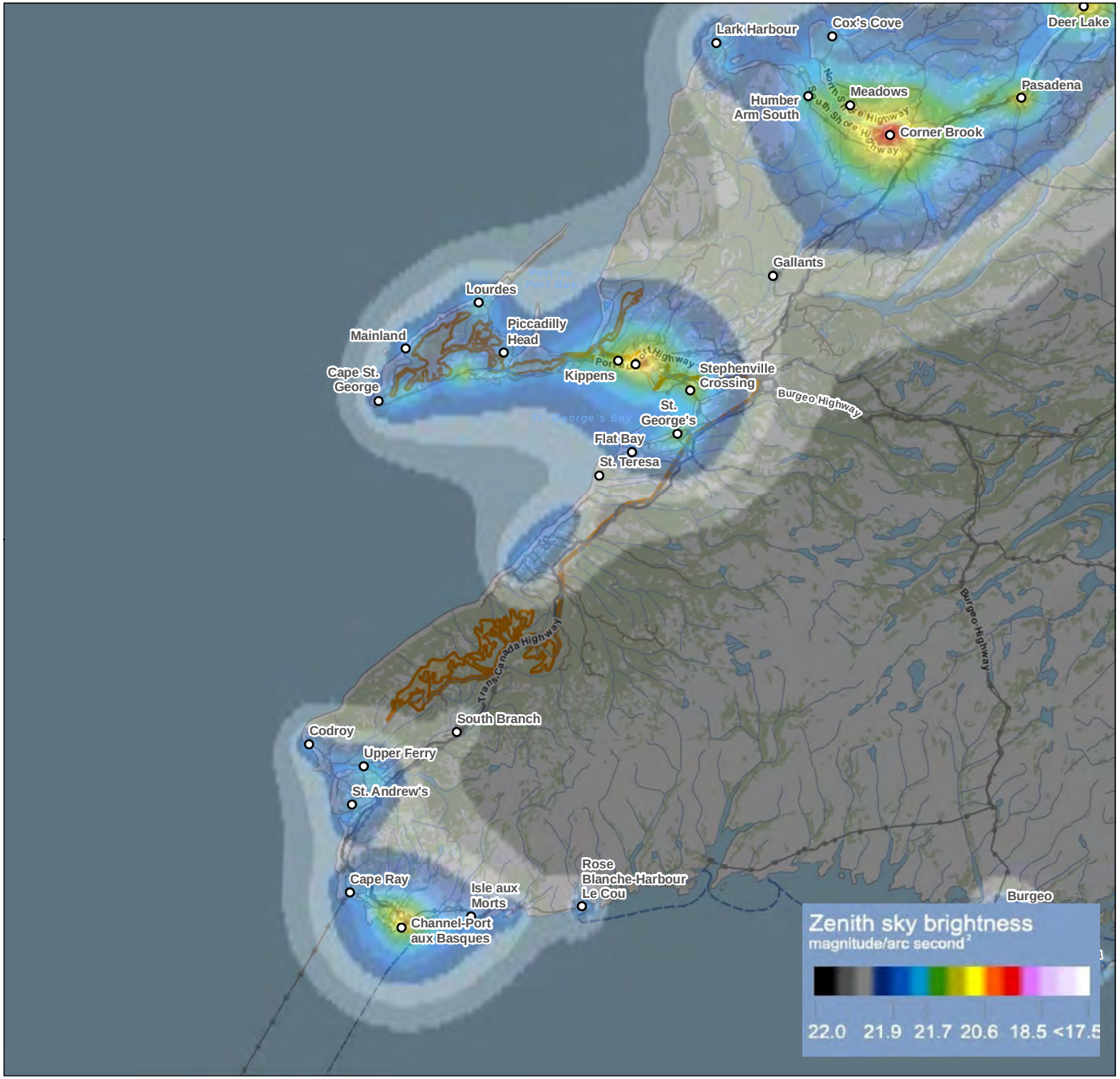
The light monitoring results are presented below in Table 6.6. Figure 6.2 shows the distribution of artificial light within and surrounding the Project Area (Interactive world light pollution map based on the National Oceanic and Atmospheric Administration [NOAA] / Earth Observation Group [EOG] overlay 2015, World Atlas 2015).

