GRADIENTWIND
ENGINEERS & SCIENTISTS

November 26, 2018

Martin Languedoc
Ages Drive Development Inc.
1357 Barfield Road
Greely, Ontario
K4P 1A1

Dear Mr. Languedoc:

Re: Ground Vibration Assessment Letter
899, 901, and 903 Ages Drive, Ottawa
GWE File No.: 18-185

1. INTRODUCTION & TERMS OF REFERENCE

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Ages Drive Development Inc. to undertake a ground vibration assessment of an industrial development located at 899, 901, and 903 Ages Drive in Ottawa, Ontario. This report summarizes the methodology, results and recommendations related to a ground vibration assessment. Gradient Wind's scope of work involved assessing ground vibration generated by local railway traffic. The assessment was performed on the basis of theoretical vibration calculation methods conforming to Ministry of the Environment, Conservation and Parks guidelines. Ground vibration calculations were based on architectural drawings received from Pye & Richards Architects Inc., dated October 4, 2018, along with input from the rail authority, and Gradient Wind's experience with other jobs along the corridor.

The development is located along Ages Drive, north of the Ages Drive & Swansea Crescent intersection. The site plan for the development contains two separate industrial buildings, equidistant from the CN Rail corridor, each with a square planform. The major source of ground vibration is the CN Rail corridor northwest of the development, which feeds into Walkley Yard to the west. The site is surrounded on all sides with industrial-use land. The site plan is provided in Appendix A.

2. METHODOLOGY

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 the 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, from a train for instance. 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 (1.0 mm/s RMS or 92 dBV), ten 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 annoyance threshold level.

2.1 Ground Vibration Criteria

In the United States, the Federal Transportation Authority (FTA) has set vibration criteria for sensitive land use next to transit corridors. This criteria for office-use is set at 83 dBV for infrequent events, corresponding to 0.36 mm/s RMS. Similar standards have been developed by the International Standards Organization (ISO)[1]. These standards indicate that the appropriate criteria for office buildings are 84 dBV (referred to 1 micro inch per second) or 0.4 mm/s RMS for vibrations. The most conservative criteria of 83 dBV was selected for this analysis.

2.2 Theoretical Ground Vibration Prediction Procedure

Potential vibration impacts of the CN Rail corridor were predicted using the FTA's Transit Noise and Vibration Impact Assessment[2] 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 vehicles, conditions of the track, construction of the track and geology; as well as the structural type of the impacted building structures. Based on the setback distance of the closest building, initial vibration levels were deduced from a curve for freight trains at 50 miles per hour (mph). Other factors considered; the track was assumed to be have welded joints. Details of the vibration calculations are presented in Appendix A.

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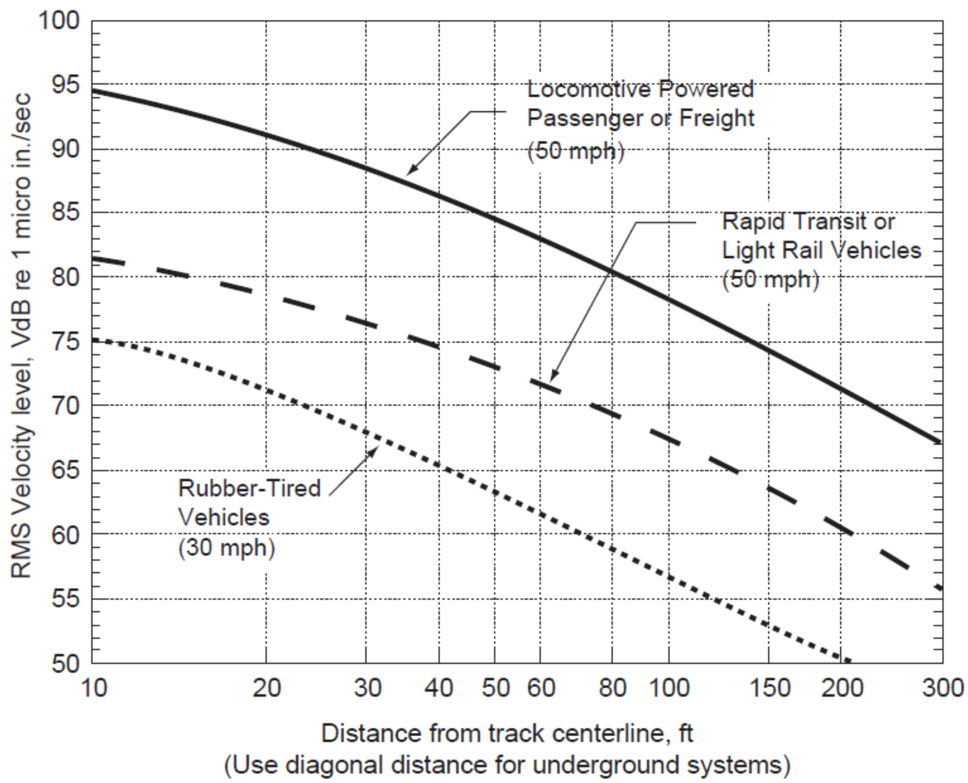
[1] ISO, "Evaluation of Human Exposure to Whole-Body Vibrations, Part 2: continuous and Shock-Induced Vibrations in Buildings (1-80 Hz)", ISO-2361-2, 1989

