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Geotechnical Engineering

Environmental Engineering

Hydrogeology

Geological Engineering

Materials Testing

Building Science

Noise and Vibration Studies

Confederation Line Level 2 Proximity Study

Proposed Multi-Storey Building
797 Richmond Road
Ottawa, Ontario

Prepared For

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May 17, 2021

Report: PG5719-2

1.0 Introduction

Paterson Group (Paterson) was commissioned by Dentech Holdings (Dentech) to conduct a Confederation Line Level 2 Proximity Study for the proposed multi-storey building to be located at 797 Richmond Road, in the City of Ottawa.

The objectives of the current study were to:

- ❑ Review all current information provided by the City of Ottawa with regards to the construction of the Confederation Line.

- ❑ Liason between the City of Ottawa and the Dentech consultant team involved with the aforementioned project.

The following report has been prepared specifically and solely for the aforementioned project which is described herein. It contains a collaboration of civil, structural and geotechnical design information as they pertain to the aforementioned project. The final draft of the noise study prepared by others was not available at the time of issuance of this report.

2.0 Development Details

It is understood that the proposed development at 797 Richmond Road will consist of a multi-storey residential building with two levels of underground parking. The development will also include associated access lanes and landscaped areas. The proposed underground parking structure for the proposed building is setback approximately 4 m from the City of Ottawa Right-of-Way along Richmond Road. The design underside of footing elevation is anticipated to be approximately 58 m and will be founded upon sound bedrock or lean concrete filled trenches extending to the bedrock surface.

At the time of submission, it is understood that the City of Ottawa proposes that the Confederation Line be constructed in close proximity to the proposed development. Current design details regarding the Confederation Line were not provided to Paterson at the time of submission. For purposes of top of tunnel and top of rail elevations, City of Ottawa Confederation Line West LRT Extension drawings dated June 2, 2016 were used. For the purposes of the tunnel alignment, the rail implementation O-Train layer was referenced on GeoOttawa.

Therefore, several assumptions will be made assuming a 'worst case' scenario regarding the Confederation Line with respect to the proposed development. The following was assumed about the Confederation Line:

- The Confederation Line alignment will be located below Richmond Road and the existing pathway and landscaped area adjacent to Richmond Road, approximately 25 m south of the subject site.

- The Confederation Line will be below ground, with the top of the tunnel located approximately 10 m below the existing ground surface (56 m - geodetic elevation). The top of rail elevation is anticipated to be approximately 50 m.

- Based on the subsurface profile at 797 Richmond Road, bedrock is assumed to be at approximate geodetic elevation of 58 m depth below the existing ground surface. Therefore, the Confederation Line will be drilled through bedrock.

- Sherbourne Station is proposed to be located approximately 27 m south-west of the proposed development.

3.0 Construction Methodology and Impact Review

Paterson has prepared a construction methodology summary along with possible impacts on the adjacent segment of the Confederation Line based on the current building design details. The Construction Methodology and Impact Review is provided in Appendix A and presents the anticipated construction items, impact review and a mitigation program recommended for the Confederation Line. One of the main issues will be vibrations associated with the bedrock blasting removal program. It is recommended that a vibration monitoring program be implemented to ensure vibration levels remain below recommended tolerances. Details of a recommended vibration monitoring program are presented below.

3.1 Vibration Monitoring and Control Program

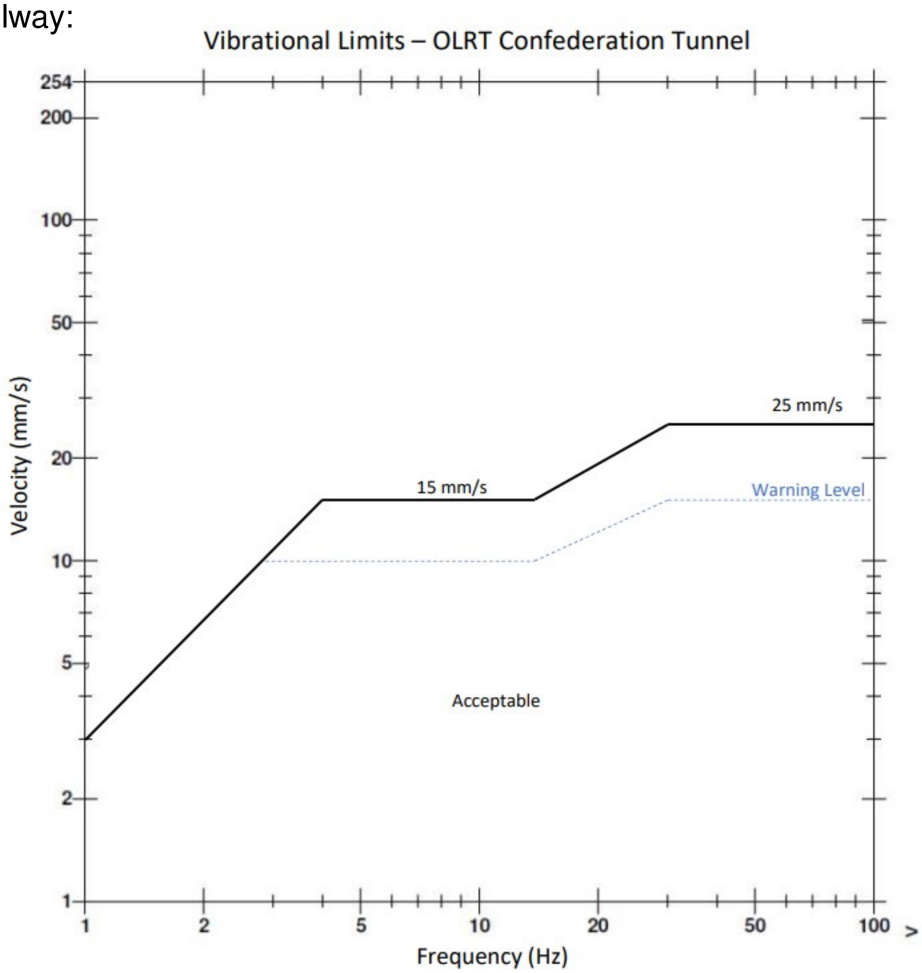
Due to the presence of the construction of the proposed Confederation Tunnel, the contractor should take extra precaution to minimize vibrations. The vibration monitoring program will be required for the full construction duration for blasting operations, dewatering, backfilling and compaction, construction traffic and other construction activities. The purpose of the Vibration Monitoring and Control Program (VMCP) is to provide a description of the measures to be implemented by the contractor to manage excavation operations and any other vibration sources during the construction for the proposed development. The VMCP will also provide a guideline for assessing results against the relevant vibration impact assessment criteria and recommendations to meet the required limits.

The monitoring program will incorporate real time results at the Confederation Tunnel, which is located in the general vicinity of the subject site. The monitoring equipment should consist of a tri-axial seismograph, capable of measuring vibration intensities up to 254 mm/s at a frequency response of 2 to 250 Hz. The monitoring equipment should be placed in the tunnel.

The location should be reviewed periodically throughout construction to ensure that the monitoring equipment remains at the closest radius to the construction activities. The vibration monitor locations should be approved by the project manager prior to installation. During construction, the vibration monitor will be relocated for the 'worst case' location for each construction activity. When an event is triggered, Paterson will review the results and provide any necessary feedback. Otherwise, the vibration results will be summarized in the weekly report.

Proposed Vibration Limits

The following figure outlines the recommended vibration limits for the Confederation Line railway:



The excavation operations should be planned and conducted under the supervision of a licensed professional engineer who is an experienced bedrock excavation consultant.

Monitoring Data

The monitoring protocol should include the following information:

Trigger Level Event

- ❏ Paterson will review all vibrations over the established warning level, illustrated by the blue line in the above figure, and;
- ❏ Paterson will notify the contractor if any vibrations occur due to construction activities and are close to exceedance level.

Exceedance Level Event

- ❏ Paterson will notify all the relevant stakeholders via email if any vibrations surpass the exceedance level, illustrated by the black line in the above figure.
- ❏ Ensure monitors are functioning
- ❏ Issue the vibration exceedance result

The data collected should include the following:

- ❏ Measured vibration levels
- ❏ Distance from the construction activity to monitoring location
- ❏ Vibration type

Monitoring should be compliant with all related regulations.

3.2 Incident/Exceedance Reporting

In case an incident/exceedance occurs from construction activities, the Senior Project Management and any relevant personnel should be notified immediately. A report should be completed which contains the following:

- ❏ Identify the location of vibration exceedance
- ❏ The date, time and nature of the exceedance/incident
- ❏ Purpose of the exceeded monitor and current vibration criteria
- ❏ Identify the likely cause of the exceedance/incident
- ❏ Describe the response action that has been completed to date
- ❏ Describe the proposed measures to address the exceedance/incident.

The contractor should implement mitigation measures for future excavation or any construction activities as necessary and provide updates on the effectiveness of the improvement. Response actions should be pre-determined prior to excavation, depending on the approach provided to protect elements. Processes and procedures should be in-place prior to completing any vibrations to identify issues and react in a quick manner in the event of an exceedance.

4.0 Proximity Study Requirement Responses

Paterson was informed by the City of Ottawa that a Level 2 Confederation Line Proximity Study should be completed for the proposed development. A Level 2 Confederation Line Proximity Study is required where the proposed development is located within the City of Ottawa's Development Zone of Influence.

The following table lists the applicable requirements for Level 1 and Level 2 study and the response location for each item:

Table 1 - List of Confederation Line Proximity Study Requirements

Level 1 Projects	Response
A site plan of the development with the centreline or reference line of the Confederation Line structure and/or right-of-way located and the relevant distances between the Confederation Line and developer's structure shown clearly;	See Confederation Line Proximity Plan (Drawing No. PG5719-2 dated May 2021) presented in Appendix A.
Plan and cross-sections of the development locating the Confederation Line structure/right-of-way and founding elevations relative to the development, including any underground storage tanks and associated piping;	Refer to the Confederation Line Proximity Plan (Drawing No. PG5719-2 dated May 2021) and Cross-Section A-A' (Drawing No. PG5719-3 dated May 2021) presented in Appendix A.
A geotechnical investigation report showing up-to-date geotechnical conditions at the site of the development. The geotechnical investigation shall be prepared in accordance with the Geotechnical Investigation and Reporting Guidelines for Development Applications in the City;	Refer to Geotechnical Investigation: Paterson Group Report PG5719-1 dated April 26, 2021 presented in Appendix B.
Structural, foundation, excavation and shoring drawings;	Structural, foundation, excavation and shoring drawings will be provided prior to the Site Plan Agreement. Based on available design details, the proposed building foundation will consist of conventional footings placed directly over a clean, bedrock surface or lean concrete filled trench extended to the bedrock surface. No negative impacts are anticipated for the Confederation Line due to the proposed building location.

Acknowledgment that the potential for noise, vibration, electro-magnetic interference and stray current from Confederation Line operations have been considered in the design of the project, and appropriate mitigation measures applied.	Refer to the draft Transportation Noise Assessment prepared by Gradient Wind Engineers & Scientists dated May 13, 2021 which is presented in Appendix C.
Level 2 Projects	**Response**
A structural analysis or calculations of the effects of loadings, including construction loading, on the Confederation Line structure, and demonstrating that the Confederation Line will not be adversely affected by the development, including solutions to mitigate any impact on the Confederation Line structure.	No building loads will be imposed on the subject alignment of the Confederation Line due to the presence of sound bedrock at founding level of the proposed building and construction of the Confederation Line taking place greater than 25 m away from the building foundation through sound bedrock. Refer to Cross-Section A-A' (Drawing No. PG5719-3 dated May 2021) and the Proximity Assessment Report PG5719-LET.01 dated May 17, 2021 presented in Appendix D.
Documentation showing that the excavation support system and permanent structure adjacent to the Confederation Line property are designated for at-rest earth pressures.	Temporary shoring system will be designed to at-rest earth pressures as required by the site Geotechnical Investigation Report. Temporary shoring drawings will be submitted once they are finalized.
Structural drawings, including foundation plans, sections and details, floor plans, column and wall schedules and loads on foundation for the development. The relationship of the development to the Confederation Line structure should be depicted in both plan and section;	No building loads will be imposed on the subject alignment of the Confederation Line due to the presence of sound bedrock at founding level of the proposed building and construction of the Confederation Line taking place greater than 25 m away from the building foundation through sound bedrock. Refer to the Confederation Line Proximity Plan (Drawing No. PG5719-2 dated May 2021) and Cross-Section A-A' (Drawing No. PG5719-3 dated May 2021) presented in Appendix A, as well as the Proximity Assessment Report PG5719-LET.01 dated May 17, 2021 presented in Appendix D. Structural drawings will be submitted once they are finalized.
Shoring design criteria and description of excavation and shoring method;	The temporary shoring system for the proposed development will consist of soldier piling and lagging. Additional shoring design criteria are provided in the aforementioned Geotechnical Investigation Report. The temporary shoring drawings will be submitted once they are finalized.

Groundwater control plan, including the determination of the short-term (during construction) and long-term effects of dewatering on the Confederation Line structure, and provision of assurances that the influences of dewatering will have no impact on the Confederation Line structure;	The Confederation Line is located below the proposed development and is understood to be bearing on bedrock. Therefore, no groundwater lowering effects on the Confederation Line due to the proposed development are anticipated. Refer to Proximity Assessment Report PG5719-LET.01 dated May 17, 2021 presented in Appendix D.
Proposal to replace/repair waterproofing system of the affected Confederation Line structure, including the Confederation Line expansion joint;	As noted above, there will be at least a 25 m buffer between the proposed Confederation Line and the proposed building at 797 Richmond Road. Therefore, the replace/repair of the waterproofing system is not applicable.
Identification of utility installations proposed through or adjacent to Confederation Line property.	At the time of writing this report, the utility design is not known. These plans will be forwarded once they are completed.
Identification of the exhaust air quality and relationship of air in-take/discharge to the Confederation Line at-grade vent shaft openings and station entrance openings.	At the time of writing this report, the mechanical design is not known. These plans will be forwarded once they are completed.
Proposal for a pre-construction condition survey of the Confederation Line structure, including a survey to confirm locations of existing walls and foundations;	A thorough pre-construction condition survey of the Confederation Line will be completed prior to the start of construction at 797 Richmond Road.
Monitoring plan for movement of the shoring and Confederation Line structure prior to and during construction of the development, including an Action Protocol.	A monitoring plan for the movement of the temporary shoring system adjacent of the Confederation Line will be completed prior to construction and will be included with the temporary shoring drawing submission.

We trust that this information satisfies your immediate request.

Paterson Group Inc.

Nicole R.L. Patey, B.Eng.

Scott S. Dennis, P.Eng.

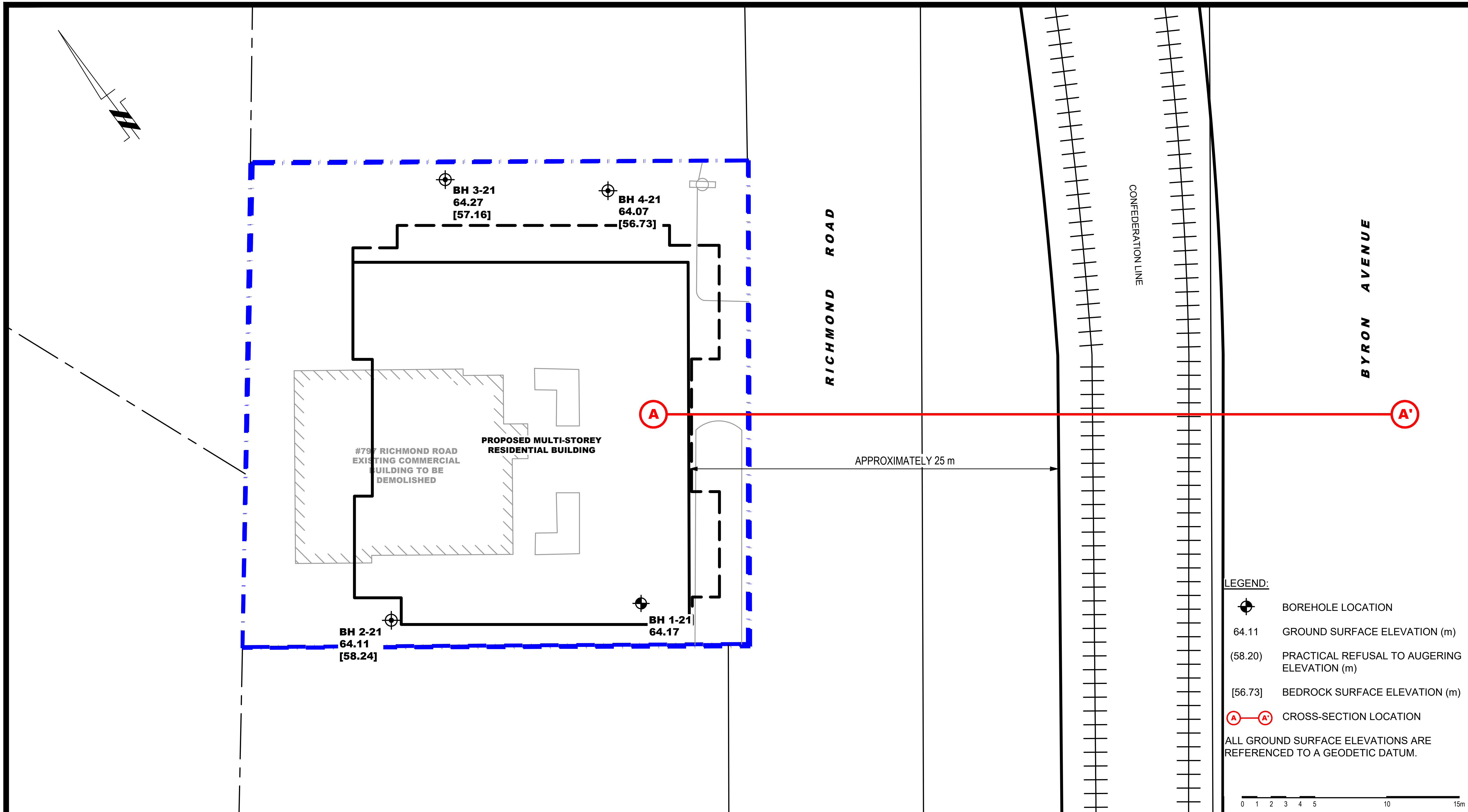
APPENDIX A

Confederation Line Proximity Plan

Cross Section A-A’

Topographic Survey Plan

Construction Methodology and Impact Review



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NO.	REVISIONS	DATE	INITIAL

DENTECH HOLDINGS
CONFEDERATION LINE PROXIMITY STUDY
PROPOSED MULTI-STOREY RESIDENTIAL BUILDING
797 RICHMOND ROAD
OTTAWA, ONTARIO