Table 6.6 Sky Glow and Illuminance Measurement Results

Monitoring Location	UTM 20 Coordinates		Sky Quality (mag/arcsec^2)				Illuminance (lux)
	Northing (m)	Easting (m)	Reading 1	Reading 2	Reading 3	Average	
1	358156.99	5376412.12	22.10	21.72	21.80	21.87	<0.01
2	354948.07	5386769.97	22.06	22.51	23.37	22.65	<0.01
3	386490.71	5375116.39	23.37	23.08	23.27	23.24	<0.01

As shown in Figure 6.2, there are existing sources of artificial light contributing to the existing ambient light environment within the Project Area. The main source of artificial light in the Project Area is from the Town of Stephenville where the sky glow reaches a peak, i.e., the lowest value of 20.3 mag/arcsec^2. As presented in Table 6.6, sky glow levels in this range are representative of a semi-polluted sky, as the contrast to the Milky Way is reduced and detail is lost. Other areas in the Project Area show slight light pollution from satellite observations, such as an area on Port au Port near Lower Cove in which the sky glow is approximately 21.2 mag/arcsec^2, a sky glow of 21.3 mag/arcsec^2 at Stephenville Crossing, and a sky glow of 21.5 mag/arcsec^2 at St. Georges. The Milky Way would still be clearly visible overhead at these levels, but not be seen near the horizon. Elsewhere in the Project Area, the sky glow levels are representative of unpolluted starry sky, where, on clear nights with no haze, many thousands of stars would be visible and the Milky Way would be clearly visible (Berry 1976; United States Department of Energy [US DOE] 2017).

Measurements of incident light were <0.01 lux at each location and sky glow averages ranged from 21.87 to 23.24 mag/arcsec^2 which is characterized as a dark, rural environmental zone, Category E1 (Table 6.4 and Table 6.6).



Stantec

Proposed Project Features

- Project Area

Other Features

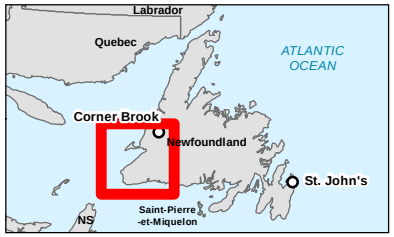
- Transmission Line, Existing
- Trans-Canada Highway
- Road
- Ferry Route
- Watercourse
- Waterbody
- Forested Area

N

0 10 20 Kilometres
(At original document size of 8.5x11)
1:1,150,000

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 21N
2. Data Sources: World Energy GH2, NRCan CanVec, Openstreetma, The New World Atlas of Artificial Night Sky Brightness
3. Background: NRCan CanVec



Project Location
Stephenville
NL

Prepared by MB on 2023-07-28
QR by AW on 2023-07-28

Client/Project
World Energy GH2
Project Nujio'qonik

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Figure No.
6.2

Distribution of Artificial Lighting Within and Surrounding the Project Area

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6.4 Discussion

The existing light environment surrounding the Project Area was mainly characterized as rural based on the results of the sky glow measurements and the review of available satellite data, with the exception of a few areas, including the Town of Stephenville, where lighting exhibited urban settlement characteristics.

Based on the results of the light trespass measurements, the area surrounding the Project Area was mainly characterized as relatively dark (relatively uninhabited rural areas) as classified by the CIE, and as a dark, rural environmental zone (Table 6.1, Table 6.2, Table 6.5)

6.5 References

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APPENDIX A
2019–2021 CAMS EAC4 Air Quality Results

PROJECT NUJIO'QONIK
Atmospheric Environment Baseline Study

Appendix A 2019–2021 CAMS EAC4 Air Quality Results

The 2019–2021 CAMS EAC4 results are presented in the tables below.

