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Geotechnical Engineering

Environmental Engineering

Hydrogeology

Geological Engineering

Materials Testing

Building Science

Archaeological Services

Confederation Line Level 3 Proximity Study

Ottawa Retirement Residence by Signature
412 Sparks Street
Ottawa, Ontario

Prepared For

Cathedral Hills GP Inc.
c/o Reichmann Seniors Housing
Development Corporation

Paterson Group Inc.
Consulting Engineers
154 Colonnade Road South
Ottawa (Nepean), Ontario
Canada K2E 7J5

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March 11, 2019

Report: PG4271-2

1.0 Introduction

Paterson Group (Paterson) was commissioned by Cathedral Hills GP Inc. c/o Reichmann Seniors Housing Development Corporation (Reichmann) to conduct a partial Level 3 Confederation Line proximity study for the proposed Ottawa Retirement Residence by Signature to be located at 412 Sparks Street in the City of Ottawa.

The objective of the current study was to:

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

❑ Liaise between the City of Ottawa and the Reichmann 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 architectural, civil, structural, geotechnical, and shoring design information as they pertain to the aforementioned project.

2.0 Development Details

Based on current plans, it is understood that the proposed development consists of a multi-storey building with 3 underground levels that include amenity spaces and indoor parking accommodations.

Based on the drawings provided by the City of Ottawa, the following is known about the Confederation Line in the vicinity of the subject site:

❑ The Confederation Line tunnel is located underlying Queen Street, which abuts the subject site to the south, with an approximate east-west alignment.

❑ The Confederation Line tunnel has top of rail (TOR) at geodetic elevations of 51.5 m to 52.2 m in the vicinity of the subject site, which is approximately 21 m below the existing ground surface (geodetic elevation 73 m) adjacent to 412 Sparks Street.

❑ Based on the subsurface profile encountered at the borehole locations at 412 Sparks Street, bedrock is expected at approximate depths of 1.2 to 1.8 m below the existing ground surface. The Confederation Line LRT tunnel is therefore expected to be surrounded by sound bedrock.

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 1 and presents the anticipated construction items, impact review and mitigation program recommended for the proposed Confederation Line LRT tunnel. 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 existing Confederation Line tunnel alignment, the contractor should take extra precaution to minimize vibrations. The 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 Line tunnel structure adjacent to 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 is to be placed within the adjacent tunnel section.

The location should be reviewed periodically throughout construction to ensure that the monitoring equipment remains with the tunnel structure 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 excavation operations should be planned and conducted under the supervision of a licensed professional engineer who is an experienced bedrock excavation consultant. The following table outlines the vibration limits for the Confederation Line tunnel:

Table 1 - Structure Vibration Limits for the Confederation Line Tunnel

Dominant Frequency Range (Hz)	Peak Particle Velocity (mm/s)	Event	Description of Event
<10	all	none	no action required
<40	>10	trigger level	Warning e-mail sent to contractor.
<40	≥15	exceedance level	Exceedance e-mail and phone call to the contractor. All operations are ceased to review on-site activities.
>40	>15	trigger level	Warning e-mail sent to contractor.
>40	≥25	exceedance level	Exceedance e-mail and phone call to the contractor. All operations are ceased to review on-site activities.

Monitoring Data

The monitoring protocol should include the following information:

Trigger Level Event

- Paterson will review all vibrations over the established warning level, 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
- 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 partial Level 3 Confederation Line Proximity Study should be completed for the proposed development. A partial Level 3 Confederation Line Proximity Study is required where the proposed development is located within 1 m of a Confederation Line structure right-of-way.

The following table lists the applicable requirements for Level 1, Level 2, and Level 3 study and the response for each item:

Table 2
List of Confederation Line Level 1 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;	Site Plan presented in Appendix 1
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;	LRT Proximity Section presented in Appendix 1
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 Report PG4271-1 dated October 31, 2017 presented in Appendix 2
Structural, foundation, excavation and shoring drawings;	Preliminary structural and foundation drawings are presented in Appendix 1. Preliminary excavation and shoring drawings are presented in Appendix 1. Based on current design details, the proposed building foundation will consist of conventional footings placed directly over a clean, 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.	A Traffic Noise & Vibration Detailed Assessment prepared by Gradient Wind Engineers & Scientists dated February 21, 2019 is presented in Appendix 3.

Table 3
List of Confederation Line Level 2 Proximity Study Requirements

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 the distance between the proposed building and Confederation Line which is approximately 4.8m or greater apart. Refer to Proximity Assessment Report PG4271-LET.01 dated February 27, 2019 presented in Appendix 4.
Documentation showing that the excavation support system and permanent structure adjacent to the Confederation Line property are designated for at-rest earth pressures.	The temporary shoring system will be designed for at-rest earth pressures as required by the site Geotechnical Report.
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.	Preliminary structural and foundation drawings indicating the relationship of the development to the Confederation Line structure are provided in Appendix 1. Detailed structural drawings will be provided once available.
Shoring design criteria and description of excavation and shoring method.	The temporary shoring for the overburden will consist of a soldier pile and lagging system, which will be cantilevered where located adjacent to the Confederation Line tunnel. At the beginning of and during excavation, the geotechnical engineer will review the stability of the bedrock face underlying the overburden. Following the review of the bedrock face, the geotechnical engineer will determine if rock reinforcement is required, and if so, the extent to which rock reinforcement is required. This determination will include consideration for the Confederation Line tunnel. Refer to Proximity Assessment Report PG4271-LET.01 dated February 27, 2019 presented in Appendix 4.
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.	Both the proposed structure and the Confederation Line tunnel will be founded on sound bedrock. The settlement of the bedrock bearing surface will be negligible and long-term effects of dewatering will not induce settlement. Refer to Proximity Assessment Report PG4271-LET.01 dated February 27, 2019 presented in Appendix 4.

Table 3 (continued)
List of Confederation Line Level 2 Proximity Study Requirements

Level 2 Projects	Response
Proposal to replace/repair waterproofing system of the affected Confederation Line structure, including the Confederation Line expansion joint.	Construction of the proposed development will not come within 6.2 m around the Confederation Line tunnel, therefore replacement and/or repair of the waterproofing system is not considered to be required.
Identification of utility installations proposed through or adjacent to Confederation Line property.	At the time of writing this report, the civil design is not known. These plans will be forwarded once they are completed. Refer to Proximity Assessment Report PG4271-LET.01 dated February 27, 2019 presented in Appendix 4.
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. Refer to Proximity Assessment Report PG4271-LET.01 dated February 27, 2019 presented in Appendix 4.
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 survey of the Confederation Line will be completed.
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 program to evaluate potential movement of the Confederation Line tunnel structure will be completed during the construction period.

Table 4
List of Confederation Line Level 3 Proximity Study Requirements

Level 3 Projects	Response
A general Ontario Building Code (OBC) compliance review, specifically including Section 3.12 Rapid Transit Stations, and including a plan depicting egress routes from the station.	As the proposed building does not connect to the Confederation Line LRT tunnel, an OBC review of egress routes from the station is not considered to be required.
Wind and snow load analyses.	The tunnel adjacent to the subject site is located below ground, therefore, wind and snow load analyses are not considered to be required.
Drawings/documentation of construction method, hoarding, construction access, and haul routes.	These drawings and documentation will be provided once available.
Details of remedial work to municipal structures to support roof at wall opening, including structural loads, and calculations.	The proposed building does not connect to the Confederation Line tunnel, therefore this is not considered to be required.
Details of stairs, doors, sprinklers and ventilation for the development connection.	The proposed building does not connect to the Confederation Line tunnel, therefore this is not considered to be required.
Provision of architectural finish material selection, including samples.	The proposed building does not connect to the Confederation Line tunnel, therefore this is not considered to be required.
Wayfinding and signage plans.	The proposed building does not connect to the Confederation Line tunnel, therefore this is not considered to be required.
Landscape plans.	The tunnel adjacent to the subject site is located below ground, therefore, landscape plans are not considered to be required.
Drawings of collector booth, CCTV, intercom, fire alarm, easier access elevator, all designated in conformance with the relevant OC Transpo Design Guidelines, including accessibility requirements.	The proposed building does not connect to the Confederation Line tunnel, therefore this is not considered to be required.
Provision of construction record (as-built) reproducible drawings and electronic files for municipal documentation records. The electronic file and the drawings are to be in Microstation (.dgn) format.	These drawings will be provided by the Contractor at the completion of construction.

We trust that this information satisfies your immediate request.

Best Regards,

Paterson Group Inc.

Scott S. Dennis, P.Eng.

LICENSED PROFESSIONAL ENGINEER
Mar. 11-2019
D. J. GILBERT
100116130
PROVINCE OF ONTARIO

David J. Gilbert, P.Eng.

Report Distribution

❏ Reichmann Seniors Housing Development Corporation (1 copy)
❏ Paterson Group (1 copy)

APPENDIX 1

Site Plan

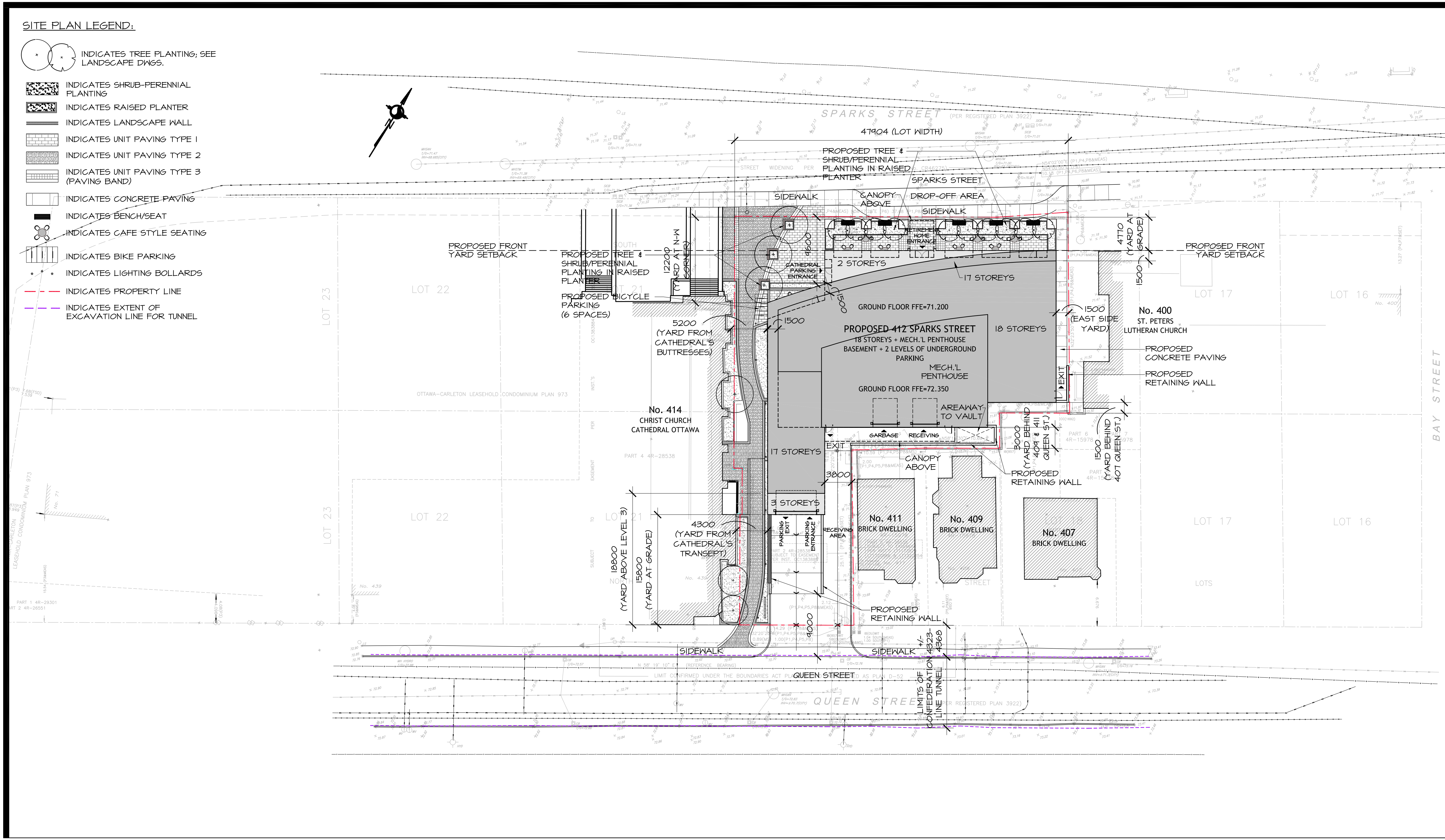
Transverse LRT and Building Section

Topographic Survey Plan

Preliminary Structural and Foundation Drawings

Preliminary Excavation and Shoring Drawings

Construction Methodology and Impact Review



Signature RETIREMENT LIVING

REICHMANN SENIORS HOUSING DEVELOPMENT CORP.

OTTAWA RETIREMENT RESIDENCE BY SIGNATURE

Proposed Site Plan

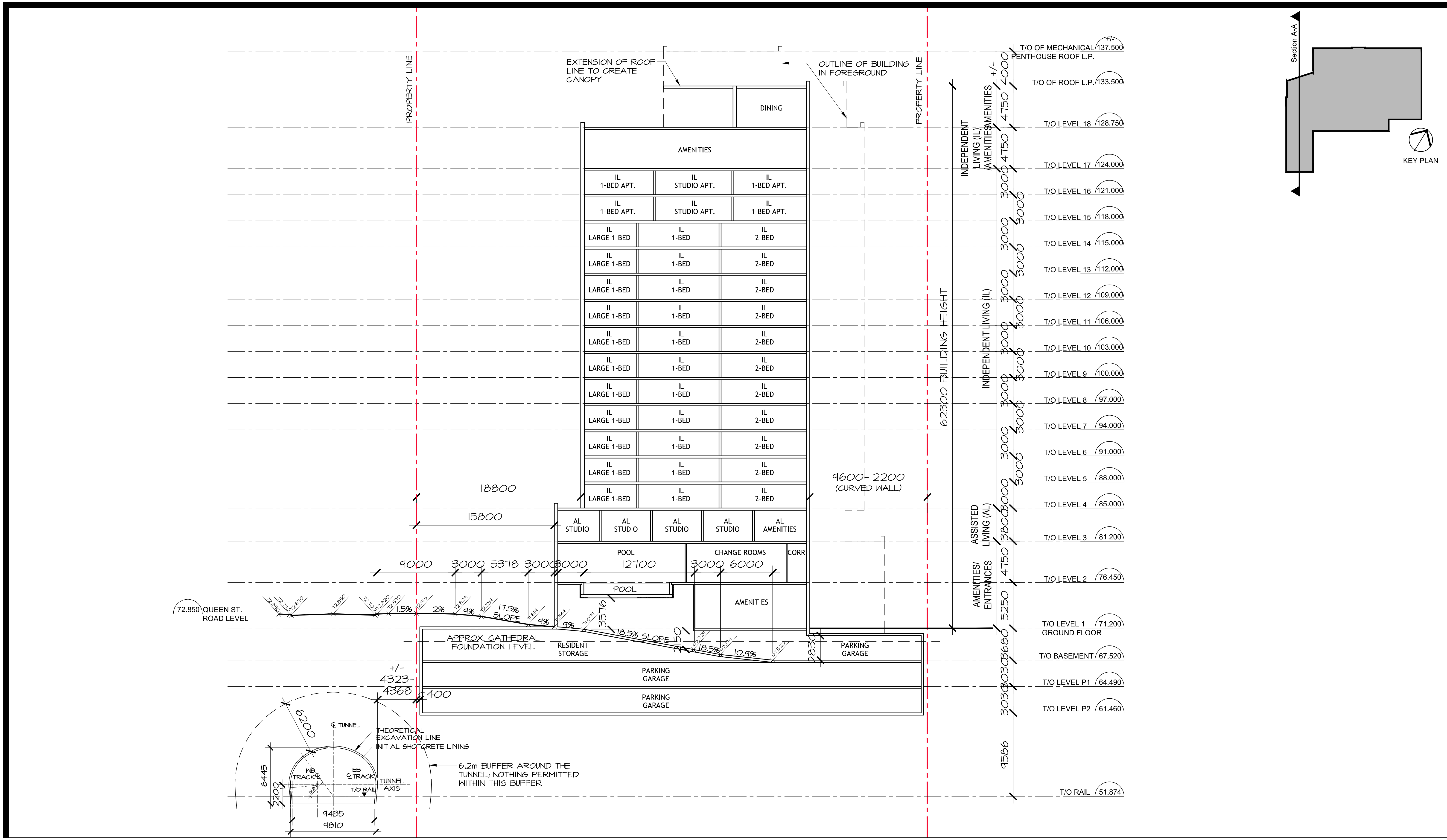
SCALE 1:500

0 5 10 20 30 40 50ft

0 1 2 3 4 5 10 15 20.0m

February 20, 2019

HOBIN ARCHITECTURE



Signature RETIREMENT LIVING

REICHMANN SENIORS HOUSING DEVELOPMENT CORP.

