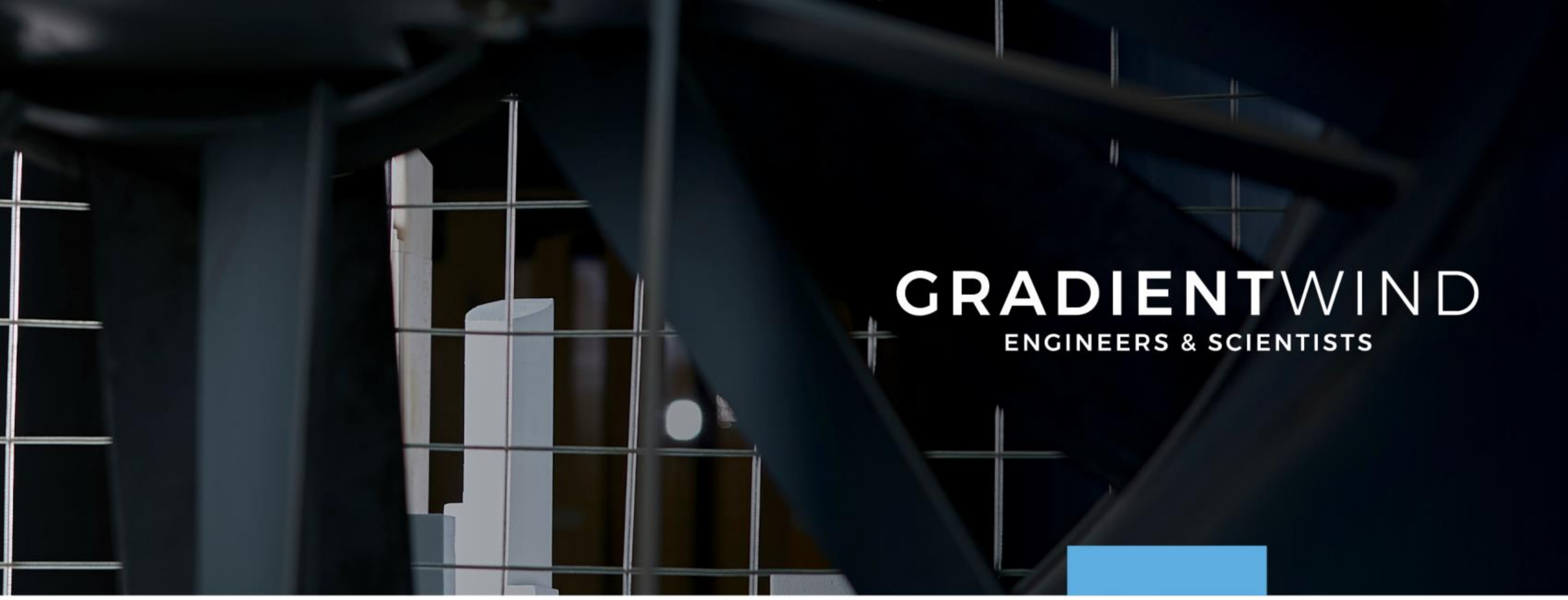
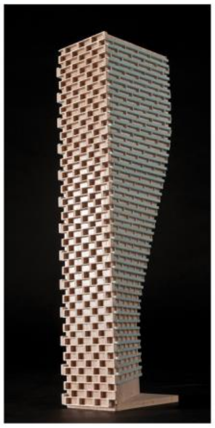
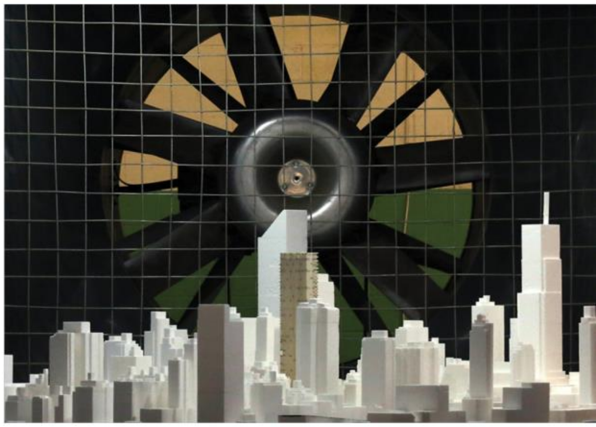


TRANSPORTATION NOISE AND VIBRATION ASSESSMENT

1047 Richmond Road
Ottawa, Ontario

Report: 21-416- Transportation Noise and Vibration





September 5, 2024

PREPARED FOR
1047 Richmond Nominee Inc.
77 King Street W, Suite 3410
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PREPARED BY
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Joshua Foster, P.Eng., Lead Engineer

EXECUTIVE SUMMARY

This report describes a transportation noise and vibration assessment undertaken in support of a Site Plan Control (SPC) application for the proposed residential development located at 1047 Richmond Road in Ottawa, Ontario. The proposed development comprises two towers rising from two three-storey podia. The primary source of roadway traffic noise is Richmond Road to the south. As the site is in proximity to the future proposed Ottawa-Carleton Regional Transit Commission (OC Transpo) Light Rail Transit (LRT) Confederation Line, a ground vibration impact assessment from the proposed underground LRT system on the development was conducted following the procedures outlined in the Federal Transit Authorities (FTA) protocol. Figure 1 illustrates a complete site plan with the surrounding context.

The assessment is based on (i) theoretical noise prediction methods that conform to the Ministry of the Environment, Conservation and Parks (MECP) NPC-300, Ministry of Transportation Ontario (MTO), and City of Ottawa Environmental Noise Control Guidelines (ENCG) guidelines; (ii) future vehicular traffic volumes corresponding to roadway classification, roadway traffic volumes obtained from the City of Ottawa, and LRT information from the Rail Implementation Office; (iii) architectural drawings provided by Roderick Lahey Architect Inc. in August 2024; and (iv) ground-borne vibration criteria as specified by the Federal Transit Authority (FTA) Protocol.

The results of the current analysis indicate that noise levels will range between 48 and 60 dBA during the daytime period (07:00-23:00) and between 41 and 53 dBA during the nighttime period (23:00-07:00). The highest noise level (60 dBA) occurs at the south façade of Tower A, which is nearest and most exposed to Richmond Road. Figures 5 and 6 illustrate daytime and nighttime noise contours of the site 4.5 m above grade.

The results indicate that upgraded building components will not be required for Tower A, as noise levels predicted due to transportation traffic do not exceed the criteria of 65 dBA during the daytime. Central air conditioning will be required for all units. In addition, a Type D Warning Clause will also be required in all Lease, Purchase and Sale Agreements, as summarized in section 6.

The results also indicate that noise levels at the at-grade amenity area and the Level 4 amenity terraces are expected to be between 51 dBA and 56 dBA, respectively. Since the noise levels at the at-grade amenity are below 55 dBA, no acoustic mitigation is required. As noise levels at the Level 4 outdoor amenity are slightly above 55 dBA, acoustic mitigation in the form of a 1.5 m tall noise screen surrounding the northeast, east, and southwest perimeter is recommended but not required. If no mitigation is provided, a Type A Warning Clause will also be required in all Lease, Purchase and Sale Agreements, as summarized in Section 6. Figure 4 illustrates the proposed barrier location.

Estimated vibration levels at the foundation nearest to the OC Transpo LRT Confederation Line are expected to be 0.044 mm/s RMS (65 dBV), based on the FTA protocol and an offset distance of 32 m to the nearest track centerline. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.14 mm/s RMS at the foundation, concerns due to vibration impacts on the site are not expected. As vibration levels are acceptable, correspondingly, regenerated noise levels are also expected to be acceptable.

