

2020-05-21

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Project Manager, Capital Works
Wastewater Collection & Conveyance
Public Works, Region of Peel

Cc: Jimmy Thannickal, P.Eng., Jacobs Engineering Inc.

Subject: East to West Wastewater Diversion Strategy - Vibration Impact Assessment for Construction Activities at 185 Derry Road West, Mississauga

Dear Ajay:

The Region of Peel (Region) is planning a large 11 km long 2.4 m sanitary sewer trunk upgrade as part of its East to West Wastewater Diversion Project (the Project). WSP Canada Inc., was retained by Region to conduct a Vibration Impact Assessment for the house at 185-205 Derry Road West (the Hunter House), Mississauga Ontario due to planned construction activities in support of engineering design work being completed by Jacobs Engineering Inc. (Jacobs).

EXECUTIVE SUMMARY

This assessment was conducted to determine the potential impact of construction activities from the Project on the Hunter House. As part of this assessment, drawings, construction activities, construction vibration guidelines, and City of Mississauga bylaws were reviewed. This assessment reviewed background information including heritage report for the conditions of the Hunter House structure and geotechnical report for ground conditions. This report considers the Project activities in two phases, the construction phase and site restoration phase (discussed further below).

The assessment determined appropriate vibration criteria for the Hunter House and established the vibration Zone of Influence (ZOI), the extent around the construction area where vibration is a concern for damage. The assessment indicated that the Hunter House is outside the ZOI for both phases of the Project. The assessment discussed a buffer distance of 40 m from the Hunter House and provided vibration monitoring guidelines for the Project's construction and restoration activities.

BACKGROUND

A review of the site plan drawing indicated that the Hunter House is located northeast of the construction zone. A heritage impact assessment report completed by Stantec Consulting Ltd. "Heritage Impact Assessment – 185-205 Derry Road West, Mississauga, Ontario", dated April 9, 2020 (referred herein as the Heritage Report), identified the Hunter House as designated under the Part IV of the *Ontario Heritage Act*, under by-law 339-41 in 1981.

Therefore, considering the heritage designation of the Hunter House, Jacobs and Region have initiated this vibration impact assessment for work occurring near the Hunter House.

VIBRATION ASSESSMENT METHODOLOGY

ASSESSMENT APPROACH

The following methodology was used in assessing vibration effects of the Project:

- Reviewed 100% design review drawings relating to document 2020-029T, construction activities and equipment typically used to determine the source of vibration and locations where it is transmitted to ground;
- Reviewed the Heritage Report to determine the details of the Hunter House and to determine appropriate limits;
- Reviewed geotechnical borehole records provided in Geotechnical Data Report – Contract 1, East to West Diversion Sanitary dated March 26, 2020 to understand the propagation of vibration;
- Predicted vibration from various activities and compared them to the vibration limits. Determine the extent around the construction zone which may be impacted by vibration emanating from construction activities and is called Zone of Vibration Influence (ZOI); and
- Determined vibration controls or best management practices (if required) such that the vibration effects are acceptable within the project area.

VIBRATION DESCRIPTORS

Vibration is generally measured in peak particle velocity (PPV) or root mean square (RMS) oscillatory velocity, acceleration or displacement. The PPV is defined as the maximum instantaneous positive or negative peak of the vibration signal measured in millimetres/second (mm/sec). The US Federal Transit Administration (FTA) publication “Transit Noise and Vibration Impact Assessment” suggests the use of PPV for assessment of construction as it relates to the stress that a structure receives due to vibration. The PPV was used in estimating vibration levels in this study.

VIBRATION CRITERIA

As part of background review Noise Control By-Law 360-79, from the Corporation of The City of Mississauga (the City) was reviewed, which generally focus on noise aspects. Further review indicated the City did not have vibration limits that can be applied to this Project.

Further as part of information package provided by Jacobs, the City of Toronto BY-LAW No. 514-2008 (regulation of vibrations from construction activity) was also provided to WSP. This by-law has been updated within Toronto Municipal Code Chapter 363 (TMC 363) and was reviewed for applicable vibration criteria. Since, the City or Region does not have a vibration limit applicable for this project, TMC 363 was reviewed.