Title:
CONFEDERATION LINE PROXIMITY PLAN

Scale: 1:250	Date: 05/2021
Drawn by: NFRV	Report No.: PG5719-2
Checked by: NP	Dwg. No.: PG5719-2
Approved by: SD	Revision No.:

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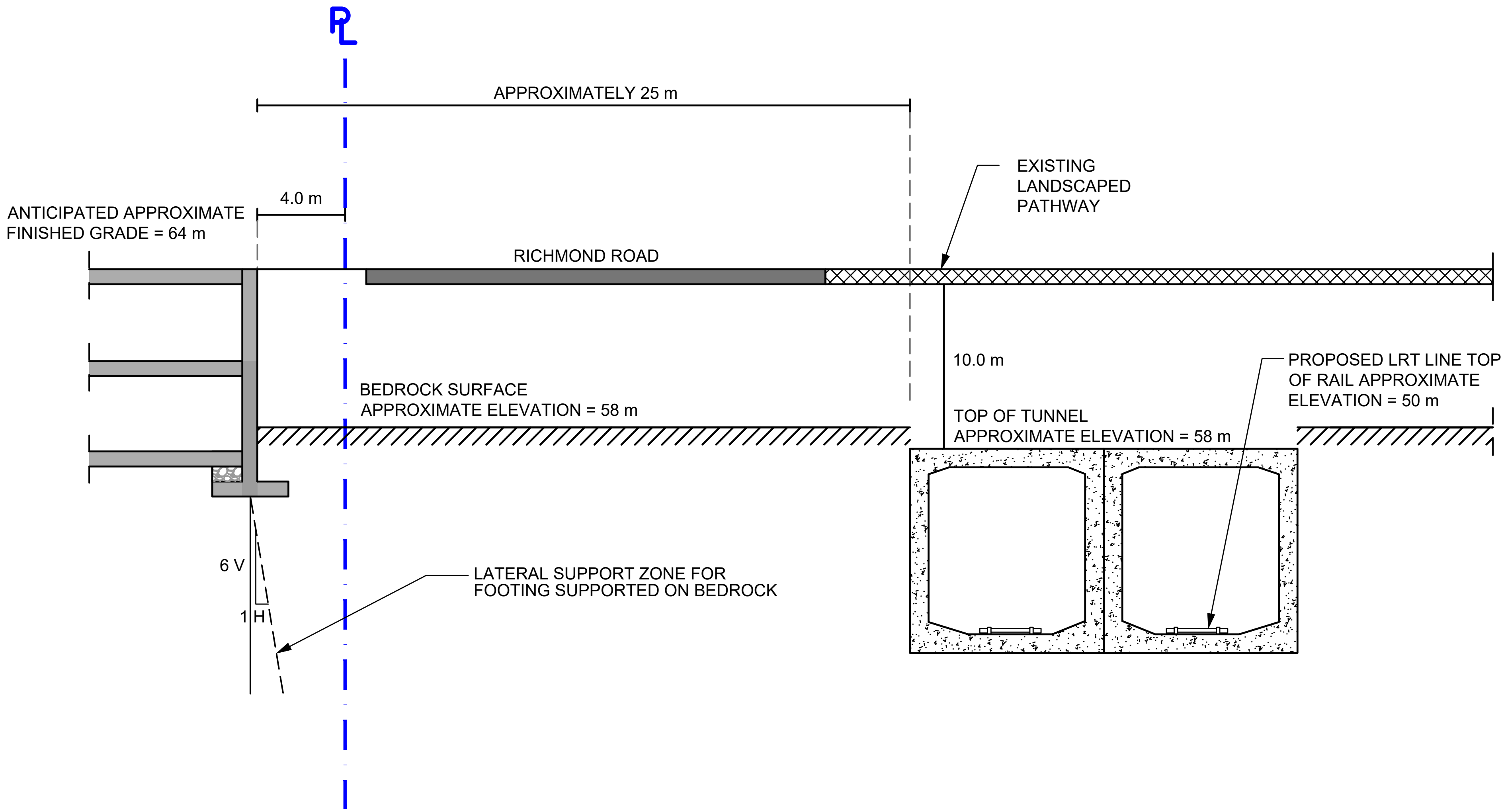
CROSS SECTION A -A '



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DENTECH HOLDINGS

CONFEDERATION RAIL TUNNEL PROXIMITY STUDY
797 RICHMOND ROAD

OTTAWA, ONTARIO

Title:

CROSS SECTION A-A'

Scale: N.T.S.	**Date:** 05/2021
Drawn by: NFRV	**Report No.:** PG5719-2
Checked by: NP	**Drawing No.:** PG5719-3
Approved by: SD	**Revision No.:**

p:\autocad drawings\geotechnical\pg57xx\pg5719\pg5719-3 cross section a-a'.dwg

PLAN OF SURVEY

PART OF LOT 26 AND 27
CONCESSION 1 (OTTAWA FRONT)
Geographic Township Of Nepean
CITY OF OTTAWA

Prepared by Annis, O'Sullivan, Vollebekk Ltd.

Scale 1 : 100

4 3 2 1 0 2 4 Metres

Metric

DISTANCES SHOWN ON THIS PLAN ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048

Surveyor's Certificate

I CERTIFY THAT :

1. This survey and plan are correct and in accordance with the Surveys Act and the Surveyors Act and the regulations made under them.
2. The survey was completed on the 22nd day of October, 2020.

Oct. 26, 2020
Date

Richard R. Gauthier
Ontario Land Surveyor

Notes & Legend

	Denotes	
—□—	"	Survey Monument Planted
—■—	"	Survey Monument Found
SIB	"	Standard Iron Bar
SSIB	"	Short Standard Iron Bar
IB	"	Iron Bar
CP	"	Concrete Pin
CC	"	Cut Cross
(WIT)	"	Witness
Meas.	"	Measured
(AOG)	"	Annis, O'Sullivan, Vollebekk Ltd.
(P1)	"	(AOG) Plan Dated December 29, 2000
(P2)	"	(AOG) Plan Dated June 21, 1999
(P3)	"	Plan 4R-9070
(P4)	"	Plan 4R-11351
(P5)	"	Plan 4R-24451
(P6)	"	Plan 4R-25579
(P7)	"	Plan 4R-25167
◯	"	Deciduous Tree
✳	"	Coniferous Tree
FH	"	Fire Hydrant
WV	"	Water Valve
RW	"	Retaining Wall
MH-B	"	Maintenance Hole (Bell Telephone)
MH-H	"	Maintenance Hole (Hydro)
MH	"	Maintenance Hole (Unidentified)
VC	"	Valve Chamber (Watermain)
— S —	"	Underground Sanitary Sewer
— W —	"	Underground Water
— G —	"	Underground Gas
— OHW —	"	Overhead Wires
CB	"	Catch Basin
GM	"	Gas Meter
B	"	Bollard
CLF	"	Chain Link Fence
BF	"	Board Fence
RWI	"	Retaining Wall Interlock
RWC	"	Retaining Wall Concrete
	"	Gate
UP	"	Utility Pole
UPW	"	Utility Pole Wooden
LS	"	Light Standard
Ø	"	Diameter
+ 65.00	"	Location of Elevations
+ 65.00*	"	Location of Concrete Elevations
+ 65.00**	"	Top of Concrete Curb Elevations
C/L	"	Centreline
	"	Property Line

ASSOCIATION OF ONTARIO LAND SURVEYORS
PLAN SUBMISSION FORM
2141730

THIS PLAN IS NOT VALID UNLESS IT IS AN EMBOSSED ORIGINAL COPY ISSUED BY THE SURVEYOR In accordance with Regulation 1026, Section 29 (3).

ELEVATION NOTES

1. Elevations shown are geodetic and are referred to the CGVD28 geodetic datum.
2. It is the responsibility of the user of this information to verify that the job benchmark has not been altered or disturbed and that it's relative elevation and description agrees with the information shown on this drawing.

UTILITY NOTES

1. This drawing cannot be accepted as acknowledging all of the utilities and it will be the responsibility of the user to contact the respective utility authorities for confirmation.
2. Only visible surface utilities were located.
3. Underground utility data derived from City of Ottawa utility sheet reference E-02-09C.
4. A field location of underground plant by the pertinent utility authority is mandatory before any work involving breaking ground, probing, excavating etc.

Bearings are grid, derived from Can-Net 2016 Real Time Network GPS observations, MTM Zone 9 (76°30' West Longitude) NAD-83 (original).

For Comparison purposes, a rotation of 0°01'50" Counter Clock-wise was applied to Plans (P1,P2,P4,P5 & P6)

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Job No. 21113-20 Holdings Ptlt 26&27 PL 1 (O.F) T F | ST

Construction Methodology and Impact Review		
Construction Item	**Potential Impact**	**Mitigation Program**
Item A - Installation of Temporary Shoring System - Where adequate space is not available for the overburden to be sloped, the overburden along the perimeter of the proposed building footprint will need to be shored in order to complete the construction of the underground parking levels. The shoring system is anticipated to consist of a soldier pile and lagging or interlocking sheet pile system along the south side, which is nearest to the Confederation Line.	Vibration issues during shoring system installation	Design of the temporary shoring system, in particular vibrations during installation, will take into consideration the presence of the Confederation Line. Installation of the shoring system is not anticipated to have an adverse impact on the Confederation Line, nonetheless, a vibration monitoring device is recommended to be installed to monitor vibrations. The vibration monitor would be remotely connected to permit real time monitoring and a vibration monitoring program would be implemented as detailed in Subsection 3.1 - Vibration Monitoring and Control Program of Paterson Group Report PG5719-2 dated May 17, 2021.
Item B - Bedrock Blasting and Removal Program - Blasting of the bedrock will be required for the proposed building and parking garage structure construction. It is expected that bedrock removal is required based on the current design concepts for the proposed development.	Structural damage of Confederation Line due to vibrations from blasting program.	Structural damage to the Confederation Line during bedrock blasting and removal is not anticipated, nonetheless, a vibration monitoring device is recommended to be installed in the tunnel in order to monitor vibrations. The vibration monitor would be remotely connected to permit real time monitoring and a vibration monitoring program would be implemented as detailed in Subsection 3.1 - Vibration Monitoring and Control Program of Paterson Group Report PG5719-2 dated May 17, 2021.
Item C - Construction of Footings and Foundation Walls - The proposed building will include 2 levels of underground parking. Therefore, the footings will be placed over a clean, surface sounded dolostone bedrock bearing surface or lean concrete filled trenches extending to the bedrock surface.	Building footing loading on adjacent Confederation Line, and excavation within the lateral support zone of the Confederation Line.	Due to the distance between the proposed building and the Confederation Line, the zone of influence from the proposed footings will not intersect the rail line structure and associated infrastructure. Further, although the underground parking levels for the proposed building will extend approximately 6 m below existing ground surface, due to the approximate 25 m distance between the proposed building and rail line structure, the building excavation will not impact the lateral support zone of the Confederation Line.

APPENDIX B

Geotechnical Investigation:

Report PG5719-1 dated April 26, 2021

patersongroup

Geotechnical Engineering

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April 26, 2021

Report PG5719-1

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Appendices

Appendix 1 Soil Profile and Test Data Sheets
Symbols and Terms
Analytical Testing Results

Appendix 2 Figure 1 - Key Plan
Drawing PG5719-1 - Test Hole Location Plan

1.0 Introduction

Paterson Group (Paterson) was commissioned by Dentech Holdings Inc. to conduct a geotechnical investigation for the proposed multi-storey building to be located at 797 Richmond Road, in the city of Ottawa, Ontario (refer to Figure 1 - Key Plan presented in Appendix 2).

The objectives of the geotechnical investigation were to:

- ❑ determine the subsoil and groundwater conditions at this site by means of test holes.
- ❑ provide geotechnical recommendations for the design of the proposed development including construction considerations which may affect its design.

The following report has been prepared specifically and solely for the aforementioned project. This report contains geotechnical findings and includes recommendations pertaining to the design and construction of the proposed development as they are understood at the time of writing this report.

Investigating the presence or potential presence of contamination on the subject property was not part of the scope for this current geotechnical investigation. Therefore the current report does not address environmental concerns.

2.0 Proposed Development

It is understood that the proposed project will consist of a multi-storey building with two levels of underground parking. It is expected that the proposed building will be municipally serviced.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

The field program for the investigation was carried out on March 3 and 4, 2021. At that time, four (4) boreholes were advanced to a maximum depth of 9.9 m below the existing ground surface. The test hole locations were distributed across the site in a manner to provide general coverage of the subject site. The locations of the test holes are shown on Drawing PG5719-1 - Test Hole Location Plan included in Appendix 2.

The boreholes were drilled using a low-clearance track mounted auger drill rig operated by a two person crew. All fieldwork was conducted under the full-time supervision of Paterson personnel under the direction of a senior engineer. The drilling procedure consisted of augering to the required depths at the selected locations, sampling and testing the overburden.

Sampling and In Situ Testing

Soil samples were collected from the boreholes using two different techniques, namely, sampled directly from the auger flights (AU) or collected using a 50 mm diameter split-spoon (SS) sampler. Rock cores (RC) were obtained using 47.6 mm inside diameter coring equipment. All samples were visually inspected and initially classified on site. The auger and split-spoon samples were placed in sealed plastic bags, and rock cores were placed in cardboard boxes. All samples were transported to our laboratory for further examination and classification. The depths at which the auger, split spoon and rock core samples were recovered from the boreholes are shown as AU, SS and RC, respectively, on the Soil Profile and Test Data sheets presented in Appendix 1.

A Standard Penetration Test (SPT) was conducted in conjunction with the recovery of the split spoon samples. The SPT results are recorded as "N" values on the Soil Profile and Test Data sheets. The "N" value is the number of blows required to drive the split spoon sampler 300 mm into the soil after a 150 mm initial penetration using a 63.5 kg hammer falling from a height of 760 mm.

Bedrock samples were recovered using a core barrel and diamond drilling techniques. The depths at which rock core samples were recovered from the boreholes are shown as RC on the Soil Profile and Test Data sheets in Appendix 1.

A recovery value and a Rock Quality Designation (RQD) value were calculated for each drilled section (core run) of bedrock and are shown on the borehole logs. The recovery value is the ratio, in percentage, of the length of the bedrock sample recovered over the length of the drilled section (core run). The RQD value is the ratio, in percentage, of the total length of intact rock pieces longer than 100 mm in one core run over the length of the core run. These values are indicative of the quality of the bedrock.

The subsurface conditions observed in the test holes were recorded in detail in the field. The soil profiles are presented on the Soil Profile and Test Data sheets in Appendix 1 of this report.

Groundwater

Monitoring wells were installed in three (3) of the boreholes to permit monitoring of the groundwater levels subsequent to the completion of the sampling program. Ground observations are discussed in Subsection 4.3 and presented in the Soil Profile and Test Data sheets in Appendix 1.

Sample Storage

All samples will be stored in the laboratory for a period of one month after issuance of this report. They will then be discarded unless we are otherwise directed.

3.2 Field Survey

The test hole locations were selected by Paterson to provide general coverage of the proposed development, taking into consideration the existing site features and underground utilities. The test hole locations and ground surface elevations at each test hole location were surveyed by Paterson and are referenced to a geodetic datum. The approximate location of the test holes and ground surface elevation at each test hole location are presented on Drawing PG5719-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

Soil and bedrock samples were recovered from the subject site and visually examined in our laboratory to review the results of the field logging. Soil and bedrock samples will be stored for a period of one month after this report is completed, unless otherwise directed.

3.4 Analytical Testing

One soil sample was submitted for analytical testing to assess the corrosion potential for exposed ferrous metals and the potential of sulphate attacks against subsurface concrete structures. The sample was submitted to determine the concentration of sulphate and chloride, the resistivity and the pH of the sample. The results are presented in Appendix 1 and are discussed further in Subsection 6.7.

4.0 Observations

4.1 Surface Conditions

The subject site is currently occupied by a one storey commercial building with an associated asphalt covered access lane and parking area. The subject site is bordered by a mid-rise building to the east, a gravel parking lot to the north, an automobile service garage to the west and Richmond Road to the south. The existing ground surface across the subject site is relatively flat and at-grade with Richmond Road.

4.2 Subsurface Profile

Overburden

Generally, the subsurface profile at the borehole locations consists of a 80 to 100 mm thick asphalt surface underlain by a fill layer extending to approximate depths of 1.5 to 2.2 m. The fill was generally observed to consist of a brown silty sand to silty clay with some crushed stone and gravel.

The fill layer was observed to be underlain by a deposit of glacial till consisting of brown to grey compact silty sand, with clay, gravel, cobbles and boulders. The glacial till deposit was encountered at approximate depths ranging from 1.5 to 2.3 m below the existing ground surface at all boreholes locations.

Practical refusal to augering was encountered in boreholes at approximate depths ranging from 5.4 and 6.4 m below the existing ground surface.

Bedrock

Bedrock was encountered in boreholes BH 2-21, BH 3-21 and BH 4-21 at depths ranging from 5.9 m to 7.3 m below existing ground surface. Bedrock was cored within these boreholes to a maximum depth of 9.9 m and was observe to consist of grey dolostone with interbedded black shale. Based on the RQD values, the bedrock cores were generally noted to be of good to excellent condition.

Based on available geological mapping, the subject site is located in an area where the bedrock consists of interbedded dolostone and limestone from the Gull River Formation at depths ranging from 5 to 10 m.

Specific details of the soil profile at each test hole location are presented on the Soil Profile and Test Data sheets in Appendix 1.

4.3 Groundwater

Groundwater level readings were measured at the monitoring wells locations on March 16, 2021. The observed groundwater levels are summarized in Table 1 below.

Table 1 - Summary of Groundwater Level Readings

Test Hole Number	Ground Surface Elevation (m)	Groundwater Depth (m)	Groundwater Elevation (m)	Recording Date
BH 2-21	64.11	4.87	59.24	March 16, 2021
BH 3-21	64.27	7.36	56.91	March 16, 2021
BH 4-21	64.07	6.10	57.97	March 16, 2021

It should be noted that groundwater levels could be influenced by surface water infiltrating the backfilled boreholes. The long-term groundwater level can also be estimated based on the recovered soil samples' moisture levels, colouring and consistency. Based on these observations, the long-term groundwater level is anticipated at a depth of approximately 5 to 6 m below ground surface. However, groundwater levels are subject to seasonal fluctuations and could vary at the time of construction.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is considered suitable for the proposed project. It is anticipated that the proposed multi-storey building will be founded on conventional spread footings placed on a clean, undisturbed, compact glacial till or bedrock bearing surface.

Where bedrock is not encountered at the design underside of footing elevation or the proposed building exceed the bearing resistance values provided herein for the undisturbed, compact glacial till, consideration should be taken to transferring the building loads to the bedrock surface by means of a lean concrete in-filled trench. Our foundation design recommendations are further detailed in Subsection 5.3.

The above and other considerations are further discussed in the following sections.