Table A.1 Air Quality Results from CAMS EAC4 – Location 1 (2019–2021)

Value	Concentrations (µg/m^3)				
	PM_{10}	**$PM_{2.5}$**	**CO**	**NO_2**	**SO_2**
Maximum 3-Hour Value	81.70	43.20	322.37	75.39	10.38
98th Percentile of 3-Hour Values	34.00	22.17	203.77	36.55	5.05
90th Percentile of 3-Hour Values	21.40	13.80	173.08	17.22	3.03
3-hour Rolling Average 90th Percentile of 3-Hour Values	18.94	12.34	173.08	17.22	3.03
Maximum 24-hour Average	54.86	28.10	297.83	47.78	4.99
Maximum 24-hour (Excluding 3-Hour Values >90th Percentile)	18.94	12.34	171.59	16.83	2.84
3-Year Average of 99th Percentile of the Daily Maximum Hour	41.60	25.60	213.21	41.62	6.05
3-Year Average of 98th Percentile of the Daily Maximum Hour	34.00	22.17	203.77	36.55	5.05
3-Year Average of 24-hour 98th Percentile	28.33	17.75	198.78	27.99	3.83
Maximum Annual Average	11.38	7.32	153.49	7.46	1.58

Notes:
The raw data used to generate this table is in 3-hour increments
NL AAQS for 24-hour time averaging period: SO_2 - 300 ug/m^3, NO_2 - 200 ug/m^3, $PM_{2.5}$ - 25 ug/m^3
NL AAQS for 8-hour time averaging period: CO – 15,000 ug/m^3
NL AAQS for the annual time averaging period: SO_2 - 60 ug/m^3, NO_2 - 100 ug/m^3, $PM_{2.5}$ – 8.8 ug/m^3
Source: Inness et al. (2019)

Table A.2 Air Quality Results from CAMS EAC4 – Location 2 (2019–2021)

Value	Concentrations (µg/m^3)				
	PM_{10}	**$PM_{2.5}$**	**CO**	**NO_2**	**SO_2**
Maximum 3-Hour Value	102.00	51.90	313.97	62.21	5.84
98th Percentile of 3-Hour Values	38.57	23.70	200.34	25.41	3.36
90th Percentile of 3-Hour Values	22.80	14.50	170.66	12.08	2.00
3-hour Rolling Average 90th Percentile of 3-Hour Values	20.49	13.05	170.66	12.08	2.00
Maximum 24-hour Average	69.26	35.36	282.10	41.05	2.84
Maximum 24-hour (Excluding 3-Hour Values >90th Percentile)	20.49	13.05	168.83	11.49	1.88
3-Year Average of 99th Percentile of the Daily Maximum Hour	47.70	28.27	211.19	30.96	3.91
3-Year Average of 98th Percentile of the Daily Maximum Hour	38.57	23.70	200.34	25.41	3.36
3-Year Average of 24-hour 98th Percentile	31.31	20.04	193.02	20.35	2.50
Maximum Annual Average	11.87	7.49	152.25	5.15	1.03

Notes:
The raw data used to generate this table is in 3-hour increments
NL AAQS for 24-hour time averaging period: SO_2 - 300 ug/m^3, NO_2 - 200 ug/m^3, $PM_{2.5}$ - 25 ug/m^3
NL AAQS for 8-hour time averaging period: CO – 15,000 ug/m^3
NL AAQS for the annual time averaging period: SO_2 - 60 ug/m^3, NO_2 - 100 ug/m^3, $PM_{2.5}$ – 8.8 ug/m^3
Source: Inness et al. (2019)

Table A.3 Air Quality Results from CAMS EAC4 – Location 3 (2019–2021)

