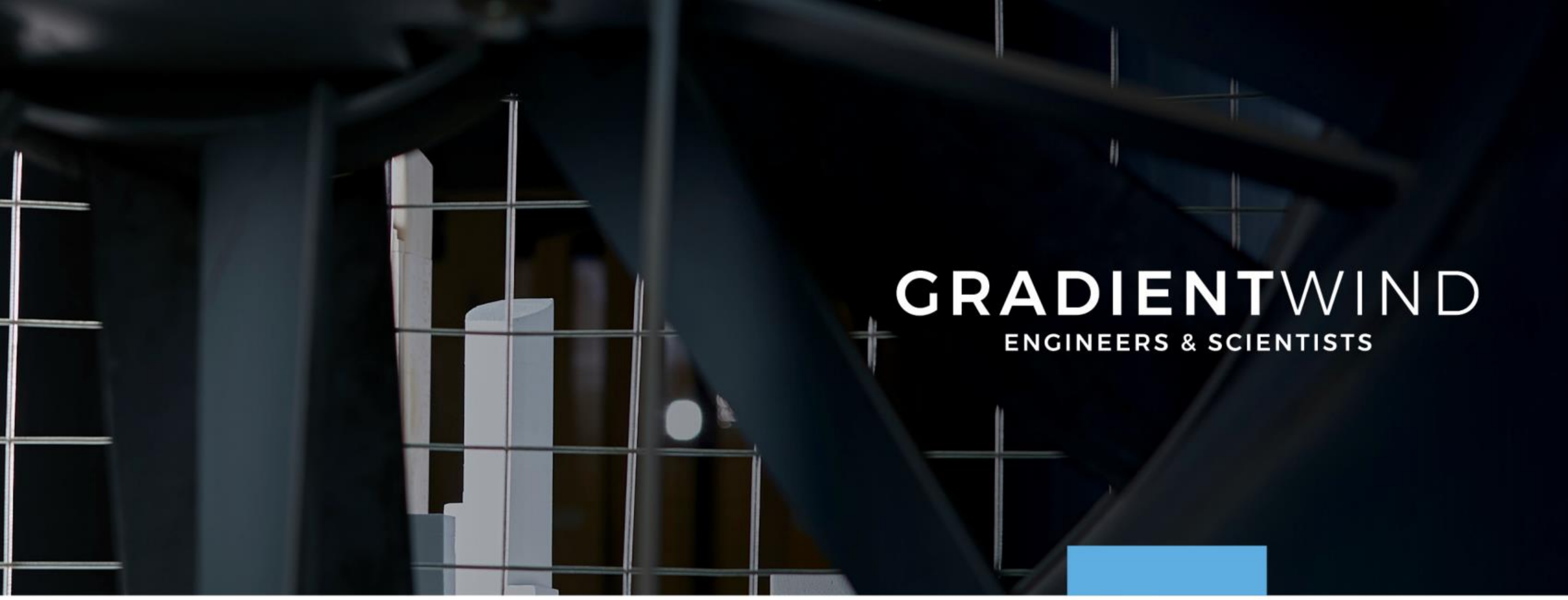
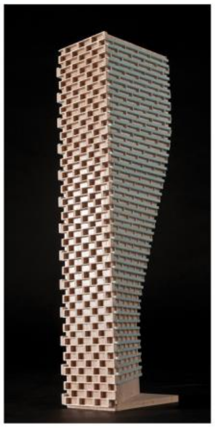
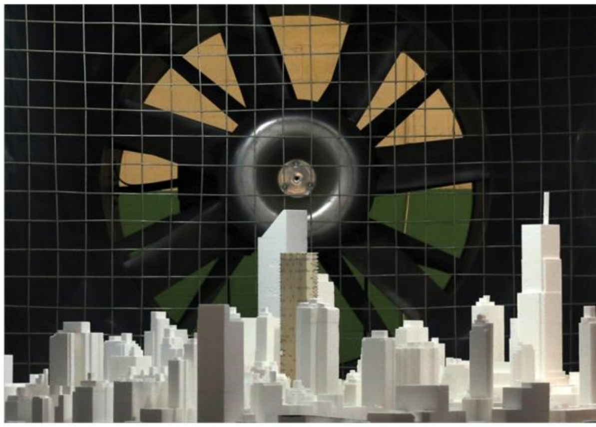


TRAFFIC NOISE & VIBRATION DETAILED ASSESSMENT

Ottawa Retirement Residence by Signature
Ottawa, Ontario

GRADIENT WIND REPORT: 18-176 – Noise & Vibration R3





February 21, 2019

PREPARED FOR
Cathedral Hills GP Inc.
c/o Reichmann Seniors Housing Development Corporation
22 St. Clair Avenue East, Suite 1200
Toronto, ON M4T 2S3
Attn: Victoria S. Lucas, Director of Design

PREPARED BY
Michael Lafortune, C.E.T., Environmental Scientist
Joshua Foster, P.Eng., Principal

EXECUTIVE SUMMARY

This report describes a traffic noise and vibration assessment undertaken in support of site plan application for the proposed Ottawa Retirement Residence by Signature in Ottawa, Ontario. The proposed development is an eighteen-storey building of nearly rectangular plan form. Indoor amenities occupy 1st, 2nd and partial 17th levels with common dining located on the 18th level, and the mechanical penthouse occupying the 19th level. Apartments/independent living/assisting living units occupy remaining above-ground floors. The major sources of traffic noise are Wellington Street and Albert Street. Figure 1 illustrates a complete site plan with surrounding context.

The assessment is based on (i) theoretical noise prediction methods that conform to the Ministry of the Environment, Conservation and Parks (MOECP) and City of Ottawa requirements; (ii) noise level criteria as specified by the City of Ottawa's Environmental Noise Control Guidelines (ENCG); (iii) future vehicular traffic volumes based on the City of Ottawa's Official Plan roadway classifications; and (iv) site plan drawings prepared by Hobin Architecture dated February 20, 2019.

The results of the current analysis indicate that noise levels will range between 41 and 60 dBA during the daytime period (07:00-23:00) and between 33 and 52 dBA during the nighttime period (23:00-07:00). The highest noise level (60 dBA) occurs at the north façade, which is nearest and most exposed to Wellington Street.

Results of the calculations indicate that the development will require forced air heating with provision for central air conditioning. Air conditioning will allow occupants to keep windows closed and maintain a comfortable living environment. A Warning Clause will also be required be placed on all Lease, Purchase and Sale Agreements, as summarized in Section 6.

Noise levels at the 3rd Floor Terrace (Receptor 5) are expected to approach 57 dBA during the daytime period. If this area is to be used as an outdoor living area, noise control measures are required to reduce the L_{eq} to 55 dBA. Further analysis investigated the noise mitigating impact of incorporating a noise attenuating guardrail with a height of 1.5 m surrounding the terrace. Results of the investigation proved that noise levels can be reduced to 53 dBA. The guardrail must be constructed from materials having a minimum surface density of 20 kg/m^2 (STC rating of 30) and contain no gaps. Design of the guardrail will conform to the requirements outlined in Part 5 of the ENCG. The following information will be required by the City for review prior to installation of the barrier:

1. Shop drawings, signed and sealed by a qualified Professional Engineer licenced by the Professional Engineers of Ontario, showing the details of the acoustic barrier systems components, including material specifications.
2. Structural drawing(s), signed by a qualified Professional Engineer licenced by the Professional Engineers of Ontario, showing foundation details and specifying design criteria, climatic design loads, as well as applicable geotechnical data used in the design.
3. Layout plan, and wall elevations, showing proposed colours and patterns.

Based on an offset distance of 13 metres between the Confederation line railway centerline and the nearest sensitive building foundation, the estimated vibration level at the nearest point of reception is expected to be 0.08 mm/s RMS (59.3 dBV) based on the FTA protocol. Details of the calculation are provided in Appendix B. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required.

According to the United States Federal Transit Authority's vibration assessment protocol, ground borne noise can be estimated by subtracting 35 dB from the velocity vibration level in dBV. Since measured vibration levels were found to be less than 0.10 mm/s peak partial velocity (ppv), ground borne noise levels are also expected to be below the ground borne noise criteria of 35 dB.

With regards to stationary noise impacts from roof top mechanical units situated on the study building to the surrounding noise-sensitive areas, once the mechanical plans for the proposed building become available, a stationary noise study will be performed. This study will include recommendations for any noise control measures that may be necessary to ensure noise levels at the surrounding noise-sensitive buildings due to mechanical equipment on the roof of the proposed building are below the City of Ottawa's Noise Guidelines.

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Reichmann Seniors Housing Development Corporation on behalf of Cathedral Hills GP Inc. to undertake a traffic noise and vibration assessment for the proposed Ottawa Retirement Residence by Signature.