5.2 Site Grading and Preparation

Stripping Depth

Topsoil and fill, such as those containing organic or deleterious materials, should be stripped from under any buildings and other settlement sensitive structures. Care should be taken not to disturb adequate bearing soils below the subgrade level during site preparation activities.

Fill Placement

Fill placed for grading beneath the structure(s) or other settlement sensitive areas should consist, unless otherwise specified, of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. This material should be tested and approved prior to the delivery to the site. The engineered fill should be placed in maximum 300 mm thick lifts and compacted to 98% of the materials Standard Proctor Maximum Dry Density (SPMDD).

Non-specified existing fill along with site-excavate soil can be placed as general landscaping fill where surface settlement is a minor concern. The backfill should be spread in thin lifts and, at minimum, compacted by the tracks of the spreading equipment to minimize voids. If the non-specified fill is to be placed to increase the subgrade level for areas to be paved, the fill should be compacted in maximum 300 mm lifts and compacted to 95% of the material's SPMDD. Non-specified existing fill and site excavated soils are not suitable for placement as backfill against foundations walls unless a composite drainage blanket connected to a perimeter drainage system is provided.

Bedrock Removal

Bedrock removal can be accomplished by hoe ramming where the bedrock is weathered and/or where only small quantities of the bedrock need to be removed. Sound bedrock may be removed by line drilling, controlled blasting and/or hoe ramming.

Prior to considering blasting operations, the blasting effects on the existing services, buildings and other structures should be addressed. A pre-blast or pre-construction survey of the existing structures located in proximity of the blasting operations should be carried out prior to commencing site activities. The extent of the survey should be determined by the blasting consultant and should be sufficient to respond to any inquiries/claims related to the blasting operations.

As a general guideline, peak particle velocities (measured at the structures) should not exceed 25 mm per second during the blasting program to reduce the risks of damage to the existing structures.

The blasting operations should be planned and conducted under the supervision of a licensed professional engineer who is also an experienced blasting consultant.

Vibration Considerations

Construction operations are also the cause of vibrations, and possibly, sources of nuisance to the community. Therefore, means to reduce the vibration levels should be incorporated in the construction operations to maintain, as much as possible, a cooperative environment with the residents.

The following construction equipment could be a source of vibrations: piling rig, hoe ram, compactor, dozer, crane, truck traffic, etc. Vibrations, whether caused by blasting operations or by construction operations, could be the source of detrimental vibrations on the adjoining buildings and structures. Therefore, it is recommended that all vibrations be limited.

Two parameters are used to determine the permissible vibrations, namely, the maximum peak particle velocity and the frequency. For low frequency vibrations, the maximum allowable peak particle velocity is less than that for high frequency vibrations. As a guideline, the peak particle velocity should be less than 15 mm/s between frequencies of 4 to 12 Hz, and 50 mm/s above a frequency of 40 Hz (interpolate between 12 and 40 Hz). These guidelines are for current construction standards.

Considering that these guidelines are above perceptible human level and, in some cases, could be very disturbing to some people, it is recommended that a preconstruction survey be completed to minimize the risks of claims during or following the construction of the proposed buildings.

5.3 Foundation Design

Bearing Resistance Values

Footings placed directly on clean, surface sounded bedrock, can be designed using a factored bearing resistance value at Ultimate Limit States (ULS) of **2,000 kPa**, incorporating a geotechnical resistance factor of 0.5.

A clean, surface-sounded bedrock bearing surface should be free of loose materials, and have no near surface seams, voids, fissures or open joints which can be detected from surface sounding with a rock hammer.

Lean Concrete Trenches

Where bedrock is encountered below the design underside of footing elevation or should the bearing pressures from the proposed building exceed the bearing resistance values provided herein for the undisturbed, compact glacial till, the conventional spread footings are recommended to be supported on lean concrete trenches which extend to the bedrock

In this case, as the bedrock is anticipated to be encountered below the underside of footing elevation, zero-entry vertical trenches would be excavated to the clean, surface-sounded bedrock, and backfilled with lean concrete to the founding elevation (minimum **15 MPa** 28-day compressive strength). Typically, the excavation side walls will be used as the form to support the concrete. The trench excavation should be at least 300 mm wider than all sides of the footing (strip and pad footings) at the base of the excavation. The additional width of the concrete poured against an undisturbed trench sidewall will suffice in providing a direct transfer of the footing load to the underlying bedrock. Once the trench excavation is approved by the geotechnical engineer, lean concrete can be poured up to the proposed founding elevation.

The effectiveness of this operation will depend on the ability of maintaining vertical trenches until the lean concrete can be poured. It is suggested that once the bottom of the excavation is exposed, a test pit should be undertaken to assess the water infiltration issues and stability of the excavation sidewalls extending to the bedrock surface.

Footings placed on lean concrete filled trenches extending to the bedrock surface can be designed using a factored bearing resistance value at ultimate limit states (ULS) of **2,000 kPa.**

Shallow Footings on Glacial Till Bearing Surface

Footings placed on an undisturbed, compact glacial till bearing surface can be designed using a bearing resistance value at serviceability limit states (SLS) of **200 kPa** and a factored bearing resistance value at ultimate limit states (ULS) of **300 kPa**. A geotechnical resistance factor of 0.5 was applied to the bearing resistance value at ULS.

An undisturbed soil bearing surface consists of one from which all topsoil and deleterious material, such as loose, frozen or disturbed soil, whether in situ or not, have been removed in dry conditions, prior to the placement of concrete for footings.

Soil/Bedrock Transition Areas

Where a building is founded partly on bedrock and partly on soil, it is recommended to decrease the soil bearing resistance value by 25% for the footings placed on soil bearing media to reduce the potential long term total and differential settlements. Also, at the soil/bedrock and bedrock/soil transitions, it is recommended that the upper 0.5 m of the bedrock be removed for a minimum length of 2 m (on the bedrock side) and replaced with nominally compacted OPSS Granular A or Granular B Type II material. The width of the subexcavation should be at least the proposed footing width plus 0.5 m. Steel reinforcement, extending at least 3 m on both sides of the 2 m long transition, should be placed in the top part of the footings and foundation walls.

Settlement

Footings placed on a soil bearing surface and designed using the bearing resistance values at SLS given for the soil bearing surface will be subjected to potential post construction total and differential settlements of 25 and 20 mm, respectively.

Footings bearing on directly on a sound bedrock or lean concrete trenches placed directly on an acceptable bedrock bearing surface and designed for the bearing resistance values provided herein will be subjected to negligible post-construction total and differential settlements.

Lateral Support

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels.

Adequate lateral support is provided to a compact to dense silty sand and glacial till bearing surface above the groundwater table when a plane extending horizontally and vertically from the underside of the footing at a minimum of 1.5H:1V passes only through in situ soil of the same or higher bearing capacity as the bearing medium soil.

Adequate lateral support is provided to a sound bedrock bearing medium when a plane extending down and out from the bottom edge of the footing at a minimum of 1H:6V (or flatter) passes only through sound bedrock or a material of the same or higher capacity as the bedrock, such as concrete. A heavily fractured, weathered bedrock bearing medium will require a lateral support zone of 1H:1V (or flatter).

5.4 Design for Earthquakes

For design purposes, the site class for seismic site response can be taken as **Class C** for the foundations considered at this site. A higher site class, such as Class A or B, is possible for footings placed within 3 m of the bedrock surface. However, the higher seismic site class would need to be confirmed by site-specific shear wave velocity testing. The soils underlying the subject site are not susceptible to liquefaction. Reference should be made to the latest revision of the Ontario Building Code (OBC) 2012 for a full discussion of the earthquake design requirements.

5.5 Basement Slab

With the removal of all topsoil and deleterious fill from within the footprint of the proposed building, the native soil or bedrock surface will be considered an acceptable subgrade on which to commence backfilling for floor slab construction. The recommended pavement structures noted in Subsection 5.7 will be applicable for the founding level of the proposed parking garage structure. However, if storage or other uses of the lower level will involve the construction of a concrete floor slab, the upper 200 mm of sub-slab fill is recommended to consist of 19 mm clear crushed stone.

All backfill material within the footprint of the proposed building should be placed in maximum 300 mm thick loose layers and compacted to a minimum of 98% of the SPMDD.

In consideration of the groundwater conditions encountered at the time of the fieldwork, a subfloor drainage system, consisting of lines of perforated drainage pipe subdrains connected to a sump pit, should be provided in the clear stone under the lower parking level. The spacing of the underfloor drainage system should be confirmed at the time of completing the excavation when water infiltration can be better assessed (discussed further in Subsection 6.1).

5.6 Basement Wall

There are several combinations of backfill materials and retained soils that could be applicable for the basement walls of the subject structure. However, the conditions can be well-represented by assuming the retained soil consists of a material with an angle of internal friction of 30 degrees and a bulk (drained) unit weight of 20 kN/m^3. The applicable effective (undrained) unit weight of the retained soil can be taken as 13 kN/m^3, where applicable. A hydrostatic pressure should be added to the total static earth pressure when using the effective unit weight.

Lateral Earth Pressures

The static horizontal earth pressure (p_o) can be calculated using a triangular earth pressure distribution equal to $K_o \cdot \gamma \cdot H$ where:

K_o = at-rest earth pressure coefficient of the applicable retained soil, 0.5
γ = unit weight of fill of the applicable retained soil (kN/m^3)
H = height of the wall (m)

An additional pressure having a magnitude equal to $K_o \cdot q$ and acting on the entire height of the wall should be added to the above diagram for any surcharge loading, q (kPa), that may be placed at ground surface adjacent to the wall. The surcharge pressure will only be applicable for static analyses and should not be used in conjunction with the seismic loading case.

Actual earth pressures could be higher than the “at-rest” case if care is not exercised during the compaction of the backfill materials to maintain a minimum separation of 0.3 m from the walls with the compaction equipment.

Seismic Earth Pressures

The total seismic force (P_{AE}) includes both the earth force component (P_o) and the seismic component (ΔP_{AE}). The seismic earth force (ΔP_{AE}) can be calculated using $0.375 \cdot a_c \cdot \gamma \cdot H^2/g$ where:

a_c = $(1.45\text{-}a_{max}/g)a_{max}$
γ = unit weight of fill of the applicable retained soil (kN/m^3)
H = height of the wall (m)
g = gravity, 9.81 m/s^2

The peak ground acceleration, (a_{max}), for the Ottawa area is 0.32g according to OBC 2012. Note that the vertical seismic coefficient is assumed to be zero.

The earth force component (P_o) under seismic conditions can be calculated using $P_o = 0.5\ K_o\ \gamma\ H^2$, where $K_o = 0.5$ for the soil conditions noted above.

The total earth force (P_{AE}) is considered to act at a height, h (m), from the base of the wall, where:

$h = \{P_o \cdot (H/3) + \Delta P_{AE} \cdot (0.6 \cdot H)\}/P_{AE}$

The earth forces calculated are unfactored. For the ULS case, the earth loads should be factored as live loads, as per OBC 2012.

5.7 Pavement Structure

Pavement Design

For design purposes, the pavement structure presented in the following tables could be used for the design of the pavement structure for the car only parking areas and access lanes.

Table 2 - Recommended Pavement Structure - Car Only Parking Areas

Thickness (mm)	Material Description
50	Wear Course - HL-3 or Superpave 12.5 Asphaltic Concrete
150	BASE - OPSS Granular A Crushed Stone
300	SUBBASE - OPSS Granular B Type II
SUBGRADE - Either fill, in situ soil, or OPSS Granular B Type I or II material placed over in situ soil or fill	

Table 3 - Recommended Pavement Structure - Access Lanes and Heavy Truck Parking Areas	
Thickness (mm)	**Material Description**
40	Wear Course - HL-3 or Superpave 12.5 Asphaltic Concrete
50	Binder Course - HL-8 or Superpave 19.0 Asphaltic Concrete
150	BASE - OPSS Granular A Crushed Stone
450	SUBBASE - OPSS Granular B Type II
SUBGRADE - Either fill, in situ soil, or OPSS Granular B Type I or II material placed over in situ soil or fill	

If soft spots develop in the subgrade during compaction or due to construction traffic, the affected areas should be excavated and replaced with OPSS Granular B Type II material.

Minimum Performance Graded (PG) 58-34 asphalt cement should be used for this project. The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 100% of the SPMDD with suitable vibratory equipment.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

Foundation Drainage

It is expected that the building footprint will occupy majority of the subject site. It is expected that insufficient room will be available for exterior backfill along these walls and, therefore, the foundation wall will be blind poured against a waterproofing and drainage system placed over the shoring face.

Since the founding level of the proposed structure will be located below the expected high groundwater level, consideration may be given to installing a groundwater infiltration suppression system to control the final groundwater infiltration volumes.

By waterproofing the vertical excavation walls and ensuring that the system continues horizontally below the perimeter footings, it will be possible to lessen the groundwater volumes entering the excavation. This can be accomplished by placing a waterproofing membrane layer against the shoring surface. The membrane should start from the bottom of the excavation when pouring the perimeter strip footings. The waterproofing membrane should extend a minimum of 1 m above the long term groundwater table to the approximate geodetic elevation of 60 m. A composite drainage system extending up to the proposed finished grade should be incorporated against the waterproofing membrane to act as a protection layer and to drain any water breaching the waterproofing membrane system. A groundwater infiltration suppression system should also be provided for any elevator shaft and sump pump pits (pit bottoms and walls) located within the lowest basement level.

The composite drainage system (such as Delta Drain 6000 or equivalent) should extend down to the footing level. It is recommended that 150 mm diameter sleeves at 3 m spacing on centres be cast in the foundation wall at the footing interface to allow the infiltration of water to flow to an interior perimeter drainage pipe. The perimeter drainage pipe should direct water to sump pit(s) within the lower basement area.

Underfloor Drainage

It is anticipated that underfloor drainage will be required to control water infiltration. For preliminary design purposes, we recommend that 100 or 150 mm perforated pipes be placed at approximate 6 m centres. The spacing of the underfloor drainage system should be confirmed at the time of completing the excavation when water infiltration can be better assessed.

Foundation Backfill

Backfill against the exterior sides of the foundation walls should consist of free-draining, non frost susceptible granular materials. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should be used for this purpose. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for re-use as backfill against the foundation walls, unless used in conjunction with a composite drainage blanket, such as Delta Drain 6000 or equivalent.

6.2 Protection of Footings Against Frost Action

Perimeter footings of heated structures are recommended to be protected against the deleterious effects of frost action. A minimum of 1.5 m of soil cover alone, or a combination of soil cover and foundation insulation should be provided.

The parking garage should not require protection against frost action due to the founding depth. Unheated structures, such as the access ramp wall footings, may be required to be insulated against the deleterious effect of frost action. A minimum of 2.1 m of soil cover alone, or a minimum of 0.6 m of soil cover, in conjunction with foundation insulation, should be provided.

6.3 Excavation Side Slopes

Temporary Side Slopes

The temporary excavation side slopes anticipated should either be excavated to acceptable slopes or retained by shoring systems from the beginning of the excavation until the structure is backfilled.

The subsoil at this site is considered to be mainly a Type 2 and 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects. The excavation side slopes above the groundwater level extending to a maximum depth of 3 m should be cut back at 1H:1V or flatter. The flatter slope is required for excavation below the groundwater level. It may be possible that in localized areas, where Type 3 soils are present, a 1.5H:1V excavation side slope may be required.

Excavated soil should not be stockpiled directly at the top of excavations and heavy equipment should be kept away from the excavation sides.

Slopes in excess of 3 m in height should be periodically inspected by the geotechnical consultant in order to detect if the slopes are exhibiting signs of distress.

It is recommended that a trench box be used at all times to protect personnel working in trenches with steep or vertical sides. It is expected that services will be installed by "cut and cover" methods and excavations will not be left open for extended periods of time.

Temporary Shoring

It is anticipated that temporary shoring is required to complete the required excavation where insufficient room is available for open cut methods. The shoring requirements designed by a structural engineer specializing in those works will depend on the depth of the excavation, the proximity of the adjacent structures and the elevation of the adjacent building foundations and underground services. The design and implementation of these temporary systems will be the responsibility of the excavation contractor and their design team. Inspections and approval of the temporary system will also be the responsibility of the designer. Geotechnical information provided below is to assist the designer in completing a suitable and safe shoring system. The designer should take into account the impact of a significant precipitation event and designate design measures to ensure that a precipitation will not negatively impact the shoring system or soils supported by the system. Any changes to the approved shoring design system should be reported immediately to the owner's structural design prior to implementation.

The temporary system could consist of soldier pile and lagging system or interlocking steel sheet piling. Any additional loading due to street traffic, construction equipment, adjacent structures and facilities, etc., should be included to the earth pressures described below. These systems could be cantilevered, anchored or braced. Generally, it is expected that the shoring systems will be provided with tie-back rock anchors to ensure their stability. The shoring system is recommended to be adequately supported to resist toe failure and inspected to ensure that the sheet piles extend well below the excavation base. It should be noted if consideration is being given to utilizing a raker style support for the shoring system that lateral movements can occur and the structural engineer should ensure that the design selected minimizes these movements to tolerable levels.

The earth pressures acting on the temporary shoring system may be calculated with the following parameters.

Table 4 - Soil Parameters	
Parameters	**Values**
Active Earth Pressure Coefficient (K_a)	0.33
Passive Earth Pressure Coefficient (K_p)	3
At-Rest Earth Pressure Coefficient (K_o)	0.5
Unit Weight (γ), kN/m^3	20
Submerged Unit Weight(γ), kN/m^3	13

The active earth pressure should be calculated where wall movements are permissible while the at-rest pressure should be calculated if no movement is permissible. The dry unit weight should be calculated above the groundwater level while the effective unit weight should be calculated below the groundwater level.

The hydrostatic groundwater pressure should be included to the earth pressure distribution wherever the effective unit weight are calculated for earth pressures. If the groundwater level is lowered, the dry unit weight for the soil/bedrock should be calculated full weight, with no hydrostatic groundwater pressure component.

For design purposes, the minimum factor of safety of 1.5 should be calculated.

6.4 Pipe Bedding and Backfill

Bedding and backfill materials should be in accordance with the most recent Material Specifications & Standard Detail Drawings from the Department of Public Works and Services, Infrastructure Services Branch of the City of Ottawa.

At least 150 mm of OPSS Granular A should be used for pipe bedding for sewer and water pipes when placed on soil subgrade. A minimum of 300 mm of OPSS Granular A should be placed for bedding for sewer or water pipes when placed on bedrock subgrade. The bedding should extend to the spring line of the pipe. Cover material, from the spring line to at least 300 mm above the obvert of the pipe should consist of OPSS Granular A. The bedding and cover materials should be placed in maximum 225 mm thick lifts compacted to a minimum of 99% of the material's SPMDD.

It should generally be possible to re-use the site materials above the cover material if the operations are carried out in dry weather conditions.