With regard to stationary noise impacts from proposed mechanical systems on the building, they will be designed to ensure compliance with the ENCG sound level limits. Noise impacts can generally be minimized by judicious selection and placement of the equipment. Where necessary, noise screens and silencers can be placed into the design. It is recommended a stationary noise study be conducted once mechanical plans for the proposed building become available. This study would assess the impacts of stationary noise from rooftop mechanical units serving the proposed building on surrounding noise-sensitive areas.

TABLE OF CONTENTS

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Fengate Asset Management to undertake a transportation noise and vibration assessment, in support of a Site Plan Control (SPC) application for the proposed residential development located at 1047 Richmond Road in Ottawa, Ontario. This report summarizes the methodology, results, and recommendations related to the assessment of exterior noise and vibration levels generated by local transportation traffic.

This assessment is based on theoretical noise calculation methods conforming to the Ministry of the Environment, Conservation and Parks (MECP) NPC-300[1], Ministry of Transportation Ontario (MTO)[2], and City of Ottawa Environmental Noise Control Guidelines (ENCG)[3] guidelines. Noise calculations were based on architectural drawings provided by Roderick Lahey Architect Inc. in August 2024, with future traffic volumes corresponding to roadway classification and theoretical roadway capacities, and recent satellite imagery.

2. TERMS OF REFERENCE

The focus of this transportation noise assessment is "Tower A" of the proposed residential development located at 1047 Richmond Road in Ottawa, Ontario. The subject site is located on a nearly rectangular parcel of land north of the intersection of New Orchard Avenue North and Richmond Road.

The proposed development comprises two towers rising from two four-storey podia. The two towers are identified as "Tower A" (36 storeys) and "Tower B" (38 storeys) which are situated in the southwest corner and northeast corner of the subject site, respectively. A park is provided at the southwest corner of the subject site. Tower A and Tower B are topped with a mechanical penthouse and both buildings share two below-grade parking levels which are accessed by a parking ramp located to the north of Tower A via a loading/service laneway extending along the north elevation of the subject site from New Orchard Avenue North. A central drop-off courtyard is accessed from the noted laneway.

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[1] Ontario Ministry of the Environment and Climate Change – Environmental Noise Guidelines, Publication NPC-300, Queens Printer for Ontario, Toronto, 2013
[2] Ministry of Transportation Ontario, "*Environmental Guide for Noise*", August 2021
[3] City of Ottawa Environmental Noise Control Guidelines, January 2016

Above the two levels of underground parking, Level 1 of Tower A includes retail space fronting a proposed park at the southwest corner of the site, a residential lobby along the east elevation, and a loading area and garbage room at the northwest elevation, with residential units and shared building support spaces throughout the remainder of the level. An at-grade outdoor amenity area is located east of Tower A. Level 2 of Tower A includes storage lockers to the northeast and residential units throughout the remainder of the level. At Level 3, the podium steps back towards Tower A in the east and north directions to incorporate private terraces. At Level 4, the podium steps back towards Tower A in the east direction to incorporate an outdoor amenity area. The remainder of Level 4 comprises of indoor amenity space. Tower A rises from the podium with a rectangular planform. All floors serving Towers A between Level 5 and Level 35 comprise residential units. Level 36 includes an indoor amenity space to the northeast with residential units throughout the remainder of the level.

The site is surrounded by Sir John A. Macdonald Parkway and the Trans-Canada Trail northeast, high-rise residential buildings to the northeast and to the southwest, and mostly low-rise residential buildings for the remaining compass directions. Additionally, the Ottawa-Carleton Regional Transit Commission (OC Transpo) Light Rail Transit (LRT) Confederation Line extension and the future New Orchard Station are currently under construction approximately 20 m to the south of the subject site. The primary source of roadway traffic noise is Richmond Road to the south. Figure 1 illustrates a complete site plan with the surrounding context.

The primary source of ground-borne vibration is the future OC Transpo LRT line located to the south of the subject site. As per the City of Ottawa's Official Plan, the LRT system is situated within 75 m from the nearest property line. As a result, a ground vibration impact assessment from the underground LRT system on the proposed development was conducted following the procedures outlined in the Federal Transit Authorities (FTA) protocol. Airborne noise transmission from the LRT onto the development was considered to be negligible compared to surface transportation noise as the LRT is located entirely underground.

With regard to stationary noise impacts from proposed mechanical systems on the building, they will be designed to ensure compliance with the ENCG sound level limits. Noise impacts can generally be minimized by judicious selection and placement of the equipment. Where necessary, noise screens and silencers can be placed into the design. It is recommended a stationary noise study be conducted once mechanical plans for the proposed building become available. This study would assess the impacts of stationary noise from rooftop mechanical units serving the proposed building on surrounding noise-sensitive areas.

3. OBJECTIVES

The principal objectives of this study are to (i) calculate the future noise levels on the study building produced by local transportation sources, (ii) predict vibration levels on the study building produced from the LRT system, and (iii) explore potential noise mitigation where required.

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. NPC-300 specifies that the recommended indoor noise limit range (that is relevant to this study) is 50, 45 and 40 dBA for retail/office/indoor amenity space, living rooms, and sleeping quarters, respectively, as listed in Table 1.

TABLE 1: INDOOR SOUND LEVEL CRITERIA (ROAD) [4]

Type of Space	Time Period	L_{eq} (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[5]. A closed window due to a ventilation requirement will bring noise levels down to achieve an acceptable indoor environment[6]. 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[7].

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 should be provided to reduce noise levels where technically and administratively feasible to acceptable levels at or below the criterion.

[4] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Table C-9
[5] Burberry, P.B. (2014). Mitchell's Environment and Services. Routledge, Page 125
[6] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.8
[7] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3

4.2.2 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[8] 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.

TABLE 2: ROADWAY TRAFFIC DATA

Segment	Roadway Traffic Data	Speed Limit (km/h)	Traffic Volumes
Richmond Road	2-Lane Urban Arterial Undivided (2-UAU)	50	**15,000**

4.2.3 Theoretical Roadway Traffic Noise Predictions

The impact of transportation noise sources on the development was determined by computer modelling. Transportation noise source modelling is based on the software program *Predictor-Lima* which utilizes the United States Federal Highway Administration's Traffic Noise Model (TNM) to represent the roadway line sources. The TNM model is also being accepted in the updated Environmental Guide for Noise of Ontario, 2021 by the Ministry of Transportation (MTO)[9]. This computer program can represent three-dimensional surfaces and first reflections of sound waves over a suitable spectrum for human hearing. A set of comparative calculations were performed in the current Ontario traffic noise prediction model STAMSON for comparisons to Predictor simulation results. The STAMSON model is, however, older and requires each receptor to be calculated separately. STAMSON also does not accurately account for building reflections and multiple screening elements, and curved road geometry. A total of 6 receptor locations were identified around the site, as illustrated in Figure 2.

[8] City of Ottawa Transportation Master Plan, November 2013
[9] Ministry of Transportation Ontario, "*Environmental Guide for Noise*", August 2021, pg. 16

Roadway noise calculations were performed by treating each segment as separate line sources of noise, and by using existing and proposed building locations as noise barriers. 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 roads was taken to be 92% / 8%, respectively.
- Default ground surfaces were taken to be reflective due to the presence of hard (paved) ground.
- Topography was assumed to be a flat/gentle slope surrounding the study building.
- Noise receptors were strategically placed at 6 locations around the study area (see Figure 2).

4.3 Ground Vibration and 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 or subway. 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

The Canadian Railway Association and Canadian Association of Municipalities have set standards for new sensitive land developments within 300 metres of a railway right-of-way, as published in their document *Guidelines for New Development in Proximity to Railway Operations*[10], which 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.