The present scope of work involves assessing exterior and interior noise levels generated by local roadway traffic sources, as well as vibration levels generated by local underground light rail transit (LRT) activity. The assessment was performed on the basis of theoretical noise calculation methods conforming to the City of Ottawa[1] and Ministry of the Environment, Conservation and Parks (MOECP)[2] guidelines. Noise calculations were based on architectural drawings prepared by Hobin Architecture dated February 20, 2019, with future roadway traffic volumes corresponding to the City of Ottawa's Official Plan (OP) roadway classifications and LRT information from the Rail Implementation Office.

2. TERMS OF REFERENCE

The focus of this traffic noise and vibration assessment is the Ottawa Retirement Residence by Signature. The development site is a parcel of land directly east of the Christ Church Cathedral. The proposed development is an eighteen-storey building of nearly rectangular planform with slight rectangular insets, as well as rectangular extensions at the north and south corners. Indoor amenities occupy 1st, 2nd and partial 17th levels with common dining located on the 18th level, and the mechanical penthouse occupying the 19th level. Apartments/independent living/assisting living units occupy remaining above-ground floors. Balconies are provided for all units. Balconies less than 4 m in depth are not considered as Outdoor Living Areas (OLAs). Outdoor terraces are located along the north side of the 3rd level and the southwest side of the 18th level.

The site is surrounded by low, mid-rise and high-rise residential as well as places of worship, small scale commercial and office buildings. The major sources of traffic noise are Wellington Street and Albert Street.

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[1] City of Ottawa Environmental Noise Control Guidelines, January 2016
[2] Ontario Ministry of the Environment, Conservation and Parks – Environmental Noise Guidelines, Publication NPC-300, Queens Printer for Ontario, Toronto, 2013

The future Confederation Line LRT runs underground adjacent to the site, which is the primary source of ground vibrations. Figure 1 illustrates a complete site plan with surrounding context.

3. OBJECTIVES

The main goals of this work are to (i) calculate the future noise levels on the study building produced by local roadway traffic sources, (ii) calculate the future vibration levels on the study building produced by local LRT traffic, and (iii) ensure that interior noise levels and vibration levels do not exceed the allowable limits specified by the City of Ottawa's Environmental Noise Control Guidelines as outlined in Section 4 of this report.

4. METHODOLOGY

4.1 Background

Noise can be defined as any obtrusive sound. It is created at a source, transmitted through a medium, such as air, and intercepted by a receiver. Noise may be characterized in terms of the power of the source or the sound pressure at a specific distance. While the power of a source is characteristic of that particular source, the sound pressure depends on the location of the receiver and the path that the noise takes to reach the receiver. Measurement of noise is based on the decibel unit, dBA, which is a logarithmic ratio referenced to a standard noise level (2×10^{-5} Pascals). The 'A' suffix refers to a weighting scale, which better represents how the noise is perceived by the human ear. With this scale, a doubling of power results in a 3 dBA increase in measured noise levels and is just perceptible to most people. An increase of 10 dBA is often perceived to be twice as loud.

4.2 Roadway Traffic Noise

4.2.1 Criteria for Roadway Traffic Noise

For surface roadway traffic noise, the equivalent sound energy level, L_{eq}, provides a measure of the time varying noise levels, which is well correlated with the annoyance of sound. It is defined as the continuous sound level, which has the same energy as a time varying noise level over a period of time. For roadways, the L_{eq} is commonly calculated on the basis of a 16-hour (L_{eq16}) daytime (07:00-23:00) / 8-hour (L_{eq8}) nighttime (23:00-07:00) split to assess its impact on residential buildings. The City of Ottawa's Environmental Noise Control Guidelines (ENCG) specifies that the recommended indoor noise limit range (that is relevant to this study) is 45 for living rooms and 40 dBA sleeping quarters for roadway as listed in Table 1.

TABLE 1: INDOOR SOUND LEVEL CRITERIA (ROAD)[3]

Type of Space	Time Period	Leq (dBA)
General offices, reception areas, retail stores, etc.	07:00 – 23:00	50
Living/dining/den areas of **residences**, hospitals, schools, **nursing/retirement homes**, day-care centres, theatres, places of worship, libraries, individual or semi-private offices, conference rooms, etc.	07:00 – 23:00	45
Sleeping quarters of hotels/motels	23:00 – 07:00	45
Sleeping quarters of **residences**, hospitals, **nursing/retirement homes**, etc.	23:00 – 07:00	40

Predicted noise levels at the plane of window (POW) dictate the action required to achieve the recommended sound levels. An open window is considered to provide a 10 dBA reduction in noise, while a standard closed window is capable of providing a minimum 20 dBA noise reduction[4]. A closed window due to a ventilation requirement will bring noise levels down to achieve an acceptable indoor environment[5]. Therefore, where noise levels exceed 55 dBA daytime and 50 dBA nighttime, the ventilation for the building should consider the need for having windows and doors closed, which triggers the need for forced air heating with provision for central air conditioning. Where noise levels exceed 65 dBA daytime and 60 dBA nighttime, air conditioning will be required and building components will require higher levels of sound attenuation[6].

The sound level criterion for outdoor living areas is 55 dBA, which applies during the daytime (07:00 to 23:00). When noise levels exceed 55 dBA, mitigation must be provided to reduce noise levels where technically and administratively feasible to acceptable levels at or below the criterion.

[3] Adapted from ENCG 2016 – Tables 2.2b and 2.2c
[4] Burberry, P.B. (2014). Mitchell's Environment and Services. Routledge, Page 125
[5] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.8
[6] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3

4.2.2 Theoretical Roadway Noise Predictions

Noise predictions were performed with the aid of the MOECP computerized noise assessment program, STAMSON 5.04, for road analysis. Appendix A includes the STAMSON 5.04 input and output data.

Roadway traffic noise calculations were performed by treating each roadway segment as separate line sources of noise. In addition to the traffic volumes summarized in Table 2, theoretical noise predictions were based on the following parameters:

- Truck traffic on all roadways was taken to comprise 5% heavy trucks and 7% medium trucks, as per ENCG requirements for noise level predictions.
- The day/night split for all streets was taken to be 92%/8%, respectively.
- Ground surfaces were taken to be reflective or absorptive, based on source-receiver ground characteristics (pavement/grass).
- The escarpment north of the site was considered with Wellington Street approximately 7 m lower then site grade. Where this topography breaks line of sight the escarpment was considered as a barrier as well. Albert Street is approximately 2 m above grade.
- Receptor height was taken to be 54.3, 11.5 and 59 m above grade for 17th Floor, 3rd Floor and 18th Floor receptors, respectively.
- Buildings used as barrier elements are indicated with heights in Figure 3-6.
- Noise receptors were strategically placed at 6 locations around the study area (see Figure 2).
- Receptor distances and exposure angles are illustrated in Figure 3-6.

4.2.1 Roadway Traffic Volumes

The ENCG dictates that noise calculations should consider future sound levels based on a roadway's classification at the mature state of development. Therefore, traffic volumes are based on the roadway classifications outlined in the City of Ottawa's Official Plan (OP) and Transportation Master Plan[7] which provide additional details on future roadway expansions. Average Annual Daily Traffic (AADT) volumes are then based on data in Table B1 of the ENCG for each roadway classification. Table 2 (below) summarizes the AADT values used for each roadway included in this assessment.

---

[7] City of Ottawa Transportation Master Plan, November 2013

TABLE 2: ROADWAY TRAFFIC DATA

Segment	Roadway Type	Speed Limit (km/h)	Traffic Volumes
Wellington Street	4-UAU	50	**30,000**
Albert Street	2-UAU	50	**15,000**

4.3 Ground Vibration & Ground-borne Noise

Transit systems and heavy vehicles on roadways can produce perceptible levels of ground vibrations, especially when they are in close proximity to residential neighbourhoods or vibration-sensitive buildings. Similar to sound waves in air, vibrations in solids are generated at a source, propagated through a medium, and intercepted by a receiver. In the case of ground vibrations, the medium can be uniform, or more often, a complex layering of soils and rock strata. Also, similar to sound waves in air, ground vibrations produce perceptible motions and regenerated noise known as 'ground-borne noise' when the vibrations encounter a hollow structure such as a building. Ground-borne noise and vibrations are generated when there is excitation of the ground, such as from a train. Repetitive motion of the wheels on the track or rubber tires passing over an uneven surface causes vibration to propagate through the soil. When they encounter a building, vibrations pass along the structure of the building beginning at the foundation and propagating to all floors. Air inside the building excited by the vibrating walls and floors represents regenerated airborne noise. Characteristics of the soil and the building are imparted to the noise, thereby creating a unique noise signature.

Human response to ground vibrations is dependent on the magnitude of the vibrations, which is measured by the root mean square (RMS) of the movement of a particle on a surface. Typical units of ground vibration measures are millimeters per second (mm/s), or inch per second (in/s). Since vibrations can vary over a wide range, it is also convenient to represent them in decibel units, or dBV. In North America, it is common practice to use the reference value of one micro-inch per second (µin/s) to represent vibration levels for this purpose. The threshold level of human perception to vibrations is about 0.10 mm/s RMS or about 72 dBV. Although somewhat variable, the threshold of annoyance for continuous vibrations is 0.5 mm/s RMS (or 85 dBV), five times higher than the perception threshold, whereas the threshold for significant structural damage is 10 mm/s RMS (or 112 dBV), at least one hundred times higher than the perception threshold level.