Where hard surface areas are considered above the trench backfill, the trench backfill material within the frost zone (about 1.8 m below finished grade) and above the cover material should match the soils exposed at the trench walls to minimize differential frost heaving. The trench backfill should be placed in maximum 225 mm thick loose lifts and compacted to a minimum of 95% of the material's SPMDD. All cobbles larger than 200 mm in their longest direction should be segregated from re-use as trench backfill.

6.5 Groundwater Control

The contractor should be prepared to direct water away from all bearing surfaces and subgrades, regardless of the source, to prevent disturbance to the founding medium.

It is anticipated that pumping from open sumps will be sufficient to control the groundwater influx through the sides of the excavations.

A temporary Ministry of the Environment, Conservation and Parks (MECP) permit to take water (PTTW) may be required for this project if more than 400,000 L/day of ground and/or surface water is to be pumped during the construction phase. A minimum of 4 to 5 months should be allowed for completion of the PTTW application package and issuance of the permit by the MECP.

For typical ground or surface water volumes being pumped during the construction phase, between 50,000 to 400,000 L/day, it is required to register in the Environmental Activity and Sector Registry (EASR). A minimum of two to four weeks should be allotted for completion of the EASR registration and the Water Taking and Discharge Plan to be prepared by a Qualified Person as stipulated under O.Reg. 63/16. If a project qualifies for a PTTW based upon anticipated conditions, an EASR will not be allowed as a temporary dewatering measure while awaiting the MECP review of the PTTW application.

Long-Term Groundwater Control

Our recommendations for the proposed building's long-term groundwater control are presented in Subsection 6.1. Any groundwater encountered along the perimeter or sub-slab drainage system will be directed to the proposed buildings' sump pit. Provided that the selected groundwater infiltration control system is properly implemented and approved by Paterson at the time of construction, it is expected that groundwater flow will be low (i.e. less than 40,000 L/day) with peak periods noted after rain events. It is anticipated that the groundwater flow will be controllable using conventional open sumps.

Impacts on Neighbouring Structures

It is understood that three underground levels are planned for the proposed development. It is anticipated that the neighbouring buildings are founded within the glacial till layer. Therefore, based on the proximity of neighbouring buildings and minimal zone impacted by the groundwater lowering, the proposed development will not negatively impact the neighbouring structures.

It should be noted that no issues are expected with respect to groundwater lowering that would cause long term damage to adjacent structures surrounding the proposed development.

6.6 Winter Construction

Precautions must be taken if winter construction is considered for this project. The subsoil conditions at this site consist of frost susceptible materials. In the presence of water and freezing conditions, ice could form within the soil mass. Heaving and settlement upon thawing could occur.

In the event of construction during below zero temperatures, the founding stratum should be protected from freezing temperatures by the use of straw, propane heaters and tarpaulins or other suitable means. In this regard, the base of the excavations should be insulated from sub-zero temperatures immediately upon exposure and until such time as heat is adequately supplied to the building and the footings are protected with sufficient soil cover to prevent freezing at founding level.

Trench excavations and pavement construction are also difficult activities to complete during freezing conditions without introducing frost in the subgrade or in the excavation walls and bottoms. Precautions should be taken if such activities are to be carried out during freezing conditions. Additional information could be provided, if required.

6.7 Corrosion Potential and Sulphate

One (1) sample was submitted for testing. The analytical test results of the soil sample indicate that the sulphate content is less than 0.1%. These results along with the chloride and pH value are indicative that Type 10 Portland cement (Type GU) would be appropriate for this site. The chloride content and the pH of the sample indicate they are not significant factors in creating a corrosive environment for exposed ferrous metals at this site, whereas the resistivity is indicative of a low to moderate corrosive environment.

7.0 Recommendations

A materials testing and observation services program is a requirement for the provided foundation design data to be applicable. The following aspects of the program should be performed by the geotechnical consultant:

- ❏ Review of the geotechnical aspects of the excavating contractor's shoring design, prior to construction.
- ❏ Review proposed foundation drainage design and requirements.
- ❏ Complete field reviews of the proposed groundwater infiltration suppression system for the foundation, elevator shaft and sump pump systems.
- ❏ Observation of all bearing surfaces prior to the placement of concrete.
- ❏ Sampling and testing of the concrete and fill materials used.
- ❏ Periodic observation of the condition of unsupported excavation side slopes in excess of 3 m in height, if applicable.
- ❏ Observation of all subgrades prior to backfilling.
- ❏ Observation of all subgrades prior to backfilling and follow-up field density tests to determine the level of compaction achieved.
- ❏ Sampling and testing of the bituminous concrete including mix design reviews.

A report confirming that these works have been conducted in general accordance with our recommendations could be issued, upon request, following the completion of a satisfactory materials testing and observation program by the geotechnical consultant.

8.0 Statement of Limitations

The recommendations provided in this report are in accordance with Paterson's present understanding of the project. We request permission to review the recommendations when the drawings and specifications are completed.

A geotechnical investigation is a limited sampling of a site. Should any conditions at the site be encountered which differ from those at the test locations, Paterson requests immediate notification to permit reassessment of the recommendations.

The recommendations provided herein should only be used by the design professionals associated with this project. They are not intended for contractors bidding on or undertaking the work. The latter should evaluate the factual information provided in this report and determine its suitability and completeness for their intended construction schedule and methods. Additional testing may be required for their purposes.

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Dentech Holdings Inc. or their agents is not authorized without review by Paterson for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

April 27, 2021

Vincent Duquette, EIT.

David J. Gilbert, P.Eng.

Report Distribution:

- ❑ Dentech Holdings Inc. (email copy)
- ❑ Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL TESTING RESULTS

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Residential Building
797 Richmond Road - Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5719

REMARKS

HOLE NO. BH 1-21

BORINGS BY CME-55 Low Clearance Drill **DATE** 2021 March 3

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	64.17
Asphaltic Concrete	0.10						
FILL: Crushed stone with silty sand	0.64	AU	1				
FILL: Brown silty sand some gravel, clay, trace asphalt and organics	1.45	SS	2	46	25	1	63.17
FILL: Brown silty sand some clay and gravel	1.98	SS	3	46	7		
Brown **SILTY CLAY** trace sand	2.29					2	62.17
GLACIAL TILL: Compact brown silty sand to silty clay with gravel, cobbles and boulders		SS	4	33	18		
		SS	5	58	11	3	61.17
- Increasing clay content with depth		SS	6	75	7	4	60.17
		SS	7	50	9	5	59.17
- Grey by 5.3 m depth	5.97	SS	8	63	13		
End of Borehole							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Monitoring Well Construction

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Residential Building
797 Richmond Road - Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME-55 Low Clearance Drill

DATE 2021 March 3

FILE NO. PG5719

HOLE NO. BH 2-21

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20 40 60 80)	Monitoring Well Construction
GROUND SURFACE						0	64.11		
Asphaltic Concrete 0.08									
FILL: Crushed stone with brown silty sand 0.69		AU	1						
FILL: Brown silty sand with gravel, trace organics 1.52		SS	2	38	12	1	63.11		
GLACIAL TILL: Compact brown silty sand to silty clay with gravel, trace cobbles and boulders		SS	3	54	16	2	62.11		
		SS	4	67	40	3	61.11		
		SS	5	63	16				
		SS	6	75	33	4	60.11		
4.88		SS	7	67	2				
GLACIAL TILL: Grey clayey silt with sand, gravel, cobbles and boulders		SS	8	90	+50	5	59.11		
5.87		RC	1	100	0	6	58.11		
BEDROCK: Good to excellent quality grey dolostone with interbedded black shale		RC	2	100	77	7	57.11		
		RC	3	100	97	8	56.11		
8.48									
End of Borehole									
(GWL @ 4.87 m depth - March 16, 2021)									

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Residential Building
797 Richmond Road - Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5719

REMARKS

HOLE NO. BH 3-21

BORINGS BY CME-55 Low Clearance Drill

DATE 2021 March 3

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	64.27
Asphaltic Concrete — 0.08							
FILL: Crushed stone with brown silty sand — 0.53		AU	1				
FILL: Brown silty sand with crushed stone, construction debris, and organics — 1.52		SS	2	79	41	1	63.27
FILL: Brown silty sand with gravel, trace crushed stone — 2.13		SS	3	71	15	2	62.27
GLACIAL TILL: Compact brown silty sand to silty clay with gravel, trace cobbles and boulders		SS	4	63	16		
- Grey by 3.0 m depth		SS	5	46	9	3	61.27
- Decreasing clay content with depth		SS	6	54	23	4	60.27
		SS	7	42	40	5	59.27
		SS	8	54	31	6	58.27
		SS	9	21	36		
— 7.11		SS	10	61	+50	7	57.27
BEDROCK: Fair to good quality grey dolostone with interbedded black shale		RC	1	100	46		
		RC	2	100	67	8	56.27
		RC	3	100	78	9	55.27
— 9.91							
End of Borehole							
(GWL @ 7.36 m depth - March 16, 2021)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Monitoring Well Construction

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Residential Building
797 Richmond Road - Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME-55 Low Clearance Drill

DATE 2021 March 4

FILE NO. PG5719

HOLE NO. BH 4-21

SOIL DESCRIPTION	Strata depth (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	64.07
Asphaltic Concrete	0.08						
FILL: Crushed stone with brown silty sand	0.66	AU	1				
FILL: Brown silty sand with gravel and brick fragments	1.45	SS	2	71	21	1	63.07
FILL: Brown silty clay with sand, some gravel, trace brick fragments and glass	2.21	SS	3	50	10	2	62.07
GLACIAL TILL: Compact brown silty sand with clay, gravel, cobbles and boulders		SS	4	42	19		
- Grey by 3.0 m depth		SS	5	54	8	3	61.07
- Decreasing clay content with depth		SS	6	50	9	4	60.07
	5.26	SS	7	46	36	5	59.07
GLACIAL TILL: Compact to dense grey silty sand with gravel, cobbles and boulders		SS	8	75	26	6	58.07
		SS	9	13	61	7	57.07
	7.34	RC	1	100	80		
BEDROCK: Good to excellent quality grey dolostone with interbedded black shale		RC	2	100	93	8	56.07
	9.68	RC	3	100	96	9	55.07
End of Borehole							
(GWL @ 6.10 m depth - March 16, 2021)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Monitoring Well Construction

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

SYMBOLS AND TERMS

SOIL DESCRIPTION

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

Desiccated	-	having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure.
Varved	-	composed of regular alternating layers of silt and clay.
Stratified	-	composed of alternating layers of different soil types, e.g. silt and sand or silt and clay.
Well-Graded	-	Having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
Uniformly-Graded	-	Predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) 'N' value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

Relative Density	'N' Value	Relative Density %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

Consistency	Undrained Shear Strength (kPa)	'N' Value
Very Soft	<12	<2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their “sensitivity”. The sensitivity is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

Terminology used for describing soil strata based upon texture, or the proportion of individual particle sizes present is provided on the Textural Soil Classification Chart at the end of this information package.

ROCK DESCRIPTION

The structural description of the bedrock mass is based on the Rock Quality Designation (RQD).

The RQD classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be a result of closely-spaced discontinuities (resulting from shearing, jointing, faulting, or weathering) in the rock mass and are not counted. RQD is ideally determined from NXL size core. However, it can be used on smaller core sizes, such as BX, if the bulk of the fractures caused by drilling stresses (called “mechanical breaks”) are easily distinguishable from the normal in situ fractures.

RQD %	ROCK QUALITY
90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

SAMPLE TYPES

SS	-	Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))
TW	-	Thin wall tube or Shelby tube
PS	-	Piston sample
AU	-	Auger sample or bulk sample
WS	-	Wash sample
RC	-	Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

MC%	-	Natural moisture content or water content of sample, %
LL	-	Liquid Limit, % (water content above which soil behaves as a liquid)
PL	-	Plastic limit, % (water content above which soil behaves plastically)
PI	-	Plasticity index, % (difference between LL and PL)
Dxx	-	Grain size which xx% of the soil, by weight, is of finer grain sizes These grain size descriptions are not used below 0.075 mm grain size
D10	-	Grain size at which 10% of the soil is finer (effective grain size)
D60	-	Grain size at which 60% of the soil is finer
Cc	-	Concavity coefficient = $(D30)^2$ / (D10 x D60)
Cu	-	Uniformity coefficient = D60 / D10

Cc and Cu are used to assess the grading of sands and gravels:
Well-graded gravels have: $1 < Cc < 3$ and $Cu > 4$
Well-graded sands have: $1 < Cc < 3$ and $Cu > 6$
Sands and gravels not meeting the above requirements are poorly-graded or uniformly-graded.
Cc and Cu are not applicable for the description of soils with more than 10% silt and clay (more than 10% finer than 0.075 mm or the #200 sieve)

CONSOLIDATION TEST

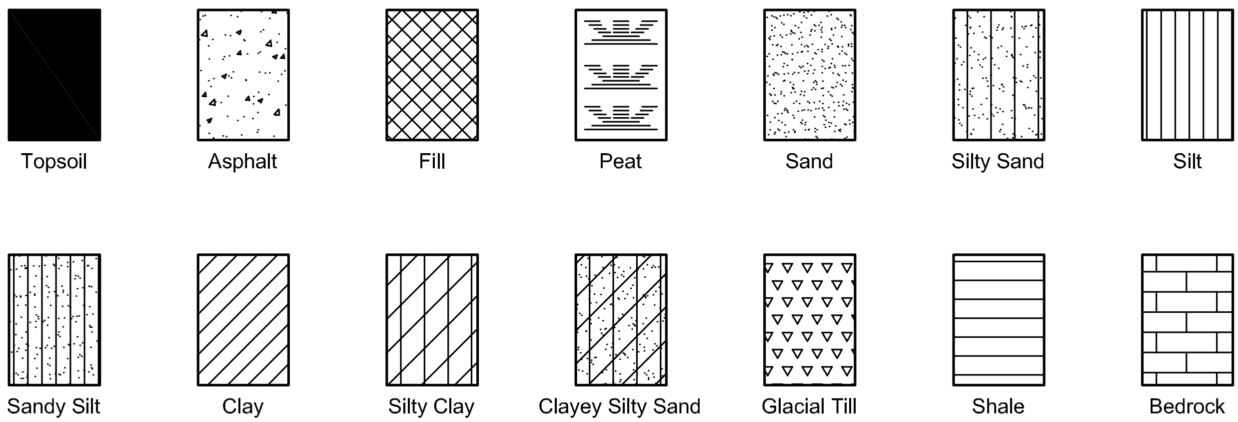
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void Ratio		Initial sample void ratio = volume of voids / volume of solids
Wo	-	Initial water content (at start of consolidation test)

PERMEABILITY TEST

k	-	Coefficient of permeability or hydraulic conductivity is a measure of the ability of water to flow through the sample. The value of k is measured at a specified unit weight for (remoulded) cohesionless soil samples, because its value will vary with the unit weight or density of the sample during the test.

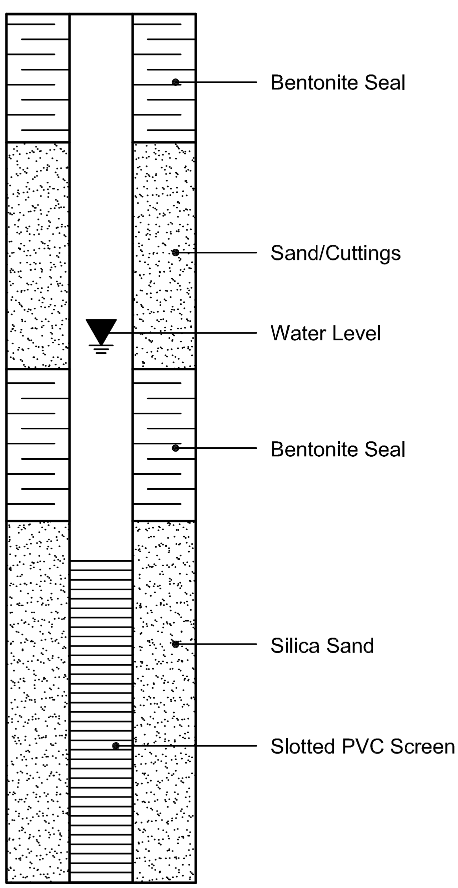
SYMBOLS AND TERMS (continued)

STRATA PLOT

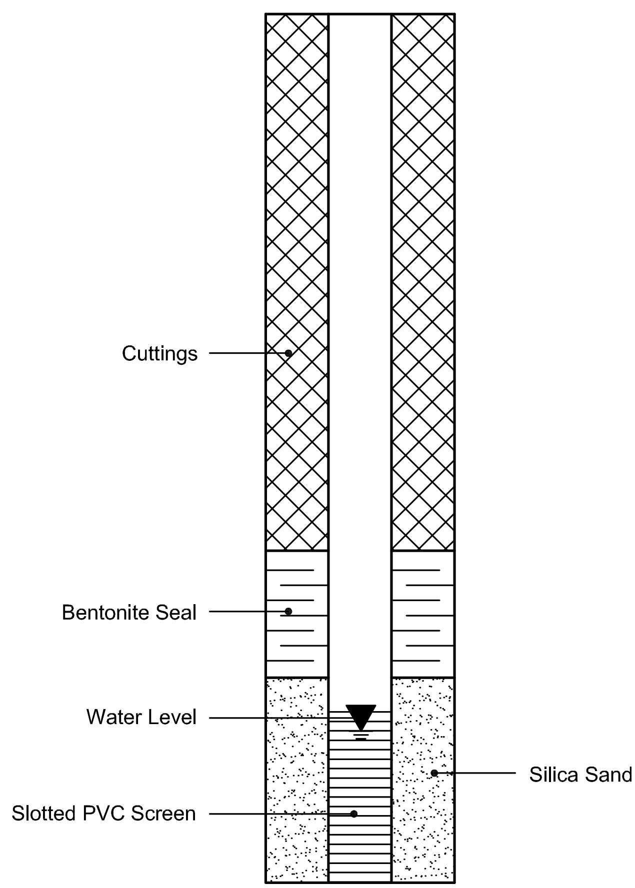


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Certificate of Analysis

Client: Paterson Group Consulting Engineers

Client PO: 33000

Report Date: 13-Apr-2021

Order Date: 12-Apr-2021

Project Description: PG5719

	Client ID:	BH2-SS4	-	-	-
	Sample Date:	04-Mar-21 09:00	-	-	-
	Sample ID:	2116052-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	92.3	-	-	-
General Inorganics					
pH	0.05 pH Units	7.95 [1]	-	-	-
Resistivity	0.10 Ohm.m	41.7	-	-	-
Anions					
Chloride	5 ug/g dry	56 [1]	-	-	-
Sulphate	5 ug/g dry	53 [1]	-	-	-