4.3.2 Theoretical Ground Vibration Prediction Procedure

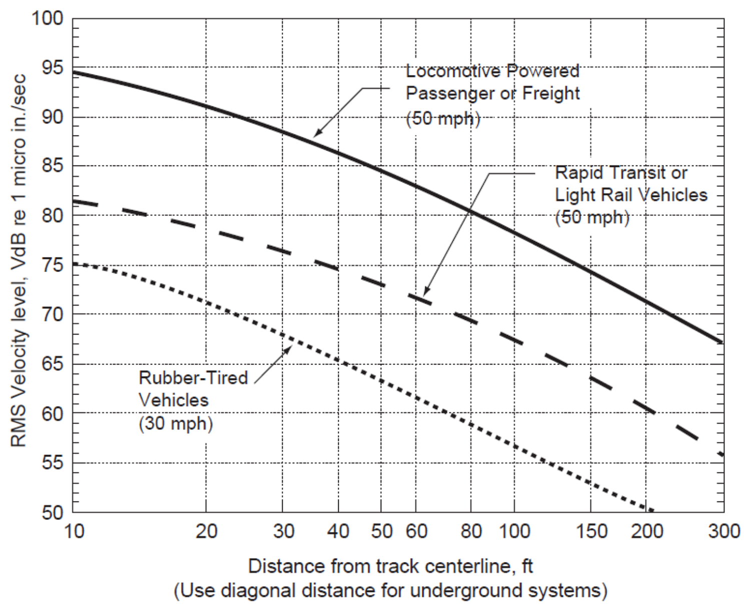
Potential vibration impacts of the trains were predicted using the Federal Transit Authority's (FTA) *Transit Noise and Vibration Impact Assessment*[11] protocol. The FTA general vibration assessment is based on an upper bound generic set of curves that show vibration level attenuation with distance. These curves, illustrated in the figure on the following page, 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. The vibration impact on the building was determined using a set of curves for Rapid Transit at a speed of 50 mph. Adjustment factors were considered based on the following information:

- The maximum operating speed of the LRT line is 43 mph (70 km/h) at peak.
- The setback distance between the development and the closest track is 32 m.

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

[11] John A. Volpe National Transportation Systems Center, Transit Noise and Vibration Impact Assessment, Federal Transit Administration, September 2018

- The vehicles are assumed to have soft primary suspensions.
- Tracks are not welded, though in otherwise good condition.
- Soil conditions do not efficiently propagate vibrations.
- The building's foundation will bear on bedrock.
- Type of transit structure is Station.



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

5. RESULTS

5.1 Roadway Traffic Noise Levels

The results of the transportation noise calculations are summarized in Table 3 below.

TABLE 3: EXTERIOR NOISE LEVELS DUE TO ROADWAY TRAFFIC SOURCES

Receptor Number	Receptor Height Above Grade/Roof (m)	Receptor Location	Roadway Noise Level (dBA)	
			Day	Night
R1	109.5	POW - Level 36 Tower A - South Façade	60	53
R2	109.5	POW - Level 36 Tower A - East Façade	58	51
R3	109.5	POW - Level 36 Tower A - North Façade	48	41
R4	109.5	POW - Level 36 Tower A - West Façade	52	45
R5	13.5	OLA - Level 4 Tower A - Outdoor Amenity	56	**N/A***
R6	1.5	OLA - At-Grade Outdoor Amenity	51	**N/A***

*Noise levels during the nighttime are not considered for OLAs

The results of the current analysis indicate that noise levels will range between 48 and 60 dBA during the daytime period (07:00-23:00) and between 41 and 53 dBA during the nighttime period (23:00-07:00). The highest noise level (60 dBA) occurs at the south façade of Tower A, which is nearest and most exposed to Richmond Road. Figures 5 and 6 illustrate daytime and nighttime noise contours of the site 4.5 m above grade.

Table 4 shows a comparison in results between Predictor-Lima and STAMSON. Noise levels calculated in STAMSON were found to have a good correlation with Predictor-Lima and variability between the two programs was within an acceptable level of ±0-3 dBA. STAMSON input parameters are shown in Appendix A.

TABLE 4: RESULTS OF STAMSON/PREDICTOR-LIMA CORRELATION

Receptor ID	Receptor Height (m)	Receptor Location	STAMSON 5.04 Noise Level (dBA)		PREDICTOR-LIMA Noise Level (dBA)	
			Day	Night	Day	Night
R1	109.5	POW - Level 36 Tower A - South Façade	63	55	60	53
R5	13.5	OLA - Level 4 Tower A - Outdoor Amenity	59	**N/A***	56	**N/A***

*Noise levels during the nighttime are not considered for OLAs

5.1.1 Noise Control Measures

The results indicate that upgraded building components will not be required for Tower A, as noise levels predicted due to transportation traffic do not exceed the criteria of 65 dBA during the daytime. Central air conditioning will be required for all units. In addition, a Type D Warning Clause will also be required in all Lease, Purchase and Sale Agreements, as summarized in section 6.

The results also indicate that noise levels at the at-grade amenity area and the Level 4 amenity terraces are expected to be between 51 dBA and 56 dBA, respectively. Since the noise levels at the at-grade amenity are below 55 dBA, no acoustic mitigation is required. As noise levels at the Level 4 outdoor amenity are slightly above 55 dBA, further analysis was conducted to investigate the noise mitigating impact of raising the perimeter guards from 1.0 m to 2.0 m above the walking surface (see Table 5). The preferred barrier height for the level 5 central amenity area is associated with the noise levels in **bold** font in Table 5. As noise levels at the Level 4 amenity terraces do not exceed 60 dBA, acoustic mitigation in the form of a 1.5 m tall noise screen surrounding the northeast, east, and southwest perimeter is recommended but not required. If no mitigation is provided, a Type A Warning Clause will also be required in all Lease, Purchase and Sale Agreements, as summarized in Section 6. Figure 4 illustrates the proposed barrier location.

TABLE 5: RESULTS OF NOISE BARRIER INVESTIGATION

Receptor Number	Receptor Location	Daytime L_{eq} Noise Levels (dBA)			
		No Barrier	With 1.0m Barrier	With 1.5m Barrier	With 2.0m Barrier
5	OLA - Level 4 Tower A Outdoor Amenity	56	56	**55**	53

5.2 Ground Vibrations and Ground-Borne Noise Levels

Estimated vibration levels at the foundation nearest to the OC Transpo LRT Confederation Line are expected to be 0.044 mm/s RMS (65 dBV), based on the FTA protocol and an offset distance of 32 m to the nearest track centerline. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.14 mm/s RMS at the foundation, concerns due to vibration impacts on the site are not expected. As vibration levels are acceptable, correspondingly, regenerated noise levels are also expected to be acceptable.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the current analysis indicate that noise levels will range between 48 and 60 dBA during the daytime period (07:00-23:00) and between 41 and 53 dBA during the nighttime period (23:00-07:00). The highest noise level (60 dBA) occurs at the south façade of Tower A, which is nearest and most exposed to Richmond Road. Figures 5 and 6 illustrate daytime and nighttime noise contours of the site 4.5 m above grade.

The results indicate that upgraded building components will not be required for Tower A, as noise levels predicted due to transportation traffic do not exceed the criteria of 65 dBA during the daytime. Central air conditioning will be required for all units. In addition, a Type D Warning Clause will also be required in all Lease, Purchase and Sale Agreements, as summarized in below.

Type D:

"This dwelling unit has been supplied with a central air conditioning system which will allow windows and exterior doors to remain closed, thereby ensuring that the indoor sound levels are within the sound level limits of the Municipality and the Ministry of the Environment."

The results also indicate that noise levels at the at-grade amenity area and the Level 4 amenity terraces are expected to be between 51 dBA and 56 dBA, respectively. Since the noise levels at the at-grade amenity are below 55 dBA, no acoustic mitigation is required. As noise levels at the Level 4 outdoor amenity are slightly above 55 dBA, acoustic mitigation in the form of a 1.5 m tall noise screen surrounding the northeast, east, and southwest perimeter is recommended but not required. If no mitigation is provided, a Type A Warning Clause will also be required in all Lease, Purchase and Sale Agreements, as summarized in below.