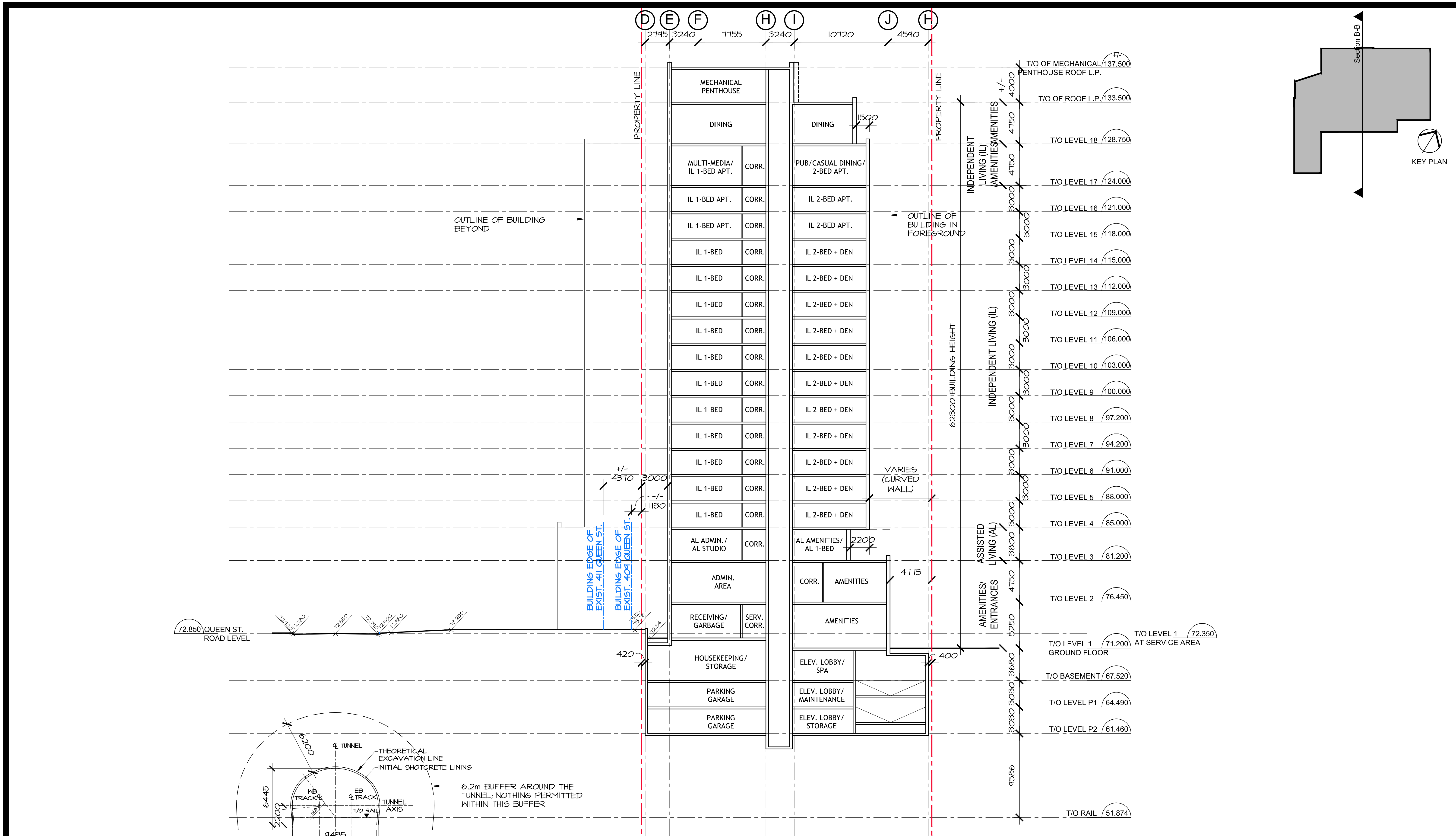
OTTAWA RETIREMENT RESIDENCE BY SIGNATURE

Proposed North-South Building Section | Section A-A

SCALE 1:400

February 20, 2019

HOBIN ARCHITECTURE



Signature RETIREMENT LIVING

REICHMANN SENIORS HOUSING DEVELOPMENT CORP.

OTTAWA RETIREMENT RESIDENCE BY SIGNATURE

Proposed North-South Building Section | Section B-B (Located behind 409 & 411 Queen Street Properties)

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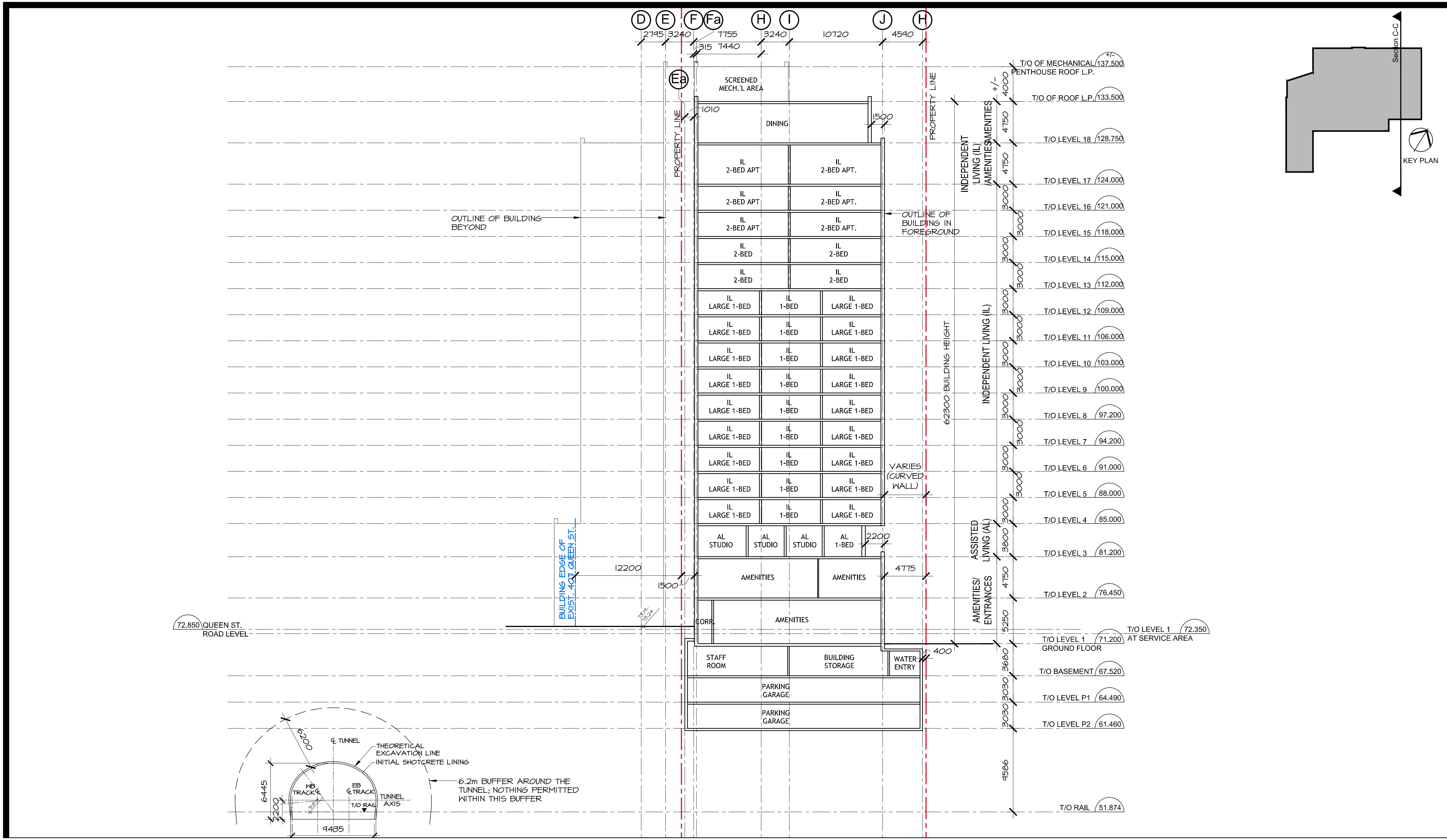
February 20, 2019

HOBIN ARCHITECTURE



Signature RETIREMENT LIVING

REICHMANN SENIORS HOUSING DEVELOPMENT CORP.

OTTAWA RETIREMENT RESIDENCE BY SIGNATURE

Proposed North-South Building Section | Section C-C (Located behind 407 Queen Street Property)

SCALE 1:400

February 20, 2019

HOBIN ARCHITECTURE

3/5/2019 11:38 AM

ASSOCIATION OF ONTARIO LAND SURVEYORS
PLAN SUBMISSION FORM
2024294

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

Stantec

Stantec Geomatics Ltd.
400 - 1331 Clyde Avenue
Ottawa ON
Tel. 613.722.4420
www.stantec.com

TOPOGRAPHIC PLAN OF SURVEY
PART OF LOTS 18, 19 & 20 SOUTH OF SPARKS STREET (NUMBERING WESTWARD) AND PART OF LOTS 19 & 20 NORTH OF QUEEN STREET (NUMBERING WESTWARD) REGISTERED PLAN 3922 CITY OF OTTAWA

Scale 1:200

5 0 5 15 METRES

METRIC CONVERSION

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

BEARING NOTE

BEARINGS ARE ASTRONOMIC AND ARE REFERRED TO THE NORTHERLY LIMIT OF QUEEN STREET AS SHOWN ON PLAN 4R-28538, HAVING A BEARING OF N 59° 19' 10" E.

ELEVATION NOTE

ELEVATIONS ARE REFERRED TO THE CANADIAN GEODETIC VERTICAL DATUM (CGVD-1928:1978) AND ARE DERIVED FROM CITY BENCHMARK MONUMENT No. 3621 (INDEX No. 165), HAVING A PUBLISHED ELEVATION OF 68.725m.

UTILITY NOTE

LOCATION OF UNDERGROUND SERVICES ARE APPROXIMATE AND ARE PER THE CITY OF OTTAWA UCC SHEET No.s D-11-12, D-11-13, D-11-17, D-11-18 & OTTAWA PUBLIC WORKS PLANS (PLAN & PROFILE) 3330 (SHEETS 2 & 3) 1635 (SHEETS 14 & 15) & E1a-02 AND MUST BE VERIFIED PRIOR TO CONSTRUCTION.

LEGEND (IF APPLICABLE)

■		DENOTES	FOUND MONUMENTS
□		"	SET MONUMENTS
IB		"	IRON BAR
IBø		"	ROUND IRON BAR
SIB		"	STANDARD IRON BAR
SSIB		"	SHORT STANDARD IRON BAR
CC		"	CUT CROSS
CP		"	CONCRETE PIN
WIT		"	WITNESS
PIN		"	PROPERTY IDENTIFICATION NUMBER
MEAS,MS		"	MEASURED
PROP		"	PROPORTIONED
OU		"	ORIGIN UNKNOWN
SG		"	STANTEC GEOMATICS LTD.
P		"	REGISTERED PLAN 3922
P1		"	PLAN 4R-28538
P2		"	PLAN 4R-29301
P3		"	PLAN 4R-26551
P4		"	PLAN 4R-14400
P5		"	PLAN 4R-15978
P6		"	PLAN 4R-1689
P7		"	PLAN BY 632 DATED JULY 14, 1955
P8		"	PLAN 4R-26199
P9		"	PLAN BY 725 DATED JAN. 29, 1976
	ACU	"	AIR CONDITIONING UNIT
	AN	"	ANCHOR
	BH	"	BOREHOLE
	BOL	"	BOLLARD
	CB	"	CATCH BASIN
	DCB	"	DOUBLE CB
	CBMH	"	CB MANHOLE
	DCBMH	"	DOUBLE CB MANHOLE
	CBSI	"	SIDE INLET CB
	CSV	"	VALVE CURB STOP
	DRN	"	DRAIN
	EPOST	"	ELECTRICAL OUTLET
	GP	"	POLE GUYWIRE
	GSR	"	GAS SERVICE REGULATOR
	GV	"	GAS VALVE
	HLS	"	LIGHT STANDARD HYDRO
	HM	"	HYDRO METER
	HTN	"	HYDRO TRANSFORMER
	HW	"	HAND WELL
	HYD	"	FIRE HYDRANT
	JBX	"	JUNCTION BOX
	MP	"	MONITORING PIN
	MH	"	MAINTENANCE HOLE UNIDENTIFIED
	MHB	"	MAINTENANCE HOLE BELL
	MHF	"	MAINTENANCE HOLE FIBRE OPTIC
	MHH	"	MAINTENANCE HOLE HYDRO
	MHI	"	MAINTENANCE HOLE INVERT
	MHSA	"	MAINTENANCE HOLE SANITARY
	MHST	"	MAINTENANCE HOLE STORM
	MHT	"	MAINTENANCE HOLE TRAFFIC
	MW	"	MONITORING WELL
	PKM	"	PARKING METER
	PLBX	"	PULL BOX
	PLR	"	PILLAR
	SCV	"	SPRINKLER CONTROL VALVE
	SH	"	SPRINKLER HEAD
	SIA	"	SIAMESE CONNECTION
	SN	"	SIGN
	TBL	"	TABLE
	TB BELL	"	TERMINAL BOX - BELL
	TB CATV	"	TERMINAL BOX - CABLE
	TCB	"	TRAFFIC CONTROL BOX
	TSL	"	TRAFFIC SIGNAL LIGHT
	UMB	"	MARKER BELL UNDERGROUND
	UMC	"	MARKER CABLE UNDERGROUND
	UMG	"	MARKER GAS UNDERGROUND
	UMO	"	MARKER OIL UNDERGROUND
	UP	"	UTILITY POLE
	VB	"	VALVE BOX
	VC	"	VALVE CHAMBER
	WV	"	WATER VALVE
		"	TREE CONIFEROUS
		"	TREE DECIDUOUS

SURVEYOR'S CERTIFICATE

I CERTIFY THAT :

1. THIS SURVEY AND PLAN ARE CORRECT AND IN ACCORDANCE WITH THE SURVEYS ACT, THE SURVEYORS ACT AND THE REGULATIONS MADE UNDER THEM.
2. THE SURVEY WAS COMPLETED ON THE 19th DAY OF SEPTEMBER, 2017 .

REVISION NOTE:

PLAN REVISED TO INDICATE TREE LOCATIONS & SIZES PER FIELD SURVEY DATED JANUARY 15, 2019.

March 5/19
DATE

BRIAN J. WEBSTER
ONTARIO LAND SURVEYOR

REVISION NOTE:

PLAN REVISED TO REFLECT BEDROCK AND FOOTING LOCATIONS WEST SIDE OF 439 QUEEN STREET, PER FIELD SURVEY DATED NOVEMBER 27TH., 2018.