4.3.1 Ground Vibration Criteria

In the United States, the Federal Transportation Authority (FTA) has set vibration criteria for sensitive land uses next to transit corridors. Similar standards have been developed by a partnership between the MOECP and the Toronto Transit Commission[8]. These standards indicate that the appropriate criteria for residential buildings is 0.10 mm/s RMS for vibrations. For main line railways, a document titled Guidelines for New Development in Proximity to Railway Operations[9], indicates that vibration conditions should not exceed 0.14 mm/s RMS averaged over a one second time-period at the first floor and above of the proposed building. As the main vibration source is due to the LRT lines, which will have frequent events, the 0.10 mm/s RMS (72 dBV) vibration criteria and 35 dBA ground borne noise criteria were adopted for this study.

4.3.2 Theoretical Ground Vibration Prediction Procedure

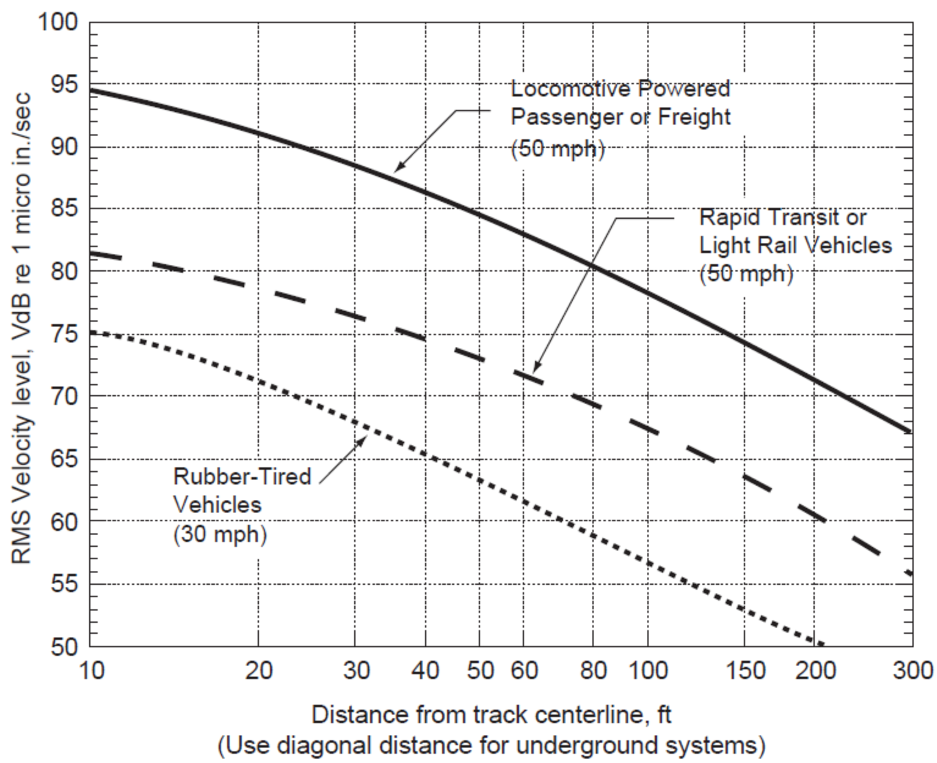
Potential vibration impacts of the future Confederation LRT rail line, currently under construction, were predicted using the FTA's Transit Noise and Vibration Impact Assessment[10] protocol. The FTA general vibration assessment is based on an upper bound generic set of curves that show vibration level attenuation with distance. These curves, illustrated in the figure below, are based on ground vibration measurements at various transit systems throughout North America. Vibration levels at points of reception are adjusted by various factors to incorporate known characteristics of the system being analyzed, such as operating speed of vehicle, conditions of the track, construction of the track and geology, as well as the structural type of the impacted building structures. Based on the setback distance of the nearest point of the building, initial vibration levels were deduced from a curve for light rail trains at 50 miles per hour (mph) and applying an adjustment factor of -4.2 dBV to account for an operational

[8] MOECP/TTC Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop, June 16, 1993

[9] Dialog and J.E. Coulter Associates Limited, prepared for The Federation of Canadian Municipalities and The Railway Association of Canada, May 2013

[10] C. E. Hanson; D. A. Towers; and L. D. Meister, Transit Noise and Vibration Impact Assessment, Federal Transit Administration, May 2006.

speed of 31 mph (50 km/h). The track was assumed to be jointed with no welds. Details of the vibration calculations are presented in Appendix B.



FTA GENERALIZED CURVES OF VIBRATION LEVELS VERSUS DISTANCE (ADOPTED FROM FIGURE 10-1, FTA TRANSIT NOISE AND VIBRATION IMPACT ASSESSMENT)

5. RESULTS AND DISCUSSION

5.1 Roadway Traffic Noise Levels

The results of the roadway traffic noise calculations are summarized in Table 3 below. A complete set of input and output data from all STAMSON 5.04 calculations are available in Appendix A.

TABLE 3: EXTERIOR NOISE LEVELS DUE TO ROAD TRAFFIC

Receptor Number	Receptor Height Above Grade (m)	Receptor Location	STAMSON 5.04 Noise Level (dBA)	
			Day	Night
1	54.3	POW – 17th Floor – North Façade	60	52
2	54.3	POW – 17th Floor – East Façade	57	49
3	54.3	POW – 17th Floor – South Façade	41	33
4	54.3	POW – 17th Floor – West Façade	55	47
5	11.5	OLA – 3rd Floor Terrace	57	49
6	59	OLA – 18th Floor Terrace	43	35

The results of the current analysis indicate that noise levels will range between 41 and 60 dBA during the daytime period (07:00-23:00) and between 33 and 52 dBA during the nighttime period (23:00-07:00). The highest noise level (60 dBA) occurs at the north façade, which is nearest and most exposed to Wellington Street.

The noise levels predicted due to roadway traffic do not exceed the criteria listed in Section 4.2 for building components. As discussed in Section 4.3, the development will require forced air heating with provision for central air conditioning. Air conditioning will allow occupants to keep windows closed and maintain a comfortable living environment. In addition to ventilation requirements, Warning Clauses will also be required in all Lease, Purchase and Sale Agreements, as summarized in Section 6.

5.2 Noise Barrier Calculation

Noise levels at the 3rd Floor Terrace (Receptor 5) are expected to approach 57 dBA during the daytime period. If this area is to be used as an outdoor living area, noise control measures are required to reduce the L_{eq} to 55 dBA. Further analysis investigated the noise mitigating impact of incorporating a noise attenuating guardrail with a height of 1.5 m surrounding the terrace. Results of the investigation proved that noise levels can only be reduced to 53 dBA. Table 4 summarizes the results of the barrier investigation. The guardrail must be constructed from materials having a minimum surface density of 20 kg/m^2 (STC rating of 30) and contain no gaps. Design of the guardrail will conform to the requirements outlined in Part 5 of the ENCG.

TABLE 4: RESULTS OF NOISE BARRIER INVESTIGATION

Location	Reference Receptor	Barrier Height (m)	Daytime Leq Noise Levels (dBA)	
			With Barrier	Without Barrier
5	11.5	OLA – 3rd Floor Terrace	53	57

5.3 Ground Vibrations & Ground-borne Noise Levels

Based on an offset distance of 13 metres between the Confederation line railway centerline and the nearest sensitive building foundation, the estimated vibration level at the nearest point of reception is expected to be 0.08 mm/s RMS (59.3 dBV) based on the FTA protocol. Details of the calculation are provided in Appendix B. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required.

According to the United States Federal Transit Authority's vibration assessment protocol, ground borne noise can be estimated by subtracting 35 dB from the velocity vibration level in dBV. Since measured vibration levels were found to be less than 0.10 mm/s peak partial velocity (ppv), ground borne noise levels are also expected to be below the ground borne noise criteria of 35 dB.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the current analysis indicate that noise levels will range between 41 and 60 dBA during the daytime period (07:00-23:00) and between 33 and 52 dBA during the nighttime period (23:00-07:00). The highest noise level (60 dBA) occurs at the north façade, which is nearest and most exposed to Wellington Street.