Type A:

"Purchasers/tenants are advised that sound levels due to increasing road traffic (rail traffic) (air traffic) may occasionally interfere with some activities of the dwelling occupants as the sound levels exceed the sound level limits of the Municipality and the Ministry of the Environment."

As the development is adjacent to a future proposed LRT line and station, the Rail Construction Program Office recommends that the warning clause identified below be included in all Lease, Purchase and Sale Agreements.

"The Owner hereby acknowledges and agrees:

i) The proximity of the proposed development of the lands described in Schedule "A" hereto (the "Lands") to the City's existing and future transit operations, may result in noise, vibration, electromagnetic interferences, stray current transmissions, smoke and particulate matter (collectively referred to as "Interferences") to the development;

ii) *It has been advised by the City to apply reasonable attenuation measures with respect to the level of the Interferences on and within the Lands and the proposed development; and*

iii) *The Owner acknowledges and agrees all agreements of purchase and sale and lease agreements, and all information on all plans and documents used for marketing purposes, for the whole or any part of the subject lands, shall contain the following clauses which shall also be incorporated in all transfer/deeds and leases from the Owner so that the clauses shall be covenants running with the lands for the benefit of the owner of the adjacent road:*

'The Transferee/Lessee for himself, his heirs, executors, administrators, successors and assigns acknowledges being advised that a public transit light-rail rapid transit system (LRT) is proposed to be located in proximity to the subject lands, and the construction, operation and maintenance of the LRT may result in environmental impacts including, but not limited to noise, vibration, electromagnetic interferences, stray current transmissions, smoke and particulate matter (collectively referred to as the Interferences) to the subject lands. The Transferee/Lessee acknowledges and agrees that despite the inclusion of noise control features within the subject lands, Interferences may continue to be of concern, occasionally interfering with some activities of the occupants on the subject lands.

The Transferee covenants with the Transferor and the Lessee covenants with the Lessor that the above clauses verbatim shall be included in all subsequent lease agreements, agreements of purchase and sale and deeds conveying the lands described herein, which covenants shall run with the lands and are for the benefit of the owner of the adjacent road.'"

Estimated vibration levels at the foundation nearest to the OC Transpo LRT Confederation Line are expected to be 0.044 mm/s RMS (65 dBV), based on the FTA protocol and an offset distance of 32 m to the nearest track centerline. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.14 mm/s RMS at the foundation, concerns due to vibration impacts on the site are not expected. As vibration levels are acceptable, correspondingly, regenerated noise levels are also expected to be acceptable.

With regard to stationary noise impacts from proposed mechanical systems on the building, they will be designed to ensure compliance with the ENCG sound level limits. Noise impacts can generally be minimized by judicious selection and placement of the equipment. Where necessary, noise screens and silencers can be placed into the design. It is recommended a stationary noise study be conducted once mechanical plans for the proposed building become available. This study would assess the impacts of stationary noise from rooftop mechanical units serving the proposed building on surrounding noise-sensitive areas.

This concludes our transportation noise and vibration 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,

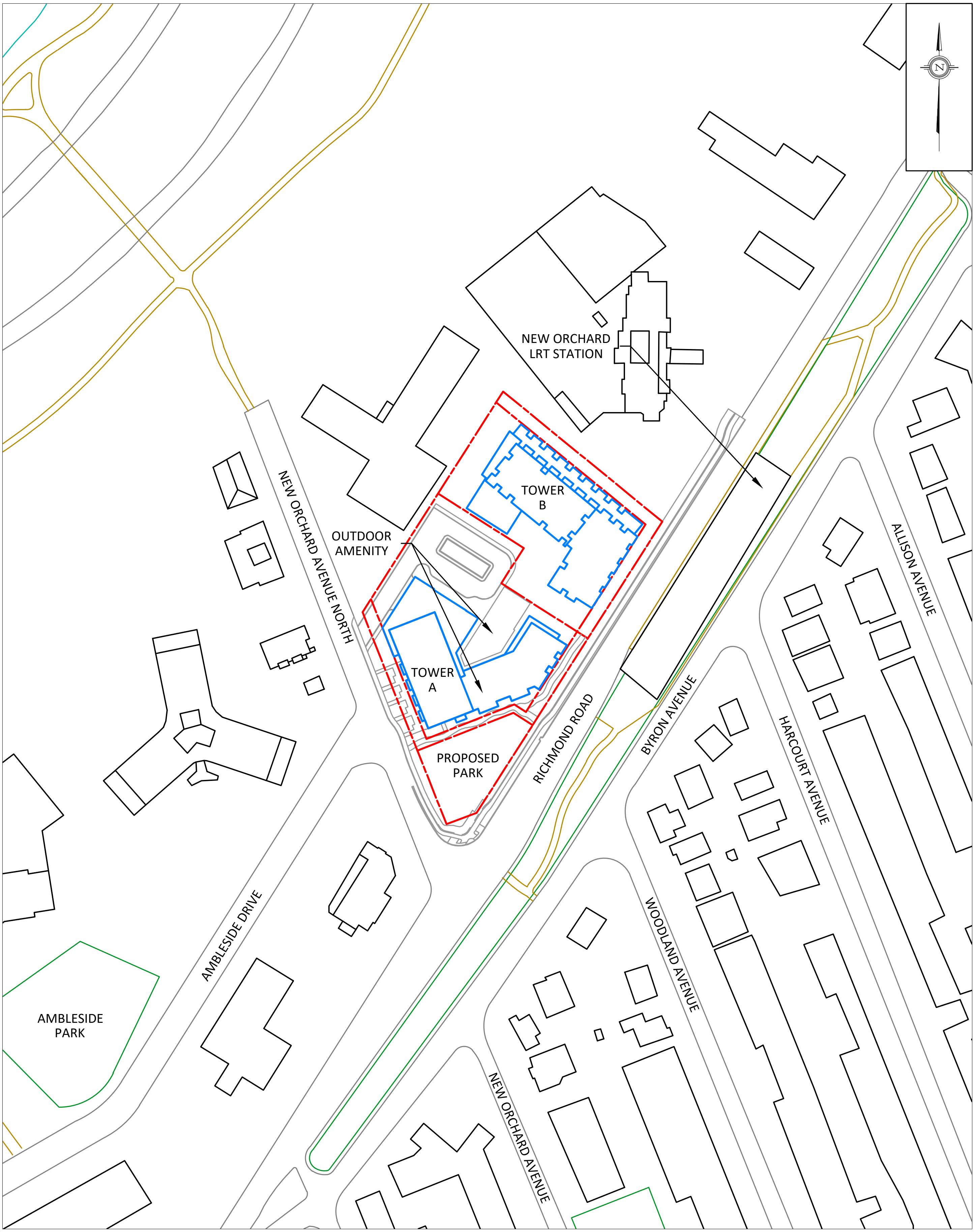
Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. R. FOSTER
100155655
Sep 9, 2024
PROVINCE OF ONTARIO