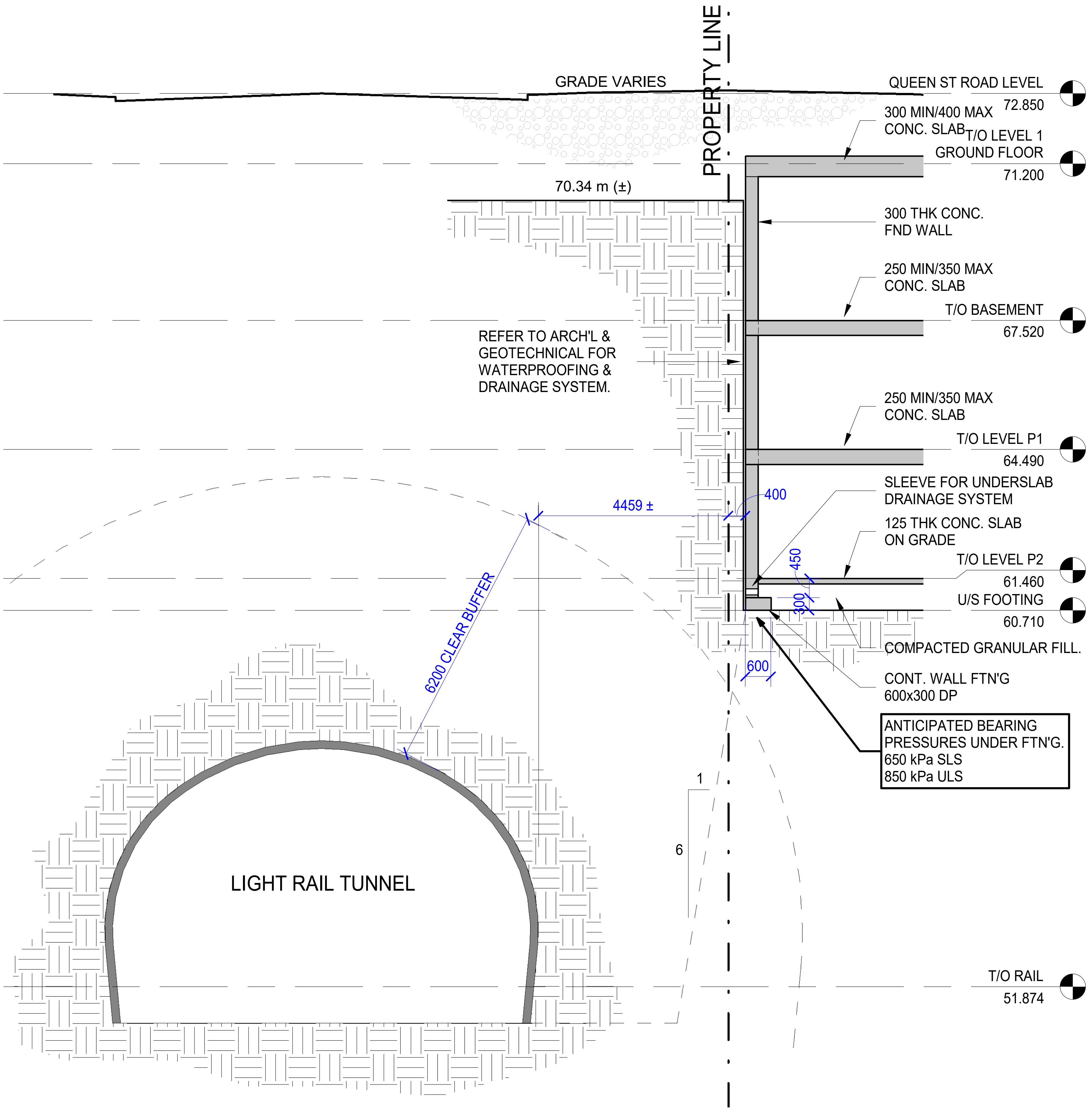
REVISION NOTE:

PLAN REVISED TO REFLECT UNDERGROUND STREET UTILITIES PER CITY OF OTTAWA UPDATED DRAWINGS D-11-12, D-11-13 , D-11-17 AND D-11-18.

DATE

BRIAN J. WEBSTER
ONTARIO LAND SURVEYOR

SRO MAP COORD: X= 366802 Y= 5031208				
DRAWN: ME	CHECKED: KJ	PM: KJ	FIELD: ES	PROJECT No.: 161613750-111

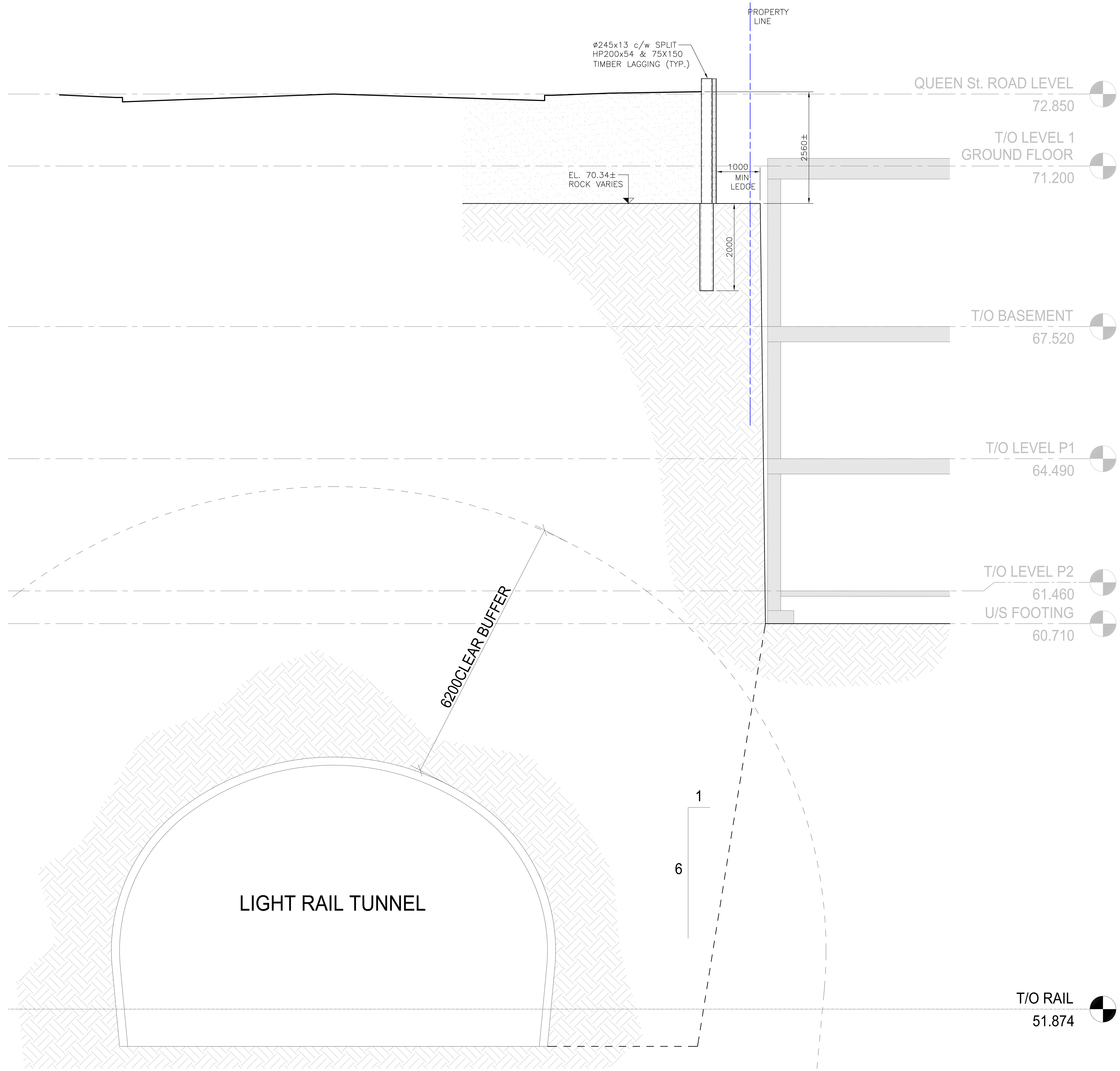


STAMP

CUNLIFFE
TEL 729-7242
FAX 728-1461
CUNLIFFE & ASSOCIATES
CONSULTING STRUCTURAL ENGINEERS
102-1737 WOODWARD DR. OTTAWA ON. K2C 0P9

No.	DESCRIPTION	M / D / Y
2	ISSUE FOR PROXIMITY STUDY	02-20-2019
1	ISSUE FOR REVIEW	01-30-2019

TITLE:	SECTION @ LIGHT RAIL TUNNEL PROXIMITY	DATE:	FEB 20, 2019
PROJECT:	OTTAWA RETIREMENT RESIDENCE BY SIGNATURE	PROJ No.:	18-149
CLIENT:	HOBIN ARCHITECTURE	DWG. No.:	SK1



THE LOCATION OF UTILITIES IS APPROXIMATE ONLY, AND THE EXACT LOCATION SHOULD BE DETERMINED BY CONSULTING THE MUNICIPAL AUTHORITIES AND UTILITY COMPANIES CONCERNED.
THE CONTRACTOR SHALL PROVE THE LOCATION OF UTILITIES AND SHALL BE RESPONSIBLE FOR ADEQUATE PROTECTION FROM DAMAGE DURING CONSTRUCTION.

LICENSED PROFESSIONAL ENGINEER B. URIEV 100081510 MARCH 1, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER R. PIEZ 100123880 Mar. 1, 2019 PROVINCE OF ONTARIO

No.	Date	Revision	By:
1	MAR. 1/19	GENERAL REVISION	B.U.

REMISZ
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57 Auriga Dr. Suite 102
Ottawa, ON, K2E 8B2
tel.: (613) 225-1162
fax: (613) 225-4529

Client
CATHEDRAL HILLS GP Inc. c/o: REICHMANN SENIORS HOUSING DEVELOPMENT CORP.

Project
OTTAWA RETIREMENT RESIDENCE BY SIGNATURE 412 SPARKS St., OTTAWA, ON

Drawing
TYPICAL SHORING SECTION @QUEEN STREET AND LRT TUNNEL

Designed	B.U.	Date	FEB. 2019
Drawn	R.P.	Scale	1:50
Checked	R.P.	Sheet	1 OF 1
Project No.	2018–152	Dwg. No.	SK–01

frame 790x505 mm

Construction Methodology and Impact Review		
Construction Item	**Potential Impact**	**Mitigation Program**
Item A - Installation of Temporary Shoring System - 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 system, which will be cantilevered where located adjacent to the Confederation Line tunnel.	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 existing Confederation Line tunnel. The soldier pile installations will terminate above geodetic elevation 66, which is well above the tunnel. Installation of the shoring system is not anticipated to have an adverse impact on the tunnel, nonetheless, a series of vibration monitoring devices are recommended to be installed within the tunnel structure. The vibration monitors 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 Program of Report PG4271-2 dated February 19, 2019.
Item B - Excavation and Removal of Overburden to Bedrock Surface - The existing LRT tunnel top of rail (TOR) is located at elevation 51.9 m.	Undermining LRT Tunnel and causing structural damage.	Structural damage to the LRT tunnel during excavation is not anticipated based on the tunnel profile provided and available borehole information, which indicates that the proposed development will be founded well below bedrock surface and the founding elevation of the proposed development, at approximate geodetic elevation 60.7 m, will not extend below the tunnel.
Item C - Bedrock Blasting and Removal Program - Blasting of the bedrock will be required for the proposed tower and parking garage structure construction. It is expected that up to approximately 9 to 10 m of bedrock removal is required based on the current design concepts for the proposed development.	Structural damage of LRT tunnel due to vibrations from blasting program.	Structural damage to the tunnel during bedrock blasting and removal is not anticipated, nonetheless, a series of vibration monitoring devices are recommended to be installed within the tunnel structure. The vibration monitors 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 Program of Report PG4271-2 dated February 19, 2019.
Item D - Installation of Footings and Foundation Walls - The portion of the proposed building adjacent to the LRT alignment consists of 3 levels of underground parking. Therefore, the footings will be placed over a clean, limestone bedrock bearing surface.	Building footing loading on adjacent LRT structure.	The zone of influence from the proposed footings will not intersect with the existing tunnel. Therefore, no interaction or influence will be exerted by the new development on the tunnel foundation and foundation wall. The foundation walls of the proposed structure will not transfer load to the adjacent bedrock or tunnel, as all load will be transferred to the footings.

APPENDIX 2

Geotechnical Investigation:

Report PG4271-1 dated October 31, 2017

Geotechnical Engineering

Environmental Engineering

Hydrogeology

Geological Engineering

Materials Testing

Building Science

Archaeological Services

patersongroup

Geotechnical Investigation

Proposed Multi-Storey Building
Cathedral Hills - 412 Sparks Street
Ottawa, Ontario

Prepared For

Reichmann Seniors Housing Development Corporation

Paterson Group Inc.
Consulting Engineers
154 Colonnade Road South
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Canada K2E 7J5

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October 31, 2017

Report PG4271-1

Table of Contents

Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Reichmann Seniors Housing Development Corp. to conduct a geotechnical investigation for the proposed multi-storey building to be located at 412 Sparks Street along the east side of the Christ Church Cathedral between Sparks Street and Queen Street, in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan in Appendix 2 of this report).

The objectives of the investigation were to:

❑ Determine the subsoil and groundwater conditions at this site by means of boreholes.

❑ Provide geotechnical recommendations for the design of the proposed development including construction considerations which may affect the design.

The following report has been prepared specifically and solely for the aforementioned project which is described herein. It contains our findings and includes geotechnical recommendations pertaining to the design and construction of the subject 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 of work of this present investigation. Therefore, the present report does not address environmental issues.

2.0 Proposed Project

It is understood that the proposed project includes a multi-storey building with four underground parking levels.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

The field program for the investigation was carried out between December 15 and 17, 2010. At that time, four boreholes of the overall investigation were placed within the proposed building location. The test hole locations were selected in a manner to provide general coverage of the overall subject site at that time. The test hole locations are shown on Drawing PG4271-1 - Test Hole Location Plan included in Appendix 2.

The boreholes were put down using a track and truck-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 recovered using a 50 mm diameter split-spoon sampler or from the auger flights. The split-spoon and auger samples were classified on site, placed in sealed plastic bags, and transported to our laboratory for further review. The depths at which the split-spoon and auger samples were recovered from the boreholes are shown as SS and AU, respectively, on the Soil Profile and Test Data sheets in Appendix 1.

The 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.

Rock samples were recovered from all boreholes using a core barrel and diamond drilling techniques. The rock samples were classified on site, placed in hard cardboard core boxes and transported to our laboratory. The depths at which the rock core samples were recovered from the boreholes are shown as RC on the Soil Profile and Test Data sheets in Appendix 1.

Diamond drilling was carried out at BH 1 and BH 4 to determine the nature of the bedrock. The recovery value and the rock quality designation value (RQD) 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 sound rock pieces longer than 100 mm in one core run over the length of the core run. Both values are indicative of the quality of the bedrock.

Subsurface conditions observed in the boreholes 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

Flexible polyethylene standpipes were installed in all boreholes to permit the monitoring of groundwater levels subsequent to the completion of the sampling program.

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 borehole locations were selected and surveyed by Paterson personnel. The ground surface elevation at each borehole location was referenced to a temporary benchmark (TBM), consisting of the top of spindle of the fire hydrant, located at 424 Queen Street. A geodetic elevation of 73.60 m was provided for the TBM based on available survey plans. The location and ground surface elevations at borehole locations are presented on Drawing PG4271-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

Soil samples were recovered from the subject site and visually examined in our laboratory to review the results of the field logging.

3.4 Analytical Testing

One (1) 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

At the time of the field program, the subject site was occupied by a gravel covered parking lot for the Christ Church Cathedral. The ground surface across the subject site was relatively flat and at grade with Sparks Street and approximately 1 m lower than Queen Street and the east neighbouring residential buildings. Also, based on findings from a previous review of the neighbouring building foundations, the adjacent buildings are founded directly over a weathered bedrock surface.

4.2 Subsurface Profile

In general, the soil profile encountered at the test holes consists of either topsoil, pavement structure or silty sand fill at ground surface. A native silty sand with some gravel was noted below the abovenoted layers at all borehole locations within the subject site. Practical refusal to augering was encountered at all borehole locations between 0.7 to 2 m depth.

Grey limestone bedrock with shale beddings was cored at BH 1. The RQD values of the bedrock ranged between 24 to 100%. These values are indicative of a poor to excellent rock quality. Generally, the bedrock quality was excellent. Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for the details of the profiles encountered at each test hole location.

Based on available geological mapping, the subject site is located in an area where the bedrock consists of interbedded shale and limestone of the Verulam Formation at depths ranging from 0 to 1 m.

4.3 Groundwater

Groundwater levels were measured in the standpipes on December 22, 2010 and the results are presented in Table 1. It should be noted that the groundwater levels are subject to seasonal fluctuations. Therefore, groundwater levels could vary at the time of construction.

Table 1 - Measured Groundwater Levels			
Test Hole Number	**Ground Surface Elevation (m)**	**Water Level - December 22, 2010**	
		Depth (m)	**Elevation (m)**
BH 1	71.56	2.34	69.22
BH 2	71.13	Dry	--
BH 3	71.29	Dry	--
BH 7	71.64	Dry	--

5.0 Discussion

5.1 Geotechnical Assessment

The subject site is considered adequate from a geotechnical perspective for the proposed development. It is anticipated that the proposed building will be founded on shallow footings placed on a clean, surface sounded bedrock.

Bedrock removal will be required to complete the underground parking levels of the proposed multi-storey buildings. It is expected that a line drilling and controlled blasting program will be completed for bedrock removal required for the proposed underground parking levels. The blasting operations should be planned and carried out under the guidance of a professional engineer with experience in blasting operations.

It is should be noted that a 3 to 5 m high retaining wall is present along the north side of Sparks Street due to a significant grade change downward to the north. However, due to the shallow nature of the bedrock formation, no slope stability issues exist for the subject site.

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

5.2 Site Preparation

Stripping Depth

Due to the depth of the bedrock at the subject site and the anticipated founding level for the proposed buildings, it is anticipated that all existing overburden material will be excavated from within the footprint of the proposed building. Bedrock excavation will be required for the construction of the underground parking levels.