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

Based on the information provided from the rail authority (see Appendix A), the following parameters were used:

- The maximum operating speed of a train along this section of track is expected to be no greater than 60 mph (97 km/h)
- The vehicles are assumed to have well maintained wheels
- Tracks are continually welded and maintained in good condition
- The tracks will be offset from the building foundation by 23 m
- The foundations of the building will be on soil and spread footings



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

3. RESULTS & RECCOMENDATIONS

Based on an offset distance of 23 meters between the railway centerline and the nearest foundation, the estimated vibration level at the nearest façade is expected to be 0.24 mm/s RMS (80 dBV) based on the FTA protocol. Details of the calculation are provided in Appendix A. Since predicted vibration levels do not exceed the criterion of 83 dBV, vibration mitigation will not 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 not exceed the criterion, corresponding ground borne noise levels are not expected to exceed the ground borne noise criterion of 48 dBA.

Should you have any questions, or wish to discuss our findings further, please call us (613) 836-0934 or contact us by e-mail at joshua.foster@gradientwind.com. 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
Nov 26, 2018
PROVINCE OF ONTARIO

Michael Lafortune, C.E.T.
Environmental Scientist
GWE18-185 – Vibration Letter

Joshua Foster, P.Eng.
Principal

APPENDIX A

FTA VIBRATION CALCULATIONS AND SUPPORTING INFORMATION

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

GME18-185 15-Nov-18

Possible Vibration Impacts on 899-903 Ages Drive
Perdicted using FTA General Assesment