The review indicated the vibration limits specified in TMC 363 are generic limits for a broad range of buildings including new buildings. These limits are not considered suitable for heritage buildings which are susceptible for vibration due to their age, and special features such as architectural elements. As the Hunter House is a heritage building, the TMC 363 limits are not considered applicable for this Project.

From the review of the Heritage Report, Section 5 of the Heritage Report discusses that the Hunter House is a unique late 19th century residence that blends Gothic Revival style with Italianate architectural elements. In addition, it states that the Hunter House displays a high degree of craftsmanship throughout and notable in the dichromatic brickwork on all elevations, the carved keystones, and the detailed roofline, which includes a projecting eaves with decorative brackets and moulded frieze. It discusses the architectural elements in detail and concludes that the Hunter House shows architectural styles and has a high degree of craftsmanship present on all exterior building elevations. In addition, the Heritage Report indicated a buffer of 50 metres for construction activities. Due to this, Jacobs raised

concerns about the potential for damages to structure and cosmetic damage (interior and exterior façades) due to vibration.

Given the heritage designation of the Hunter House, WSP recommends the use of the German Standard DIN 4150-3 vibration limits for sensitive buildings. The vibration limits in the DIN 4150-3 standard are more stringent than those found in TMC 363 and are generally used for heritage structures. These vibration limits for are summarized in **Table 1** below.

Table 1 Vibration Limits for the Hunter House

FREQUENCY OF VIBRATION (HZ)	PEAK PARTICLE VELOCITY LIMITS [MM/S]
1 to 10	3
10 to 50	3 to 8
50 to 100	8 to 10

Reference: DIN 4150-3 Standard

PREDICTION METHOD

In order to estimate the vibration through predictions, the actual force generated at the interface of the ground using the chosen construction method and equipment type are required. At this early stage however, the objective is to assess the risk associated with the method. Therefore, a conservative but simplified model for the construction-related vibrations, based on the vibration propagation model in the U.S. Department of Transportation, Federal Transit Administration (FTA) document, “Transit Noise and Vibration Impact Assessment Manual”, dated September 2018 (FTA Document) was used. Onsite ground propagation conditions were approximated using the ground conditions provided from the Geotechnical Report.

The prediction focused on two aspects:

VIBRATION ZONE OF INFLUENCE (ZOI)

A ZOI is an extent of area from a construction boundary, within which there is high potential for a vibration level of concern for structures that may be detected. The ZOI for this assessment was estimated using the lowest vibration limit provided in **Table 1** at 3 mm/s for both construction and site restoration phases. Therefore, vibration levels outside the ZOI are expected to be less than 3 mm/s.

BUFFER ZONE

The existing ambient vibration near Hunter House was assumed to be less than 1 mm/s. This is based on WSP’s experience in measuring vibration at locations with similar setback from roads and adjacent properties. As such a buffer distance for which construction activities did not exceed ambient vibration (i.e. 1 mm/s) was estimated and provided in this report. Activities occurring outside this buffer zone are not expected to have an impact on the existing ambient vibration levels of the Hunter House.

VIBRATION MANAGEMENT STRATEGY

The following strategy was considered in determining control and measurement requirements:

- 1 If the Hunter House is located within ZOI, vibration control strategies will be investigated and recommended;
- 2 If construction area is located within buffer distance (or any other activity within buffer distance), vibration monitoring will be recommended; and
- 3 Construction activities occurring outside this buffer distance vibration monitoring is optional.

ONSITE ACTIVITIES

Based on discussions with Jacobs and the Region, it is understood that the onsite activities can be broadly divided into two phases for the Project: Construction phase and Site Restoration phase. Information related to these activities were obtained from Jacobs and the Region during a call on April 9, 2020.

Based on the information provided and review of project 100% design review drawings relating to document 2020-029T, it is understood certain activities related to construction will occurring near the Hunter House as well. An area map showing project location, the Hunter House and the main construction area is provided in **Figure 1**.