Bedrock Removal

Based on the volume of the bedrock encountered in the area, it is expected that line-drilling in conjunction with hoe-ramming or controlled blasting will be required to remove the bedrock. In areas of weathered bedrock and where only a small quantity of bedrock is to be removed, bedrock removal may be possible by 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.

Excavation side slopes in sound bedrock can be carried out using almost vertical side walls. Where bedrock is of lower quality, the excavation face should be free of any loose rock. An area specific review should be completed by the geotechnical consultant at the time of construction to determine if rock bolting or other remedial measures are required to provide a safe excavation face for areas where low quality bedrock is encountered. A minimum 1 m horizontal ledge, should be left between the bottom of the overburden excavation and the top of the bedrock surface to provide an area to allow for potential sloughing or to provide a stable base for the overburden shoring system.

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 as much as possible 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 the source of vibrations: piling rig, hoe ram, compactor, dozer, crane, truck traffic, etc. The construction of the shoring system using soldier piles or sheet piling will require the use of this equipment. Vibrations, whether it is caused by blasting operations or by construction operations could be the cause of the source of detrimental vibrations on the adjacent 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). It should be noted that these guidelines are for today's construction standards. Considering that these guidelines are above perceptible human level and, in some cases, could be very disturbing to some people, and that several sensitive buildings are in the immediate vicinity of the site, it is recommended that a pre-construction survey be completed to minimize the risks of claims during or following the construction of the proposed buildings.

Fill Placement

Fill used for grading beneath the proposed buildings should consist of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. The fill should be tested and approved prior to delivery to the site. It should be placed in lifts no greater than 300 mm thick and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the proposed buildings should be compacted to at least 98% of its standard Proctor maximum dry density (SPMDD).

Non-specified existing fill along with site-excavated soil can be used as general landscaping fill where settlement of the ground surface is of minor concern. These materials should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids. If these materials are to be used to build up the subgrade level for areas to be paved, they should be compacted in thin lifts to a minimum density of 95% of their respective SPMDD.

5.3 Foundation Design

Footings placed on a clean, surface sounded limestone bedrock surface 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.

A factored bearing resistance value at ULS of **4,500 kPa**, incorporating a geotechnical resistance factor of 0.5, could be used if founded on limestone bedrock and the bedrock is free of seams, fractures and voids within 1.5 m below the founding level. This could be verified by completing and probing 50 mm diameter drill holes to a depth of 1.5 m below the founding level within the footprint(s) of the footing(s). At least one drill hole should be completed per major footing. The drill hole inspection should be carried out by the geotechnical consultant.

Footings bearing on an acceptable bedrock bearing surface and designed using the bearing resistance values provided herein will be subjected to negligible potential post-construction total and differential settlements.

5.4 Design for Earthquakes

Shear wave velocity testing was completed for the subject site to accurately determine the applicable seismic site classification for the proposed building from Table 4.1.8.4.A of the Ontario Building Code 2012. The shear wave velocity testing and analysis were completed by Paterson personnel. The results of the shear wave profile at two (2) shot locations are presented in Appendix 2.

Field Program

The shear wave testing location was located across the south portion of the subject site. Paterson field personnel placed 22 horizontal geophones in a straight line in roughly an east-west orientation. The 4.5 Hz. horizontal geophones were mounted to the surface by means of a 75 mm ground spike attached to the geophone land case. The geophones were spaced at 3 m intervals and were connected by a geophone spread cable to a Geode 24 Channel seismograph.

The seismograph was also connected to a computer laptop and a hammer trigger switch attached to a 12 pound dead blow hammer. The hammer trigger switch sends a start signal to the seismograph. The hammer is used to strike an I-Beam seated into the ground surface, which creates a polarized shear wave. The hammer shots are repeated between four (4) to eight (8) times at each shot location to improve signal to noise ratio. The shot locations are also completed in forward and reverse directions (ie.- striking both sides of the I-Beam seated parallel to the geophone array). The shot locations are located at the centre of the geophone array and 3, 4.5 and 20 m away from the first and last geophone.

Data Processing and Interpretation

The analysis was completed by Dr. Dariush Motazedian with Carleton University and reviewed by Paterson personnel. The shear wave velocity measurement was made using reflection/refraction methods. The interpretation is performed by recovering arrival times from direct and refracted waves. The interpretation is repeated at each shot location to provide an average shear wave velocity (Vs) for each shot location. The layer intercept times, velocities from different layers and critical distances are interpreted from the shear wave records to compute the bedrock depth at each location. The bedrock velocity was interpreted using the main refractor wave velocity, this is considered a conservative estimate of the bedrock velocity due to the increasing quality of the bedrock with depth. It should be noted that as bedrock quality increases, the bedrock shear wave velocity also increases.

It is understood that the proposed building will be founded directly on a bedrock bearing surface. Based on the testing results, the bedrock shear wave velocity is 2,600 m/s.

The Vs_{30} was calculated using the standard equation for average shear wave velocity calculation from the Ontario Building Code (OBC) 2012.

$$V_{s30} = \frac{Depth_{OfInterest}(m)}{\sum\left(\frac{(Depth_{Layer1}(m)}{Vs_{Layer1}(m/s)} + \frac{Depth_{Layer2}(m)}{Vs_{Layer2}(m/s)}\right)}$$

$$V_{s30} = \frac{30m}{\sum\left(\frac{30m}{2{,}600m/s}\right)}$$

Based on the results
of the seismic testing, the average shear wave velocity of the 30 m profile directly below the proposed underside of foundation, Vs_{30}, was calculated to be **2,600 m/s**. Therefore, a seismic **Site Class A** is applicable for the proposed building as per Table 4.1.8.4.A of the OBC 2012. The soils underlying the subject site are not susceptible to liquefaction.

5.5 Basement Slab

It is expected that the basement area for the proposed multi-storey building will be mostly parking and the recommended pavement structure noted in Subsection 5.6 will be applicable. All backfill material within the footprint of the proposed building should be placed in maximum 300 mm thick loose layers and compacted to at least 98% of its SPMDD.

In consideration of the groundwater conditions encountered during the investigation, a subfloor drainage system, consisting of lines of perforated drainage pipe subdrains connected to a positive outlet, should be provided in the clear stone backfill under the lower basement floor.

5.6 Basement Wall

It is expected that a portion of the basement walls are to be poured against a composite drainage blanket, which will be placed against the exposed bedrock face. A nominal coefficient of at-rest earth pressure of 0.05 is recommended in conjunction with a dry unit weight of 23.5 kN/m^3 (effective unit weight of 15.5 kN/m^3). A seismic earth pressure component will not be applicable for the foundation wall, which is to be poured against the bedrock face. It is expected that the seismic earth pressure will be transferred to the underground floor slabs, which should be designed to accommodate these pressures. A hydrostatic groundwater pressure should be added for the portion below the groundwater level.

Undrained conditions are anticipated (i.e. below the groundwater level). Therefore, the applicable effective unit weight of the retained soil should be 13 kN/m^3, where applicable. A hydrostatic pressure should be added to the total static earth pressure when calculating the effective unit weight.

Two distinct conditions, static and seismic, should be reviewed for design calculations. The parameters for design calculations for the two conditions are presented below.

Static Conditions

The static horizontal earth pressure (p_o) could be calculated with 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 with 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 Conditions

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}) could be calculated using $0.375 \cdot a_c \cdot \gamma \cdot H^2/g$ where:

a_c = $(1.45 - a_{max}/g)a_{max}$
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. The vertical seismic coefficient is assumed to be zero.

The earth force component (P_o) under seismic conditions could be calculated using $P_o = 0.5\ K_o\ \gamma\ H^2$, where $K_o = 0.5$ for the soil conditions presented 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 Rock Anchor Design

Overview of Anchor Features - Grouted Rock Anchors

The geotechnical design of grouted rock anchors in limestone bedrock is based upon two possible failure modes. The anchor can fail either by shear failure along the grout/rock interface or by pullout of a 60 to 90 degree cone of rock with the apex of the cone near the middle of the bonded length of the anchor. It should be noted that interaction may develop between the failure cones of anchors that are relatively close to one another resulting in a total group capacity smaller than the sum of the load capacity of each anchor taken individually.

A third failure mode of shear failure along the grout/steel interface should also be reviewed by the structural engineer to ensure all typical failure modes have been reviewed. Typical rock anchor suppliers, such as Dywidag Systems International (DSI Canada) or Williams Form Engineering, have qualified personnel on staff to recommend appropriate rock anchor size and materials.

It should be further noted that centre-to-centre spacing between anchors should be at least four (4) times the anchor hole diameter and greater than one fifth (1/5) of the total anchor length (minimum of 1.2 m) to lower the group influence effects. It is also recommended that anchors in close proximity to each other be grouted at the same time to ensure any fractures or voids are completely in-filled and that fluid grout does not flow from one hole to an adjacent empty one.

Anchors can be of the “passive” or the “post-tensioned” type, depending on whether the anchor tendon is provided with post-tensioned load or not prior to being put into service. To resist seismic uplift pressures, a passive rock anchor system can be used. It should be noted that a post-tensioned anchor will take the uplift load with much less deflection than a passive anchor.

It is recommended that the anchor be provided with a bonded length, or fixed anchor length, at the base of the anchor, which will provide the anchor capacity, as well an unbonded length, or free anchor length, between the rock surface and the start of the bonded length. As the depth at which the apex of the shear failure cone develops is midway along the bonded length, a fully bonded anchor would tend to have a much shallower cone, and therefore less geotechnical resistance, than one where the bonded length is limited to the bottom part of the overall anchor.

Permanent anchors should be provided with corrosion protection. As a minimum, this requires that the entire drill hole be filled with cementious grout. The free anchor length is provided by installing a plastic sleeve to act as a bond break, with the sleeve filled with grout or a corrosion inhibiting mastic. Double corrosion protection can be provided with factory assembled systems, such as those available from Dywidag Systems International or Williams Form Engineering Corp.

Grout to Rock Bond

Based on bedrock testing results, the unconfined compressive strength of limestone bedrock ranges between 60 and 120 MPa, which is stronger than most routine grouts. A factored tensile grout to rock bond resistance value at ULS of **1.0 MPa**, incorporating a resistance factor of 0.3, can be used. A minimum grout strength of 40 MPa is recommended.

Rock Cone Uplift

As discussed previously, the geotechnical capacity of the rock anchors depends on the dimensions of the rock anchors and the configuration of the anchorage system. Based on existing bedrock information, a **Rock Mass Rating (RMR) of 69** was assigned to the bedrock, and Hoek and Brown parameters (**m and s**) were taken as **0.575 and 0.00293**, respectively.

Recommended Grouted Rock Anchor Lengths

Parameters used to calculate grouted rock anchor lengths are provided in Table 2.

Table 2 - Parameters used in Rock Anchor Review	
Grout to Rock Bond Strength - Factored at ULS	1.0 MPa
Compressive Strength - Grout	40 MPa
Rock Mass Rating (RMR) - Good quality Limestone Hoek and Brown parameters	69 m=0.575 and s=0.00293
Unconfined compressive strength - Limestone	60 MPa
Unit weight - Submerged Bedrock	15 kN/m^3
Apex angle of failure cone	60°
Apex of failure cone	mid-point of fixed anchor length

The fixed anchor length will depend on the diameter of the drill holes. Recommended anchor lengths for a 125 mm diameter hole are provided in Table 3. It should be noted that the factored tensile resistance values given in Table 3 are based on a single anchor with no group influence effects. A detailed analysis of the anchorage system, including potential group influence effects, could be provided once the details of the loading for the proposed building are known.

Table 3 - Recommended Rock Anchor Lengths - Grouted Rock Anchor

Diameter of Drill Hole (mm)	Anchor Lengths (m)			Factored Tensile Resistance (kN)
	Bonded Length	Unbonded Length	Total Length	
125	1.1	0.7	1.8	250
	1.8	0.7	2.5	450
	2	1	3	600
	2.1	1.2	3.3	750

Other considerations

The anchor drill holes should be inspected by geotechnical personnel and should be flushed clean prior to grouting. The use of grout tube to place grout from the bottom up in the anchor holes is recommended.

The geotechnical capacity of each rock anchor should be proof tested at the time of construction. More information on testing can be provided upon request.

5.8 Pavement Structure

Car only parking areas and access lanes are anticipated at this site. The proposed pavement structures are shown in Tables 4 and 5.

Table 4 - 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 5 - Recommended Pavement Structure - Access Lanes

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
400	**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 Ontario Provincial Standard Specification (OPSS) Granular B Type I or Type II material.

The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 98% of the material's SPMDD using suitable vibratory equipment.

Minimum Performance Graded (PG) 58-34 asphalt cement should be used for this project.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

It is recommended that a perimeter foundation drainage system be provided for the proposed structure. It is understood that insufficient room is available for exterior backfill. It is suggested that this system could be as follows:

- ❑ Bedrock vertical surface
- ❑ composite drainage layer

It is recommended that the composite drainage system (such as Delta Drain 3000 or equivalent) extend down to the footing level. It is recommended that 150 mm diameter sleeves at 3 m centres be cast in the footing or at the foundation wall/footing interface to allow the infiltration of water to flow to the interior perimeter drainage pipe. The perimeter drainage pipe and underfloor drainage system should direct water to sump pit(s) within the lower basement area.

Underfloor drainage may be required to control water infiltration within the bedrock. For design purposes, we recommend that 150 mm diameter perforated, corrugated PVC pipes be placed at 3 to 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.

6.2 Protection of Footings Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effects of frost action. A minimum of 1.5 m of soil cover alone, or a minimum of 0.6 m of soil cover, in conjunction with foundation insulation, should be provided in this regard.

Exterior unheated footings, such as those for isolated exterior piers, are more prone to deleterious movement associated with frost action than the exterior walls of the structure proper and require additional protection, such as soil cover of 2.1 m or a combination of soil cover and foundation insulation.

6.3 Excavation Side Slopes

Unsupported Excavation

The unsupported 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. 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.

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 Requirements

The temporary shoring requirements 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.

For preliminary design purposes, the temporary system may 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 added to the earth pressures described below. These systems can 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 earth pressures acting on the shoring system may be calculated using the following parameters.

Table 6 - 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

Soldier Pile and Lagging System

The active earth pressure acting on a soldier pile and lagging shoring system can be calculated using a rectangular earth pressure distribution with a maximum pressure of 0.65 K γ H for strutted or anchored shoring or a triangular earth pressure distribution with a maximum value of K γ H for a cantilever shoring system. H is the height of the excavation.

The active earth pressure should be used where wall movements are permissible while the at-rest pressure should be used if no movement is permissible.

The total unit weight should be used above the groundwater level while the submerged unit weight should be used below the groundwater level.

The hydrostatic groundwater pressure should be added to the earth pressure distribution wherever the submerged unit weights are used for earth pressure calculations should the level on the groundwater not be lowered below the bottom of the excavation. If the groundwater level is lowered, the total unit weight for the soil should be used full weight, with no hydrostatic groundwater pressure component.

If a soldier pile and lagging system is used, the piles could be socketed in the bedrock in pre-augered holes. The augered holes should be advanced at least 2 m into the bedrock and at least 2 m below the bottom of the excavation.

A minimum factor of safety of 1.5 should be used.

6.4 Pipe Bedding and Backfill

Bedding and backfill materials should be in accordance with City of Ottawa standards and specifications.

The pipe bedding for sewer and water pipes should consist of at least 150 mm of OPSS Granular A material. If the bedding is placed on bedrock, the thickness of the bedding should be increased to 300 mm for sewer pipes. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of its SPMDD. The bedding material should extend at least to the spring line of the pipe.

The cover material, which should consist of OPSS Granular A, should extend from the spring line of the pipe to at least 300 mm above the obvert of the pipe. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of its SPMDD.

It should generally be possible to re-use the moist (not wet) silty sand above the cover material if the excavation and filling 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) should match the soils exposed at the trench walls to minimize differential frost heaving. The trench backfill should be placed in maximum 300 mm thick loose lifts and compacted to a minimum of 95% of the material's SPMDD.

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.

The rate of flow of groundwater into the excavation through the overburden should be low to moderate for the expected at this site. 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 and Climate Change (MOECC) 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 4 to 5 months should be allowed for completion of the PTTW application package and issuance of the permit by the MOECC.

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 on 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 MOECC 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 which encounters the building's perimeter groundwater infiltration control system will be directed to the proposed building's sump pit. It is expected that groundwater flow will be low (i.e.- less than 10,000 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 preliminary concepts indicate that four levels of underground parking are planned for the proposed building. Based on the existing groundwater level and shallow nature of the bedrock formation in the area, 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 building.

6.6 Winter Construction

Precautions must be taken if winter construction is considered for this project.

The subsoil conditions at this site mostly consist of frost susceptible materials. In 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.

The trench excavations should be carried out in a manner to avoid the introduction of frozen materials, snow or ice into the trenches.