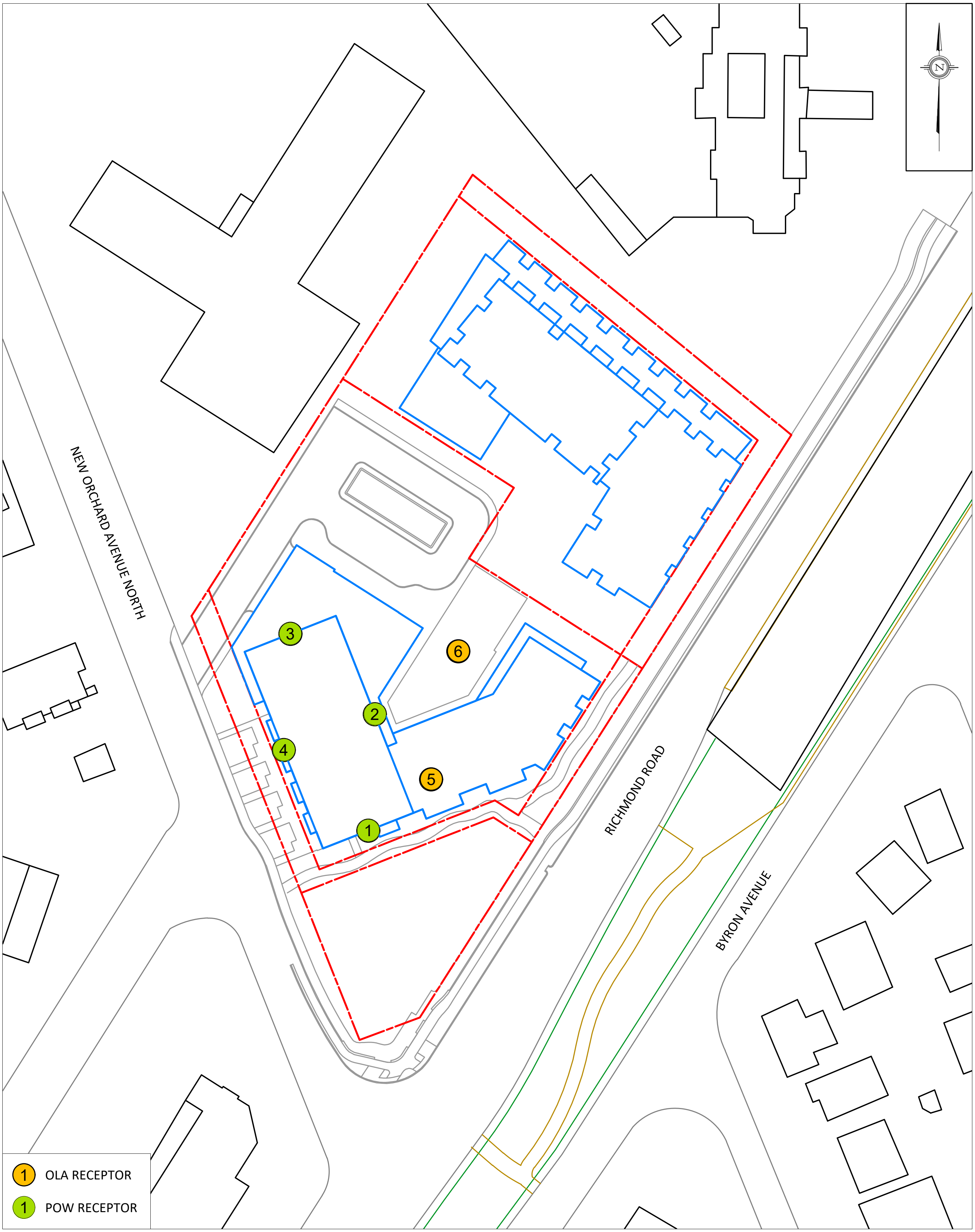
Benjamin Page, AdvDip.
Junior Environmental Scientist

Joshua Foster, P.Eng.
Lead Engineer

Gradient Wind File 21-416- Transportation and Vibration



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD, OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT: 1047 RICHMOND ROAD, OTTAWA TRANSPORTATION NOISE AND VIBRATION ASSESSMENT		DESCRIPTION: FIGURE 1: PROPOSED SITE PLAN AND SURROUNDING CONTEXT
	SCALE: 1:2000	DRAWING NO. 21-416-1	
	DATE: SEPTEMBER 5, 2024	DRAWN BY: B.P.	



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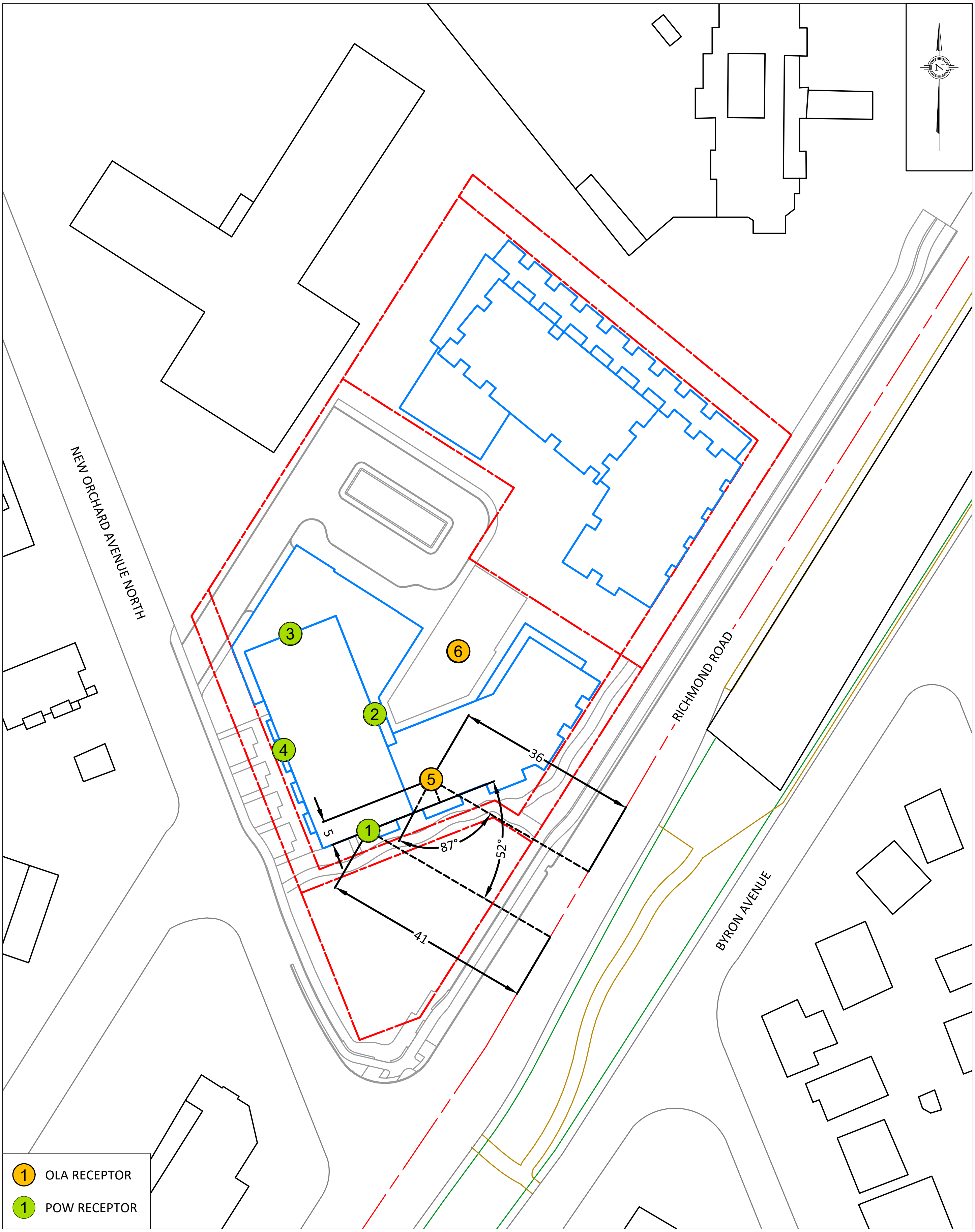
PROJECT	1047 RICHMOND ROAD, OTTAWA TRANSPORTATION NOISE AND VIBRATION ASSESSMENT		
SCALE	1:1000	DRAWING NO.	21-416-2
DATE	SEPTEMBER 5, 2024	DRAWN BY	B.P.