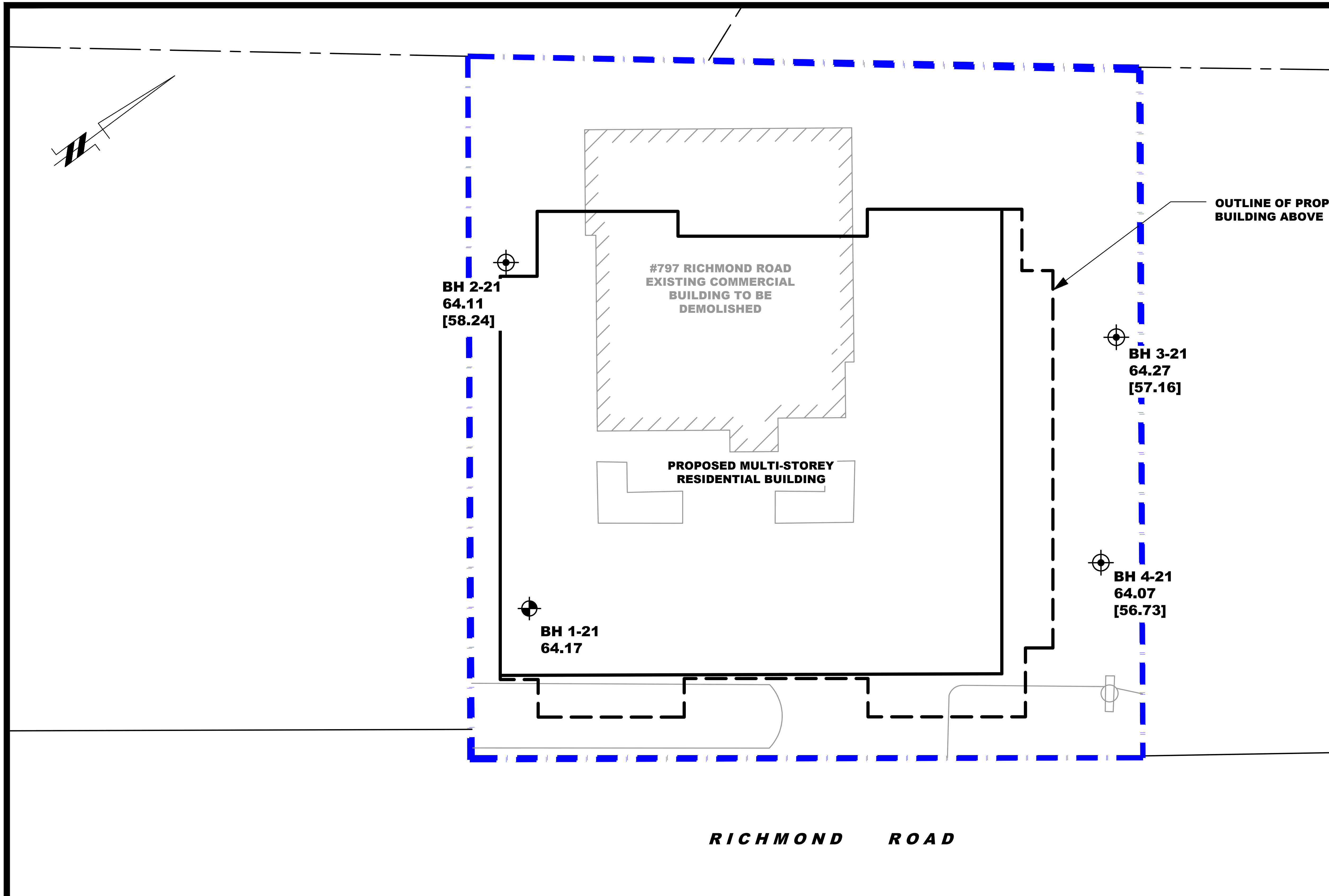
APPENDIX 2

FIGURE 1 - KEY PLAN

DRAWING PG5719-1 - TEST HOLE LOCATION PLAN

FIGURE 1

KEY PLAN



LEGEND:

BOREHOLE LOCATION

64.11	GROUND SURFACE ELEVATION (m)
(58.20)	PRACTICAL REFUSAL TO AUGERING ELEVATION (m)
[56.73]	BEDROCK SURFACE ELEVATION (m)

ALL GROUND SURFACE ELEVATIONS ARE REFERENCED TO A GEODETIC DATUM.

SCALE: 1:200

0 1 2 3 4 5 10m

patersongroup
consulting engineers

154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL

DENTECH HOLDINGS

GEOTECHNICAL INVESTIGATION
PROPOSED MULTI-STOREY RESIDENTIAL BUILDING
797 RICHMOND ROAD

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:200	Date: 03/2021
Drawn by: NFRV	Report No.: PG5719-1
Checked by: VD	Dwg. No.: **PG5719-1**
Approved by: DJG	Revision No.:

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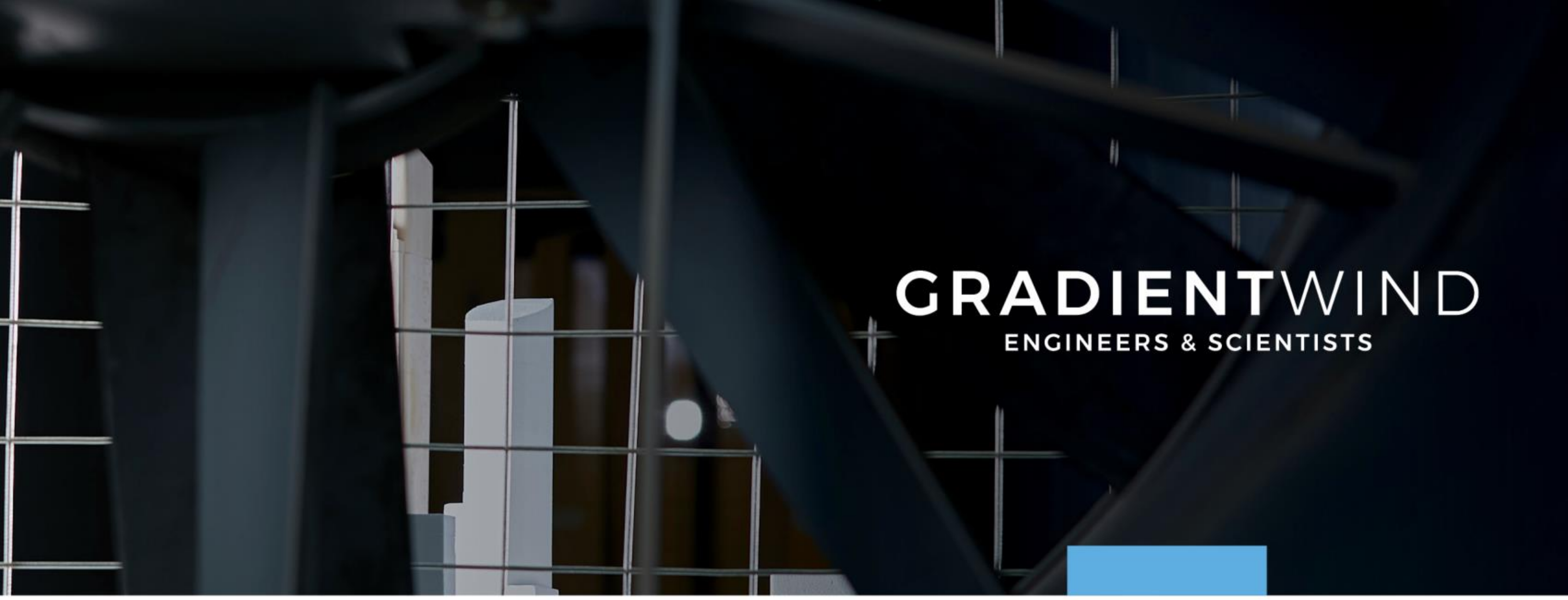
APPENDIX C

Noise and Vibration Study:

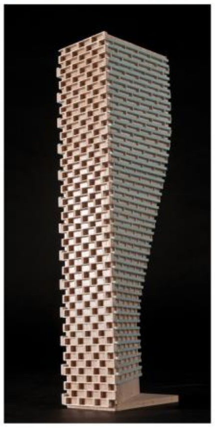
Draft - Prepared by Gradient Wind Engineers and Scientists dated May 13, 2021

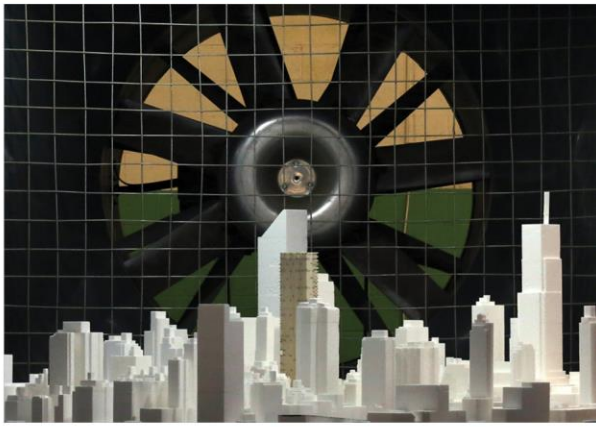


TRANSPOTATION NOISE AND VIBRATION ASSESSMENT

797 Richmond Road
Ottawa, Ontario

REPORT: GWE21-048-Noise & Vibration





May 13, 2021

PREPARED FOR
Dentech Holdings Inc.
797 Richmond Road
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PREPARED BY
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GRADIENTWIND.COM

EXECUTIVE SUMMARY

This report describes a transportation noise and vibration assessment is prepared to satisfy concurrent Zoning By-law Amendment (ZBLA) and Site Plan Control Application (SPA) submissions for the proposed development located at 797 Richmond Road in Ottawa, Ontario. The proposed development is a nine-storey building with commercial units at grade, and residential units comprising floors 2 to 9. The building is topped with a mechanical penthouse and a rooftop outdoor amenity area. Throughout this report, the Richmond Road elevation is referred to as the south elevation. 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 City of Ottawa Environmental Noise Control Guidelines (ENCG); (ii) noise level criteria as specified by the ENCG guidelines; (iii) 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; and (iv) architectural drawings of the development prepared by Chmiel Architects Inc., dated April 15, 2021.

The major sources of transportation noise are Richmond Road which borders the site directly to the south, Byron Avenue, and Sherbourne Road (see Figure 1). The Light Rail Transit (LRT) Confederation Line under development will run parallel to Richmond Road and Byron Avenue, directly in between these roadways. Sherbourne Station will be located across Richmond Road from the study building. The section of the LRT Confederation Line running along the study site will travel underground, and therefore was excluded from the transportation noise analysis as noise levels are dominated by roadway traffic. However, potential ground vibration impacts caused by the LRT were analyzed in this study.

The results of the current analysis indicate that noise levels will range between 65 and 69 dBA at the Plane of Window (POW) receptors during the daytime period (07:00-23:00) and between 57 and 62 dBA during the nighttime period (23:00-07:00). The highest noise level (69 dBA) occurs along the south façade of the building, which is nearest and most exposed to Richmond Road. Building components with a higher Sound Transmission Class (STC) rating will be required where noise levels exceed 65 dBA, indicated in Figure 3.

In addition to upgraded windows, the installation of central air conditioning (or similar mechanical system) will be required for all units in the development, which will allow occupants to keep windows closed and

maintain a comfortable living environment. A Warning Clause[1] will be required in all Agreements of Lease, Purchase and Sale for these units, as summarized in section 6.

The building's proposed HVAC equipment has potential for noise impacts on surrounding buildings and the study building itself. Typically, noise levels can be controlled by judicious selection and placement of the equipment and the introduction of silencers or noise screens where needed. A stationary noise assessment for on-site sources will be completed once the mechanical information for the building's HVAC systems is known.

Noise levels at the Outdoor Living Area (OLA) receptor on the east side of the building rooftop are expected to approach 51 dBA, which is below the ENCG limit of 55 dBA for OLAs. The outdoor amenity area located on the north side of the building rooftop is less exposed to the transportation noise sources, thus noise levels are also expected to be within the ENCG criteria.

The estimated vibration level due to Light Rail Transit in the area is expected to be 0.054 mm/s RMS (67 dBV) at the nearest point of reception based on the FTA protocol. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required.

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

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Appendix A – STAMSON 5.04 Input and Output Data and Supporting Information

Appendix B – FTA Vibration Calculations

1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Dentech Holdings Inc. to undertake a transportation noise and vibration assessment to satisfy concurrent Zoning By-law Amendment (ZBLA) and Site Plan Control Application (SPA) submissions for the proposed development located at 797 Richmond Road in Ottawa (hereinafter referred to as “study building” or “proposed development”). This report summarizes the methodology, results, and recommendations related to a transportation noise and ground vibration assessment.

The present scope of work involves assessing exterior and interior noise levels generated by local transportation sources, as well as vibration levels generated by local light rail transit (LRT) activity. The assessment is based on (i) theoretical noise prediction methods that conform to the City of Ottawa Environmental Noise Control Guidelines[2] (ENCG); (ii) noise level criteria as specified by the ENCG guidelines; (iii) 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; and (iv) architectural drawings of the development prepared by Chmiel Architects Inc., dated April 15, 2021.

2. TERMS OF REFERENCE

The study building is located at 797 Richmond Road on the north elevation of Richmond Road, approximately 80 meters (m) to the west of the intersection of Cleary Avenue and Richmond Road. Throughout this report, the Richmond Road elevation is referred to as the south elevation.

The proposed development comprises a 9-storey building plus a mechanical penthouse. Above two levels of underground parking, the grade level has a nearly square planform and comprises retail units along the east and west elevations, a main lobby along the south elevation, and shared building support spaces throughout the remainder of the level. At Level 2, the building steps out at the north and east elevations. Levels 2 through 9 comprise residential units with balconies on all façades. Above Level 9, the building steps back from the north and south elevations at the roof level. The roof level comprises mechanical space along the west elevation, and outdoor amenity areas towards the east side and north elevations. The roof level also accommodates mechanical space along the south elevation.

---

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

The study site is surrounded by low to mid-rise residential and commercial buildings to the west and north, Richmond Road to the south, and a high-rise residential building to the east along Richmond Road. The major sources of transportation noise are Richmond Road which borders the site directly to the south, Byron Avenue, and Sherbourne Road. The Light Rail Transit (LRT) Confederation Line under development will run parallel to Richmond Road and Byron Avenue, directly in between these roadways. Sherbourne Station will be located across Richmond Road from the study building. The section of the LRT Confederation Line running along the study site will travel underground, and therefore was excluded from the transportation noise analysis as noise levels are dominated by roadways. However, potential ground vibration impacts caused by the LRT were analyzed in this study. Figure 1 illustrates a complete site plan and 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 transportation noise 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 Transportation Noise

4.2.1 Criteria for Transportation Noise

For vehicle traffic, 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 that 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 50, 45 and 40 dBA for retail, living rooms and sleeping quarters, respectively, as listed in Table 1. However, to account for deficiencies in building construction and control peak noise, these levels should be targeted toward 47, 42 and 37 dBA.

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

Type of Space	Time Period	Leq (dBA)	
		Road	Rail
General offices, reception areas, **retail** stores, etc.	07:00 – 23:00	50	45
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	40
Sleeping quarters of hotels/motels	23:00 – 07:00	45	40
Sleeping quarters of **residences**, hospitals, nursing/retirement homes, etc.	23:00 – 07:00	40	35

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]. Therefore, where

[3] Adapted from ENCG 2016 – Tables 2.2b and 2.2c
[4] Burberry, P.B. (2014). Mitchell's Environment and Services. Routledge, Page 125

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 normally triggers the need for central air conditioning (or similar systems). Where noise levels exceed 65 dBA daytime and 60 dBA nighttime building components will require higher levels of sound attenuation[5].

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.

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[6] 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-UAU	50	15,000
Byron Avenue	2-UCU	40	8,000
Sherbourne Road	2-UMCU	50	12,000

4.2.3 Theoretical Transportation Noise Predictions

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

[5] MOECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3
[6] City of Ottawa Transportation Master Plan, November 2013

Roadway noise calculations were performed by treating each road segment as a separate line source of noise, and by using existing building locations as noise barriers. In addition to the traffic volumes summarized in Table 4, 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 was taken to be 92%/8% respectively for all streets.
- Ground surfaces were taken to be absorptive and reflective based on specific source-receiver path ground characteristics.
- Site topography was assumed to be a flat/gentle slope surrounding the study building.
- Noise receptors were strategically placed at 5 locations around the study building (see Figure 2).
- Receptor height was taken to be 27 meters at level 9 for the center of the window (height to 9th floor slab + 1.5 meters) for receptors 1-4, and 30 meters for the rooftop Receptor 5.
- A standard 1.1 meter tall parapet was assumed to enclose the rooftop outdoor amenity area.
- For select sources where appropriate, Receptors 1-5 considered the high-rise building at 75 Clearly Avenue as a barrier partially obstructing exposure to the sources.
- Receptor distances and exposure angles are illustrated in Appendix A Figures 1-3.

4.3 Indoor Noise Calculations

The difference between outdoor and indoor noise levels is the noise attenuation provided by the building envelope. According to common industry practice, complete walls and individual wall elements are rated according to the Sound Transmission Class (STC). The STC ratings of common residential walls built in conformance with the Ontario Building Code (2012) typically exceed STC 35, depending on exterior cladding, thickness and interior finish details. For example, concrete and masonry walls can achieve STC 50 or more. Curtainwall systems typically provide around STC 35, depending on the glazing elements. Standard good quality double-glazed non-operable windows can have STC ratings ranging from 25 to 40 depending on the window manufacturer, pane thickness and inter-pane spacing. As previously mentioned, the windows are the known weak point in a partition.

According to the ENCG, when daytime noise levels at the plane of the window exceed 65 dBA, calculations must be performed to evaluate the sound transmission quality of the building components to ensure acceptable indoor noise levels. The calculation procedure[7] considers:

- Window type and total area as a percentage of total room floor area
- Exterior wall type and total area as a percentage of the total room floor area
- Acoustic absorption characteristics of the room
- Outdoor noise source type and approach geometry
- Indoor sound level criteria, which varies according to the intended use of a space

Based on published research[8], exterior walls possess specific sound attenuation characteristics that are used as a basis for calculating the required STC ratings of windows in the same partition. Due to the limited information available at the time of the study, which was prepared for site plan approval, final detailed floor layouts and building elevations were unavailable and therefore detailed STC calculations could not be performed at this time. As a guideline, the anticipated STC requirements for windows have been estimated based on the overall noise reduction required for each intended use of space (STC = outdoor noise level – targeted indoor noise levels).

4.4 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 vibrations to propagate through the soil. When they

[7] Building Practice Note: Controlling Sound Transmission into Buildings by J.D. Quirt, National Research Council of Canada, September 1985
[8] CMHC, Road & Rail Noise: Effects on Housing

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.

4.4.1 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[9]. 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[10], 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.