Results of the calculations indicate that the development will require forced air heating with provision for central air conditioning. Air conditioning will allow occupants to keep windows closed and maintain a comfortable living environment. The following Warning Clause[11] will also be required be placed on all Lease, Purchase and Sale Agreements, as summarized below:

> *"Purchasers/tenants are advised that despite the inclusion of noise control features in the development and within the building units, sound levels due to increasing roadway traffic may, on occasion, interfere with some activities of the dwelling occupants, as the sound levels exceed the sound level limits of the City and the Ministry of the Environment and Climate Change.*
>
> *To help address the need for sound attenuation, this development has been designed with forced air heating with provision for air conditioning. Air conditioning will allow windows and exterior doors to remain closed, thereby ensuring that the indoor sound levels are within the sound level limits of the City and the Ministry of the Environment and Climate Change.*
>
> *To ensure that provincial sound level limits are not exceeded, it is important to maintain these sound attenuation features."*

Noise levels at the 3rd Floor Terrace (Receptor 5) are expected to approach 57 dBA during the daytime period. If this area is to be used as an outdoor living area, noise control measures are required to reduce the L_{eq} to 55 dBA. Further analysis investigated the noise mitigating impact of incorporating a noise attenuating guardrail with a height of 1.5 m surrounding the terrace. Results of the investigation proved that noise levels can be reduced to 53 dBA. The guardrail must be constructed from materials having a minimum surface density of 20 kg/m^2 (STC rating of 30) and contain no gaps. Design of the guardrail will conform to the requirements outlined in Part 5 of the ENCG. The following information will be required by the City for review prior to installation of the barrier:

1. Shop drawings, signed and sealed by a qualified Professional Engineer licenced by the Professional Engineers of Ontario, showing the details of the acoustic barrier systems components, including material specifications.

[11] City of Ottawa Environmental Noise Control Guidelines, January 2016

2. Structural drawing(s), signed by a qualified Professional Engineer licenced by the Professional Engineers of Ontario, illustrating foundation details and specifying design criteria, climatic design loads, as well as applicable geotechnical data used in the design.
3. Layout plan, and wall elevations, showing proposed colours and patterns.

Based on an offset distance of 13 metres between the Confederation line railway centerline and the nearest sensitive building foundation, the estimated vibration level at the nearest point of reception is expected to be 0.08 mm/s RMS (59.3 dBV) based on the FTA protocol. Details of the calculation are provided in Appendix B. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required.

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With regards to stationary noise impacts from roof top mechanical units situated on the study building to the surrounding noise-sensitive areas, once the mechanical plans for the proposed building become available, a stationary noise study will be performed. This study will include recommendations for any noise control measures that may be necessary to ensure noise levels at the surrounding noise-sensitive buildings due to mechanical equipment on the roof of the proposed building are below the City of Ottawa's Noise Guidelines.

This concludes our traffic noise assessment and report. If you have any questions or wish to discuss our findings, please advise us. In the interim, we thank you for the opportunity to be of service.

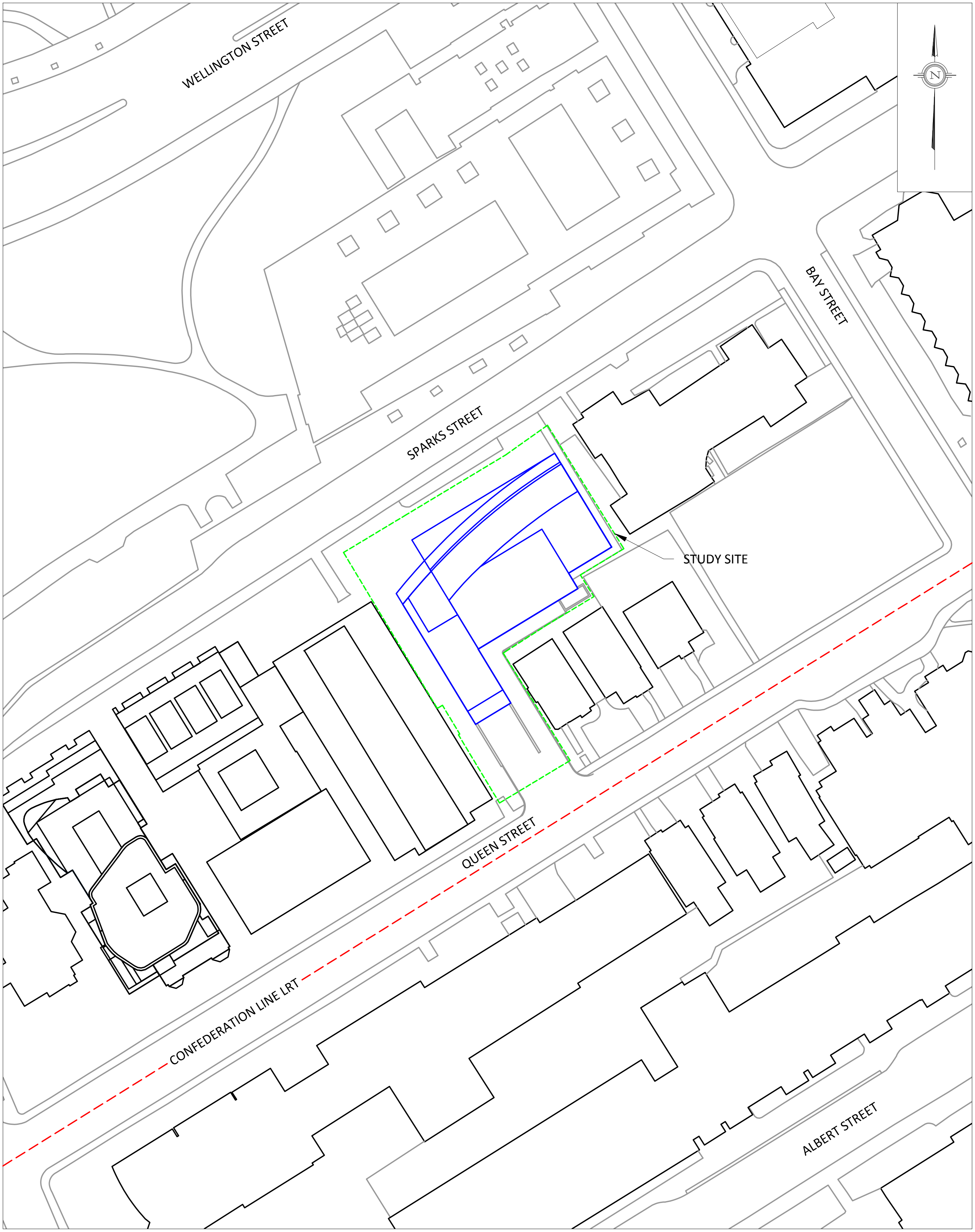
Sincerely,

Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. R. FOSTER
100155655
Feb 21, 2019
PROVINCE OF ONTARIO