DESCRIPTION

FIGURE 2:
RECEPTOR LOCATIONS



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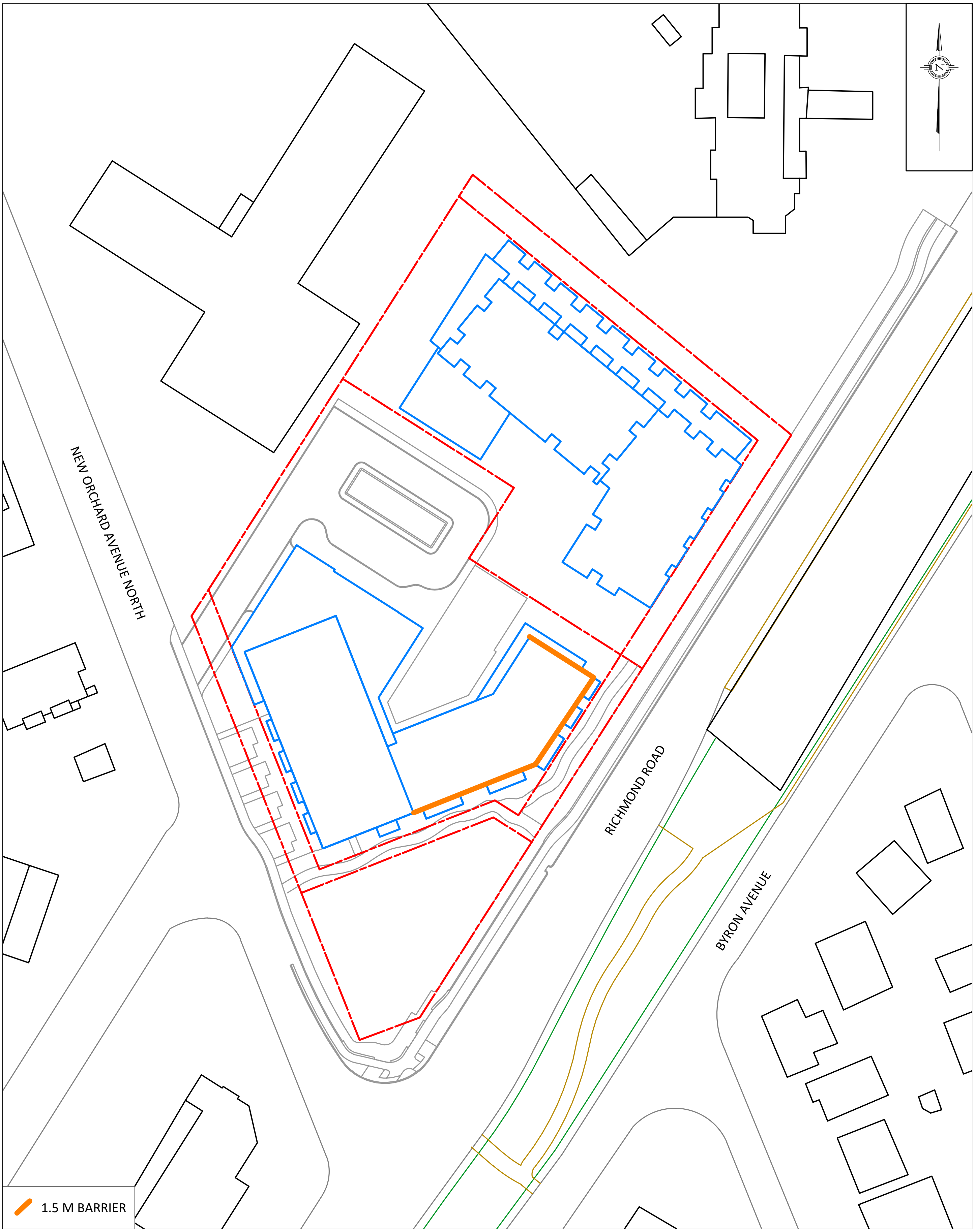
PROJECT		DESCRIPTION
1047 RICHMOND ROAD, OTTAWA TRANSPORTATION NOISE AND VIBRATION ASSESSMENT		FIGURE 3: STAMSON 5.04 INPUT DATA
SCALE: 1:1000	DRAWING NO.: 21-416-3	
DATE: SEPTEMBER 5, 2024	DRAWN BY: B.P.	



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PROJECT		DESCRIPTION
1047 RICHMOND ROAD, OTTAWA TRANSPORTATION NOISE AND VIBRATION ASSESSMENT		FIGURE 4: PROPOSED BARRIER LOCATION
SCALE: 1:1000	DRAWING NO.: 21-416-4	
DATE: SEPTEMBER 5, 2024	DRAWN BY: B.P.	

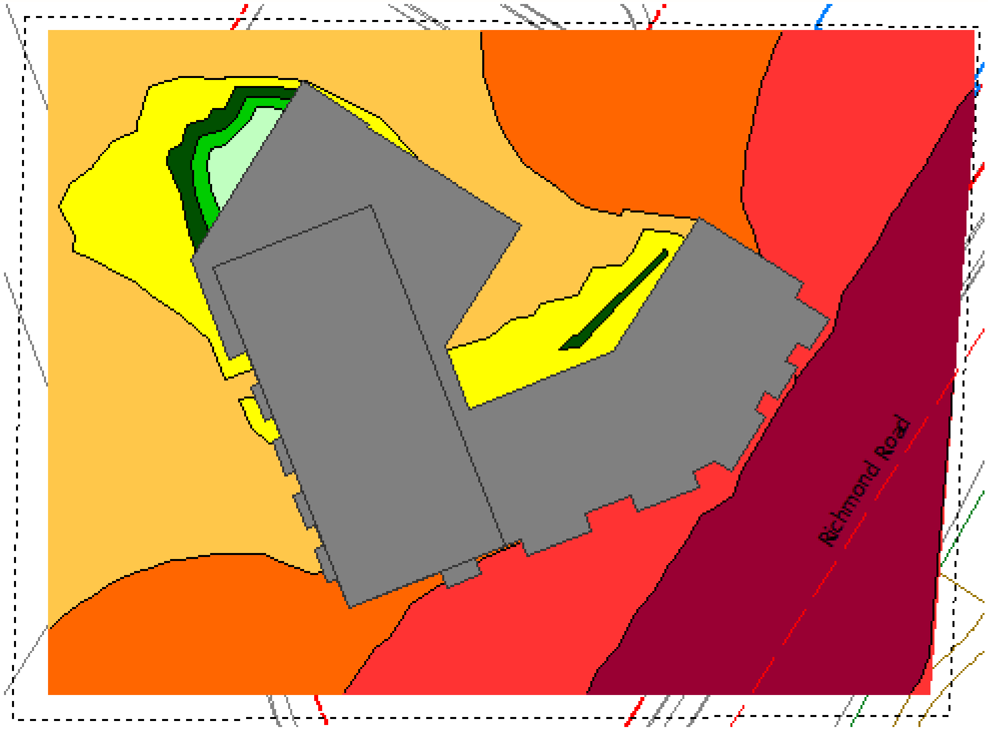


FIGURE 5: DAYTIME TRANSPORTATION NOISE CONTOURS (4.5 M ABOVE GRADE)

80 – 85 dB
75 – 80 dB
70 – 75 dB
65 – 70 dB
60 – 65 dB
55 – 60 dB
50 – 55 dB
45 – 50 dB
40 – 45 dB
35 – 40 dB
0 – 35 dB