---

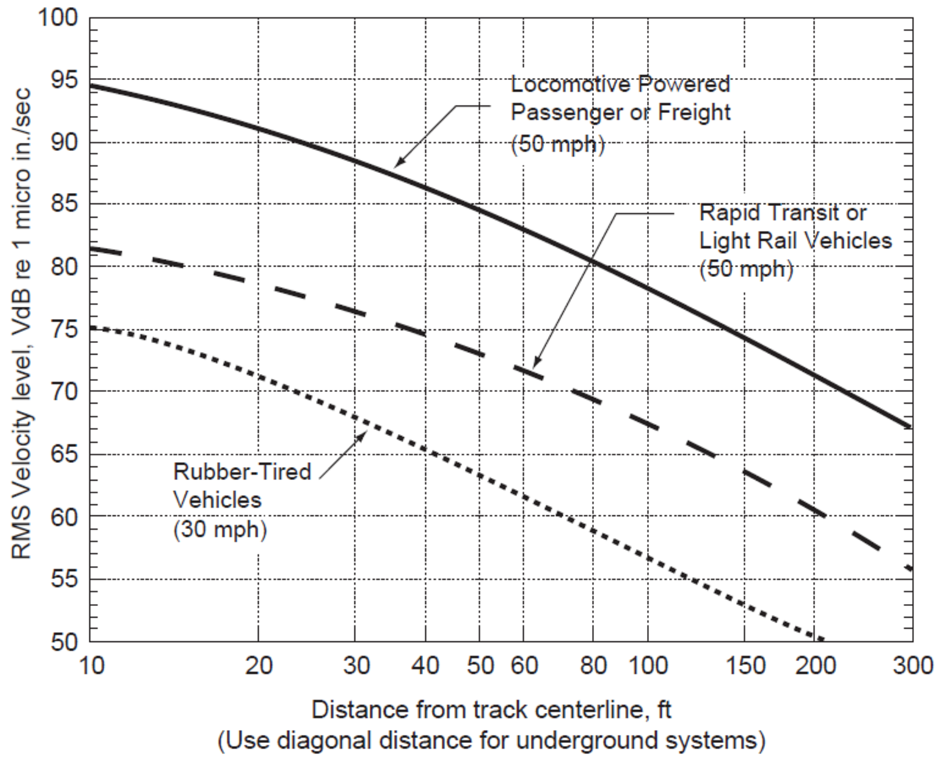
[9] MOECP/TTC Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop, June 16, 1993

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

4.4.2 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[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 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 closest 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 -1 dBV to account for an operational speed of 43.4 mph (70 km/h). The track was assumed to be jointed with no welds. Details of the vibration calculations are presented in Appendix B.

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



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 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 ROADWAY TRAFFIC SOURCES

Receptor Number	Receptor Height Above Grade (m)	Receptor Location	Traffic Noise Level (dBA)	
			Day	Night
1	27	POW / 9th Floor - South Façade	69	62
2	27	POW / 9th Floor - South Façade	69	62
3	27	POW / 9th Floor - East Façade	65	57
4	27	POW / 9th Floor - West Façade	66	58
5	30	OLA / Rooftop Amenity - East Side	51	N/A*

*Nighttime noise levels are not considered as per the ENCG

The results of the current analysis indicate that noise levels will range between 65 and 69 dBA at the Plane of Window (POW) receptors during the daytime period (07:00-23:00) and between 57 and 62 dBA during the nighttime period (23:00-07:00). The highest noise level (69 dBA) occurs along the south façade of the building, which is nearest and most exposed to Richmond Road. Noise levels at the Outdoor Living Area (OLA) receptor on the east side of the building rooftop are expected to approach 51 dBA.

5.2 Noise Control Measures

The noise levels predicted due to roadway traffic exceed the criteria listed in Section 4.2 for building components. As discussed in Section 4.3, the anticipated STC requirements for windows have been estimated based on the overall noise reduction required for each intended use of space (STC = outdoor noise level – targeted indoor noise levels). As per city of Ottawa requirements, detailed STC calculations will be required to be completed prior to building permit application for each unit type. The STC requirements for the windows are summarized below for various units within the development (see Figure 3):

- **Bedroom Windows**

(i) Bedroom windows facing south will require a minimum STC of 32

(ii) Bedroom windows facing west will require a minimum STC of 29

(iii) All other bedroom windows are to satisfy Ontario Building Code (OBC 2012) requirements

- **Living Room Windows**

(i) Living room windows facing south will require a minimum STC of 27

(ii) Living room windows facing west will require a minimum STC of 24

(iii) All other living room windows are to satisfy Ontario Building Code (OBC 2012) requirements

- **Exterior Walls**

(i) Exterior wall components on the south and west façades will require a minimum STC of 45, which will be achieved with brick cladding or an acoustical equivalent according to NRC test data[12]

The STC requirements apply to windows, doors, spandrel panels and curtainwall elements. Exterior wall components on these façades are recommended to have a minimum STC of 45, where a window/wall system is used. A review of window supplier literature indicates that the specified STC ratings can be achieved by a variety of window systems having a combination of glass thickness and inter-pane spacing. We have specified an example window configuration, however, several manufacturers and various combinations of window components, such as those proposed, will offer the necessary sound attenuation rating. It is the responsibility of the manufacturer to ensure that the specified window achieves the required STC. This can only be assured by using window configurations that have been certified by laboratory testing. The requirements for STC ratings assume that the remaining components of the building are constructed and installed according to the minimum standards of the Ontario Building Code. The specified STC requirements also apply to swinging and/or sliding patio doors.

Results of the calculations also indicate that the development will require central air conditioning, which 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.

---

[12] J.S. Bradley and J.A. Birta. Laboratory Measurements of the Sound Insulation of Building Façade Elements, National Research Council October 2000.

5.3 Ground Vibrations & Ground-borne Noise Levels

Based on an offset distance of 21 metres between the nearest railway track of the LRT Confederation Line and the building foundation, the estimated vibration level at the nearest point of reception is expected to be 0.054 mm/s RMS (67 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. The result of our analysis indicates that the ground-bourne noise levels will be at 25 dB.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the current analysis indicate that noise levels will range between 65 and 69 dBA at the Plane of Window (POW) receptors during the daytime period (07:00-23:00) and between 57 and 62 dBA during the nighttime period (23:00-07:00). The highest noise level (69 dBA) occurs along the south façade of the building, which is nearest and most exposed to Richmond Road. Building components with a higher Sound Transmission Class (STC) rating will be required where noise levels exceed 65 dBA, indicated in Figure 3.

In addition to upgraded windows, the installation of central air conditioning (or similar mechanical system) will be required for all units in the development, which will allow occupants to keep windows closed and maintain a comfortable living environment. The following Warning Clause[13] will be required in all Agreements of Lease, Purchase and Sale for these units:

> *"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 includes:*

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

- *STC rated multi-pane glass glazing elements and spandrel panels*
- *Upgraded exterior walls achieving STC 45 or greater*

This dwelling unit has also been designed with air conditioning (or similar mechanical system). 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."

In addition, the Rail Construction Program Office recommends that the warning clause identified below to be included in all agreements of purchase and sale and lease agreements for the proposed development including those prepared prior to the registration of the Site Plan Agreement:

"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.'"

The building's proposed HVAC equipment has potential for noise impacts on surrounding buildings and the study building itself. Typically, noise levels can be controlled by judicious selection and placement of the equipment and the introduction of silencers or noise screens where needed. A stationary noise assessment for on-site sources will be completed once the mechanical information for the building is known.

Noise levels at the Outdoor Living Area (OLA) receptor on the east side of the building rooftop are expected to approach 51 dBA, which is below the ENCG limit of 55 dBA for OLAs. The outdoor amenity area located on the north side of the building rooftop is less exposed to the transportation noise sources, thus noise levels are also expected to be within the ENCG criteria.

The estimated vibration level due to Light Rail Transit in the area is expected to be 0.054 mm/s RMS (67 dBV) at the nearest point of reception based on the FTA protocol. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required.

This concludes our 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.

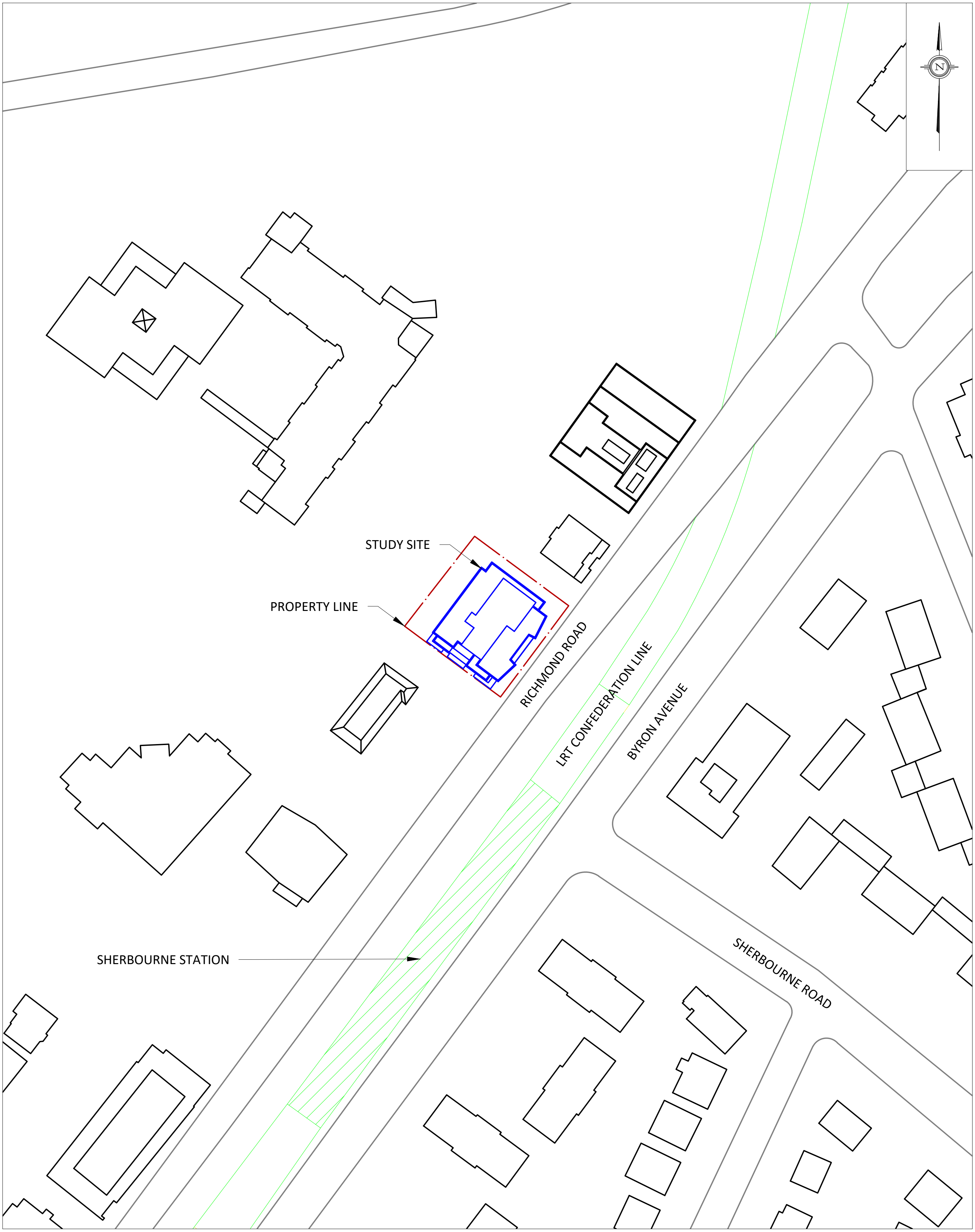
Sincerely,

Gradient Wind Engineering Inc.

Tanyon Matheson-Fitchett, B.Eng.
Junior Environmental Scientist

Joshua Foster, P.Eng.
Principal

GWE21-048



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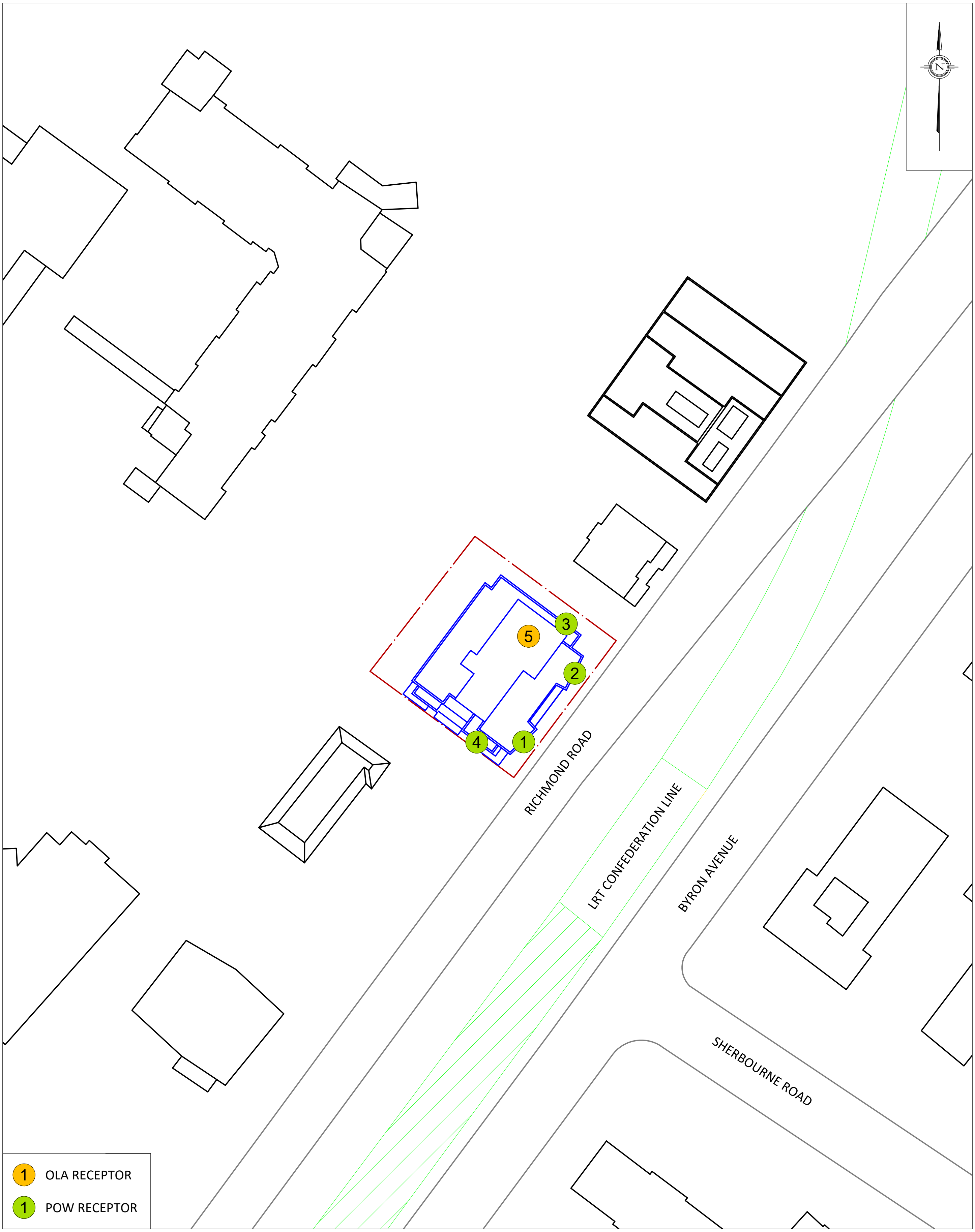
PROJECT: 797 RICHMOND ROAD, OTTAWA TRANSPORTATION NOISE AND GROUND VIBRATIONS ASSESSMENT		DESCRIPTION: FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
SCALE: 1:1500 (APPROX.)	DRAWING NO.: 21-048-1	
DATE: MAY 10, 2021	DRAWN BY: T.M.F.	



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PROJECT	797 RICHMOND ROAD, OTTAWA TRANSPORTATION NOISE AND GROUND VIBRATIONS ASSESSMENT		DESCRIPTION
SCALE	1:1000 (APPROX.)	DRAWING NO. 20-048-2	FIGURE 2: RECEPTOR LOCATIONS
DATE	MAY 10, 2021	DRAWN BY T.M.F.	

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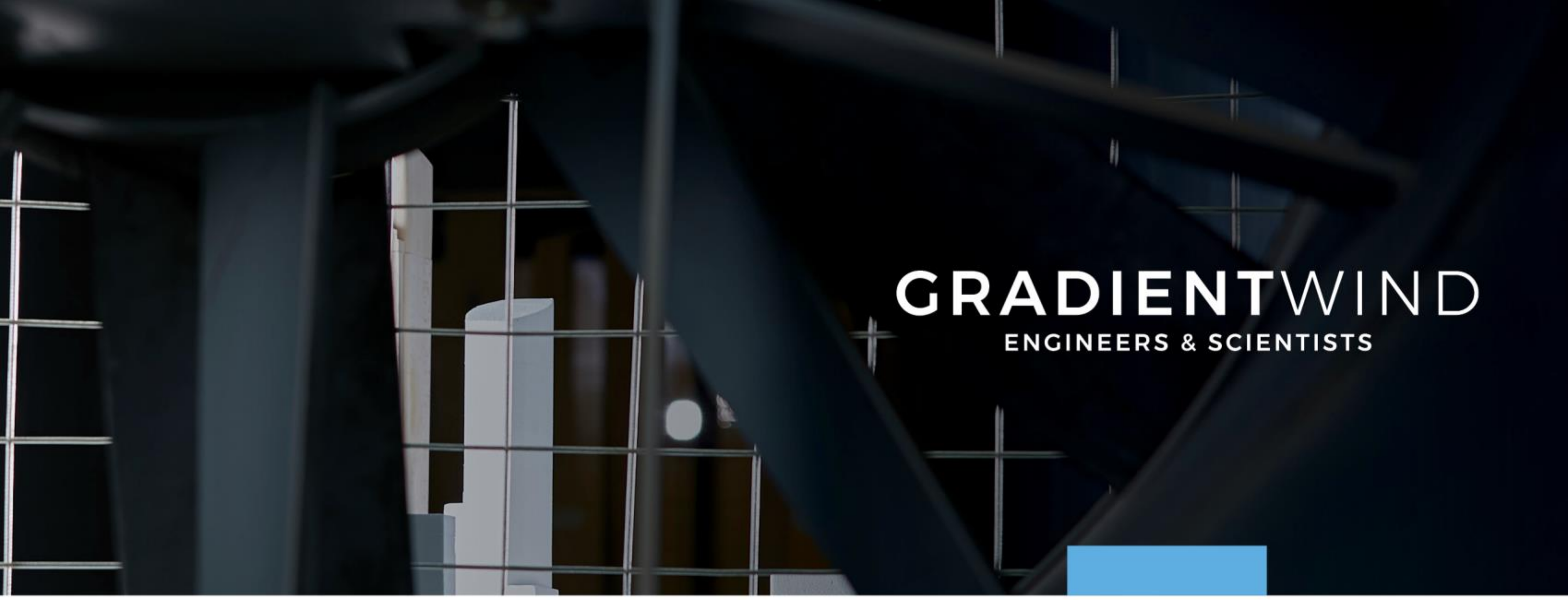
PROJECT	797 RICHMOND ROAD, OTTAWA TRANSPORTATION NOISE AND GROUND VIBRATIONS ASSESSMENT		
SCALE	1:500 (APPROX.)	DRAWING NO.	20-048-3
DATE	MAY 10, 2021	DRAWN BY	T.M.F.