Value	Concentrations (µg/m^3)				
	PM_{10}	**$PM_{2.5}$**	**CO**	**NO_2**	**SO_2**
Maximum 3-Hour Value	117.00	60.70	309.68	42.07	2.84
98th Percentile of 3-Hour Values	39.67	24.20	197.32	12.27	1.69
90th Percentile of 3-Hour Values	22.43	14.30	168.75	5.72	1.02
3-hour Rolling Average 90th Percentile of 3-Hour Values	19.75	12.74	168.75	5.72	1.02
Maximum 24-hour Average	56.64	28.91	262.41	29.27	1.70
Maximum 24-hour (Excluding 3-Hour Values >90th Percentile)	19.75	12.74	166.98	5.84	0.92
3-Year Average of 99th Percentile of the Daily Maximum Hour	48.67	28.40	207.71	15.07	1.95
3-Year Average of 98th Percentile of the Daily Maximum Hour	39.67	24.20	197.32	12.27	1.69
3-Year Average of 24-hour 98th Percentile	32.33	20.01	191.17	9.78	1.22
Maximum Annual Average	11.60	7.31	151.40	2.45	0.51

Notes:
The raw data used to generate this table is in 3-hour increments
NL AAQS for 24-hour time averaging period: SO_2 - 300 ug/m^3, NO_2 - 200 ug/m^3, $PM_{2.5}$ - 25 ug/m^3
NL AAQS for 8-hour time averaging period: CO – 15,000 ug/m^3
NL AAQS for the annual time averaging period: SO_2 - 60 ug/m^3, NO_2 - 100 ug/m^3, $PM_{2.5}$ – 8.8 ug/m^3
Source: Inness et al. (2019)

Table A.4 Air Quality Results from CAMS EAC4 – Location 4 (2019–2021)

Value	Concentrations (µg/m^3)				
	PM_{10}	**$PM_{2.5}$**	**CO**	**NO_2**	**SO_2**
Maximum 3-Hour Value	71.20	49.10	310.31	51.13	5.24
98th Percentile of 3-Hour Values	30.90	21.00	203.72	21.63	2.83
90th Percentile of 3-Hour Values	19.80	13.20	171.47	9.99	1.68
3-hour Rolling Average 90th Percentile of 3-Hour Values	17.10	11.44	171.47	9.99	1.68
Maximum 24-hour Average	34.16	22.48	288.78	35.19	2.89
Maximum 24-hour (Excluding 3-Hour Values >90th Percentile)	17.10	11.44	169.33	9.77	1.61
3-Year Average of 99th Percentile of the Daily Maximum Hour	36.83	24.70	213.58	26.54	3.23
3-Year Average of 98th Percentile of the Daily Maximum Hour	30.90	21.00	203.72	21.63	2.83
3-Year Average of 24-hour 98th Percentile	24.48	16.78	199.29	17.47	2.10
Maximum Annual Average	10.00	6.56	310.31	51.13	5.24

Notes:
The raw data used to generate this table is in 3-hour increments
NL AAQS for 24-hour time averaging period: SO_2 - 300 ug/m^3, NO_2 - 200 ug/m^3, $PM_{2.5}$ - 25 ug/m^3
NL AAQS for 8-hour time averaging period: CO – 15,000 ug/m^3
NL AAQS for the annual time averaging period: SO_2 - 60 ug/m^3, NO_2 - 100 ug/m^3, $PM_{2.5}$ – 8.8 ug/m^3
Source: Inness et al. (2019)

Table A.5 Air Quality Results from CAMS EAC4 – Location 5 (2019–2021)

Value	Concentrations (µg/m^3)				
	PM_{10}	**$PM_{2.5}$**	**CO**	**NO_2**	**SO_2**
Maximum 3-Hour Value	86.30	46.40	308.50	30.52	2.92
98th Percentile of 3-Hour Values	31.80	21.07	201.12	13.31	1.95
90th Percentile of 3-Hour Values	20.20	13.40	170.65	6.69	1.22
3-hour Rolling Average 90th Percentile of 3-Hour Values	17.51	11.55	170.65	6.69	1.22
Maximum 24-hour Average	40.60	26.36	275.15	20.73	1.71
Maximum 24-hour (Excluding 3-Hour Values >90th Percentile)	17.51	11.55	168.85	6.44	1.13
3-Year Average of 99th Percentile of the Daily Maximum Hour	37.30	25.10	213.25	16.20	2.18
3-Year Average of 98th Percentile of the Daily Maximum Hour	31.80	21.07	201.12	13.31	1.95
3-Year Average of 24-hour 98th Percentile	25.12	16.70	195.84	11.25	1.53
Maximum Annual Average	10.40	6.79	152.98	2.87	0.60