Precaution must be taken where excavations are carried in proximity of existing structures which may be adversely affected due to the freezing conditions. In particular, it should be recognized that where a shoring system is used, the soil behind the shoring system will be subjected to freezing conditions and could result in heaving of the structure(s) placed within or above frozen soil. Provisions should be made in the contract document to protect the walls of the excavations from freezing, if applicable.

6.7 Corrosion Potential and Sulphate

The results of analytical testing show that the sulphate content for the soil sample submitted is less than 0.2%. It is expected that the majority of the existing soil will be removed as part of the building construction. A Type 10 Portland cement (normal cement) would be appropriate for this site. The chloride content and the pH of the sample indicate that they are not significant factors in creating a corrosive environment for exposed ferrous metals at this site, whereas the resistivity is indicative of an aggressive to very aggressive corrosive environment.

7.0 Recommendations

It is a requirement for the foundation design data provided herein to be applicable that the following material testing and observation program be performed by the geotechnical consultant.

- ❑ Review of the geotechnical aspects of the excavating contractor's shoring design, prior to construction.
- ❑ Review the bedrock stabilization and excavation requirements.
- ❑ 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.
- ❑ 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 the completion of a satisfactory inspection program by the geotechnical consultant.

8.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project. Our recommendations should be reviewed when the project drawings and specifications are complete.

A soils investigation is a limited sampling of a site. Should any conditions at the site be encountered which differ from those at the test locations, we request that we be notified immediately in order to permit reassessment of our recommendations.

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 Reichmann Seniors Housing Development Corporation or their agent(s) is not authorized without review by this firm for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

Stephanie A. Boisvenue, P.Eng.

LICENSED PROFESSIONAL ENGINEER
Nov. 1-2017
D. J. GILBERT
100116130
PROVINCE OF ONTARIO

David J. Gilbert, P.Eng.

Report Distribution:

- ❑ Reichmann Seniors Housing Development Corporation (3 copies)
- ❑ 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 Building - Cathedral Hill Project
Queen Street, Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant, south side of Queen Street, at 424 Queen Street. Geodetic elevation = 73.60m.

REMARKS

BORINGS BY CME 55 Power Auger

DATE December 15, 2010

FILE NO. PG4271

HOLE NO. BH 1

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	71.56
Asphaltic concrete	0.08	AU	1				
FILL: Brown silty sand with gravel	0.60	AU	2				
Compact, brown **SILTY SAND,** trace gravel		SS	3	50	13	1	70.56
	1.68	SS	4	67	50+		
BEDROCK: Grey limestone with shale beddings		RC	1	100	24	2	69.56
		RC	2	100	100	3	68.56
						4	67.56
		RC	3	100	100	5	66.56
						6	65.56
		RC	4	100	92	7	64.56
		RC	5	100	97	8	63.56
	9.47	RC	6	93	93	9	62.56
End of Borehole							
(GWL @ 2.34m - Dec. 22, 2010)							

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

○ Water Content %

20 40 60 80

Piezometer 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 Building - Cathedral Hill Project
Queen Street, Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant, south side of Queen Street, at 424 Queen Street. Geodetic elevation = 73.60m.

REMARKS

BORINGS BY CME 55 Power Auger **DATE** December 15, 2010

FILE NO. PG4271

HOLE NO. BH 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	71.13		
Asphaltic concrete 0.08		AU	1						
FILL: Brown silty sand with concrete and slag		AU	2						
		SS	3	21	5	1	70.13		
1.40									
Brown **SILTY SAND** with gravel 1.75		SS	4	67	50+				
End of Borehole									
Practical refusal to augering @ 1.75m depth									
(BH dry - Dec. 22, 2010)									

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 Building - Cathedral Hill Project
Queen Street, Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant, south side of Queen Street, at 424 Queen Street. Geodetic elevation = 73.60m.

REMARKS

BORINGS BY CME 55 Power Auger

DATE December 15, 2010

FILE NO. PG4271

HOLE NO. BH 3

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 %	Piezometer Construction
GROUND SURFACE						0	71.29		
Topsoil 0.15									
Brown **SILTY SAND** 0.69		AU	1						
Brown **SILTY SAND** with organics and gravel 1.19		SS	2	47	50+	1	70.29		
End of Borehole Practical refusal to augering @ 1.19m depth (BH dry - Dec. 22, 2010)									

Pen. Resist. / Water Content scale: 20 40 60 80

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 Building - Cathedral Hill Project
Queen Street, Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant, south side of Queen Street, at 424 Queen Street. Geodetic elevation = 73.60m.

REMARKS

BORINGS BY CME 55 Power Auger

DATE December 17, 2010

FILE NO. PG4271

HOLE NO. BH 7

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)	Piezometer Construction
GROUND SURFACE						0	71.64		
FILL: Brown silty sand with gravel		SS	1	71	49				
		SS	2		11	1	70.64		
1.22									
Brown **SILTY SAND** with gravel		SS	3		50+				
1.30									
End of Borehole									
Practical refusal to augering @ 1.30m depth									
(BH dry upon completion)									

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

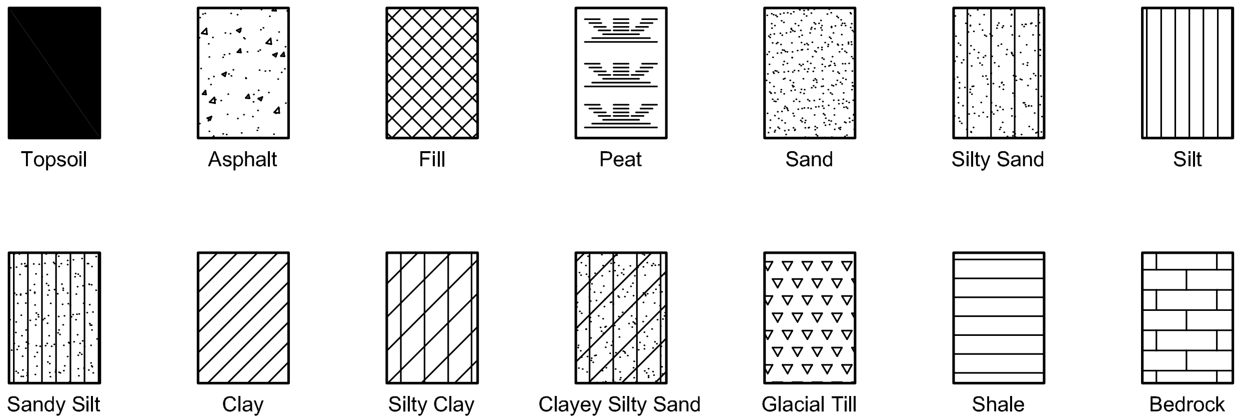
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void 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.

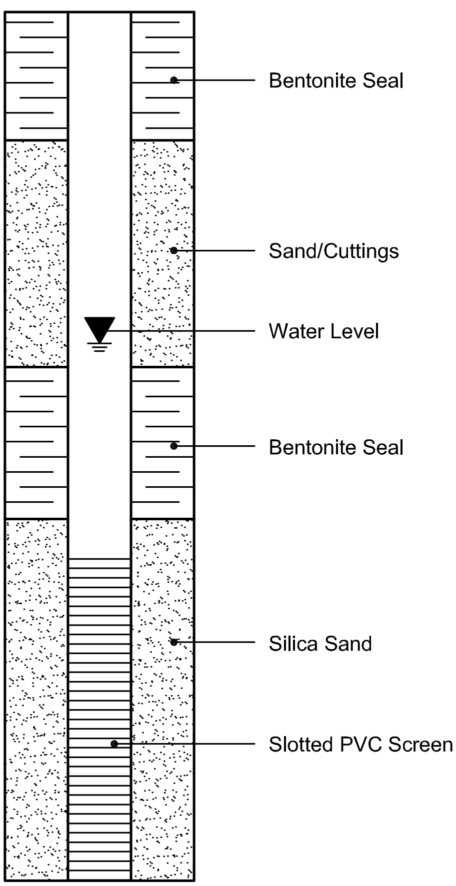
SYMBOLS AND TERMS (continued)

STRATA PLOT

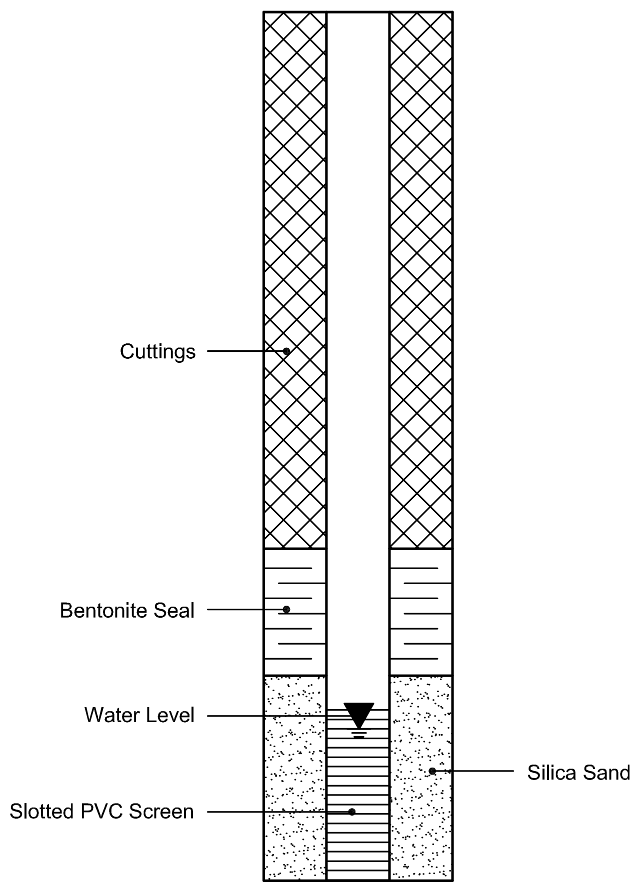


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Certificate of Analysis

Client: **Paterson Group Consulting Engineers**

Client PO: 10384

Report Date: 30-Dec-2010

Order Date:22-Dec-2010

Project Description: PG2262

	Client ID:	BH4-SS4	-	-	-
	Sample Date:	17-Dec-10	-	-	-
	Sample ID:	1052136-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	87.0	-	-	-
General Inorganics					
pH	0.05 pH Units	7.72	-	-	-
Resistivity	0.10 Ohm.m	10.6	-	-	-
Anions					
Chloride	5 ug/g dry	391	-	-	-
Sulphate	5 ug/g dry	1970	-	-	-