The onsite activities considered for the assessment are summarized below as construction and site restoration respectively.

CONSTRUCTION PHASE

The construction phase considers work associated from site preparation to building infrastructure of the Project. For convenience, it was grouped into two phases, namely (a) site preparation and site maintenance activities, and (b) infrastructure activities. A list of the activities related to the construction phase is provided below.

Site preparation and maintenance activities

- 1 Site grading at initial stage and site maintenance activities throughout the construction period are expected. The source of vibration for these activities is general construction equipment, graders and compaction with a vibratory roller.
- 2 Removal of existing sidewalk using general construction equipment and scrapers.
- 3 Construction of a temporary sidewalk for the golf course to use while construction is occurring. Use of a plate compactor is understood to occur for this work.

Infrastructure Activities

- 4 Construction of a 4 m diameter tunnel for the 2.4 m sanitary sewer trunk. A large tunneling machine is understood to be used for this work. The tunnelling will occur 45 m below grade and about 40 m away from the Hunter House.
- 5 A drop structure is being built that will extend from at grade to approximately 47 m below grade; it is also 58 m southwest from the Hunter House. The first 10 m to 15 m of the structure will be built in the overburden and the remaining depth shall be built in bedrock. Use of an smaller excavators with buckets are understood to be used for work in the overburden. Hoe ramming will be used for work in the bedrock. A mobile crane shall lower and raise material and equipment out of the hole so no additional construction work is assumed for the crane. The exterior of the hole will be drilled secant piles when 16 m below grade. No percussive or vibratory methods for pile driving are anticipated.
- 6 A diversion structure will be built west of the drop structure, connecting to an existing 1.2 m sanitary sewer trunk. This structure will be built entirely in the overburden and conventional excavation methods are required. Drilled casings are understood to be used to for construction of the drop structure.
- 7 A 1.2 m sewer trunk connecting the drop structure and diversion structure will be built. It is understood this will be done by open trench with conventional excavation methods.

SITE RESTORATION PHASE

This phase considers work associated with restoring the site in front of the Hunter House once the infrastructure activities are complete. A list of the activities related to the site restoration phase is provided below.

- 1 Site grading activities are to return the lands to their previous state. As part of this, general construction activities are expected. No compaction is assumed for this work.
- 2 The original sidewalk will be restored once construction is complete. Use of a vibratory roller is understood to be used for compaction of this work.
- 3 Removal of temporary sidewalk once construction is complete. Use of general construction equipment and scrapers were assumed for this work.

VIBRATION ASSESSMENT

VIBRATION ZOI

As discussed, a ZOI from construction boundary showing the area in which vibration has the potential to reach the lowest limits of **Table 1** (i.e. 3 mm/s) was established. For this purpose, the predictable worst-case construction activities were assumed. If the Hunter House is not within this ZOI the damage potential is considered unlikely.

Figure 2 shows the ZOI for site construction phase and **Figure 3** shows the ZOIs for site restoration phase. As shown in both figures, the Hunter House is not within the ZOIs and therefore vibration control is not considered.

BUFFER ZONE ASSESSMENT

The vibration buffer distance was also estimated considering an existing ambient vibration level of less than 1 mm/s. The assessment indicated activities occurring inside a distance of 40 m from the foundation/façade of the Hunter House has the potential to alter the ambient vibration. Therefore, vibration monitoring is recommended for all activities within 40 meters from the foundation/façade of the Hunter House, to minimize and address any future complaints.

The 40 m buffer zone from the foundation/façade of the Hunter House is shown in **Figure 2** and **Figure 3**. A list of construction activities that may be expected within the 40 m buffer zone is provided below:

- East portion of construction of the temporary sidewalk;
- Some compaction during site maintenance activities of the main construction area and construction driveway;
- East portion of removal of the temporary sidewalk during site restoration; and
- Some general construction activities for the site and compaction of the driveway during site restoration

It should be noted that while tunneling appears to fall within the buffer zone (i.e. a horizontal distance of 37 m) on **Figure 2**, due to the tunneling depth of 45 m it is interpreted as outside the buffer zone.