Michael Lafortune, C.E.T.
Environmental Scientist
GWE18-176 – Noise & Vibration

Joshua Foster, P.Eng.
Principal



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ENGINEERS & SCIENTISTS

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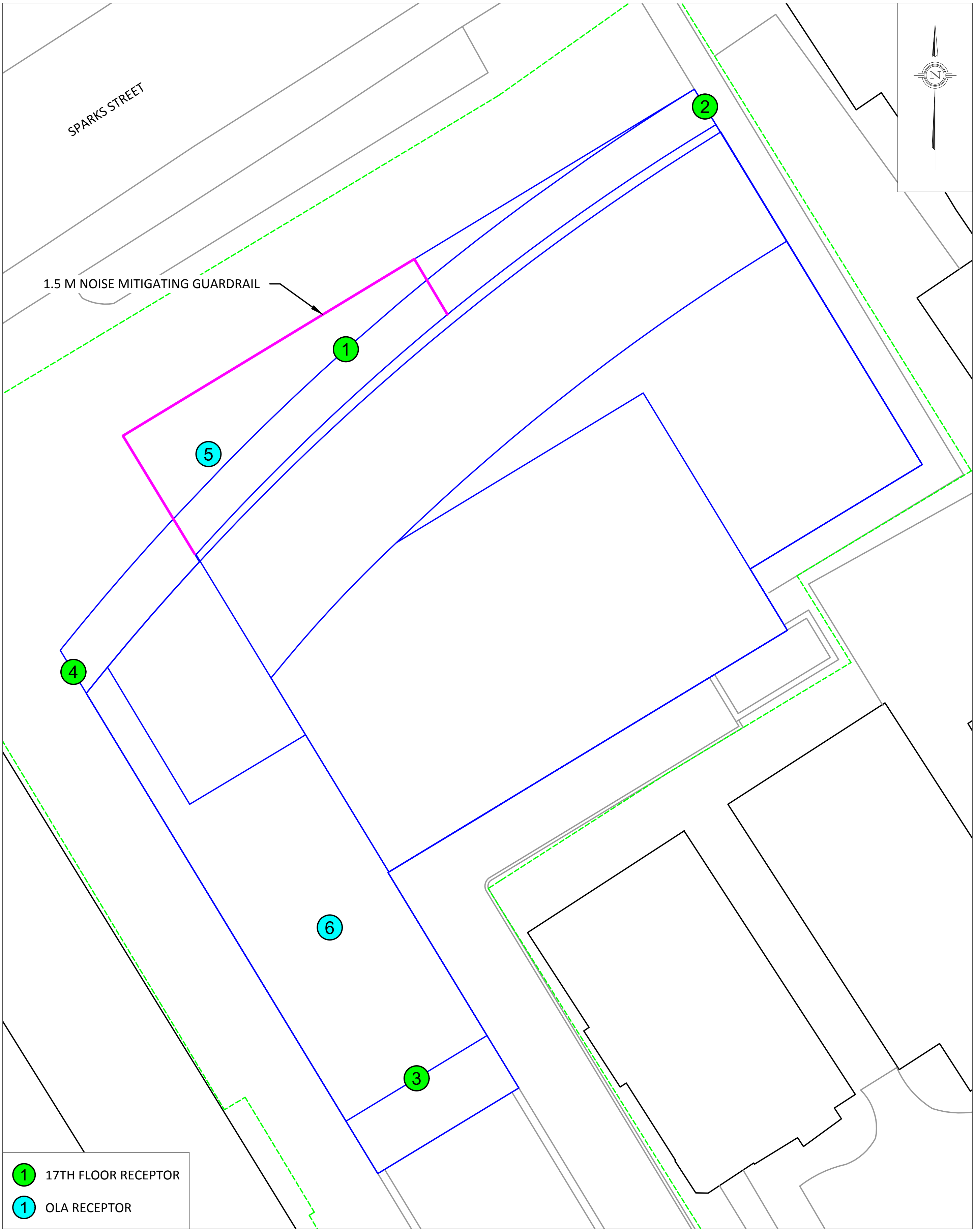
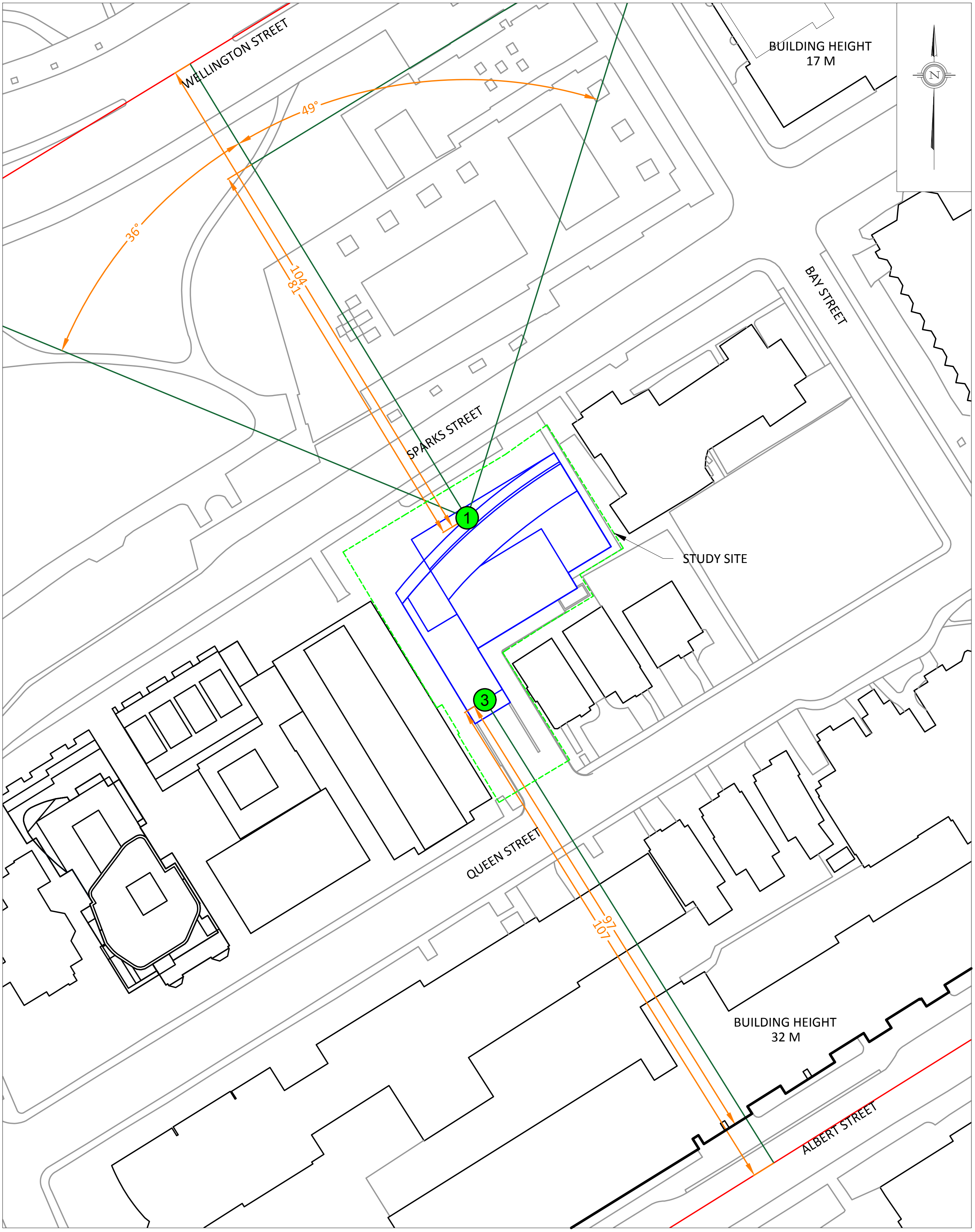
PROJECT	CATHEDRAL HILL RETIREMENT RESIDENCE BY SIGNATURE ROADWAY TRAFFIC NOISE & VIBRATION ASSESSMENT		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GWE18-176-1
DATE	JANUARY 24, 2019	DRAWN BY	M.L.

DESCRIPTION

FIGURE 1:
SITE PLAN SURROUNDING CONTEXT



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD , OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: CATHEDRAL HILL RETIREMENT RESIDENCE BY SIGNATURE ROADWAY TRAFFIC NOISE & VIBRATION ASSESSMENT		DESCRIPTION: FIGURE 2: RECEPTOR AND NOISE MITIGATING GUARDRAIL LOCATIONS
	SCALE: 1:250 (APPROX.)	DRAWING NO.: GWE18-176-2	
	DATE: JANUARY 24, 2019	DRAWN BY: M.L.	



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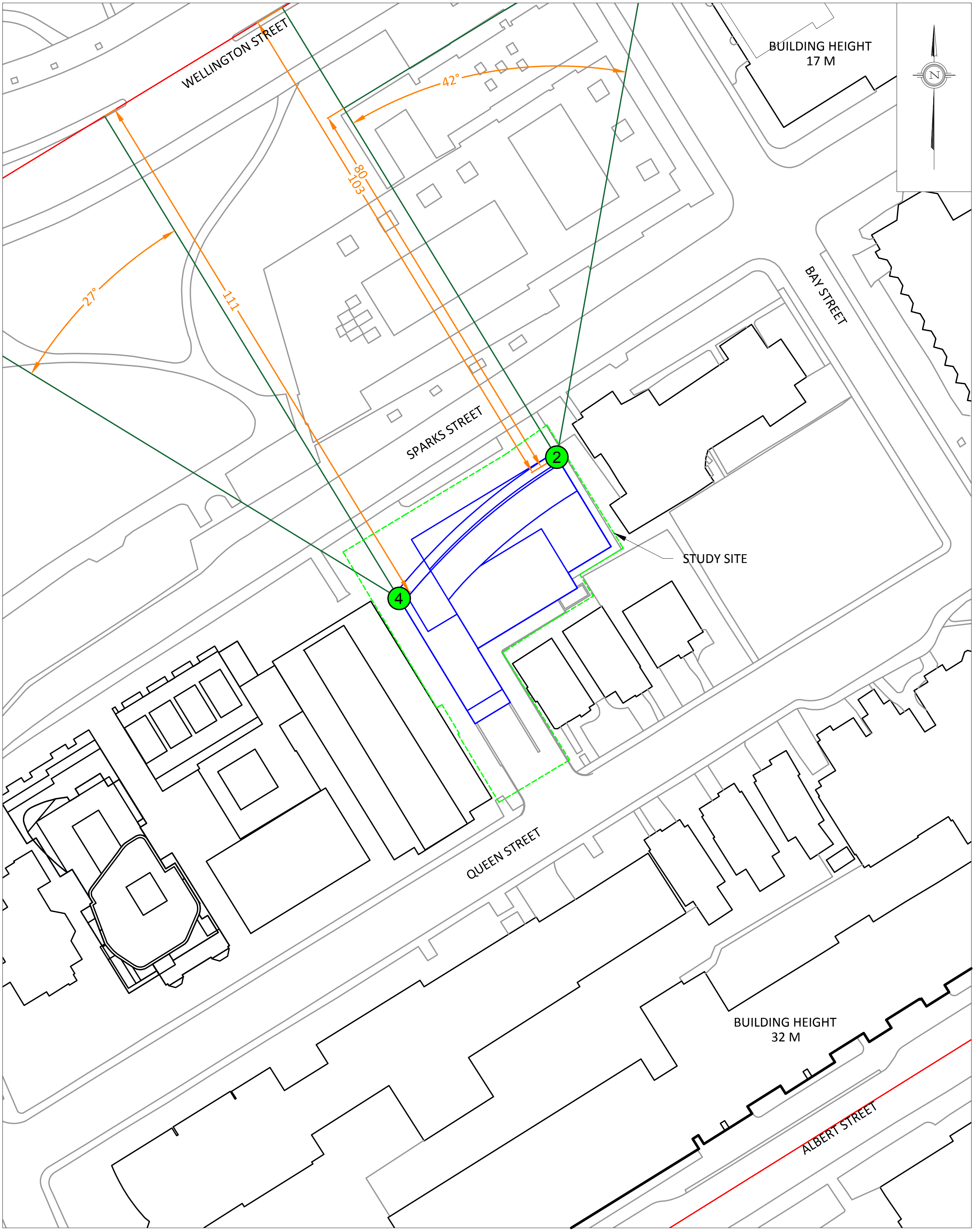
PROJECT	CATHEDRAL HILL RETIREMENT RESIDENCE BY SIGNATURE ROADWAY TRAFFIC NOISE & VIBRATION ASSESSMENT
SCALE	1:1000 (APPROX.)
DRAWING NO.	GWE18-176-3
DATE	JANUARY 24, 2019
DRAWN BY	M.L.
DESCRIPTION	FIGURE 3: STAMSON INPUT DATA - RECEPTOR 1,3