APPENDIX 2

FIGURE 1 - KEY PLAN

FIGURES 2 AND 3 - SEISMIC SHEAR WAVE VELOCITY PROFILES

DRAWING PG4271-1 - TEST HOLE LOCATION PLAN

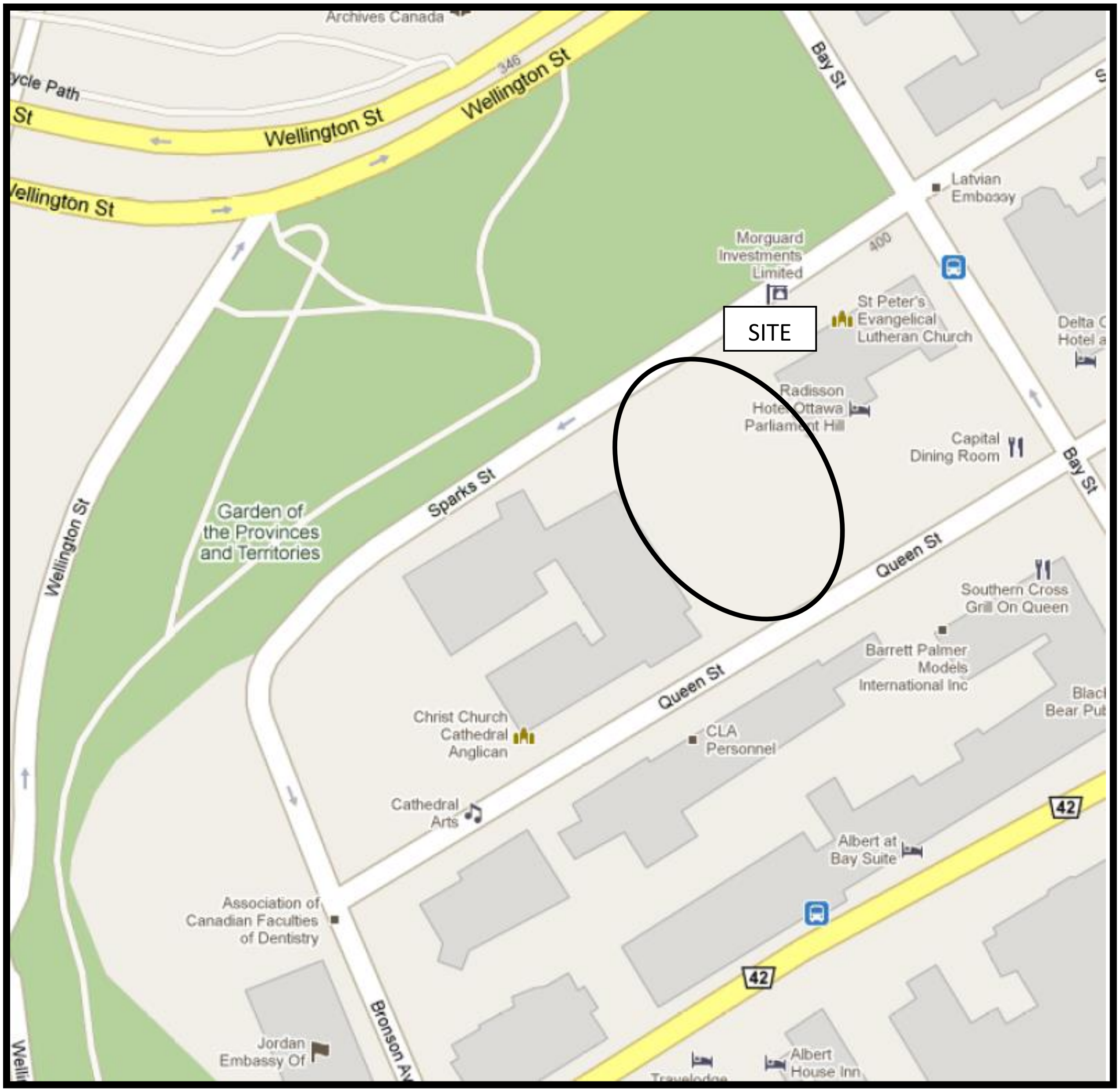


FIGURE 1

KEY PLAN

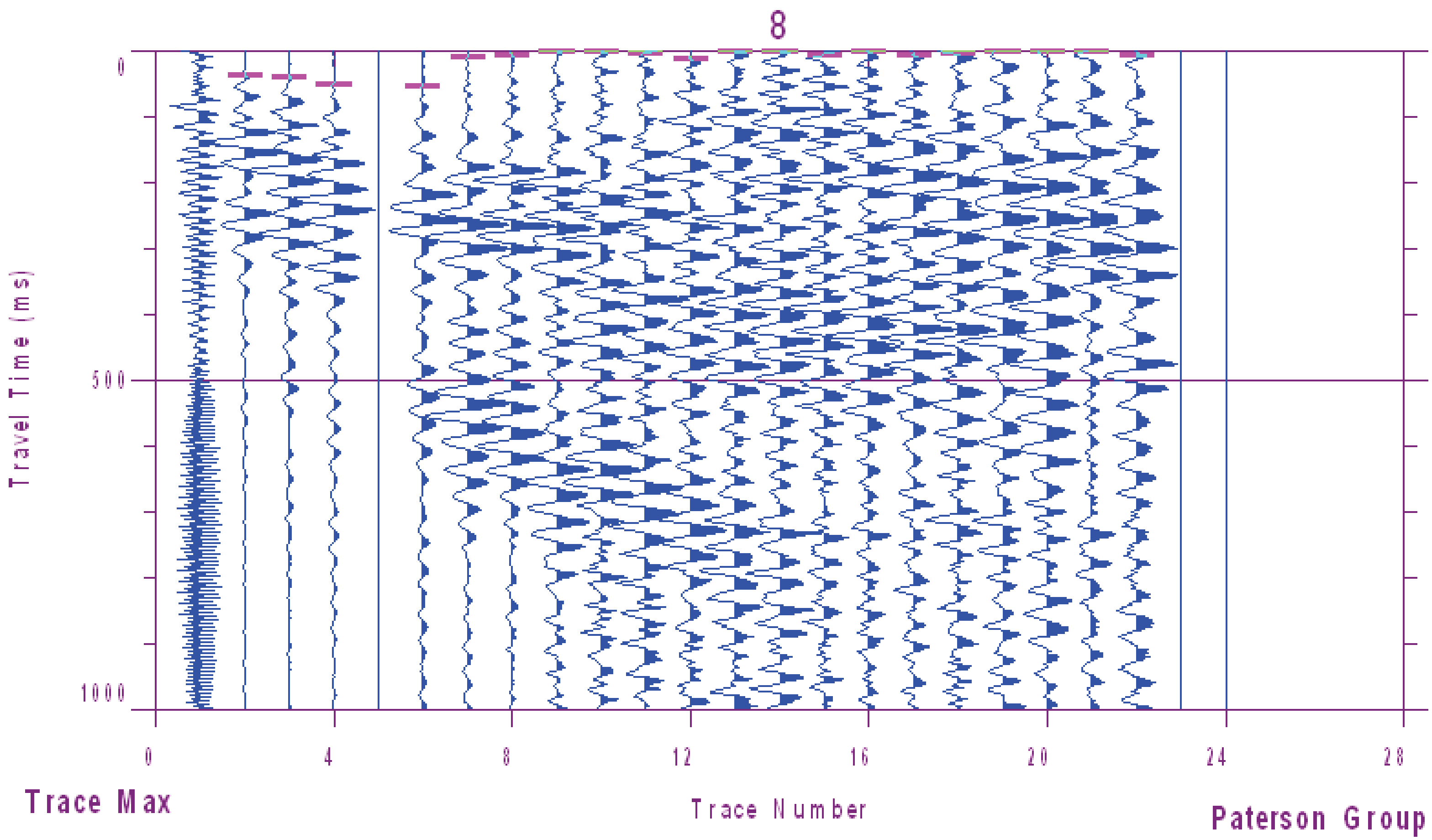


Figure 2 – Shear Wave Velocity Profile at Shot Location 34.5 m

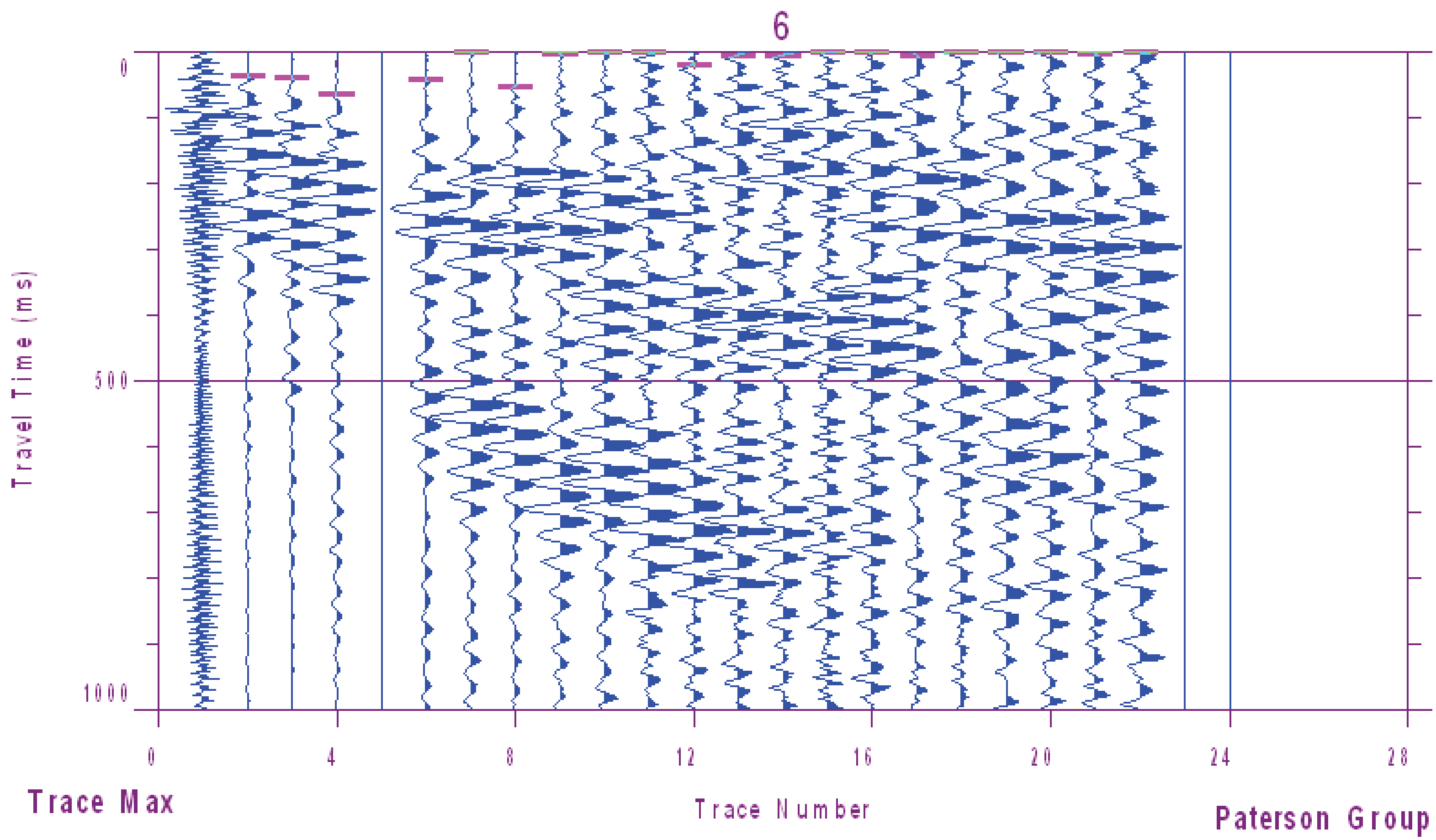
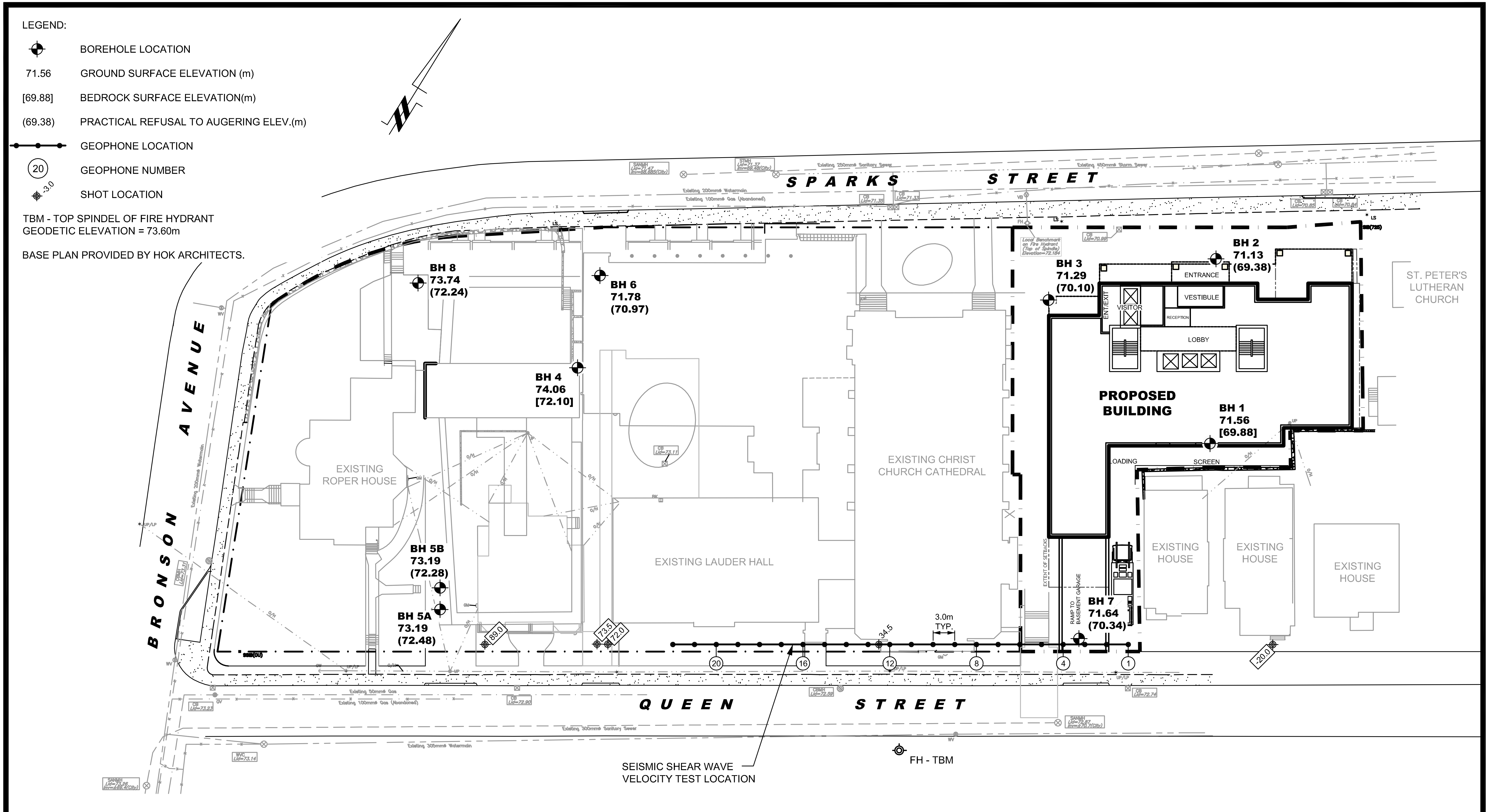


Figure 3 – Shear Wave Velocity Profile at Shot Location -3 m



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NO.	REVISIONS	DATE	INITIAL
0			

REICHMANN SENIORS HOUSING DEVELOPMENT CORP.

GEOTECHNICAL INVESTIGATION
PROP. MULTI-STOREY BUILDING-CATHEDRAL HILL PROJECT

OTTAWA, ONTARIO

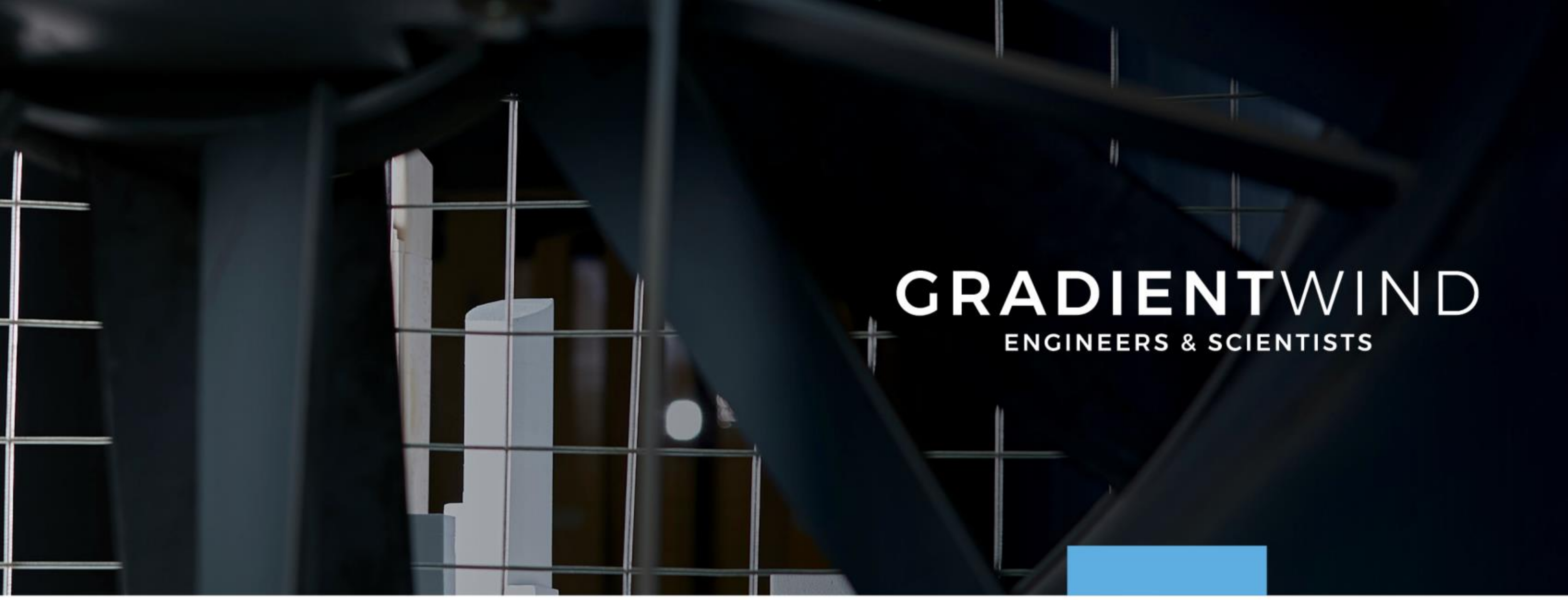
Title:

TEST HOLE LOCATION PLAN

Scale:	1:500	Date:	09/2017
Drawn by:	RCG	Report No.:	PG4271-1
Checked by:	SB	Dwg. No.:	PG4271-1
Approved by:	DJG	Revision No.:	0

APPENDIX 3

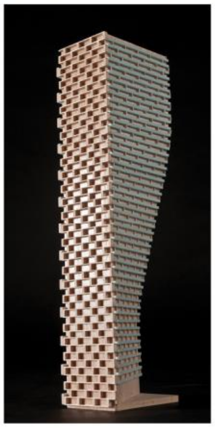
Traffic Noise & Vibration Detailed Assessment
prepared by Gradient Wind Engineers & Scientists
dated February 21, 2019