RECOMMENDATIONS

The following recommendations are provided:

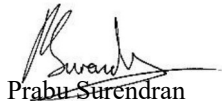
- 1 Vibration monitoring near the closest façade or directly on the foundation of the Hunter House is recommended for all activities (construction and site restoration) occurring within 40 meters from the Hunter House;
- 2 The above noted vibration monitoring shall be completed using the guideline provided as attachment in this report;
- 3 Rock breaking, or slamming the bucket of the excavator or hoe ramming or any percussive methods of construction shall be excluded within 40 metres of the Hunter House.

CONCLUSION AND CLOSURE

WSP prepared this letter report solely for the use of the intended recipients the Region of Peel and Jacobs Engineering Inc., in accordance with the agreed upon professional services agreement. This letter report detailed a vibration Zone of Influence study for the work occurring near the Hunter house as part of the Region of Peel's East to West Wastewater Diversion Strategy. The study established applicable limits and found the expected impact of vibration was not estimated to reach the house. WSP further recommended vibration monitoring still be conducted for the house to protect the Region from any future claims or complaints and provided some general recommendations to further reduce the impact of construction.

The intended recipient is solely responsible for the disclosure of any information contained in this letter report. The content and opinions contained in the present letter report are based on the observations and/or information available to WSP at the time of preparation. If a third party makes use of, relies on, or makes decisions in accordance with this letter report, said third party is solely responsible for such use, reliance or decisions. WSP does not accept responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken by said third party based on this letter report. This limitations statement is considered an integral part of this letter report.

Yours truly,



Prabu Surendran
Acoustic, Noise and Vibration Specialist



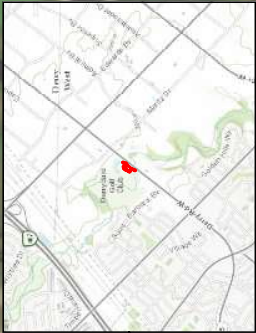
Kana Ganesh, M.A.Sc., PhD., P.Eng.
Senior Technical Director, Acoustics and Vibration

PS/KG

Encl. Figures, Guideline for Vibration Monitoring
WSP ref.: 171-16801-03

FIGURES





125 DON MILLOCK DRIVE, UNIT 2
AURORA, ONTARIO L4G 1C3
TEL: 905-764-5880 | FAX: 905-764-8831 | WWW.WSP.COM

LEGEND



STUDY AREA



MAIN CONSTRUCTION AREA



CONSTRUCTION DRIVEWAY



0 10 20 Meters

CLIENT:

REGION OF PEEL

PROJECT:

VIBRATION ASSESSMENT STUDY

PROJECT NO.

171-18801-03

DATE:

MAY 2020

DESIGNED BY:

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DRAWN BY:

TP

CHECKED BY:

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FIGURE NO.

1

SCALE:

12,000

TITLE:

STUDY AREA

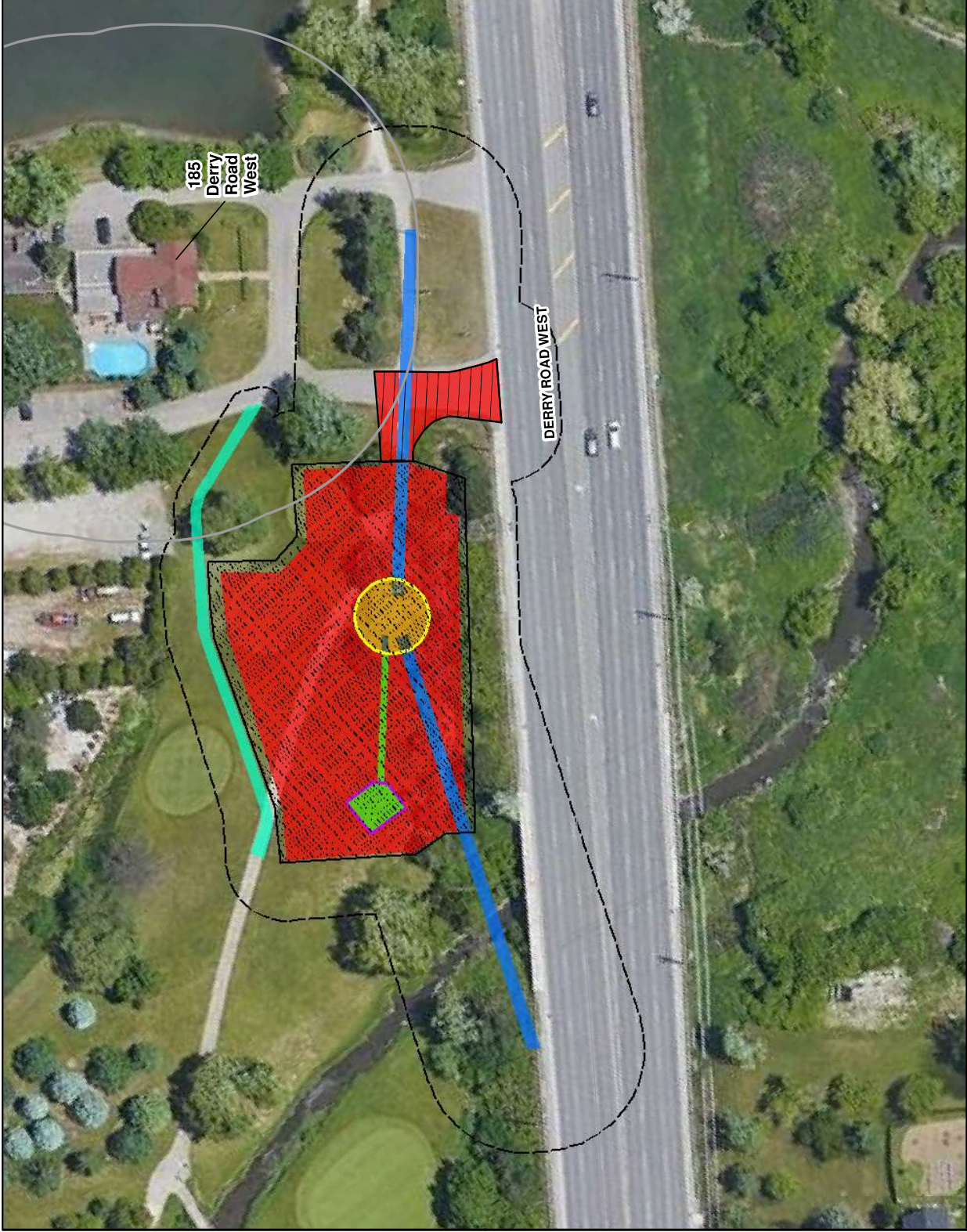
DISCIPLINE:

ENVIRONMENT

ISSUE:

REV:

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125 DON MILLOCK DRIVE, UNIT 2
AURORA, ONTARIO L4G 1N1
TEL: 905-763-5380 | FAX: 905-724-0481 | WWW.WSP.COM

LEGEND

- MAIN CONSTRUCTION AREA
- CONSTRUCTION DRIVEWAY
- SITE GRADING & MAINTENANCE ACTIVITIES
- COMPACTION (VIBRATORY ROLLER)
- COMPACTION (COMPACTOR)
- INFRASTRUCTURE ACTIVITIES
- EXCAVATION
- SECANT PILES
- TUNNELLING
- HOE RAMMING
- CASSION DRILLING
- VIBRATION ASSESSMENT
- ZOI (3 mm/s)
- 185 DERRY RD. W. 40 m BUFFER