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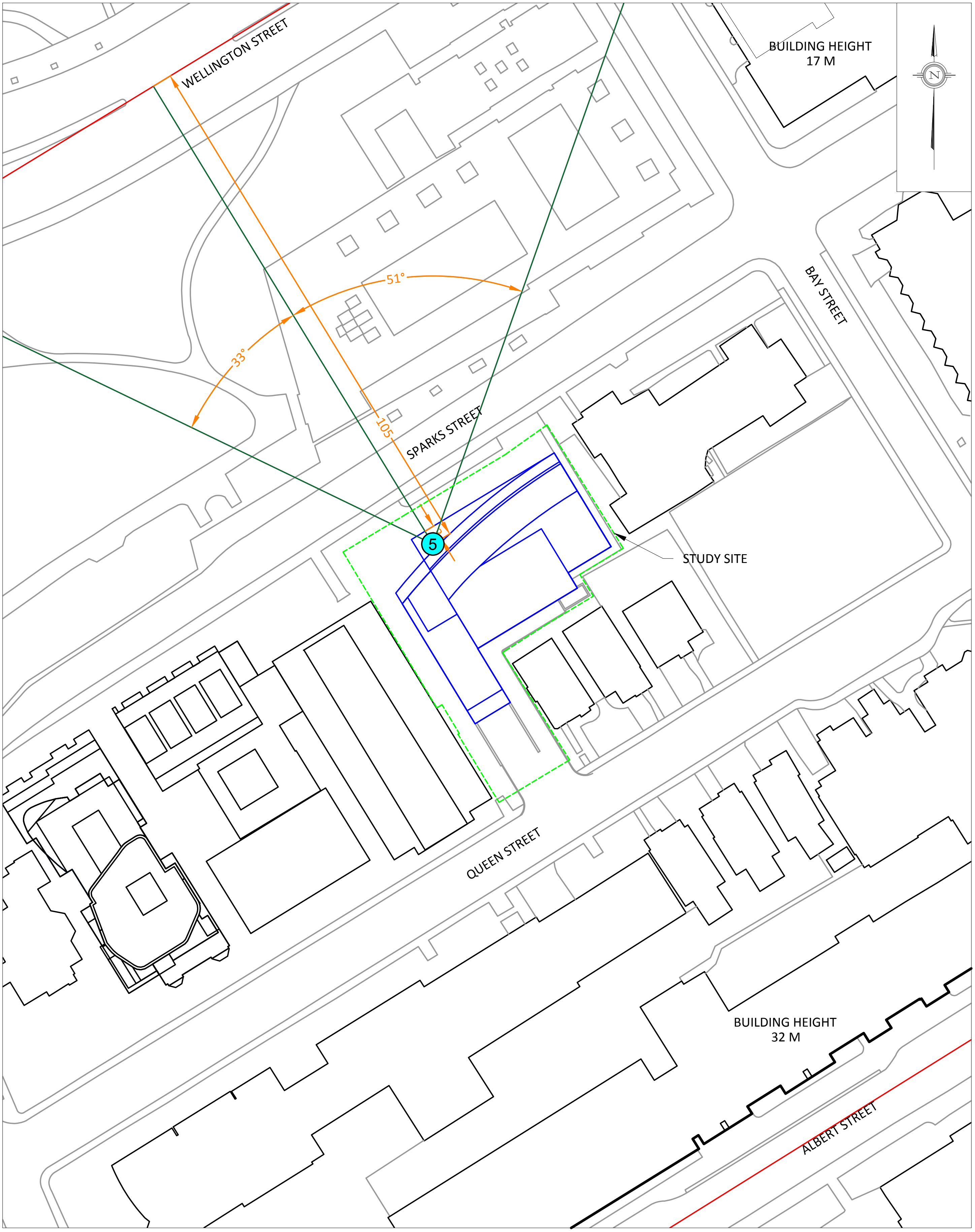
SCALE	1:1000 (APPROX.)
DRAWING NO.	GWE18-176-4
DATE	JANUARY 24, 2019
DRAWN BY	M.L.
DESCRIPTION	FIGURE 4: STAMSON INPUT DATA - RECEPTOR 2,4



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ROADWAY TRAFFIC NOISE & VIBRATION ASSESSMENT

SCALE: 1:1000 (APPROX.)

DRAWING NO.: GWE18-176-5

DATE: JANUARY 24, 2019

DRAWN BY: M.L.

DESCRIPTION: FIGURE 5:
STAMSON INPUT DATA - RECEPTOR 5

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PROJECT	CATHEDRAL HILL RETIREMENT RESIDENCE BY SIGNATURE ROADWAY TRAFFIC NOISE & VIBRATION ASSESSMENT		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GWE18-176-6
DATE	JANUARY 24, 2019	DRAWN BY	M.L.