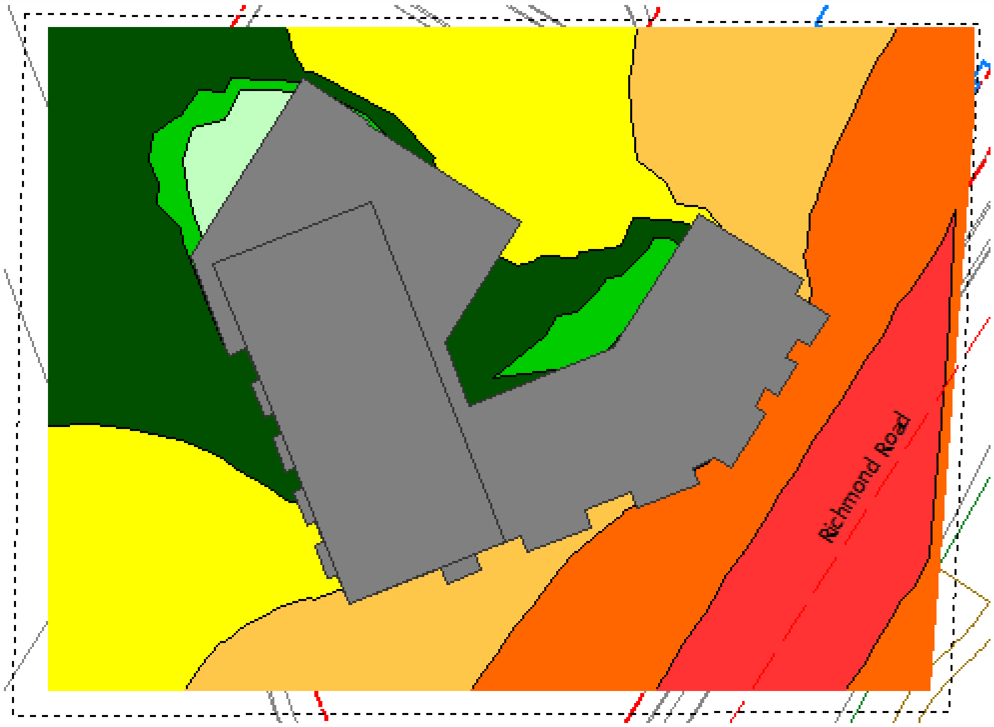
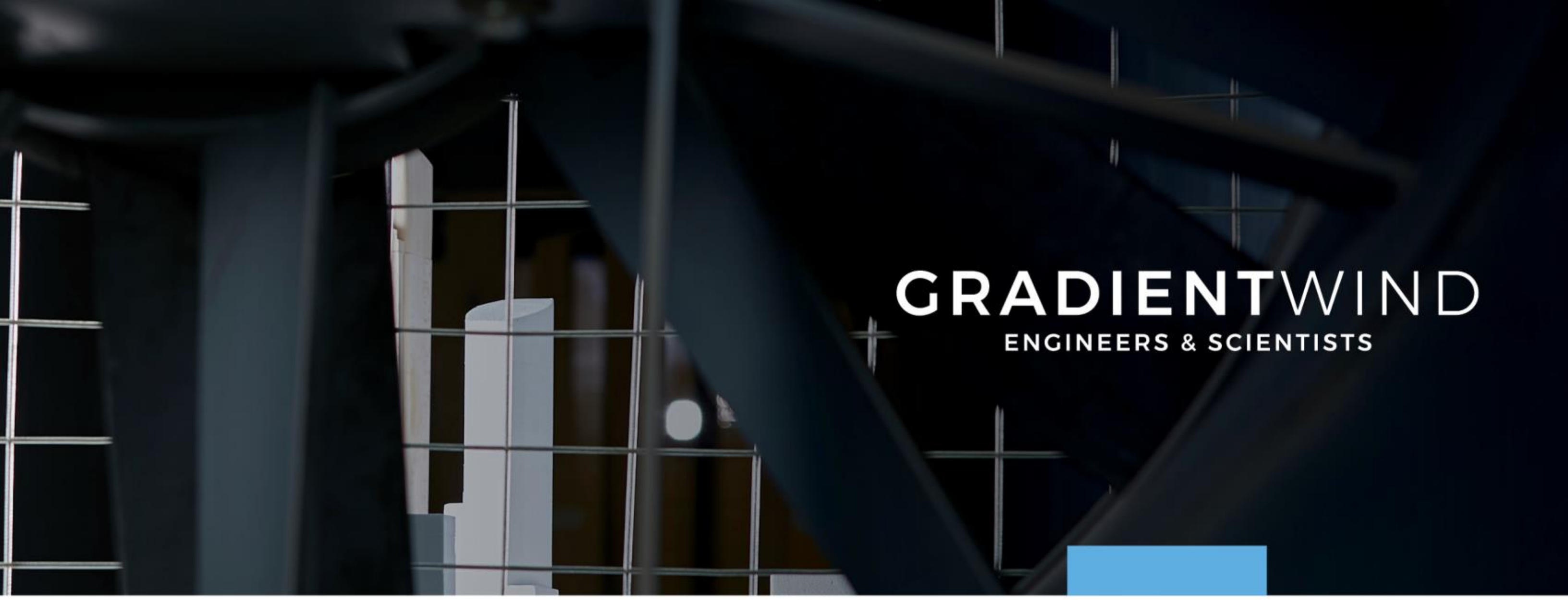
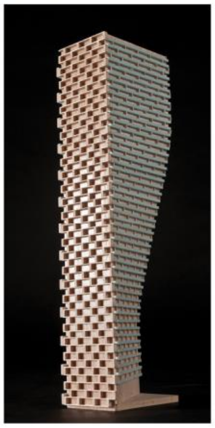
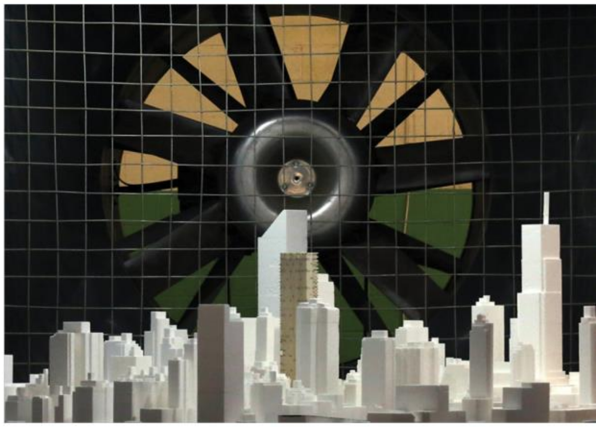


FIGURE 6: NIGHTTIME TRANSPORTATION NOISE CONTOURS (4.5 M ABOVE GRADE)

80 – 85 dB
75 – 80 dB
70 – 75 dB
65 – 70 dB
60 – 65 dB
55 – 60 dB
50 – 55 dB
45 – 50 dB
40 – 45 dB
35 – 40 dB
0 – 35 dB