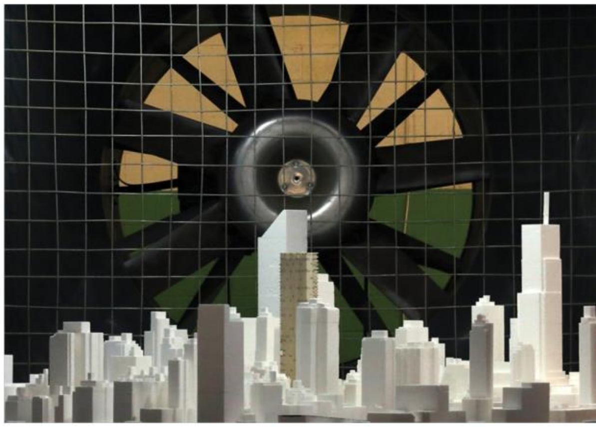


TRAFFIC NOISE & VIBRATION DETAILED ASSESSMENT

Ottawa Retirement Residence by Signature
Ottawa, Ontario

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





February 21, 2019

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

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

EXECUTIVE SUMMARY

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

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

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

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

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

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

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

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

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

TABLE OF CONTENTS

1. INTRODUCTION

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

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

2. TERMS OF REFERENCE

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

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

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

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

3. OBJECTIVES

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

4. METHODOLOGY

4.1 Background

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

4.2 Roadway Traffic Noise

4.2.1 Criteria for Roadway Traffic Noise

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

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

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

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

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

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

4.2.2 Theoretical Roadway Noise Predictions

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

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

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

4.2.1 Roadway Traffic Volumes

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

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

TABLE 2: ROADWAY TRAFFIC DATA

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

4.3 Ground Vibration & Ground-borne Noise

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

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

4.3.1 Ground Vibration Criteria

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

4.3.2 Theoretical Ground Vibration Prediction Procedure

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

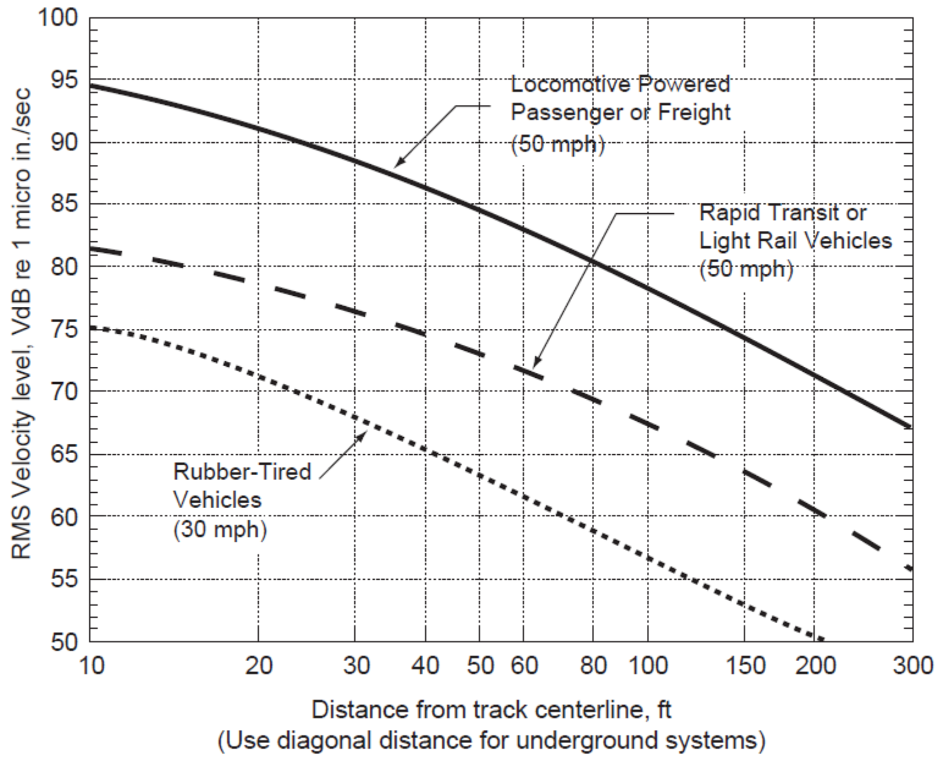
---

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

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

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

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



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

5. RESULTS AND DISCUSSION

5.1 Roadway Traffic Noise Levels

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

TABLE 3: EXTERIOR NOISE LEVELS DUE TO ROAD TRAFFIC

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

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

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

5.2 Noise Barrier Calculation

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

TABLE 4: RESULTS OF NOISE BARRIER INVESTIGATION

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

5.3 Ground Vibrations & Ground-borne Noise Levels

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

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

6. CONCLUSIONS AND RECOMMENDATIONS

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

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

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

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

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

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

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

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

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

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

GRADIENTWIND
ENGINEERS & SCIENTISTS

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

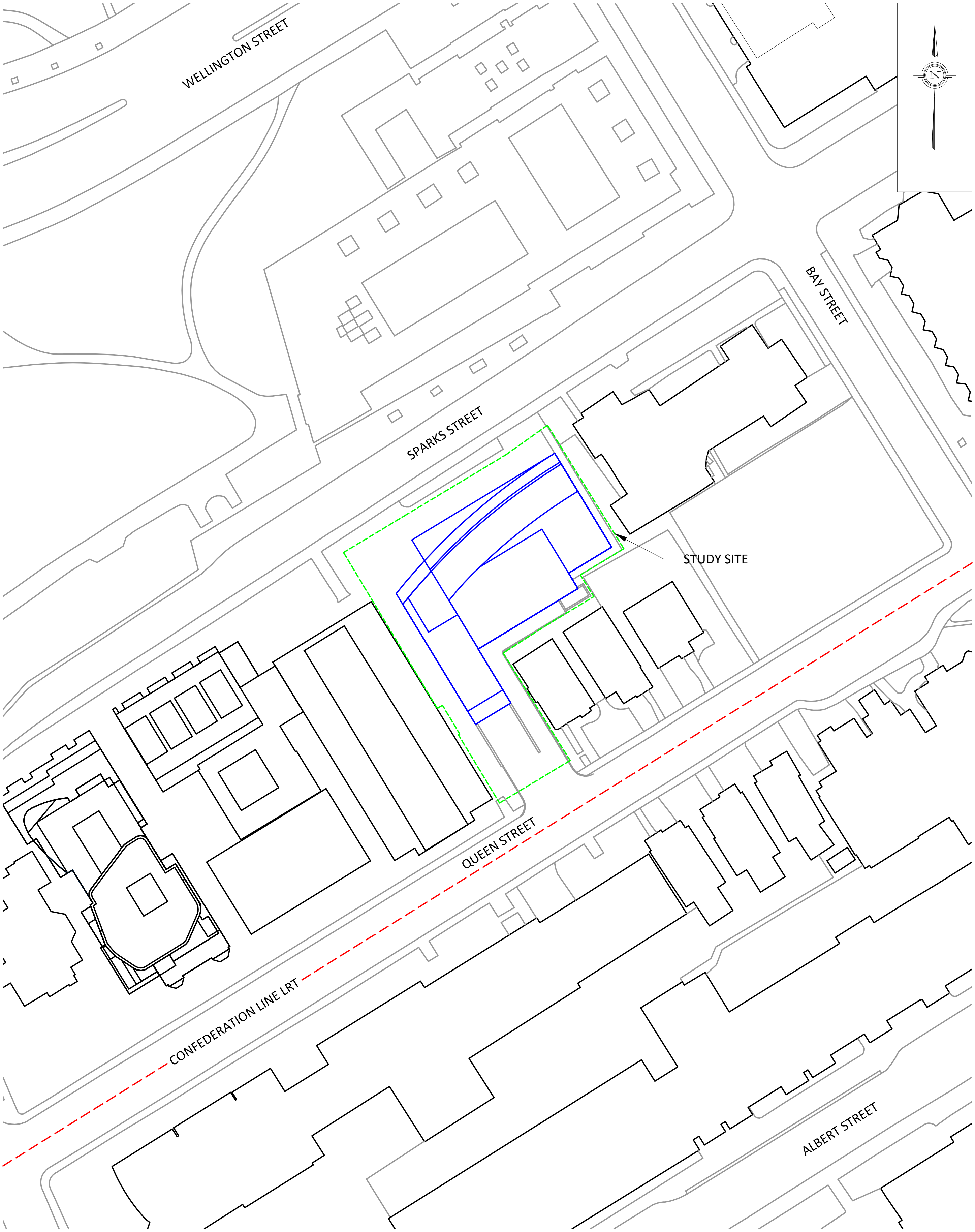
Sincerely,

Gradient Wind Engineering Inc.

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

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

Joshua Foster, P.Eng.
Principal



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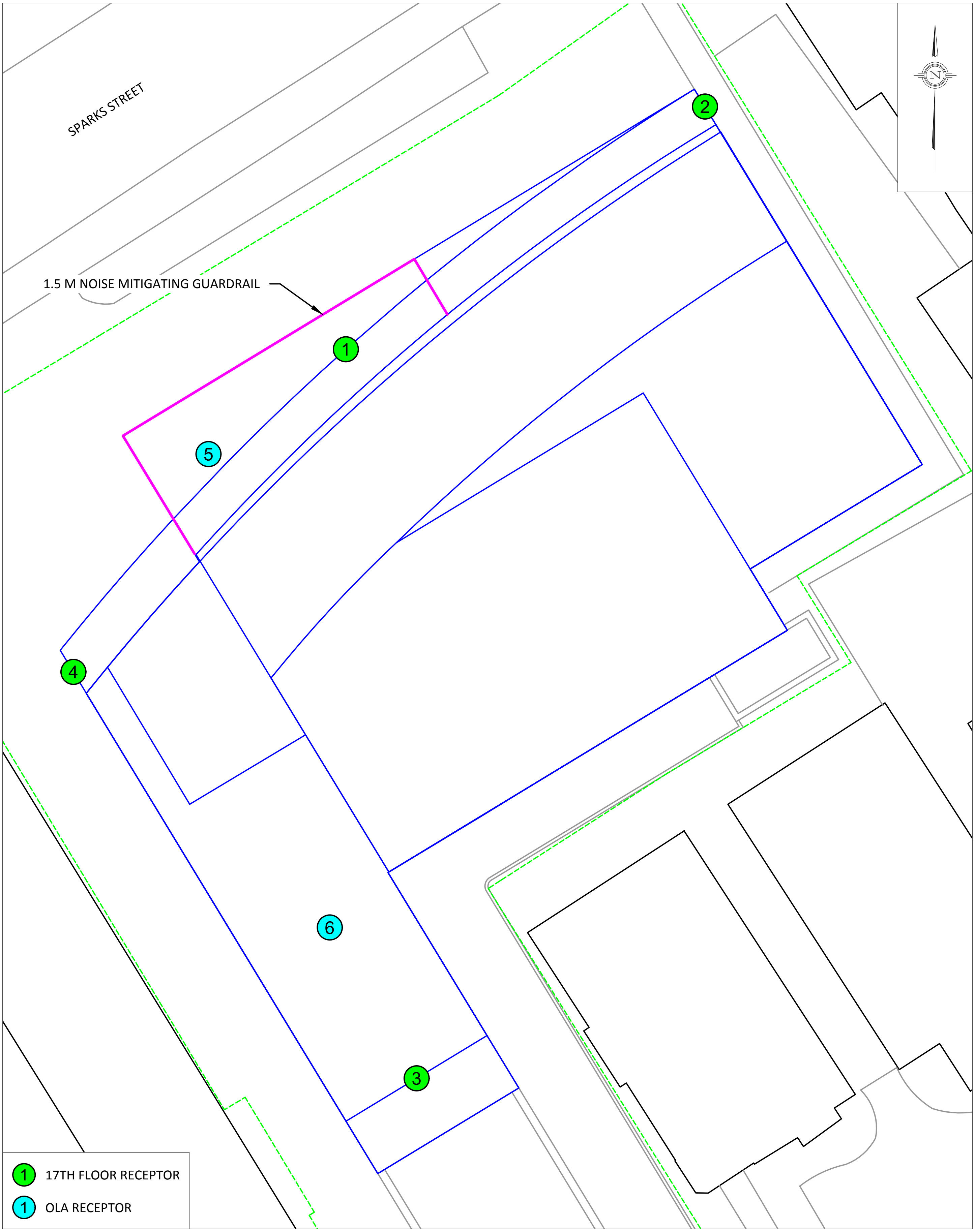
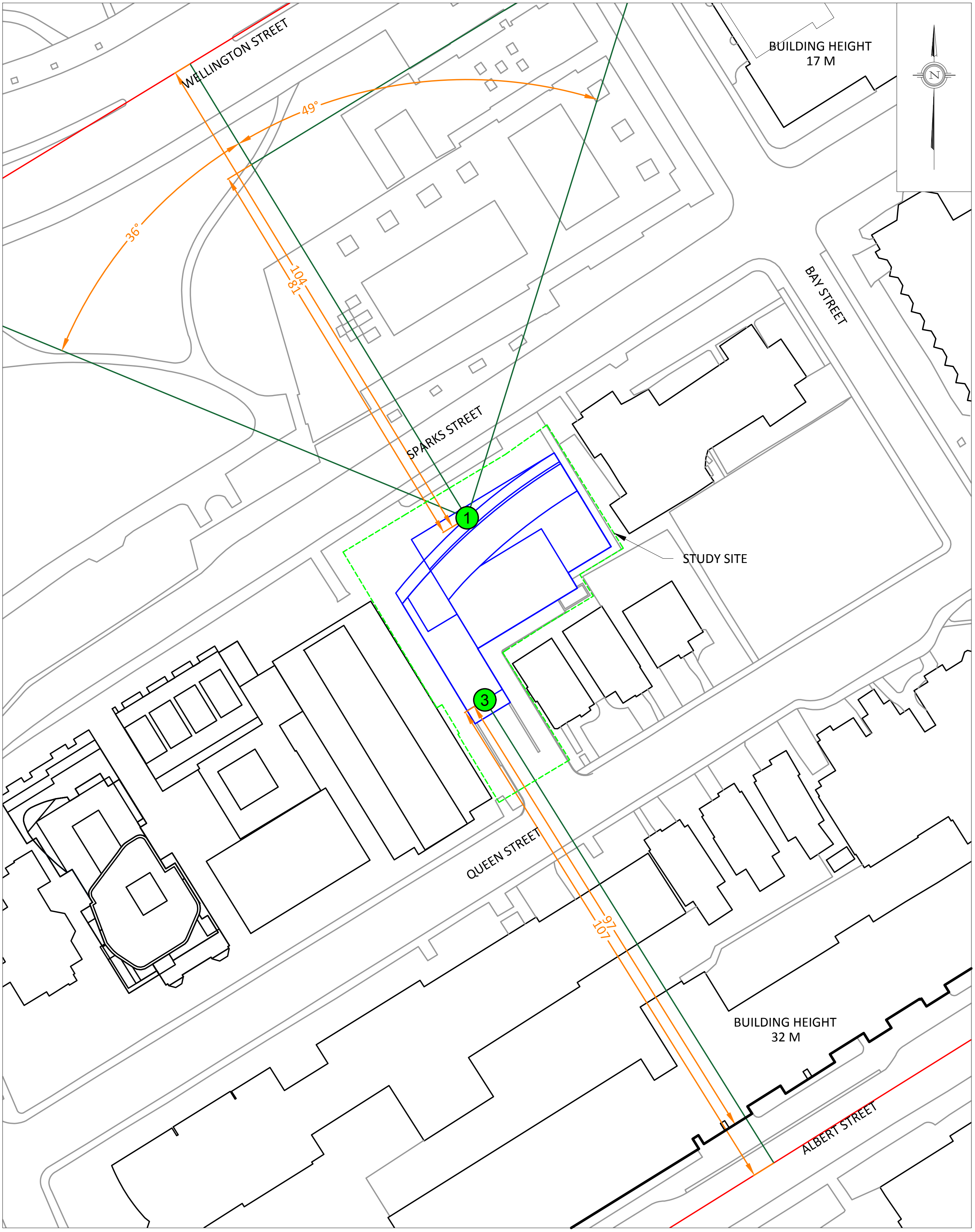
PROJECT	CATHEDRAL HILL RETIREMENT RESIDENCE BY SIGNATURE ROADWAY TRAFFIC NOISE & VIBRATION ASSESSMENT		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GWE18-176-1
DATE	JANUARY 24, 2019	DRAWN BY	M.L.

DESCRIPTION

FIGURE 1:
SITE PLAN SURROUNDING CONTEXT



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



GRADIENTWIND ENGINEERS & SCIENTISTS	PROJECT: CATHEDRAL HILL RETIREMENT RESIDENCE BY SIGNATURE ROADWAY TRAFFIC NOISE & VIBRATION ASSESSMENT		DESCRIPTION: FIGURE 3: STAMSON INPUT DATA - RECEPTOR 1,3
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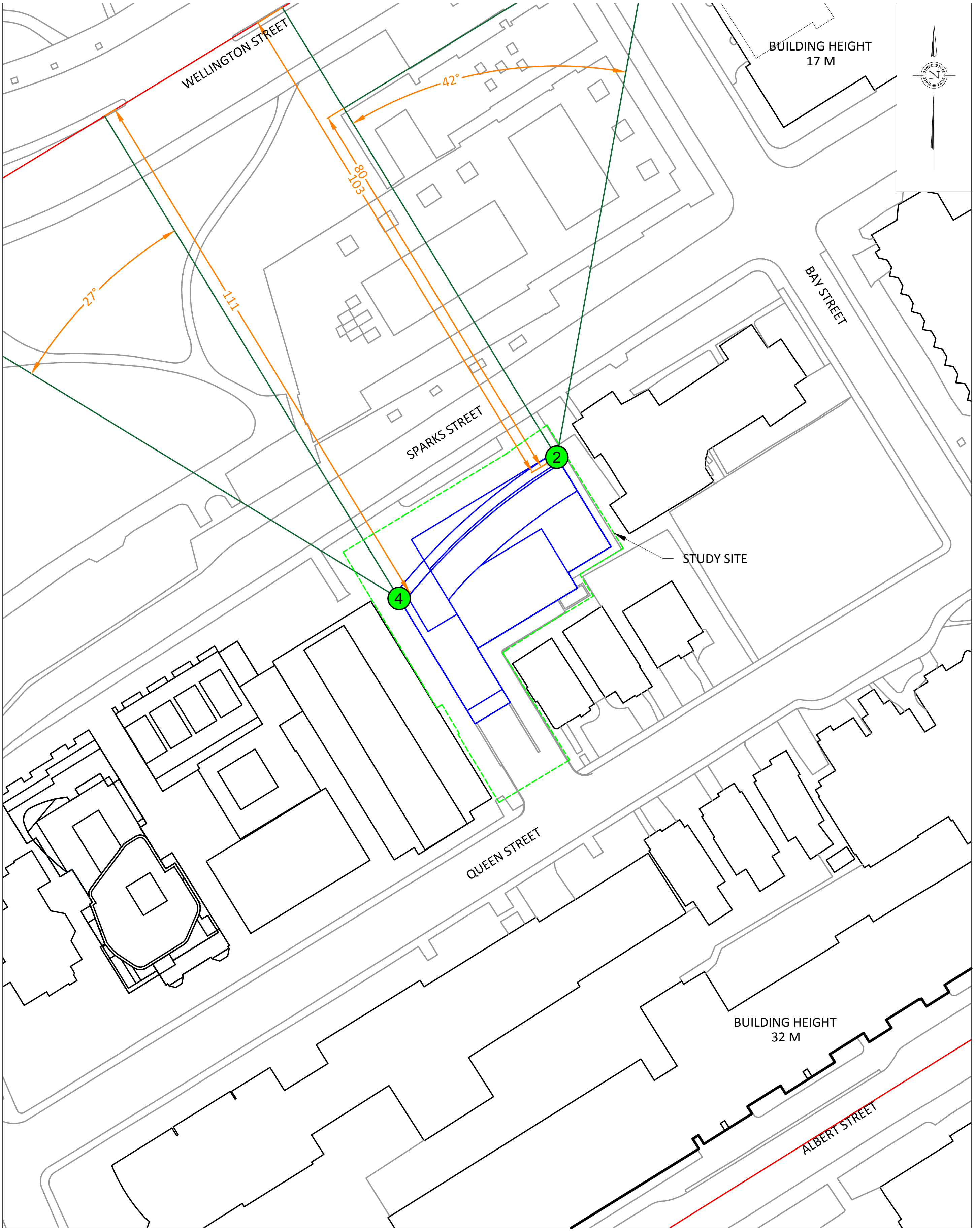
	DATE: JANUARY 24, 2019	DRAWN BY: M.L.	