DESCRIPTION

FIGURE 6:
STAMSON INPUT DATA - RECEPTOR 6

APPENDIX A

STAMSON 5.04 – INPUT AND OUTPUT DATA

127 WALGREEN ROAD, OTTAWA, ON, CANADA K0A 1L0 | 613 836 0934
GRADIENTWIND.COM

```
STAMSON 5.0        NORMAL REPORT        Date: 08-02-2019 13:41:13
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r1.te               Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Wellington (day/night)
----------------------------------------------
Car traffic volume  : 24288/2112  veh/TimePeriod  *
Medium truck volume :  1932/168   veh/TimePeriod  *
Heavy truck volume  :  1380/120   veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  30000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Wellington (day/night)
--------------------------------------------
Angle1   Angle2           : -36.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  : 104.00 / 104.00 m
Receiver height           :  54.30 / 54.30  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :  49.00 deg   Angle2 : 90.00 deg
Barrier height            :  17.00 m
Barrier receiver distance :  81.00 / 81.00  m
Source elevation          :  -7.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00

#
```

```
Results segment # 1: Wellington (day)
-------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+---------------
       1.50 !       54.30 !        7.72 !          7.72

ROAD (59.82 + 44.33 + 0.00) = 59.94 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -36     49   0.00  71.49   0.00  -8.41  -3.26   0.00   0.00   0.00
59.82
--------------------------------------------------------------------------
--
    49     90   0.00  71.49   0.00  -8.41  -6.42   0.00   0.00 -12.33
44.33
--------------------------------------------------------------------------
--

Segment Leq : 59.94 dBA

Total Leq All Segments: 59.94 dBA

#
```

```
Results segment # 1: Wellington (night)
---------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+---------------
       1.50 !       54.30 !        7.72 !         7.72

ROAD (52.23 + 36.73 + 0.00) = 52.35 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -36     49   0.00  63.89   0.00  -8.41  -3.26   0.00   0.00   0.00
52.23
--------------------------------------------------------------------------
--
    49     90   0.00  63.89   0.00  -8.41  -6.42   0.00   0.00 -12.33
36.73
--------------------------------------------------------------------------
--

Segment Leq : 52.35 dBA

Total Leq All Segments: 52.35 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 59.94
                         (NIGHT): 52.35
#
```

```
STAMSON 5.0        NORMAL REPORT        Date: 08-02-2019 13:41:19
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r2.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Wellington (day/night)
----------------------------------------------
Car traffic volume  : 24288/2112  veh/TimePeriod  *
Medium truck volume :  1932/168   veh/TimePeriod  *
Heavy truck volume  :  1380/120   veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  30000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Wellington (day/night)
--------------------------------------------
Angle1   Angle2           :   0.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  : 103.00 / 103.00 m
Receiver height           :  54.30 / 54.30  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :  42.00 deg   Angle2 : 90.00 deg
Barrier height            :  17.00 m
Barrier receiver distance :  80.00 / 80.00  m
Source elevation          :  -7.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00

#
```

```
Results segment # 1: Wellington (day)
-------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source       ! Receiver     ! Barrier      ! Elevation of
Height   (m) ! Height   (m) ! Height   (m) ! Barrier Top   (m)
-------------+--------------+--------------+---------------
       1.50 !        54.30 !         7.85 !          7.85

ROAD (56.80 + 44.69 + 0.00) = 57.06 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
     0     42   0.00  71.49   0.00  -8.37  -6.32   0.00   0.00   0.00
56.80
--------------------------------------------------------------------------
--
    42     90   0.00  71.49   0.00  -8.37  -5.74   0.00   0.00 -12.70
44.69
--------------------------------------------------------------------------
--

Segment Leq : 57.06 dBA

Total Leq All Segments: 57.06 dBA

#
```

```
Results segment # 1: Wellington (night)
---------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !       54.30 !        7.85 !         7.85

ROAD (49.21 + 37.09 + 0.00) = 49.46 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------
--
     0     42   0.00  63.89   0.00  -8.37  -6.32   0.00   0.00   0.00
49.21
-------------------------------------------------------------------------
--
    42     90   0.00  63.89   0.00  -8.37  -5.74   0.00   0.00 -12.70
37.09
-------------------------------------------------------------------------
--

Segment Leq : 49.46 dBA

Total Leq All Segments: 49.46 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 57.06
                         (NIGHT): 49.46

#
```

```
STAMSON 5.0          NORMAL REPORT          Date: 08-02-2019 13:41:24
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r3.te                        Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Albert (day/night)
------------------------------------------
Car traffic volume  : 12144/1056  veh/TimePeriod  *
Medium truck volume :   966/84    veh/TimePeriod  *
Heavy truck volume  :   690/60    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  15000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Albert (day/night)
----------------------------------------
Angle1   Angle2            : -90.00 deg   90.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      2       (Reflective ground surface)
Receiver source distance   : 107.00 / 107.00 m
Receiver height            :  54.30 / 54.30  m
Topography                 :      2       (Flat/gentle slope; with barrier)
Barrier angle1             : -90.00 deg   Angle2 : 90.00 deg
Barrier height             :  32.00 m
Barrier receiver distance  :  97.00 / 97.00  m
Source elevation           :   2.00 m
Receiver elevation         :   0.00 m
Barrier elevation          :   0.00 m
Reference angle            :   0.00

#
```

```
Results segment # 1: Albert (day)
---------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source       ! Receiver     ! Barrier      ! Elevation of
Height   (m) ! Height   (m) ! Height   (m) ! Barrier Top  (m)
-------------+--------------+--------------+---------------
       1.50 !        54.30 !         8.24 !          8.24

ROAD (0.00 + 41.02 + 0.00) = 41.02 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -90     90   0.00  68.48   0.00  -8.53   0.00   0.00   0.00 -18.93
41.02
--------------------------------------------------------------------------
--

Segment Leq : 41.02 dBA

Total Leq All Segments: 41.02 dBA

#
```

```
Results segment # 1: Albert (night)
-----------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !       54.30 !        8.24 !         8.24

ROAD (0.00 + 33.42 + 0.00) = 33.42 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -90     90   0.00  60.88   0.00  -8.53   0.00   0.00   0.00 -18.93
33.42
--------------------------------------------------------------------------
--

Segment Leq : 33.42 dBA

Total Leq All Segments: 33.42 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 41.02
                         (NIGHT): 33.42
#
```

```
STAMSON 5.0        NORMAL REPORT        Date: 08-02-2019 13:41:30
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r4.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Wellington (day/night)
----------------------------------------------
Car traffic volume  : 24288/2112  veh/TimePeriod  *
Medium truck volume :  1932/168   veh/TimePeriod  *
Heavy truck volume  :  1380/120   veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  30000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Wellington (day/night)
--------------------------------------------
Angle1   Angle2           : -27.00 deg   0.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  : 111.00 / 111.00 m
Receiver height           :  54.30 / 54.30  m
Topography                :      3       (Elevated; no barrier)
Elevation                 :   7.00 m
Reference angle           :   0.00

#
```

```
Results segment # 1: Wellington (day)
-------------------------------------

Source height = 1.50 m

ROAD (0.00 + 54.56 + 0.00) = 54.56 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -27      0   0.00  71.49   0.00  -8.69  -8.24   0.00   0.00   0.00
54.56
--------------------------------------------------------------------------
--

Segment Leq : 54.56 dBA

Total Leq All Segments: 54.56 dBA


Results segment # 1: Wellington (night)
---------------------------------------

Source height = 1.50 m

ROAD (0.00 + 46.96 + 0.00) = 46.96 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -27      0   0.00  63.89   0.00  -8.69  -8.24   0.00   0.00   0.00
46.96
--------------------------------------------------------------------------
--

Segment Leq : 46.96 dBA

Total Leq All Segments: 46.96 dBA




TOTAL Leq FROM ALL SOURCES (DAY): 54.56
                         (NIGHT): 46.96
#
```

```
STAMSON 5.0        NORMAL REPORT        Date: 23-01-2019 31:51:04
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r5.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Wellington (day/night)
----------------------------------------------
Car traffic volume  : 24288/2112  veh/TimePeriod  *
Medium truck volume :  1932/168   veh/TimePeriod  *
Heavy truck volume  :  1380/120   veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  30000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Wellington (day/night)
--------------------------------------------
Angle1   Angle2           : -33.00 deg   51.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  : 105.00 / 105.00 m
Receiver height           :  11.50 / 11.50  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -33.00 deg   Angle2 : 51.00 deg
Barrier height            :  10.00 m
Barrier receiver distance :   3.00 / 3.00   m
Source elevation          :  -7.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00

#
```

```
Results segment # 1: Wellington (day)
-------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+---------------
       1.50 !       11.50 !       11.01 !        11.01

ROAD (0.00 + 56.52 + 0.00) = 56.52 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
-------------------------------------------------------------------------
--
   -33     51   0.00  71.49   0.00  -8.45  -3.31   0.00   0.00   0.00
59.73*
   -33     51   0.36  71.49   0.00 -11.49  -3.48   0.00   0.00   0.00
56.52
-------------------------------------------------------------------------
--

 * Bright Zone !

Segment Leq : 56.52 dBA

Total Leq All Segments: 56.52 dBA

#
```

```
Results segment # 1: Wellington (night)
---------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !       11.50 !       11.01 !         11.01

ROAD (0.00 + 48.92 + 0.00) = 48.92 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -33     51   0.00  63.89   0.00  -8.45  -3.31   0.00   0.00   0.00
52.13*
   -33     51   0.36  63.89   0.00 -11.49  -3.48   0.00   0.00   0.00
48.92
--------------------------------------------------------------------------
--

 * Bright Zone !

Segment Leq : 48.92 dBA

Total Leq All Segments: 48.92 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 56.52
                         (NIGHT): 48.92
#
```

```
STAMSON 5.0        NORMAL REPORT        Date: 08-02-2019 14:04:49
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r5b.te               Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Wellington (day/night)
----------------------------------------------
Car traffic volume  : 24288/2112  veh/TimePeriod  *
Medium truck volume :  1932/168   veh/TimePeriod  *
Heavy truck volume  :  1380/120   veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  30000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Wellington (day/night)
--------------------------------------------
Angle1   Angle2            : -33.00 deg   51.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      1       (Absorptive ground surface)
Receiver source distance   : 105.00 / 105.00 m
Receiver height            :  11.50 / 11.50  m
Topography                 :      2       (Flat/gentle slope; with barrier)
Barrier angle1             : -33.00 deg   Angle2 : 51.00 deg
Barrier height             :  11.50 m
Barrier receiver distance  :   3.00 / 3.00   m
Source elevation           :  -7.00 m
Receiver elevation         :   0.00 m
Barrier elevation          :   0.00 m
Reference angle            :   0.00

#
```

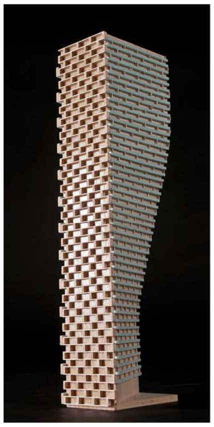
```
Results segment # 1: Wellington (day)
-------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !       11.50 !       11.01 !        11.01

ROAD (0.00 + 53.08 + 0.00) = 53.08 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -33     51   0.00  71.49   0.00  -8.45  -3.31   0.00   0.00  -6.65
53.08
--------------------------------------------------------------------------
--

Segment Leq : 53.08 dBA

Total Leq All Segments: 53.08 dBA

#
```