Train Speed 97 km/h 60 mph

	Distance from C/L	
	(m)	(ft)
CN	23.0	75.5

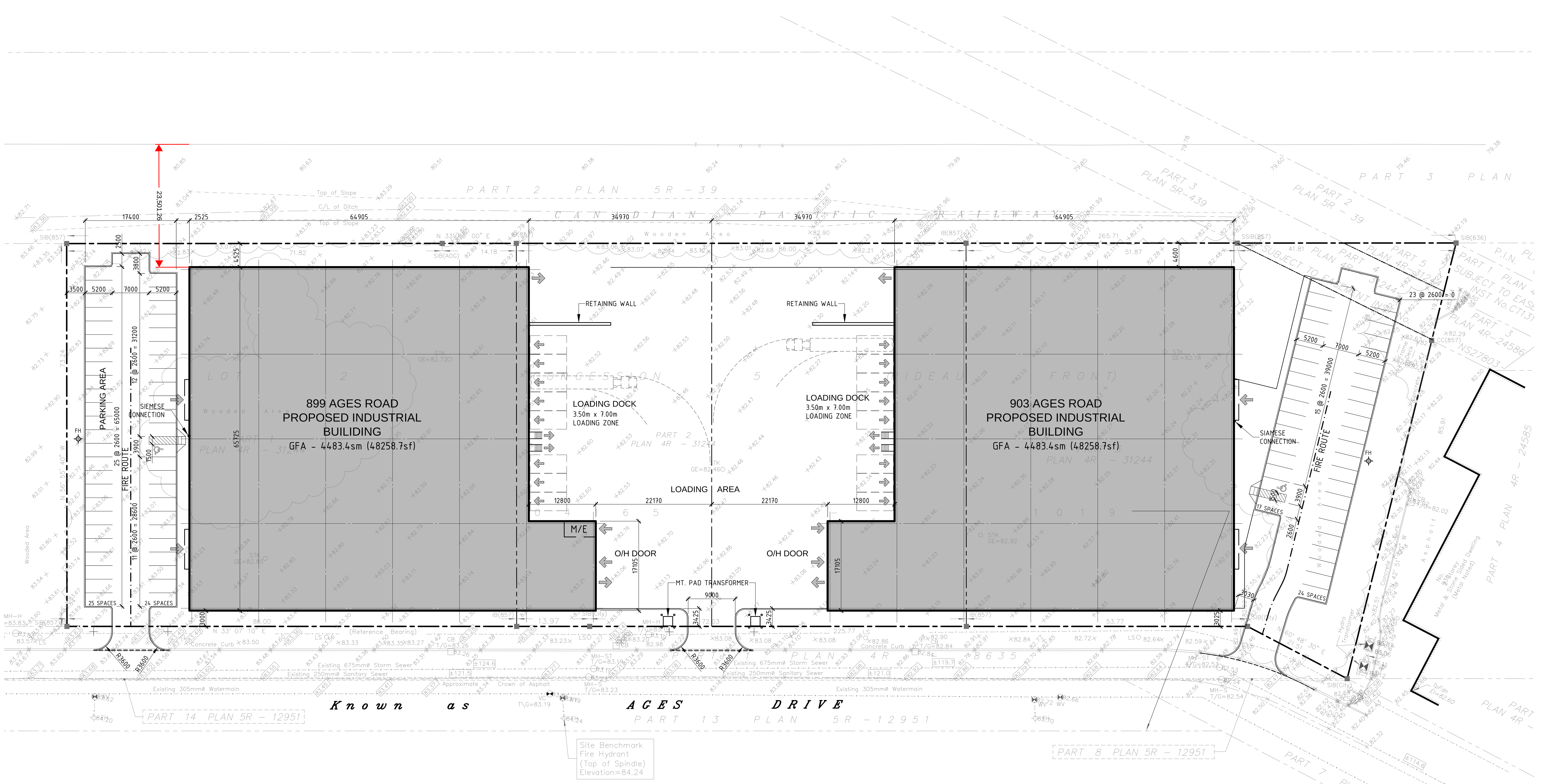
	Vibration	
From FTA Manual Fig 10-1		
Vibration Levels at distance from track	81	dBV re 1 micro in/sec
Adjustment Factors FTA Table 10-1		
Speed reference 50 mph	2	Speed Limit of 80 km/h (50 mph)
Vehicle Parameters	0	Assume Soft primary suspension, Weels run true
Track Condition	0	No worn or Corrugated Track
Track Treatments	0	None
Type of Transit Structure	0	None
Efficient vibration Propagation	0	Propagation through rock
Vibration Levels at Fdn	83	0.343
Coupling to Building Foundation	-7	1-2 Storey Massonry
Floor to Floor Attenuation	-2.0	Ground Floor Ocupied
Amplification of Floor and Walls	6	
Total Vibration Level	79.6	dBV or 0.243 mm/s
Noise Level in dBA	44.6	dBA

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

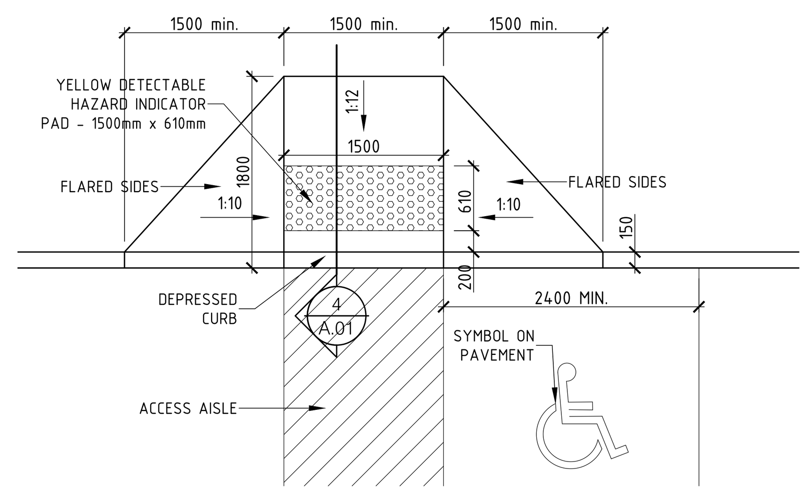
Source Factor	Adjustment to Propagation Curve			Comment
Factors Affecting Vibration Source				
Speed	Vehicle Speed	Reference Speed: 50 mph	Reference Speed: 30 mph	Vibration level is approximately proportional to $20*\log(speed/speed_{ref})$. Sometimes the variation with speed has been observed to be 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)