APPENDIX A

STAMSON SAMPLE CALCULATIONS

127 WALGREEN ROAD, OTTAWA, ON, CANADA K0A 1L0 | 613 836 0934
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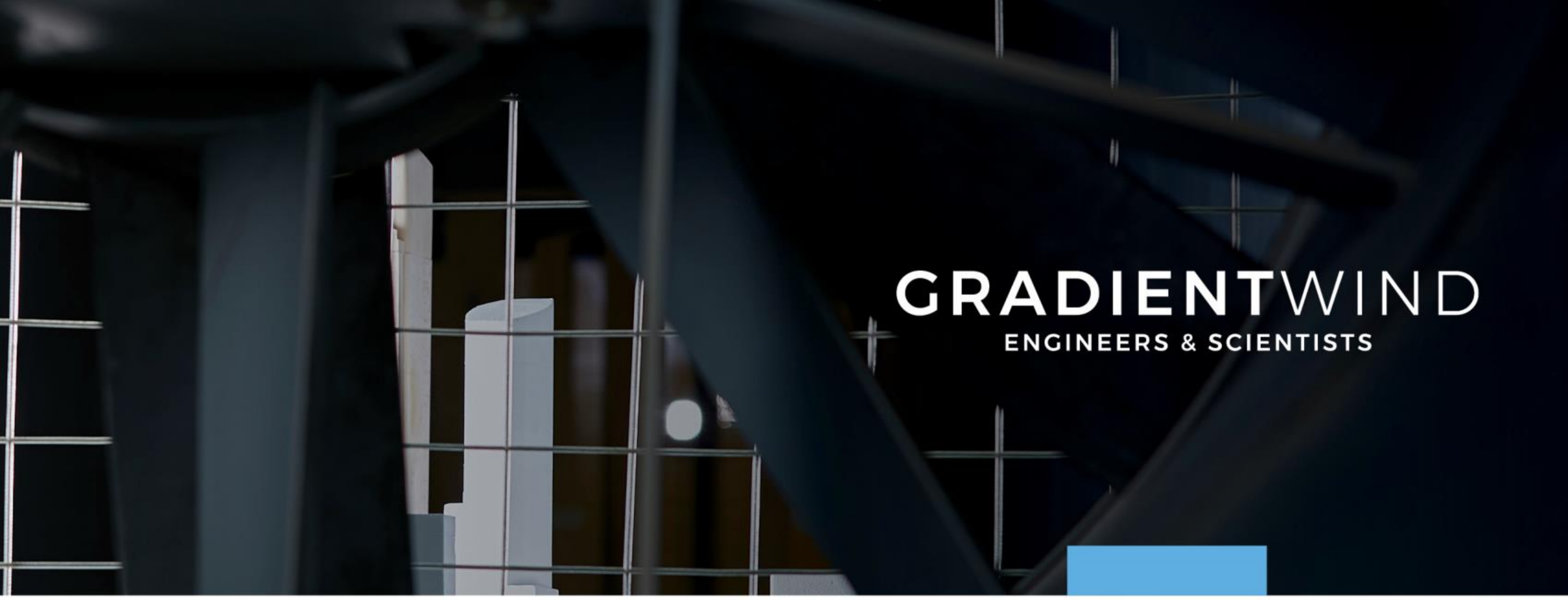
```
STAMSON 5.0        NORMAL REPORT        Date: 24-07-2024 12:23:21
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: R1.te                 Time Period: Day/Night 16/8 hours
Description:

Road data, segment # 1: Richmond Rd (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: Richmond Rd (day/night)
---------------------------------------------
Angle1   Angle2           : -52.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  41.00 / 41.00  m
Receiver height           : 118.50 / 118.50 m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00

Results segment # 1: Richmond Rd (day)
--------------------------------------

Source height = 1.50 m

ROAD (0.00 + 63.08 + 0.00) = 63.08 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -52     90   0.00  68.48   0.00  -4.37  -1.03   0.00   0.00   0.00  63.08
----------------------------------------------------------------------------

Segment Leq : 63.08 dBA

Total Leq All Segments: 63.08 dBA
```

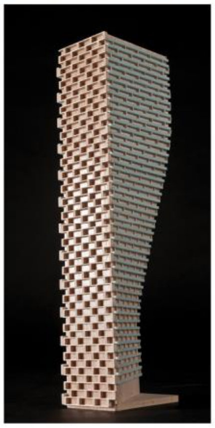
```
Results segment # 1: Richmond Rd (night)
----------------------------------------

Source height = 1.50 m

ROAD (0.00 + 55.49 + 0.00) = 55.49 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -52     90   0.00  60.88   0.00  -4.37  -1.03   0.00   0.00   0.00  55.49
----------------------------------------------------------------------------

Segment Leq : 55.49 dBA

Total Leq All Segments: 55.49 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 63.08
                         (NIGHT): 55.49
```

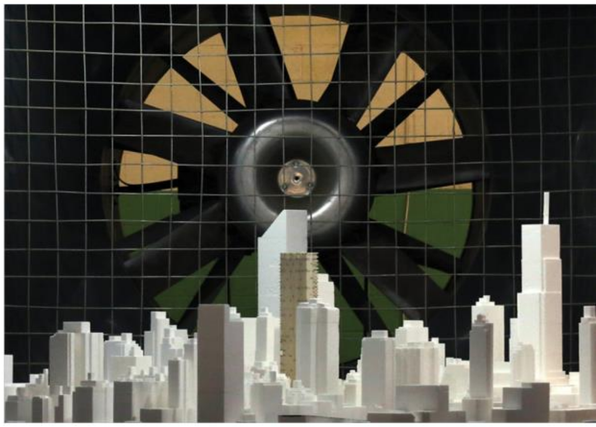
```
STAMSON 5.0        NORMAL REPORT        Date: 29-08-2024 14:38:18
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: R5.te                Time Period: Day/Night 16/8 hours
Description:

Road data, segment # 1: Richmond Rd (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: Richmond Rd (day/night)
---------------------------------------------
Angle1   Angle2           : -90.00 deg   87.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  36.00 / 36.00  m
Receiver height           :  13.50 / 13.50  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 87.00 deg
Barrier height            :  12.00 m
Barrier receiver distance :   5.00 / 5.00   m
Source elevation          :   0.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

```
Results segment # 1: Richmond Rd (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 !       13.50 !       11.83 !         11.83

ROAD (0.00 + 59.51 + 0.00) = 59.51 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     87   0.00  68.48   0.00  -3.80  -0.07   0.00   0.00  -5.09  59.51
----------------------------------------------------------------------------

Segment Leq : 59.51 dBA

Total Leq All Segments: 59.51 dBA

Barrier table for segment # 1: Richmond Rd (day)
------------------------------------------------

Barrier ! Elev of !  Road    ! Tot Leq !
Height  ! Barr Top!  dBA     !   dBA   !
--------+---------+---------+---------+
  13.00 !   13.00 !   56.42 !   56.42 !
  13.50 !   13.50 !   54.60 !   54.60 !
  14.00 !   14.00 !   52.99 !   52.99 !
  14.50 !   14.50 !   51.61 !   51.61 !
  15.00 !   15.00 !   50.39 !   50.39 !
  15.50 !   15.50 !   49.33 !   49.33 !
  16.00 !   16.00 !   48.49 !   48.49 !
  16.50 !   16.50 !   47.84 !   47.84 !
  17.00 !   17.00 !   47.34 !   47.34 !
  17.50 !   17.50 !   46.94 !   46.94 !
```

```
Results segment # 1: Richmond Rd (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 !        13.50 !        11.83 !         11.83

ROAD (0.00 + 51.91 + 0.00) = 51.91 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90     87   0.00  60.88   0.00  -3.80  -0.07   0.00   0.00  -5.09  51.91
----------------------------------------------------------------------------

Segment Leq : 51.91 dBA

Total Leq All Segments: 51.91 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 59.51
                         (NIGHT): 51.91
```







APPENDIX B

FTA VIBRATION CALCULATIONS

127 WALGREEN ROAD, OTTAWA, ON, CANADA K0A 1L0 | 613 836 0934
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GW21-416 13-Aug-24

Possible Vibration Impacts
Predicted using FTA General Assesment

Train Speed 70 km/h 43 mph

	Distance from C/L	
	(m)	(ft)
LRT	32.0	105.0

Vibration

From FTA Manual Fig 10-1

Vibration Levels at distance from track	67	dBV re 1 micro in/sec

Adjustment Factors FTA Table 10-1

Speed reference 50 mph	-1.30	Speed Limit of 70 km/h (43 mph)
Vehicle Parameters	0	Assume Soft primary suspension, Wheels run true
Track Condition	0	None
Track Treatments	0	None
Type of Transit Structure	-5	Station
Efficient vibration Propagation	0	None
Vibration Levels at Fdn	61	
Coupling to Building Foundation	0	Bear on bedrock
Floor to Floor Attenuation	-2.0	Ground Floor Occupied
Amplification of Floor and Walls	6	
Total Vibration Level	64.7	dBV or 0.044 mm/s
Noise Level in dBA	29.7	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**
		Reference Speed		
Speed	Vehicle Speed	50 mph	30 mph	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$_{ref}$).
	60 mph	+1.6 dB	+6.0 dB	
	50 mph	0.0 dB	+4.4 dB	
	40 mph	-1.9 dB	+2.5 dB	
	30 mph	-4.4 dB	0.0 dB	
	20 mph	-8.0 dB	-3.5 dB	
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.