DESCRIPTION

FIGURE 3:
WINDOW STC REQUIREMENTS



APPENDIX A

STAMSON 5.04 – INPUT AND OUTPUT DATA

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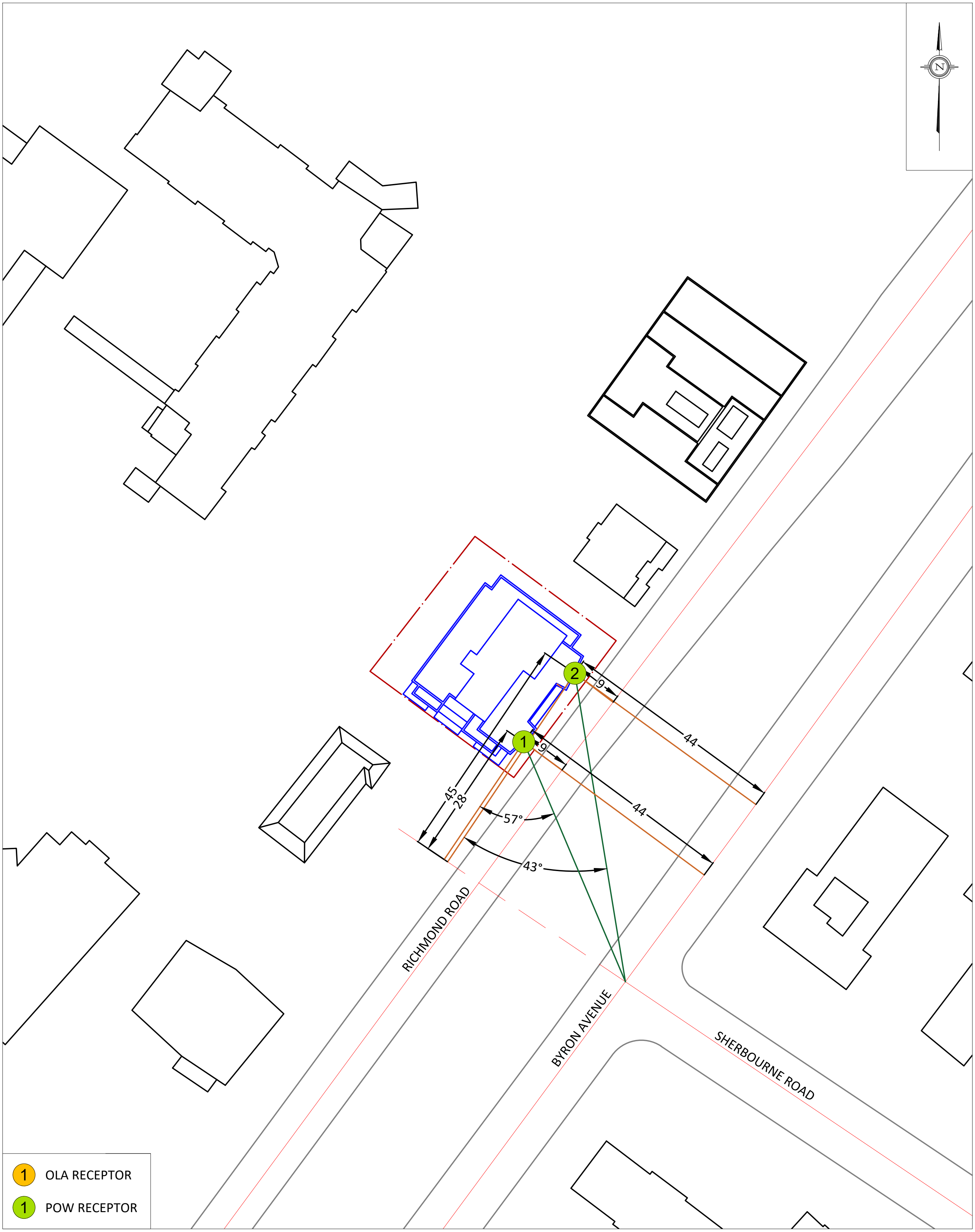

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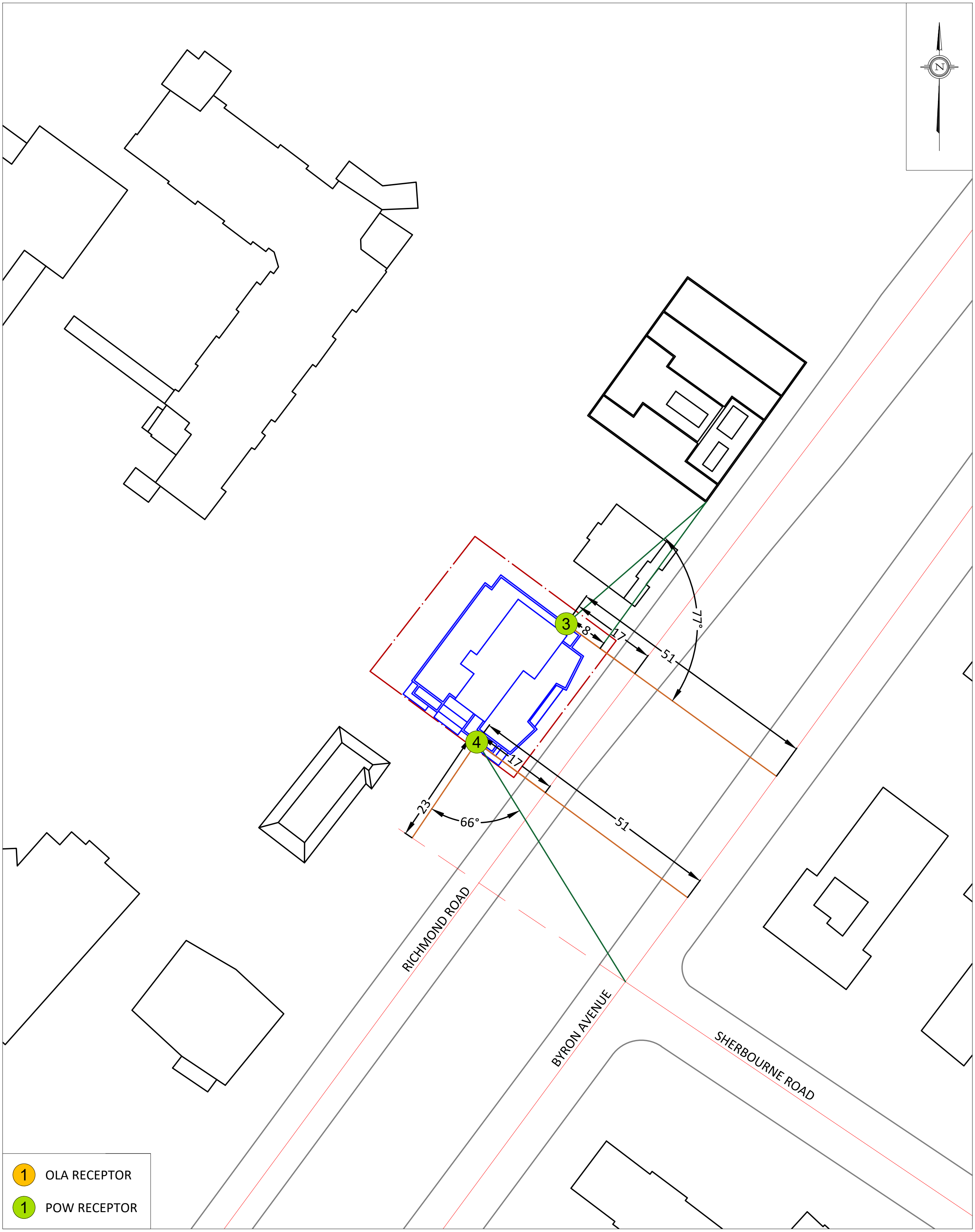
PROJECT	797 RICHMOND ROAD, OTTAWA TRANSPORTATION NOISE AND GROUND VIBRATIONS ASSESSMENT		
SCALE	1:1000 (APPROX.)	DRAWING NO.	20-048-A1
DATE	MAY 10, 2021	DRAWN BY	T.M.F.

DESCRIPTION

FIGURE A1:
RECEPTORS 1 & 2 STAMSON INPUT PARAMETERS



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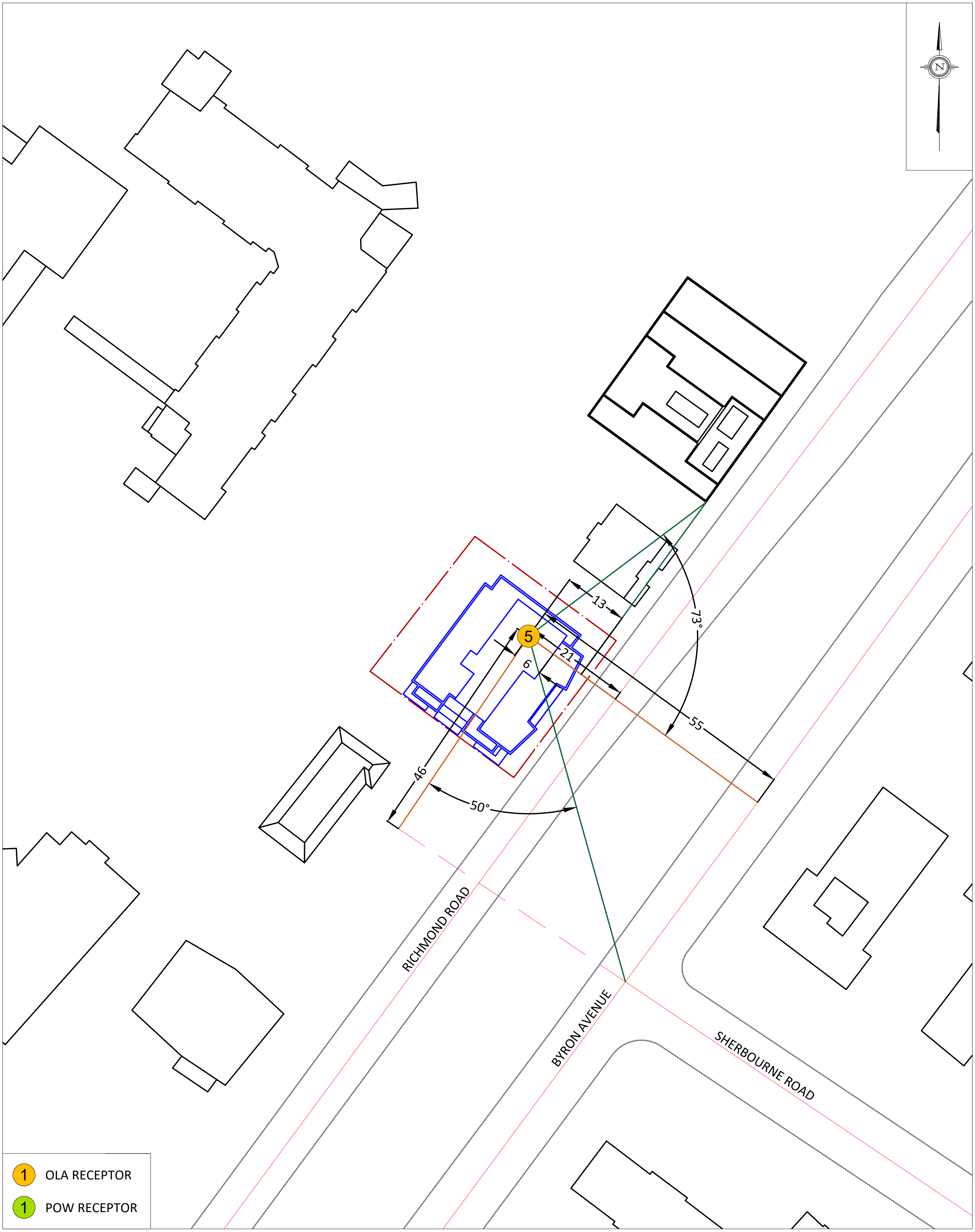
PROJECT	797 RICHMOND ROAD, OTTAWA TRANSPORTATION NOISE AND GROUND VIBRATIONS ASSESSMENT		
SCALE	1:1000 (APPROX.)	DRAWING NO.	20-048-A2
DATE	MAY 10, 2021	DRAWN BY	T.M.F.

DESCRIPTION

FIGURE A2:
RECEPTORS 3 & 4 STAMSON INPUT PARAMETERS



GRADIENTWIND ENGINEERS & SCIENTISTS 127 WALGREEN ROAD , OTTAWA, ON 613 836 0934 • GRADIENTWIND.COM	PROJECT 797 RICHMOND ROAD, OTTAWA TRANSPORTATION NOISE AND GROUND VIBRATIONS ASSESSMENT		DESCRIPTION FIGURE A3: RECEPTOR 5 STAMSON INPUT PARAMETERS
	SCALE 1:1000 (APPROX.)	DRAWING NO. 20-048-A3	
	DATE MAY 10, 2021	DRAWN BY T.M.F.	

STAMSON 5.0 NORMAL REPORT Date: 13-05-2021 11:44:21
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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

Road data, segment # 1: Richmond (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 (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 : 15.00 / 15.00 m
Receiver height : 27.00 / 27.00 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Road data, segment # 2: Byron (day/night)

Car traffic volume : 6477/563   veh/TimePeriod *
Medium truck volume :   515/45   veh/TimePeriod *
Heavy truck volume :   368/32   veh/TimePeriod *
Posted speed limit :   40 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):   8000
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 # 2: Byron (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 : 44.00 / 44.00 m
Receiver height   : 27.00 / 27.00 m
Topography   :   1   (Flat/gentle slope; no barrier)
Reference angle   :   0.00

Road data, segment # 3: Sherbourne (day/night)

Car traffic volume : 9715/845 veh/TimePeriod *
Medium truck volume : 773/67 veh/TimePeriod *
Heavy truck volume : 552/48 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): 12000
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 # 3: Sherbourne (day/night)

Angle1 Angle2 : -90.00 deg -57.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0 / 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 28.00 / 28.00 m
Receiver height : 27.00 / 27.00 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Results segment # 1: Richmond (day)

Source height = 1.50 m

ROAD (0.00 + 68.48 + 0.00) = 68.48 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	0.00	0.00	0.00	0.00	0.00	68.48

Segment Leq : 68.48 dBA

Results segment # 2: Byron (day)

Source height = 1.50 m

ROAD (0.00 + 59.28 + 0.00) = 59.28 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	90	0.00	63.96	0.00	-4.67	0.00	0.00	0.00	0.00	59.28

Segment Leq : 59.28 dBA

Results segment # 3: Sherbourne (day)

Source height = 1.50 m

ROAD (0.00 + 57.43 + 0.00) = 57.43 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	-57	0.00	67.51	0.00	-2.71	-7.37	0.00	0.00	0.00	57.43

Segment Leq : 57.43 dBA

Total Leq All Segments: 69.27 dBA

Results segment # 1: Richmond (night)

Source height = 1.50 m

ROAD (0.00 + 60.88 + 0.00) = 60.88 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	0.00	0.00	0.00	0.00	0.00	60.88

Segment Leq : 60.88 dBA

```
Results segment # 2: Byron (night)
----------------------------------

Source height = 1.50 m

ROAD (0.00 + 51.69 + 0.00) = 51.69 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
   -90    90  0.00  56.36   0.00  -4.67   0.00   0.00   0.00   0.00  51.69
--------------------------------------------------------------------------

Segment Leq : 51.69 dBA


Results segment # 3: Sherbourne (night)
---------------------------------------

Source height = 1.50 m

ROAD (0.00 + 49.83 + 0.00) = 49.83 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
   -90   -57  0.00  59.91   0.00  -2.71  -7.37   0.00   0.00   0.00  49.83
--------------------------------------------------------------------------

Segment Leq : 49.83 dBA

Total Leq All Segments: 61.67 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 69.27
                         (NIGHT): 61.67
```

STAMSON 5.0 NORMAL REPORT Date: 13-05-2021 11:45:49
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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

Road data, segment # 1: Richmond (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 (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 : 15.00 / 15.00 m
Receiver height : 27.00 / 27.00 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Road data, segment # 2: Byron (day/night)

Car traffic volume : 6477/563 veh/TimePeriod *
Medium truck volume : 515/45 veh/TimePeriod *
Heavy truck volume : 368/32 veh/TimePeriod *
Posted speed limit : 40 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): 8000
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 # 2: Byron (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 : 44.00 / 44.00 m
Receiver height : 27.00 / 27.00 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

```
Road data, segment # 3: Sherbourne (day/night)
----------------------------------------------
Car traffic volume  :  9715/845   veh/TimePeriod  *
Medium truck volume :   773/67    veh/TimePeriod  *
Heavy truck volume  :   552/48    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):  12000
    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 # 3: Sherbourne (day/night)
--------------------------------------------
Angle1   Angle2         : -90.00 deg   -43.00 deg
Wood depth              :     0       (No woods.)
No of house rows        :     0 / 0
Surface                 :     2       (Reflective ground surface)
Receiver source distance  :  45.00 / 45.00  m
Receiver height         :  27.00 / 27.00  m
Topography              :     1       (Flat/gentle slope; no barrier)
Reference angle         :   0.00
```

Results segment # 1: Richmond (day)

Source height = 1.50 m

ROAD (0.00 + 68.48 + 0.00) = 68.48 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	0.00	0.00	0.00	0.00	0.00	68.48

Segment Leq : 68.48 dBA

Results segment # 2: Byron (day)

Source height = 1.50 m

ROAD (0.00 + 59.28 + 0.00) = 59.28 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	90	0.00	63.96	0.00	-4.67	0.00	0.00	0.00	0.00	59.28

Segment Leq : 59.28 dBA

Results segment # 3: Sherbourne (day)

Source height = 1.50 m

ROAD (0.00 + 56.91 + 0.00) = 56.91 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	-43	0.00	67.51	0.00	-4.77	-5.83	0.00	0.00	0.00	56.91

Segment Leq : 56.91 dBA

Total Leq All Segments: 69.24 dBA

Results segment # 1: Richmond (night)

Source height = 1.50 m

ROAD (0.00 + 60.88 + 0.00) = 60.88 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	0.00	0.00	0.00	0.00	0.00	60.88

Segment Leq : 60.88 dBA

Results segment # 2: Byron (night)