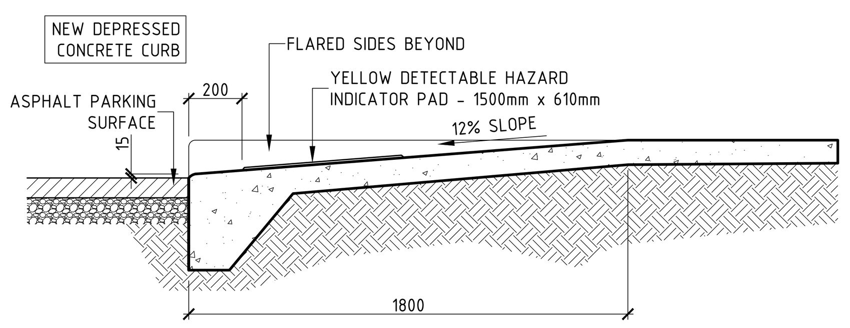
Factors Affecting Vibration Path		
Path Factor	**Adjustment to Propagation Curve**	**Comment**
Resiliently Supported Ties	-10 dB	Resiliently supported tie systems have been found to provide very effective control of low-frequency vibration.
Track Configuration (not additive, apply greatest value only)		
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.



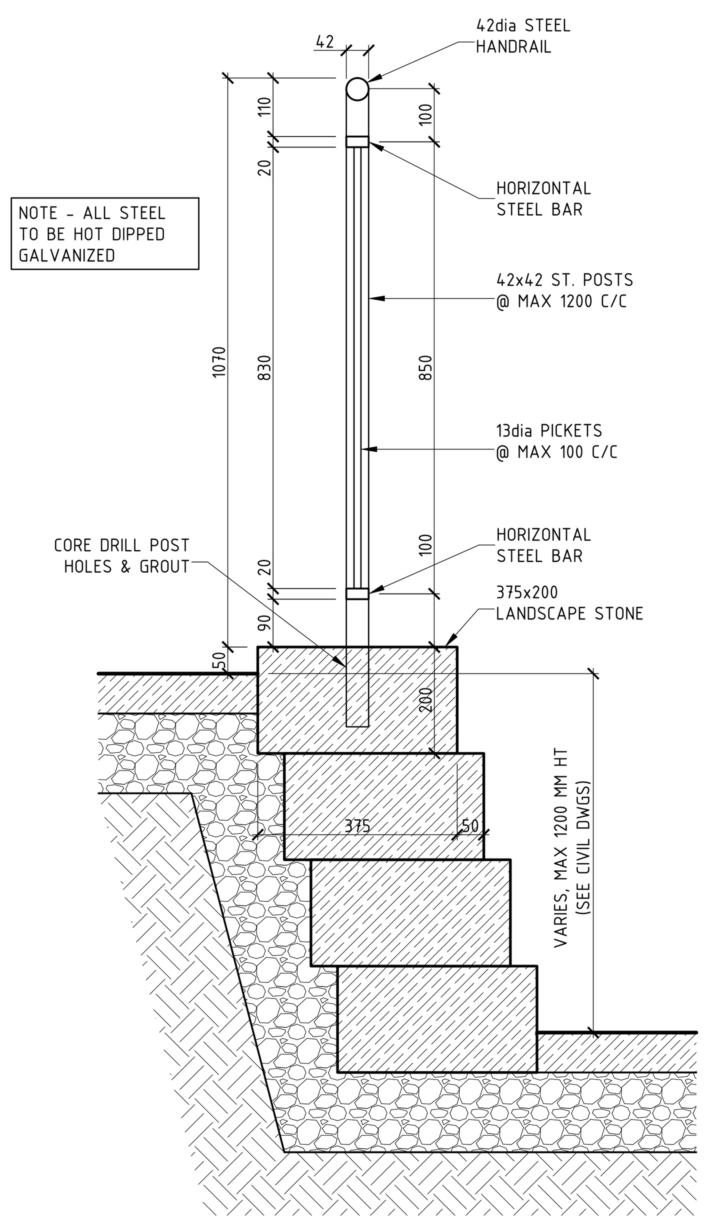
SITE DEVELOPMENT PLAN
SCALE 1:400



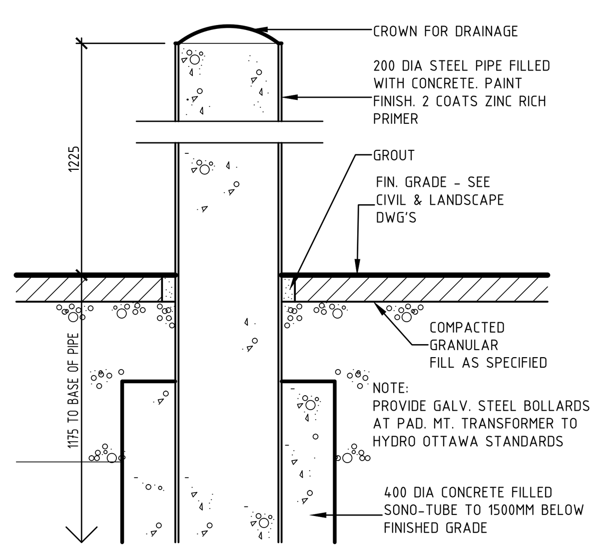
1 A001 DEPRESSED CURB - PLAN
SCALE 1:50



2 A001 DEPRESSED CURB - SECTION
SCALE 1:20



3 A001 RETAINING WALL - SECTION
SCALE 1:20



4 A001 STELL BOLLARD - SECTION
SCALE 1:10

SITE LEGEND

FH	FIRE HYDRANT
DC	DEPRESSED CURB
	CONCRETE CURB
	CONCRETE SIDEWALK
	NEW SOD
CB	CATCH BASIN, NEW
MH	MAN HOLE, NEW
HC	HANDI-CAP PARKING SIGN
FR	FIRE ROUTE SIGN
DN	DO NOT ENTER SIGN
SN	STOP SIGN
OW	ONE WAY DIRECTION
BH	BORE HOLE
LS	LIGHT STANDARD
WL	WALL MOUNTED LIGHT
PP	POWER POLE
86x23	EXISTING GRADE