Notes:
The raw data used to generate this table is in 3-hour increments
NL AAQS for 24-hour time averaging period: SO_2 - 300 ug/m^3, NO_2 - 200 ug/m^3, $PM_{2.5}$ - 25 ug/m^3
NL AAQS for 8-hour time averaging period: CO – 15,000 ug/m^3
NL AAQS for the annual time averaging period: SO_2 - 60 ug/m^3, NO_2 - 100 ug/m^3, $PM_{2.5}$ – 8.8 ug/m^3
Source: Inness et al. (2019)

Table A.6 Air Quality Results from CAMS EAC4 – Location 6 (2019–2021)

Value	Concentrations (µg/m^3)				
	PM_{10}	**$PM_{2.5}$**	**CO**	**NO_2**	**SO_2**
Maximum 3-Hour Value	86.10	44.30	303.79	13.27	2.07
98th Percentile of 3-Hour Values	35.17	22.47	198.35	4.85	1.13
90th Percentile of 3-Hour Values	23.40	14.70	169.09	2.75	0.68
3-hour Rolling Average 90th Percentile of 3-Hour Values	20.52	12.96	169.09	2.75	0.68
Maximum 24-hour Average	44.95	24.35	263.66	7.11	1.24
Maximum 24-hour (Excluding 3-Hour Values >90th Percentile)	20.52	12.96	167.25	2.42	0.63
3-Year Average of 99th Percentile of the Daily Maximum Hour	40.87	25.53	208.36	5.80	1.27
3-Year Average of 98th Percentile of the Daily Maximum Hour	35.17	22.47	198.35	4.85	1.13
3-Year Average of 24-hour 98th Percentile	29.01	18.31	193.95	3.78	0.91
Maximum Annual Average	12.30	7.74	152.30	1.26	0.32

Notes:
The raw data used to generate this table is in 3-hour increments
NL AAQS for 24-hour time averaging period: SO_2 - 300 ug/m^3, NO_2 - 200 ug/m^3, $PM_{2.5}$ - 25 ug/m^3
NL AAQS for 8-hour time averaging period: CO – 15,000 ug/m^3
NL AAQS for the annual time averaging period: SO_2 - 60 ug/m^3, NO_2 - 100 ug/m^3, $PM_{2.5}$ – 8.8 ug/m^3
Source: Inness et al. (2019)

Table A.7 Air Quality Results from CAMS EAC4 – Location 7 (2019–2021)

Value	Concentrations (µg/m^3)				
	PM_{10}	**$PM_{2.5}$**	**CO**	**NO_2**	**SO_2**
Maximum 3-Hour Value	112.00	57.00	305.35	26.51	2.39
98th Percentile of 3-Hour Values	44.27	26.00	202.68	8.20	1.38
90th Percentile of 3-Hour Values	29.30	17.60	169.44	3.74	0.85
3-hour Rolling Average 90th Percentile of 3-Hour Values	25.84	15.67	169.44	3.74	0.85
Maximum 24-hour Average	57.40	30.73	279.26	21.45	1.33
Maximum 24-hour (Excluding 3-Hour Values >90th Percentile)	25.84	15.67	166.81	3.46	0.76
3-Year Average of 99th Percentile of the Daily Maximum Hour	49.60	29.67	212.30	10.88	1.59
3-Year Average of 98th Percentile of the Daily Maximum Hour	44.27	26.00	202.68	8.20	1.38
3-Year Average of 24-hour 98th Percentile	36.06	21.29	198.23	6.99	0.99
Maximum Annual Average	14.48	8.80	152.41	1.53	0.38