0 5 10 Meters

CLIENT

REGION OF PEEL

PROJECT

VIBRATION ASSESSMENT STUDY

PROJECT NO.	DATE
171-18801-03	MAY 2020
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DRAWN BY	
TP	
CHECKED BY	
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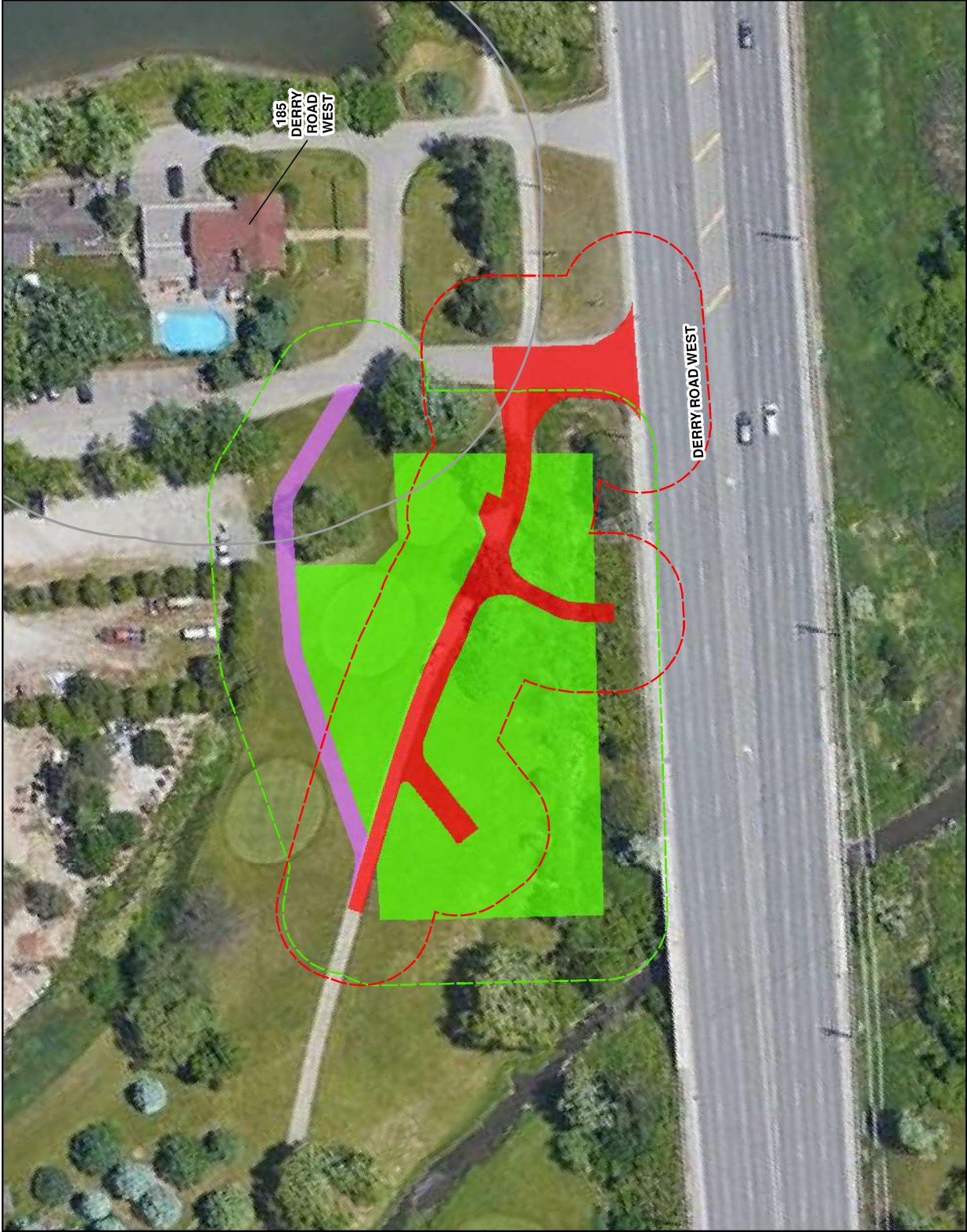
CONSTRUCTION ZOI

DISCIPLINE

ENVIRONMENT

ISSUE

REV.