	EXISTING CHAIN LINK FENCE
	NEW CHAIN LINK FENCE
	REMOVED CHAIN LINK FENCE
DS	DIRECTIONAL SIGN
G	GAS METER (NEW)

SITE PLAN NOTES

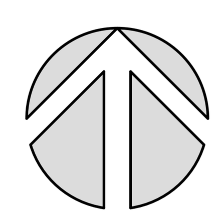
1. REINSTATE ALL LANDSCAPED AREAS WITH-IN RIGHT OF WAY, INCLUDING SWALES, DITCHES AND SIDEWALKS
2. REFER TO CIVIL DRAWINGS FOR EXTENT OF EXCAVATION , BACKFILL AND REINSTATEMENT OF PAVED AREAS, CURBS AND WALKS WITHIN RIGHT OF WAY.

NO.	ISSUE & REVISIONS	DATE
1		

SEAL

Not for construction unless SEALED and SIGNED.

PROJECT NORTH



P & R
PYE & RICHARDS ARCHITECTS INC
200-824 MEATH STREET OTTAWA ONTARIO K1Z 6E8
TEL: 613 724-7700 FAX: 613 724-1289
EMAIL: staff@pnrarch.com
WEBSITE: www.pyeandrichardsarchitects.com

PROJECT

NEW INDUSTRIAL BUILDINGS FOR SIMLUC CONTRACTORS
899, 901, 903 AGES ROAD

899 & 903 AGES RD. **Ottawa, Ontario**

DRAWING

SITE PLAN

SITE DETAILS

Do not scale. Refer any dimensional errors and/or possible trade interference/conflict to the architects for clarification prior to commencement of the work.
The conditions of the contract apply.