Notes:
The raw data used to generate this table is in 3-hour increments
NL AAQS for 24-hour time averaging period: SO_2 - 300 ug/m^3, NO_2 - 200 ug/m^3, $PM_{2.5}$ - 25 ug/m^3
NL AAQS for 8-hour time averaging period: CO – 15,000 ug/m^3
NL AAQS for the annual time averaging period: SO_2 - 60 ug/m^3, NO_2 - 100 ug/m^3, $PM_{2.5}$ – 8.8 ug/m^3
Source: Inness et al. (2019)

Table A.8 Air Quality Results from CAMS EAC4 – Location 8 (2019–2021)

Value	Concentrations (µg/m^3)				
	PM_{10}	**$PM_{2.5}$**	**CO**	**NO_2**	**SO_2**
Maximum 3-Hour Value	64.10	43.80	298.78	19.13	1.87
98th Percentile of 3-Hour Values	32.60	21.60	201.63	6.21	1.18
90th Percentile of 3-Hour Values	21.60	14.03	169.90	3.31	0.76
3-hour Rolling Average 90th Percentile of 3-Hour Values	19.40	12.59	169.90	3.31	0.76
Maximum 24-hour Average	40.24	26.00	270.23	12.51	1.13
Maximum 24-hour (Excluding 3-Hour Values >90th Percentile)	19.40	12.59	167.49	3.08	0.68
3-Year Average of 99th Percentile of the Daily Maximum Hour	37.20	25.10	213.01	7.85	1.34
3-Year Average of 98th Percentile of the Daily Maximum Hour	32.60	21.60	201.63	6.21	1.18
3-Year Average of 24-hour 98th Percentile	25.44	17.36	197.10	5.12	0.91
Maximum Annual Average	11.26	7.24	153.22	1.45	0.36

Notes:
The raw data used to generate this table is in 3-hour increments
NL AAQS for 24-hour time averaging period: SO_2 - 300 ug/m^3, NO_2 - 200 ug/m^3, $PM_{2.5}$ - 25 ug/m^3
NL AAQS for 8-hour time averaging period: CO – 15,000 ug/m^3
NL AAQS for the annual time averaging period: SO_2 - 60 ug/m^3, NO_2 - 100 ug/m^3, $PM_{2.5}$ – 8.8 ug/m^3
Source: Inness et al. (2019)

Table A.9 Air Quality Results from CAMS EAC4 – Location 9 (2019–2021)

Value	Concentrations (µg/m^3)				
	PM_{10}	**$PM_{2.5}$**	**CO**	**NO_2**	**SO_2**
Maximum 3-Hour Value	64.90	45.70	301.31	10.23	1.74
98th Percentile of 3-Hour Values	30.20	20.70	200.32	4.67	0.97
90th Percentile of 3-Hour Values	19.50	13.00	170.75	2.68	0.65
3-hour Rolling Average 90th Percentile of 3-Hour Values	17.23	11.43	170.75	2.68	0.65
Maximum 24-hour Average	36.06	23.60	267.81	5.33	0.97
Maximum 24-hour (Excluding 3-Hour Values >90th Percentile)	17.23	11.43	168.43	2.25	0.56
3-Year Average of 99th Percentile of the Daily Maximum Hour	34.90	24.10	210.16	5.28	1.09
3-Year Average of 98th Percentile of the Daily Maximum Hour	30.20	20.70	200.32	4.67	0.97
3-Year Average of 24-hour 98th Percentile	23.79	16.40	195.42	3.16	0.80
Maximum Annual Average	10.08	6.68	153.74	1.22	0.32

Notes:
The raw data used to generate this table is in 3-hour increments
NL AAQS for 24-hour time averaging period: SO_2 - 300 ug/m^3, NO_2 - 200 ug/m^3, $PM_{2.5}$ - 25 ug/m^3
NL AAQS for 8-hour time averaging period: CO – 15,000 ug/m^3
NL AAQS for the annual time averaging period: SO_2 - 60 ug/m^3, NO_2 - 100 ug/m^3, $PM_{2.5}$ – 8.8 ug/m^3
Source: Inness et al. (2019)