Source height = 1.50 m

ROAD (0.00 + 51.69 + 0.00) = 51.69 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	90	0.00	56.36	0.00	-4.67	0.00	0.00	0.00	0.00	51.69

Segment Leq : 51.69 dBA

Results segment # 3: Sherbourne (night)

Source height = 1.50 m

ROAD (0.00 + 49.31 + 0.00) = 49.31 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	-43	0.00	59.91	0.00	-4.77	-5.83	0.00	0.00	0.00	49.31

Segment Leq : 49.31 dBA

Total Leq All Segments: 61.64 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 69.24
(NIGHT): 61.64

STAMSON 5.0 NORMAL REPORT Date: 13-05-2021 11:46:56
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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

Road data, segment # 1: Richmond (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 (day/night)

Angle1 Angle2 : -90.00 deg 0.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0 / 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 17.00 / 17.00 m
Receiver height : 27.00 / 27.00 m
Topography : 2 (Flat/gentle slope; with barrier)
Barrier angle1 : -90.00 deg Angle2 : -77.00 deg
Barrier height : 47.00 m
Barrier receiver distance : 8.00 / 8.00 m
Source elevation : 0.00 m
Receiver elevation : 0.00 m
Barrier elevation : 0.00 m
Reference angle : 0.00

Road data, segment # 2: Byron (day/night)

Car traffic volume : 6477/563   veh/TimePeriod *
Medium truck volume :   515/45   veh/TimePeriod *
Heavy truck volume :   368/32   veh/TimePeriod *
Posted speed limit :   40 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):   8000
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 # 2: Byron (day/night)

Angle1   Angle2   : -90.00 deg   0.00 deg
Wood depth   :   0   (No woods.)
No of house rows   :   0 / 0
Surface   :   2   (Reflective ground surface)
Receiver source distance : 51.00 / 51.00 m
Receiver height   : 27.00 / 27.00 m
Topography   :   2   (Flat/gentle slope; with barrier)
Barrier angle1   : -90.00 deg   Angle2 : -77.00 deg
Barrier height   : 47.00 m
Barrier receiver distance :   8.00 / 8.00   m
Source elevation   :   0.00 m
Receiver elevation   :   0.00 m
Barrier elevation   :   0.00 m
Reference angle   :   0.00

```
Results segment # 1: Richmond (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 !       27.00 !       15.00 !       15.00

ROAD (0.00 + 38.53 + 64.25) = 64.26 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
   -90    -77   0.00  68.48   0.00  -0.54 -11.41   0.00   0.00 -18.00  38.53
--------------------------------------------------------------------------
   -77      0   0.00  68.48   0.00  -0.54  -3.69   0.00   0.00   0.00  64.25
--------------------------------------------------------------------------

Segment Leq : 64.26 dBA
```

```
Results segment # 2: Byron (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 !       27.00 !       23.00 !        23.00

ROAD (0.00 + 29.79 + 54.95) = 54.97 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
   -90    -77   0.00  63.96   0.00  -5.31 -11.41   0.00   0.00 -17.44  29.79
--------------------------------------------------------------------------
   -77      0   0.00  63.96   0.00  -5.31  -3.69   0.00   0.00   0.00  54.95
--------------------------------------------------------------------------

Segment Leq : 54.97 dBA

Total Leq All Segments: 64.74 dBA
```

```
Results segment # 1: Richmond (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 !       27.00 !       15.00 !        15.00

ROAD (0.00 + 30.93 + 56.65) = 56.66 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
   -90    -77   0.00  60.88   0.00  -0.54 -11.41   0.00   0.00 -18.00  30.93
--------------------------------------------------------------------------
   -77      0   0.00  60.88   0.00  -0.54  -3.69   0.00   0.00   0.00  56.65
--------------------------------------------------------------------------

Segment Leq : 56.66 dBA
```

```
Results segment # 2: Byron (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 !       27.00 !       23.00 !       23.00

ROAD (0.00 + 22.20 + 47.36) = 47.37 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
   -90    -77   0.00  56.36   0.00  -5.31 -11.41   0.00   0.00 -17.44  22.20
--------------------------------------------------------------------------
   -77      0   0.00  56.36   0.00  -5.31  -3.69   0.00   0.00   0.00  47.36
--------------------------------------------------------------------------

Segment Leq : 47.37 dBA

Total Leq All Segments: 57.14 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 64.74
                         (NIGHT): 57.14
```

STAMSON 5.0 NORMAL REPORT Date: 13-05-2021 11:47:45
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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

Road data, segment # 1: Richmond (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 (day/night)

Angle1 Angle2 : 0.00 deg 90.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0 / 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 17.00 / 17.00 m
Receiver height : 27.00 / 27.00 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Road data, segment # 2: Byron (day/night)

Car traffic volume : 6477/563   veh/TimePeriod *
Medium truck volume :   515/45   veh/TimePeriod *
Heavy truck volume :   368/32   veh/TimePeriod *
Posted speed limit :   40 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):   8000
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 # 2: Byron (day/night)

Angle1   Angle2   : 0.00 deg   90.00 deg
Wood depth   :   0   (No woods.)
No of house rows   :   0 / 0
Surface   :   2   (Reflective ground surface)
Receiver source distance : 51.00 / 51.00 m
Receiver height   : 27.00 / 27.00 m
Topography   :   1   (Flat/gentle slope; no barrier)
Reference angle   : 0.00

Road data, segment # 3: Sherbourne (day/night)

Car traffic volume : 9715/845   veh/TimePeriod *
Medium truck volume :   773/67   veh/TimePeriod *
Heavy truck volume :   552/48   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): 12000
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 # 3: Sherbourne (day/night)

Angle1   Angle2   : -90.00 deg   -66.00 deg
Wood depth   :   0   (No woods.)
No of house rows   :   0 / 0
Surface   :   2   (Reflective ground surface)
Receiver source distance : 23.00 / 23.00 m
Receiver height   : 27.00 / 27.00 m
Topography   :   1   (Flat/gentle slope; no barrier)
Reference angle   :   0.00

Results segment # 1: Richmond (day)

Source height = 1.50 m

ROAD (0.00 + 64.93 + 0.00) = 64.93 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
0	90	0.00	68.48	0.00	-0.54	-3.01	0.00	0.00	0.00	64.93

Segment Leq : 64.93 dBA

Results segment # 2: Byron (day)

Source height = 1.50 m

ROAD (0.00 + 55.63 + 0.00) = 55.63 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
0	90	0.00	63.96	0.00	-5.31	-3.01	0.00	0.00	0.00	55.63

Segment Leq : 55.63 dBA

Results segment # 3: Sherbourne (day)

Source height = 1.50 m

ROAD (0.00 + 56.90 + 0.00) = 56.90 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	-66	0.00	67.51	0.00	-1.86	-8.75	0.00	0.00	0.00	56.90

Segment Leq : 56.90 dBA

Total Leq All Segments: 65.98 dBA

Results segment # 1: Richmond (night)

Source height = 1.50 m

ROAD (0.00 + 57.33 + 0.00) = 57.33 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
0	90	0.00	60.88	0.00	-0.54	-3.01	0.00	0.00	0.00	57.33

Segment Leq : 57.33 dBA

Results segment # 2: Byron (night)

Source height = 1.50 m

ROAD (0.00 + 48.04 + 0.00) = 48.04 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
0	90	0.00	56.36	0.00	-5.31	-3.01	0.00	0.00	0.00	48.04

Segment Leq : 48.04 dBA

Results segment # 3: Sherbourne (night)

Source height = 1.50 m

ROAD (0.00 + 49.30 + 0.00) = 49.30 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	-66	0.00	59.91	0.00	-1.86	-8.75	0.00	0.00	0.00	49.30

Segment Leq : 49.30 dBA

Total Leq All Segments: 58.39 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 65.98
(NIGHT): 58.39

STAMSON 5.0   NORMAL REPORT   Date: 13-05-2021 11:48:20
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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

Road data, segment # 1: Richmond (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 (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 : 21.00 / 21.00 m
Receiver height   : 30.00 / 30.00 m
Topography   :   2   (Flat/gentle slope; with barrier)
Barrier angle1   : -90.00 deg   Angle2 : 90.00 deg
Barrier height   : 31.10 m
Barrier receiver distance :   6.00 / 6.00   m
Source elevation   : 0.00 m
Receiver elevation   : 0.00 m
Barrier elevation   : 0.00 m
Reference angle   : 0.00

Road data, segment # 2: Byron (day/night)

Car traffic volume : 6477/563 veh/TimePeriod *
Medium truck volume : 515/45 veh/TimePeriod *
Heavy truck volume : 368/32 veh/TimePeriod *
Posted speed limit : 40 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): 8000
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 # 2: Byron (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 : 55.00 / 55.00 m
Receiver height : 30.00 / 30.00 m
Topography : 2 (Flat/gentle slope; with barrier)
Barrier angle1 : -90.00 deg Angle2 : 90.00 deg
Barrier height : 31.10 m
Barrier receiver distance : 6.00 / 6.00 m
Source elevation : 0.00 m
Receiver elevation : 0.00 m
Barrier elevation : 0.00 m
Reference angle : 0.00

Road data, segment # 3: Sherbourne (day/night)

Car traffic volume : 9715/845 veh/TimePeriod *
Medium truck volume : 773/67 veh/TimePeriod *
Heavy truck volume : 552/48 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): 12000
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 # 3: Sherbourne (day/night)

Angle1 Angle2 : -90.00 deg -50.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0 / 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 46.00 / 46.00 m
Receiver height : 30.00 / 30.00 m
Topography : 2 (Flat/gentle slope; with barrier)
Barrier angle1 : -90.00 deg Angle2 : -50.00 deg
Barrier height : 31.10 m
Barrier receiver distance : 6.00 / 6.00 m
Source elevation : 0.00 m
Receiver elevation : 0.00 m
Barrier elevation : 0.00 m
Reference angle : 0.00

```
Results segment # 1: Richmond (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 !      30.00 !      21.86 !       21.86

ROAD (0.00 + 49.61 + 0.00) = 49.61 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  -1.46   0.00   0.00   0.00 -17.41  49.61
--------------------------------------------------------------------------

Segment Leq : 49.61 dBA


Results segment # 2: Byron (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 !      30.00 !      26.89 !       26.89

ROAD (0.00 + 43.56 + 0.00) = 43.56 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
   -90     90   0.00  63.96   0.00  -5.64   0.00   0.00   0.00 -14.75  43.56
--------------------------------------------------------------------------

Segment Leq : 43.56 dBA
```

```
Results segment # 3: Sherbourne (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 !       30.00 !       26.28 !        26.28

ROAD (0.00 + 43.14 + 0.00) = 43.14 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
   -90    -50   0.00  67.51   0.00  -4.87  -6.53   0.00   0.00 -12.97  43.14
--------------------------------------------------------------------------

Segment Leq : 43.14 dBA

Total Leq All Segments: 51.29 dBA


Results segment # 1: Richmond (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 !       30.00 !       21.86 !        21.86

ROAD (0.00 + 42.02 + 0.00) = 42.02 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  -1.46   0.00   0.00   0.00 -17.41  42.02
--------------------------------------------------------------------------

Segment Leq : 42.02 dBA
```

```
Results segment # 2: Byron (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 !      30.00 !      26.89 !       26.89

ROAD (0.00 + 35.97 + 0.00) = 35.97 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
--------------------------------------------------------------------------
   -90     90   0.00  56.36   0.00  -5.64   0.00   0.00   0.00 -14.75  35.97
--------------------------------------------------------------------------

Segment Leq : 35.97 dBA
```

Results segment # 3: Sherbourne (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 !       30.00 !       26.28 !        26.28
```

ROAD (0.00 + 35.54 + 0.00) = 35.54 dBA

```
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
------------------------------------------------------------------------------
   -90    -50   0.00  59.91   0.00  -4.87  -6.53   0.00   0.00 -12.97  35.54
------------------------------------------------------------------------------
```

Segment Leq : 35.54 dBA

Total Leq All Segments: 43.70 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 51.29
(NIGHT): 43.70

APPENDIX B

FTA VIBRATION CALCULATIONS

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

GW21-048 13-May-21

Possible Vibration Impacts on 797 Richmond Road
Perdicted using FTA General Assesment

Train Speed 50 km/h 30 mph

	Distance from	
	(m)	(ft)
LRT	21.0	68.9

Vibration

From FTA Manual Fig 10-1			
Vibration Levels at distance from track	71	dBV re 1 micro in/sec	
Adjustment Factors FTA Table 10-1			
Speed reference 50 mph	-4	Trains slowing into station 50 km/h (30 mph)	
Vehicle Parameters	0	Assume Soft primary suspension, Weels 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	62		0.031
Coupling to Building Foundation	0	Founded in rock	
Floor to Floor Attenuation	-1.0	Ground Floor Ocupied	
Amplification of Floor and Walls	6		
Total Vibration Level	66.6	dBV or	0.054 mm/s
Noise Level in dBA	31.6	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		Reference Speed		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 Speed	50 mph	30 mph	
	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 — <u>**Dist.**</u> / <u>**Adjust.**</u>: 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.

APPENDIX D

Proximity Assessment:

Report PG5719-LET.01 dated May 17, 2021

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May 17, 2021
Report: PG5719-LET.01

Dentech Holdings
797 Richmond Road
Ottawa, Ontario
K2A 0G7

Attention: **Mr. Joe Tallis**

Subject: **Proximity Assessment**
Proposed Multi-Storey Building
797 Richmond Road - Ottawa

Dear Sir,

Further to your request and authorization, Paterson Group (Paterson) prepared the current letter report to summarize construction issues which could occur due to the proximity the proposed building with respect to the subject alignment of the proposed Confederation Line Light Rail project. The following letter should be read in conjunction with the Geotechnical Investigation Report (Paterson Group Report PG5719-1 dated April 26, 2019).

1.0 Background Information

The proposed development at 797 Richmond Road will consist of a multi-storey building placed approximately 4 m away from the property boundary along Richmond Road. At the time of issuance of this report, drawings of the final alignment of the Confederation Line have not been provided to Paterson. However, it is understood that the subject alignment will be located below the Richmond Road right-of-way and the landscaped area adjacent to Richmond Road.

The following sections summarize our existing soils information and construction precautions for the proposed building, which may impact the subject alignment of the Confederation Line.

It should be noted that the information submitted as part of the current Proximity Study will be supplemented with construction plans issued for construction, dewatering and discharge plans, temporary shoring design drawings, foundation and subsurface walls/structure design drawings, a Blast Assessment Report and field monitoring program as described in the application conditions.

2.0 Subsurface Conditions

Based on existing geotechnical information, the subsurface conditions in the immediate area of the subject site and subject Confederation Line alignment generally consist of the following:

- ❑ Existing surface grade is at an elevation of approximately 64 m.
- ❑ The overburden thickness is approximately 5.9 to 7.3 m.
- ❑ Bedrock surface elevation is at approximately 56.7 to 58.2 m.
- ❑ The bedrock underlying the site consists of a good quality dolostone interbedded with shale bedrock. Unconfined compressive strengths of similar bedrock formations, where tested, typically exceed 50 MPa.

Tunnel Location

The GeoOttawa Rail Alignment O-Train tool indicates that an approximate setback of 21 m is present between the property line and the proposed Confederation Line, and Sherbourne Station is located approximately 27 m south-west of the property line. It is understood that the underground parking levels for the proposed building will be placed approximately 4 m away from the south property line adjacent to the Richmond Road Right-of-Way (ROW). Therefore, a approximate horizontal separation of 25 m is present between the subject alignment of the Confederation Line and the proposed building at 797 Richmond Road.

Based on preliminary design drawings issued in 2016, the underside of tunnel elevation will be at an approximate elevation of 50 m along the subject alignment. The founding elevation of the proposed building will be approximately 58 m (geodetic). Therefore, a vertical differential of approximately 8 m is present between founding levels of the two structures with a horizontal separation of at least 25 m.

3.0 Construction Precautions and Recommendations

Influence of Proposed Development on Tunnel

Based on existing soils information and building design details, the footings of the proposed building will be founded on good quality dolostone bedrock or lean concrete filled trenches extending to the bedrock surface. Therefore, lateral loads due to the building footings will be transferred directly into the bedrock well within a conservative 1H:6V zone of influence from the outside face of footing. Based on the preliminary information provided for the subject alignment and the proposed building location, the proposed building at 797 Richmond Road will not cause additional loading on the subject alignment of the Confederation Line or Sherbourne Station.

Excavation and Temporary Shoring

The overburden along the perimeter of the proposed building footprint will need to be temporarily shored with a solder pile and lagging system in order to complete the construction of the underground parking structure for the proposed building. Bedrock removal is also anticipated, which will be completed by line drilling, blasting and/or hoe ramming. The blasting and hoe ramming will be carried out by a contractor specializing in bedrock removal and completed in accordance with the Blasting Assessment Report. It is understood that the bedrock removal for the proposed building will be completed prior to the construction of the subject alignment of the proposed Confederation Line. Therefore, there will be no impact of the building excavation on the subject alignment of the proposed Confederation Line.

It should be noted that the temporary shoring system will be designed for at-rest earth pressures, using a pressure coefficient of K_0=0.5 as per geotechnical design recommendations outlined in the Geotechnical Investigation Report (Paterson Group Report PG5719-1 dated April 26, 2021).

A seismograph is to be installed either adjacent to or within the Confederation Line Tunnel as part of the Vibration Monitoring and Control Program to monitor vibrations during the bedrock removal program. A vibration monitoring program detailing trigger levels and action levels will be detailed by Paterson. The monitoring program will be required for the full construction duration for blasting operations, dewatering, backfilling and compaction, construction traffic and other construction activities.

Pre-Construction Survey

A pre-construction survey will be required for the tunnel structure. Any existing structures in the immediate area of the proposed building will also undergo a pre-construction survey as per standard construction practices, where bedrock blasting will be required.

Groundwater Control

Groundwater observations during the geotechnical investigation indicated groundwater levels between approximately 5 to 6 m below the existing ground surface. However, the Confederation Line is understood to be founded on bedrock at an elevation lower than the proposed development Therefore, no groundwater lowering effects due to the proposed development are anticipated with respect to the Confederation Line.

Tunnel Waterproofing System

Due to the separation between the proposed building at 797 Richmond Road and the subject alignment of Confederation line, it is anticipated that the replacement or repair of the waterproofing system for the tunnel structure will not be required during construction.

4.0 Conclusions and Recommendations

Based on the currently available information for the subject alignment of the proposed building and the existing soils information, the proposed building does not negatively impact the proposed tunnel alignment. It should be noted that the information submitted as part of the current Proximity Study will be supplemented with construction plans issued for construction, structural drawings, temporary shoring design drawings, foundation and subsurface walls/structure design drawings, a Blast Assessment Report and field monitoring program as described in the application conditions.

We trust that this information satisfies your immediate request.

Best Regards,

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
May 17, 2021
S. S. DENNIS
100519516
PROVINCE OF ONTARIO

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