125 DON MILLOCK DRIVE, UNIT 2
AURORA, ONTARIO L4G 1N1
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LEGEND

- GENERAL CONSTRUCTION ACTIVITIES
- REMOVAL OF TEMPORARY SIDEWALK
- COMPACTON (VIBRATORY ROLLER)
- VIBRATION ASSESSMENT
- GENERAL CONSTRUCTION ACTIVITIES ZOI (3 mm/s)
- COMPACTON (VIBRATORY ROLLER) ZOI (3 mm/s)
- 185 DERRY RD. W. 40 m BUFFER



0 4 8 Metres

CLIENT:

REGION OF PEEL

PROJECT:

VIBRATION ASSESSMENT STUDY

PROJECT NO:

DATE:

MAY 2020

DESIGNED BY:

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DRAWN BY:

TP

CHECKED BY:

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FIGURE NO:

3

SCALE:

1:500

TITLE:

SITE RESTORATION ZOI

DISCIPLINE:

ENVIRONMENT

ISSUE:

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GUIDELINE FOR VIBRATION MONITORING



Guideline for Vibration Monitoring East to West Wastewater Diversion Strategy

SCOPE

This guideline covers the requirements for vibration monitoring of existing Hunter House, primarily to monitor the construction and site restorations within 40 metres of the Hunter House measured from foundation footprint.

APPLICABLE VIBRATION LIMITS

The applicable vibration limits monitoring is provided in **Table 1**, below:

Table 1 Vibration Limits for the Hunter House

FREQUENCY OF VIBRATION (HZ)	PEAK PARTICLE VELOCITY LIMITS [MM/S]
1 to 10	3
10 to 50	3 to 8
50 to 100 ¹	8 to 10

INSTRUMENTATION

A seismograph configured to produce a continuous record shall be used for vibration monitoring that will record vibrations in three orthogonal directions in peak particle velocity. The equipment must be capable of monitoring from 1 to 100 Hz; recording at a minimum of 1024 samples per second.

MONITORING LOCATIONS

The monitoring locations should be selected to capture expected worst-case vibration from construction activity at or near the Hunter House foundation.

Geophones shall be located on the side of the Hunter House or if subject activities are occurring simultaneously on both side, monitoring shall be conducted on both sides. In other words, no subject activities shall be undertaken on either side without the monitoring on the respective side.

ON-SITE MONITORING PROCEDURE

The vibration meters should be actively monitored by either on-site personnel or via real time alert system established through a remote monitoring system. Further, continuous monitoring for the duration of the particular activity will be required.

When vibration levels reach the respective limits, the construction manager should be notified immediately, and steps outlined in Response Plans for Vibration Levels Exceeding the Limits below should be followed.

REPORTING REQUIREMENTS

Baseline – baseline monitoring report and existing condition visual/photo documentation will be included with this package.

During Construction - Vibration monitoring shall be carried out during construction and site restoration occurring within 40 metres of the Hunter House measured from foundation footprint. A weekly vibration monitoring summary report shall be provided including details on monitoring locations, measured vibration levels, and any exceedances or complaints registered during the monitoring period.



RESPONSE PLANS FOR VIBRATION LEVELS EXCEEDING THE LIMITS

Vibration limits provided in **Table 1** are not to be exceeded. Activities may be suspended in affected area with the exception of those actions necessary to avoid the exceedance of the vibration limits provided in **Table 1** or to make the work and affected properties safe and secure.

If the vibration limit is reached:

- 1** Stop work and inform the Contract Administrator (Jacob) immediately;
- 2** Investigate and report the cause of exceedance to the Contract Administrator;
- 3** Stop the particular construction activity that caused the exceedance and develop an Response Plan of Action and mitigation strategy;
- 4** Provide the Response Plan of Action and mitigation strategy for review and approval by the Contract Administrator;
- 5** Implement the reviewed and approved Response Plan of Action prior to proceeding with the activity that caused the exceedance;
- 6** Install and additional monitors as directed by the Contract Administrator.

SAFETY AND PROTECTION

The above ground location of monitoring instrumentation shall be made clearly visible to avoid accidental damage at all times. Markings shall be of sufficient size to be visible to construction equipment operators.

Instruments shall be clearly labelled in the field, each instrument having a unique identifier. The labelling shall remain legible for the duration of the monitoring period.

All instruments shall be adequately protected by the Contractor such that they are not damaged during construction.