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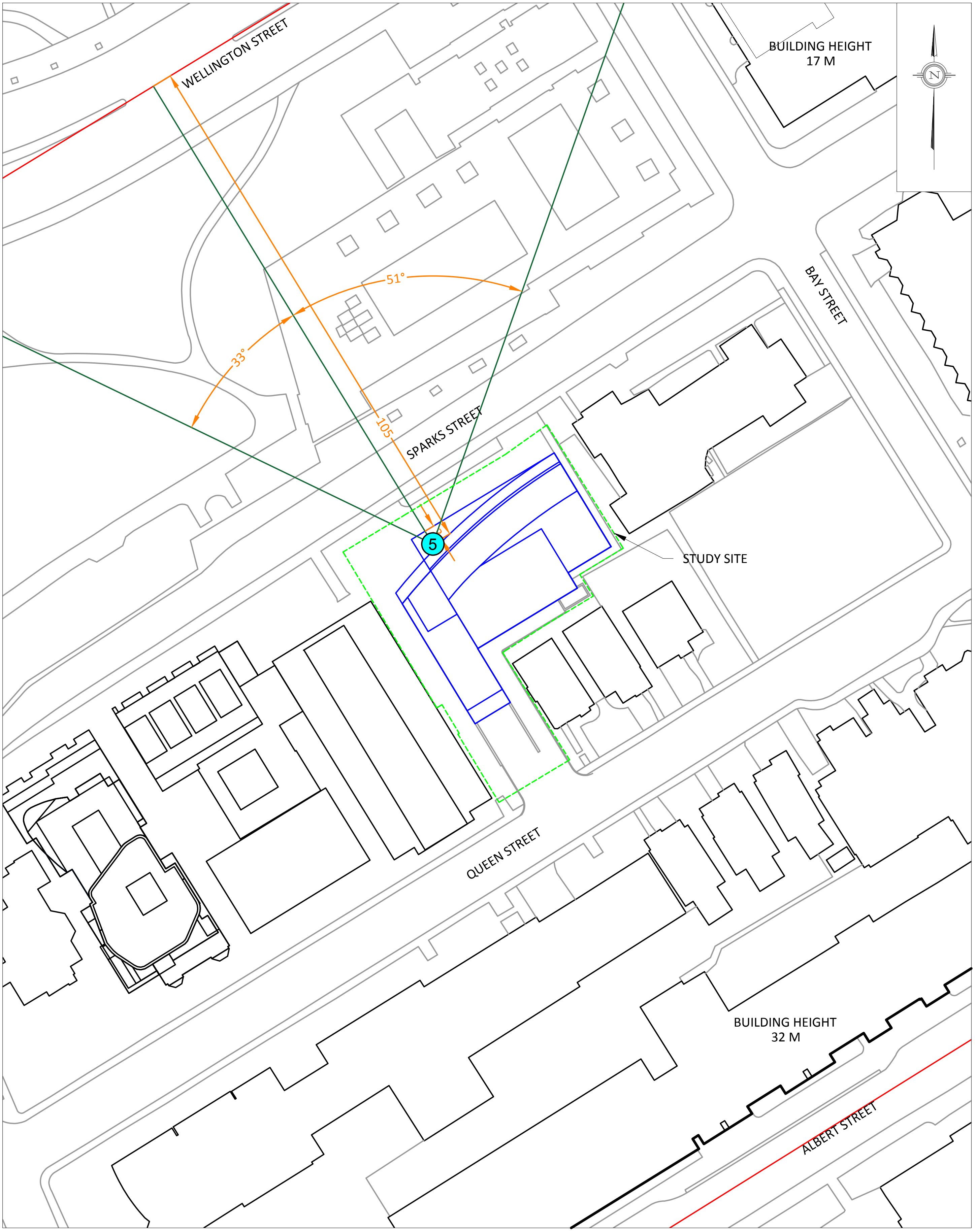
PROJECT	CATHEDRAL HILL RETIREMENT RESIDENCE BY SIGNATURE ROADWAY TRAFFIC NOISE & VIBRATION ASSESSMENT		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GWE18-176-4
DATE	JANUARY 24, 2019	DRAWN BY	M.L.

DESCRIPTION

FIGURE 4:
STAMSON INPUT DATA - RECEPTOR 2,4



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PROJECT	CATHEDRAL HILL RETIREMENT RESIDENCE BY SIGNATURE ROADWAY TRAFFIC NOISE & VIBRATION ASSESSMENT		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GWE18-176-5
DATE	JANUARY 24, 2019	DRAWN BY	M.L.

DESCRIPTION

FIGURE 5:
STAMSON INPUT DATA - RECEPTOR 5

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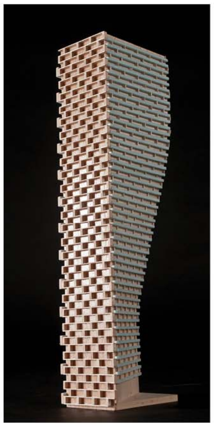
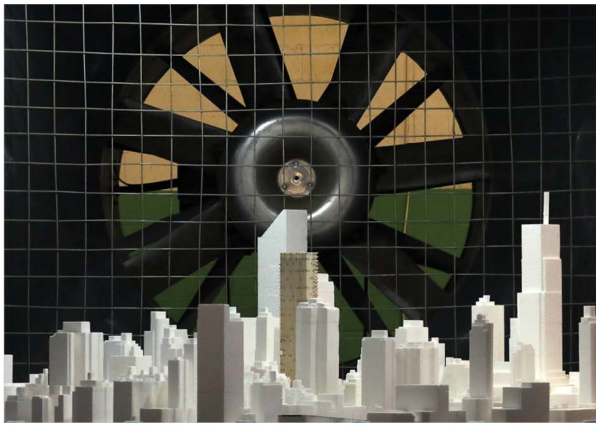
PROJECT	CATHEDRAL HILL RETIREMENT RESIDENCE BY SIGNATURE ROADWAY TRAFFIC NOISE & VIBRATION ASSESSMENT
SCALE	1:1000 (APPROX.)
DRAWING NO.	GWE18-176-6
DATE	JANUARY 24, 2019
DRAWN BY	M.L.
DESCRIPTION	FIGURE 6: STAMSON INPUT DATA - RECEPTOR 6





APPENDIX A

STAMSON 5.04 – INPUT AND OUTPUT DATA

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

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


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

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

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

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

#
```

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

Source height = 1.50 m

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

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

Segment Leq : 59.94 dBA

Total Leq All Segments: 59.94 dBA

#
```

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

Source height = 1.50 m

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

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

Segment Leq : 52.35 dBA

Total Leq All Segments: 52.35 dBA



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

#
```

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

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


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

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

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

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

#
```

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

Source height = 1.50 m

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

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

Segment Leq : 57.06 dBA

Total Leq All Segments: 57.06 dBA

#
```

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

Source height = 1.50 m

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

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

Segment Leq : 49.46 dBA

Total Leq All Segments: 49.46 dBA




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

#
```

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

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


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

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

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

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

#
```

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

Source height = 1.50 m

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

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

Segment Leq : 41.02 dBA

Total Leq All Segments: 41.02 dBA

#
```

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

Source height = 1.50 m

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

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

Segment Leq : 33.42 dBA

Total Leq All Segments: 33.42 dBA




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

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

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


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

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

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

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

#
```

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

Source height = 1.50 m

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

Segment Leq : 54.56 dBA

Total Leq All Segments: 54.56 dBA


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

Source height = 1.50 m

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

Segment Leq : 46.96 dBA

Total Leq All Segments: 46.96 dBA




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

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

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


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

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

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

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

#
```

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

Source height = 1.50 m

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

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

 * Bright Zone !

Segment Leq : 56.52 dBA

Total Leq All Segments: 56.52 dBA

#
```

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

Source height = 1.50 m

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

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

 * Bright Zone !

Segment Leq : 48.92 dBA

Total Leq All Segments: 48.92 dBA



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

#
```

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

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


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

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

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

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

#
```

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

Source height = 1.50 m

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

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

Segment Leq : 53.08 dBA

Total Leq All Segments: 53.08 dBA

#
```

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

Source height = 1.50 m

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

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

Segment Leq : 45.49 dBA

Total Leq All Segments: 45.49 dBA



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

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

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


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

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

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

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

#
```

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

Source height = 1.50 m

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

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

Segment Leq : 42.99 dBA

Total Leq All Segments: 42.99 dBA

#
```

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

Source height = 1.50 m

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

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

Segment Leq : 35.40 dBA

Total Leq All Segments: 35.40 dBA



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

APPENDIX B

FTA VIBRATION CALCULATIONS

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

GWE18-176 25-Jan-19

Possible Vibration Impacts on Cathedral Hill
Perdicted using FTA General Assesment

Train Speed 50 km/h 31 mph

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

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

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

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

APPENDIX 4

Proximity Assessment:

PG4271-LET.01 dated February 27, 2019

patersongroup

Consulting Engineers

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Geotechnical Engineering
Environmental Engineering
Hydrogeology
Geological Engineering
Materials Testing
Building Science
Archaeological Services

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February 27, 2019
Report: PG4271-LET.01

Cathedral Hills GP Inc.
c/o Reichmann Seniors Housing Development Corporation
22 St. Clair Avenue East, Suite 1200
Toronto, Ontario
M4T 2S3

Attention: **Ms. Victoria Lucas**

Subject: **Proximity Assessment**
Ottawa Retirement Residence by Signature
412 Sparks Street - Ottawa

Dear Madam,

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 of the proposed development with respect to the adjacent alignment of the Confederation Line. The following letter should be read in conjunction with Paterson Report PG4271-2 dated March 5, 2019.

1.0 Background Information

Based on current plans, it is understood that the proposed development will consist of a multi-storey building with 3 underground levels that include amenity spaces and indoor parking accommodations.

The following sections summarize our existing soils information and construction precautions for the proposed development, 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.

2.0 Subsurface Conditions

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

- Existing surface grade is at an elevation of approximately 71 to 73 m.
- The overburden thickness is approximately 1.2 to 1.8 m.
- Bedrock surface elevation is at approximately 69.4 to 70.3 m.
- The bedrock at the subject site generally consists of approximately 1 m of poor quality limestone bedrock, while the underlying bedrock was observed to be of excellent quality. Unconfined compressive strengths of similar limestone bedrock formations, where tested, typically exceed 80 MPa.

Tunnel and Station Location

Available drawings indicate that the Confederation Line abuts the south property line of the subject site. The top of rail (TOR) in the LRT tunnel is located at approximate geodetic elevations of 51.5 to 52.2 m adjacent to the proposed development site, while the lowest level floor slab of the proposed building is anticipated at approximate geodetic elevation 61.5 m. The horizontal distance between the proposed building and the Confederation Line tunnel will be 4.8 m. However, the proposed building will not be located within the 6.2 m buffer around the tunnel.

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 sound bedrock. Lateral loads due to the building footings will be transferred directly into the bedrock well within a conservative 6V:1H zone of influence from the outside face of footing. Therefore, due to the 4.8 m distance between the proposed building and the Confederation Line tunnel, the proposed building will not apply additional loading to the Confederation Line structure.

Excavation and Temporary Shoring

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 structure for the proposed development. 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.

There are no adverse effects to the Confederation Line LRT tunnel with the approach being considered for the building excavation along this alignment. Also, there will be no disturbance to the bedrock mass between the building and the tunnel.

It is anticipated that the temporary shoring system will consist of a soldier pile and lagging system designed for at-rest earth pressures, using a pressure coefficient of $K_0 = 0.5$ as per the geotechnical design recommendations outlined in Paterson Report PG4271-1 dated October 31, 2017.

The geotechnical engineer will review the stability of the rock face underlying the overburden during excavation. Following the review of the rock face, the geotechnical engineer will determine if rock reinforcement is required, and if so, the extent to which rock reinforcement is required. This determination will include consideration for the Confederation Line Tunnel.

A seismograph would be installed adjacent to the Confederation Line tunnel to monitor vibrations during the bedrock removal program. A program detailing trigger levels and action levels is provided in Section 3.1 of the Paterson Report PG4271-2 dated February 19, 2019.

Pre-Construction Survey

Due to the anticipated construction activities for the proposed building, 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. Plans for construction of underground utilities and air exchange systems for the underground parking lot will be assessed as part of the preconstruction survey. At the time of preparation of this report, the civil and mechanical drawings are currently being prepared. The civil and mechanical plans will be forwarded once they are completed.

Groundwater Control

Groundwater observations during the geotechnical investigation indicated groundwater levels at approximately 2.3 m below the existing ground surface and within the bedrock. Due to the presence of shallow bedrock at the site and in the general area, adverse effects related to ground surface settlement due to dewatering are expected to be negligible. The current groundwater level is fully within the bedrock unit, therefore, any depressurization of the groundwater table within the bedrock will have no adverse effects to surrounding structures including the Confederation Line LRT tunnel.

Tunnel Waterproofing System

Due to the separation between the proposed building and the subject alignment of the Confederation Line tunnel, it is anticipated that the replacement or repair of the waterproofing system for the tunnel structure will not be required.

4.0 Conclusions and Recommendations

Based on the currently available information for the subject alignment and the existing subsurface information, the proposed building will not negatively impact the existing Confederation Line tunnel. It should be noted that the information submitted as part of the current Proximity Study will be supplemented with construction plans issued for construction and a 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
Feb. 27-2019
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PROVINCE OF ONTARIO

Scott S. Dennis, P.Eng.

David J. Gilbert, P.Eng.

APPENDIX 5

Dewatering and Discharge Plan

dated February 27, 2019

patersongroup **memorandum**

consulting engineers

re:	**Dewatering and Discharge Plan** **Ottawa Retirement Residence by Signature** **412 Sparks Street - Ottawa**
to:	Cathedral Hills GP Inc. - **Ms. Victoria Lucas** - vlucas@rshdevco.com
date:	February 27, 2019
file:	PG4271-MEMO.03

As requested, Paterson Group (Paterson) has prepared the present memo to provide dewatering and discharge details associated with the construction of the proposed Ottawa Retirement Residence by Signature to be located at 412 Spark Street in the City of Ottawa.

Dewatering

At the time of the geotechnical field program completed at the subject site, groundwater level was observed at 2.3 m below ground surface (bgs). The long term groundwater table is expected to be within the bedrock, with any water encountered in the overburden materials likely resulting from a perched condition. The volumes of perched water requiring removal will be minimal and are expected to be encountered at the overburden/bedrock interface.

As the foundation excavation for the proposed building is anticipated to extend to a maximum depth of approximately 10 m bgs, the potential exists to encounter low to moderate volumes of groundwater. The volumes encountered will be dependant on the extent of fracturing within the bedrock occurring both naturally and as a result of blasting activities.

With respect to the potential for surface water inflow into the excavation footprint, the proposed multi-storey building is adjacent to developed land on all sides. It is therefore expected that the majority of surface water contributions to overall pumping volumes will result from precipitation falling directly onto the excavation footprint, rather than runoff from other sources. Given the potential size of the building footprint, surface water volumes at the subject site are expected to be minimal.

Discharge

Given the developed nature of the region, the discharge point for the water pumped from the excavation is expected to be to the City of Ottawa sewer system via a sewer connection along the Sparks Street entrance of the subject site. As such, it will be subject to the City of Ottawa Sewer Use Bylaws and a permit will be required in order to discharge the water to the sewer system.

In preparation of discharge activities at the subject site, it is expected that the contractor will implement a series of measures to aid in reducing total suspended solids (TSS) in the water. The following are examples of some of the measures that may be employed by the contractor to remove sediment from the wastewater:

❑ Elevating the sump system off the base of the excavation/sump pit to avoid pulling in sediment that has settled out of suspension.
❑ Surrounding the sump system with clear stone or a suitable alternative to help filter the water prior to entering the discharge hose.
❑ Wrapping both ends of the discharge system in geotextile (filter cloth) to further filter the water prior to discharge..

It is important to note that not all of the above may necessarily need to be employed at the subject site, and that the extent of treatment required prior to discharge will be dependant on the concentration and residence time of the sediment that accumulates in the water during construction activities. The contractor will be responsible for the management of construction wastewater that includes, but is not limited to, sediment filtration measures.

We trust that this information satisfies your immediate requirements.

Paterson Group Inc.

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