PROJECT NO.	18-30
SCALE -	AS NOTED
DRAWN -	R.J.M. & F.D.
CHECKED -	G.K.K.
PLOT DATE -	04/10/2018

DRAWING NO. **A001**

PLOTTED FROM: CARINA

Train Count Data

System Engineering
Engineering Services

4 Welding Way
off Administration Road
P.O. Box 1000
Concord, ON, L4K 1B9
T: 905.669.3264
F: 905.760.3406

TRANSMITTAL

To: *Destinataire :*	**Gradient Microclimate Engineering Inc.** 127 Walgreen Road Ottawa, ON KoA 1Lo	*Project :*	ALX-1.70 – Thurston Drive
Att'n:	Josh Foster	*Routing:*	Joshua@gradientwind.com
From: *Expéditeur :*	Stefan Linder	*Date:* *date :*	March 26th, 2014
Cc:	Raymond Beshro CN via e-mail		

☐ Urgent ☐ For Your Use ☐ For Review ■ For Your Information ☐ Confidential

Re: Train Traffic Data – CN Alexandria Subdivision near Thurston Road in (Click here to type)

Please find attached the requested Train Traffic Data; this data does not reflect GO Metrolinx Traffic. The application fee in the amount of **$500.00** +HST will be invoiced.

Should you have any questions, please do not hesitate to contact the undersigned at 905-669-3264.

Sincerely,
CN Design & Construction

Stefan Linder, B.Eng., MBA
Manager Public Works
stefan.linder@cn.ca

Date: 2014/03/26 Project Number: ALX-1.70 – Thurston Drive

Dear Josh:

Re: Train Traffic Data – CN Alexandria Subdivision near Thurston Drive in Ottawa, ON

The following is provided in response to Josh's 2014/03/25 request for information regarding rail traffic in the vicinity of Thurston Drive in Ottawa at approximately Mile 1.70 on CN's Alexandria Subdivision.

Typical daily traffic volumes are recorded below. However, traffic volumes may fluctuate due to overall economic conditions, varying traffic demands, weather conditions, track maintenance programs, statutory holidays and traffic detours that when required may be heavy although temporary. For the purpose of noise and vibration reports, train volumes must be escalated by 2.5% per annum for a 10-year period.

Typical daily traffic volumes at this site location are as follows:

***Maximum train speed is given in Miles per Hour**

	0700-2300			
Type of Train	Volumes	Max.Consist	Max. Speed	Max. Power
Freight	0	140	60	4
Way Freight	0	25	60	4
Passenger	16	10	95	2

	2300-0700			
Type of Train	Volumes	Max.Consist	Max. Speed	Max. Power
Freight	0	140	60	4
Way Freight	2	25	60	4
Passenger	0	10	95	2

The volumes recorded reflect westbound and eastbound freight and passenger operations on CN's Alexandria Subdivision.

Except where anti-whistling bylaws are in effect, engine-warning whistles and bells are normally sounded at all at-grade crossings. There are 0 at-grade crossing in the immediate vicinity of the study area at Mile 1.70 (Thurston Drive). Anti-whistling bylaws ARE NOT in effect at this crossing. Please note that engine warning whistles may be sounded in cases of emergency, as a safety and or warning precaution at station locations and pedestrian crossings and occasionally for operating requirements.

With respect to equipment restrictions, the gross weight of the heaviest permissible car is 286,000 lbs.

The single mainline track is considered to be continuously welded rail throughout the study area.

The Canadian National Railway continues to be strongly opposed to locating developments near railway facilities and rights-of-way due to potential safety and environmental conflicts. Development adjacent to the Railway Right-of-Way is not appropriate without sound impact mitigation measures to reduce the incompatibility. For confirmation of the applicable rail noise, vibration and safety standards, Mr. Raymond Beshro, Canadian National Railway Properties at 514-399-7627 should be contacted directly.

I trust the above information will satisfy your current request.

Sincerely,

Stefan Linder B. Eng., MBA
Manager Public Works, Eastern Region
Stefan.linder@cn.ca

cc. Raymond Beshro – CN – via e-mail