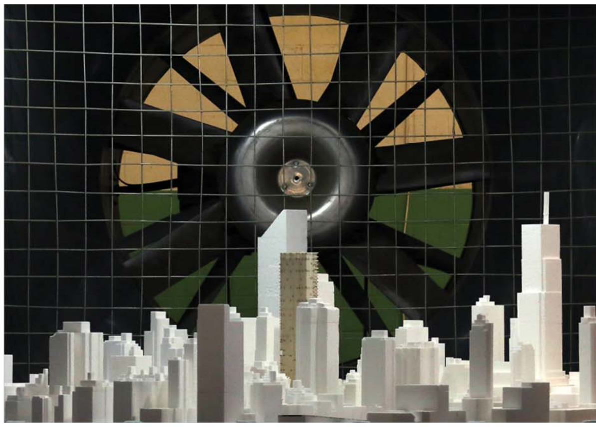
```
Results segment # 1: Wellington (night)
---------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       1.50 !       11.50 !       11.01 !        11.01

ROAD (0.00 + 45.49 + 0.00) = 45.49 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -33     51   0.00  63.89   0.00  -8.45  -3.31   0.00   0.00  -6.65
45.49
--------------------------------------------------------------------------
--

Segment Leq : 45.49 dBA

Total Leq All Segments: 45.49 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 53.08
                         (NIGHT): 45.49
#
```

```
STAMSON 5.0        NORMAL REPORT        Date: 08-02-2019 13:41:37
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r6.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Wellington (day/night)
----------------------------------------------
Car traffic volume  : 24288/2112  veh/TimePeriod  *
Medium truck volume :  1932/168   veh/TimePeriod  *
Heavy truck volume  :  1380/120   veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  30000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Wellington (day/night)
--------------------------------------------
Angle1   Angle2            : -27.00 deg   43.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      1       (Absorptive ground surface)
Receiver source distance   : 121.00 / 121.00 m
Receiver height            :  59.30 / 59.30  m
Topography                 :      2       (Flat/gentle slope; with barrier)
Barrier angle1             : -27.00 deg   Angle2 : 43.00 deg
Barrier height             :  57.80 m
Barrier receiver distance  :  10.00 / 10.00  m
Source elevation           :  -7.00 m
Receiver elevation         :   0.00 m
Barrier elevation          :   0.00 m
Reference angle            :   0.00

#
```

```
Results segment # 1: Wellington (day)
-------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+---------------
       1.50 !       59.30 !       53.94 !        53.94

ROAD (0.00 + 42.99 + 0.00) = 42.99 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
---------------------------------------------------------------------------
--
   -27     43   0.00  71.49   0.00  -9.07  -4.10   0.00   0.00 -15.33
42.99
---------------------------------------------------------------------------
--

Segment Leq : 42.99 dBA

Total Leq All Segments: 42.99 dBA

#
```

```
Results segment # 1: Wellington (night)
---------------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source       ! Receiver     ! Barrier      ! Elevation of
Height   (m) ! Height   (m) ! Height   (m) ! Barrier Top  (m)
-------------+--------------+--------------+---------------
       1.50 !        59.30 !        53.94 !        53.94

ROAD (0.00 + 35.40 + 0.00) = 35.40 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -27     43   0.00  63.89   0.00  -9.07  -4.10   0.00   0.00 -15.33
35.40
--------------------------------------------------------------------------
--

Segment Leq : 35.40 dBA

Total Leq All Segments: 35.40 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 42.99
                         (NIGHT): 35.40
```





APPENDIX B

FTA VIBRATION CALCULATIONS

127 WALGREEN ROAD, OTTAWA, ON, CANADA K0A 1L0 | 613 836 0934
GRADIENTWIND.COM

GWE18-176 25-Jan-19

Possible Vibration Impacts on Cathedral Hill
Perdicted using FTA General Assesment

Train Speed 50 km/h 31 mph

	Distance from C/L	
	(m)	(ft)
LRT	13.0	42.7

	Vibration		
From FTA Manual Fig 10-1			
Vibration Levels at distance from track	77	dBV re 1 micro in/sec	
Adjustment Factors FTA Table 10-1			
Speed reference 50 mph	-4.2	Speed limit of 50 km/h (31 mph)	
Vehicle Parameters	0	None	
Track Condition	5	Jointed Track	
Track Treatments	0	None	
Type of Transit Structure	-15	Bored tunnel in rock	
Efficient vibration Propagation	10	Proposgation in rock	
Vibration Levels at Fdn	73		0.111
Coupling to Building Foundation	-10	Large masonry on piles	
Floor to Floor Attenuation	-2.0	Ground floor sensitive	
Amplification of Floor and Walls	6		
Total Vibration Level	66.8	dBV or	0.056 mm/s
Noise Level in dBA	31.8	dBA	

Table 10-1. Adjustment Factors for Generalized Predictions of Ground-Borne Vibration and Noise			
Factors Affecting Vibration Source			
Source Factor	**Adjustment to Propagation Curve**		**Comment**
Speed	Vehicle Speed 60 mph 50 mph 40 mph 30 mph 20 mph	Reference Speed 50 mph: +1.6 dB, 0.0 dB, -1.9 dB, -4.4 dB, -8.0 dB 30 mph: +6.0 dB, +4.4 dB, +2.5 dB, 0.0 dB, -3.5 dB	Vibration level is approximately proportional to 20*log(speed/speed$_{ref}$). Sometimes the variation with speed has been observed to be as low as 10 to 15 log(speed/speed$_{ref}$).
Vehicle Parameters (not additive, apply greatest value only)			
Vehicle with stiff primary suspension	+8 dB		Transit vehicles with stiff primary suspensions have been shown to create high vibration levels. Include this adjustment when the primary suspension has a vertical resonance frequency greater than 15 Hz.
Resilient Wheels	0 dB		Resilient wheels do not generally affect ground-borne vibration except at frequencies greater than about 80 Hz.
Worn Wheels or Wheels with Flats	+10 dB		Wheel flats or wheels that are unevenly worn can cause high vibration levels. This can be prevented with wheel truing and slip-slide detectors to prevent the wheels from sliding on the track.
Track Conditions (not additive, apply greatest value only)			
Worn or Corrugated Track	+10 dB		If both the wheels and the track are worn, only one adjustment should be used. Corrugated track is a common problem. Mill scale on new rail can cause higher vibration levels until the rail has been in use for some time.
Special Trackwork	+10 dB		Wheel impacts at special trackwork will significantly increase vibration levels. The increase will be less at greater distances from the track.
Jointed Track or Uneven Road Surfaces	+5 dB		Jointed track can cause higher vibration levels than welded track. Rough roads or expansion joints are sources of increased vibration for rubber-tire transit.
Track Treatments (not additive, apply greatest value only)			
Floating Slab Trackbed	-15 dB		The reduction achieved with a floating slab trackbed is strongly dependent on the frequency characteristics of the vibration.
Ballast Mats	-10 dB		Actual reduction is strongly dependent on frequency of vibration.
High-Resilience Fasteners	-5 dB		Slab track with track fasteners that are very compliant in the vertical direction can reduce vibration at frequencies greater than 40 Hz.

Table 10-1. Adjustment Factors for Generalized Predictions of Ground-Borne Vibration and Noise (Continued)

Factors Affecting Vibration Path		
Path Factor	**Adjustment to Propagation Curve**	**Comment**
Resiliently Supported Ties	-10 dB	Resiliently supported tie systems have been found to provide very effective control of low-frequency vibration.
Track Configuration (not additive, apply greatest value only)		
Type of Transit Structure	Relative to at-grade tie & ballast: Elevated structure -10 dB Open cut 0 dB	The general rule is the heavier the structure, the lower the vibration levels. Putting the track in cut may reduce the vibration levels slightly. Rock-based subways generate higher-frequency vibration.
	Relative to bored subway tunnel in soil: Station -5 dB Cut and cover -3 dB Rock-based - 15 dB	
Ground-borne Propagation Effects		
Geologic conditions that promote efficient vibration propagation	Efficient propagation in soil +10 dB	Refer to the text for guidance on identifying areas where efficient propagation is possible.
	Propagation in rock layer **Dist.** / **Adjust.** 50 ft +2 dB 100 ft +4 dB 150 ft +6 dB 200 ft +9 dB	The positive adjustment accounts for the lower attenuation of vibration in rock compared to soil. It is generally more difficult to excite vibrations in rock than in soil at the source.
Coupling to building foundation	Wood Frame Houses -5 dB 1-2 Story Masonry -7 dB 3-4 Story Masonry -10 dB Large Masonry on Piles -10 dB Large Masonry on Spread Footings -13 dB Foundation in Rock 0 dB	The general rule is the heavier the building construction, the greater the coupling loss.
Factors Affecting Vibration Receiver		
Receiver Factor	**Adjustment to Propagation Curve**	**Comment**
Floor-to-floor attenuation	1 to 5 floors above grade: -2 dB/floor 5 to 10 floors above grade: -1 dB/floor	This factor accounts for dispersion and attenuation of the vibration energy as it propagates through a building.
Amplification due to resonances of floors, walls, and ceilings	+6 dB	The actual amplification will vary greatly depending on the type of construction. The amplification is lower near the wall/floor and wall/ceiling intersections.
Conversion to Ground-borne Noise		
Noise Level in dBA	Peak frequency of ground vibration: Low frequency (<30 Hz): -50 dB Typical (peak 30 to 60 Hz): -35 dB High frequency (>60 Hz): -20 dB	Use these adjustments to estimate the A-weighted sound level given the average vibration velocity level of the room surfaces. See text for guidelines for selecting low, typical or high frequency characteristics. Use the high-frequency adjustment for subway tunnels in rock or if the dominant frequencies of the vibration spectrum are known to be 60 Hz or greater.