NOISE AND VIBRATION ASSESSMENT REPORT

CN Spur

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Executive Summary

CN is proposing to construct a new rail spur (the Project) which would connect the Joint Access Spur (JAS) north of the Village of Jansen to the CN Watrous Subdivision east of the Town of Nokomis. The CN Spur will be 47 km in length and have a 45 m wide right-of-way (RoW) along the corridor. Stantec Consulting Ltd. (Stantec) was retained to assess the noise and vibration impacts from the Project.

This assessment was completed to quantify the noise and vibration effects at the closest sensitive receptors along the proposed Project corridor. The noise assessment approach follows the Canadian Transportation Agency (CTA) document, *Railway Noise Measurement and Reporting Methodology (August 2011)* guidance. The vibration assessment approach follows the methods recommended in the *United States (US) Federal Transit Administration (FTA) Transit Noise and Vibration Impact Assessment (FTA 2018)*. The noise and vibration effects are compared to the thresholds recommended in the CTA, Health Canada, and FTA noise and vibration guidelines.

Noise effects due to locomotive pass-by, rail cars pass-by, locomotive whistle, wheel squeal on curved tracks, rail crossover, locomotive idling, and construction were assessed. Noise effects during construction and operation are below the thresholds at all receptors.

Construction vibration is not expected to impact the receptors in the area as there are no receptors within the zone of influence of any construction equipment. Vibration effects due to locomotive pass-by and rail cars pass-by were assessed. The predicted vibration levels are below the threshold recommended in the FTA 2018 noise and vibration guidance.

Abbreviations

%HA	Percent Highly Annoyed
BHP	BHP Billiton Canada Inc
CN	Canadian National Railway Company
CP	Canadian Pacific Railway
CTA	Canadian Transportation Agency
DMU	Diesel-powered Multiple Unit
FCM	Federation of Canadian Municipalities
FTA	Federal Transit Administration
GBV	Ground-borne Vibration
GBN	Ground-borne Noise
ISO	International Standard Organization
JAS	Joint Access Spur
LFN	Low Frequency Noise
RAC	Railway Association of Canada
RoW	Right-of-way
SSMs	Supplemental Safety Measures
US	United States of America
WHO	World Health Organization

Glossary

Alignment	The horizontal location of a railroad or transit system as described by curved and tangent track.
Ambient Sound Level	The pre-project background noise or vibration level, which is often used interchangeably with “existing noise” in this manual.
Background Sound Level (i.e., Baseline)	It includes noise from all sources other than the sound of interest (i.e., sound from other industrial noise not being measured, transportation sources, animals, and nature).
Bands (octave, 1/3 octave)	A series of electronic filters separate sound into discrete frequency bands, making it possible to know how sound energy is distributed as a function of frequency. Each octave band has a centre frequency that is double the centre frequency of the octave band preceding it.
Category 1, 2, 3 Land Use	The land use categories are defined in FTA 2018 as follows: • Category 1 (High sensitivity): Land where quiet is an essential element of its intended purpose. Example land uses include preserved land for serenity and quiet, outdoor amphitheaters and concert pavilions, and national historic landmarks with considerable outdoor use. Recording studios and concert halls are also included in this category. • Category 2 (Residential): This category is applicable all residential land use and buildings where people normally sleep, such as hotels and hospitals. • Category 3 (Institutional): This category is applicable to institutional land uses with primarily daytime and evening use. Example land uses include schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds, and recreational facilities are also included in this category.
Crossover	Two turnouts with the track between the frogs (common crossing or the crossing point of two rails) arranged to form a continuous passage between two nearby and generally parallel tracks.
Daytime	The hours from 7:00 am to 10:00 pm.

day-night Sound Level (L_{dn})	An equivalent continuous sound level taken over 24 hours, with the night-time (10 p.m. to 7 a.m.) contributions adjusted by +10 dB. (This is a type of rating level because of the night-time adjustments.) The night-time adjustment (or addition of 10 dB to the night-time period) is used to account for the expected increased annoyance due to noise-induced sleep disturbance and the increased residential population at night relative to daytime, by a factor of 2–3. US EPA 1974 suggests that in quiet areas, the night-time levels naturally drop by about 10 dB and this level of adjustment has been used with success in the U.S.
dB - Decibel	A logarithmic unit associated with sound pressure levels and sound power levels.
dBA - Decibel, A-Weighted	A logarithmic unit where the recorded sound has been filtered using the A frequency weighting scale. A-weighting somewhat mimics the response of the human ear to sounds at different frequencies. A-weighted sound pressure levels are denoted by the suffix 'A' (i.e., dBA), and the term pressure is normally omitted from the description (i.e., sound level or noise level).
dBAi	A-weighted decibel level for measuring and report impulse sound signals in maximum sound level.
dBC - Decibel, C-Weighted	The logarithmic units associated with a sound pressure level, where the sound pressure signals has been filtered using a frequency weighting. The C-weighting approximates the sensitivity of human hearing at industrial noise levels (above about 85 dBA). C-weighted sound pressure levels are denoted by the suffix 'C' (i.e., dBC). C-weighted levels are often used in low-frequency noise analysis, as the filtering effect is nearly flat at lower frequencies.
Decibel Addition	In acoustics, due to the logarithmic nature of the decibel scale, the addition of two or more sound pressure levels (denoted as SPL_1, SPL_2, … SPL_n) is done as follows: $SPL_1 + SPL_2 + \ldots SPL_n = 10 \log (10^{(SPL1/10)} + 10^{(SPL2/10)} + \ldots + 10^{(SPLn/10)})$ As an example: 50 dB + 50 dB = 53 dB

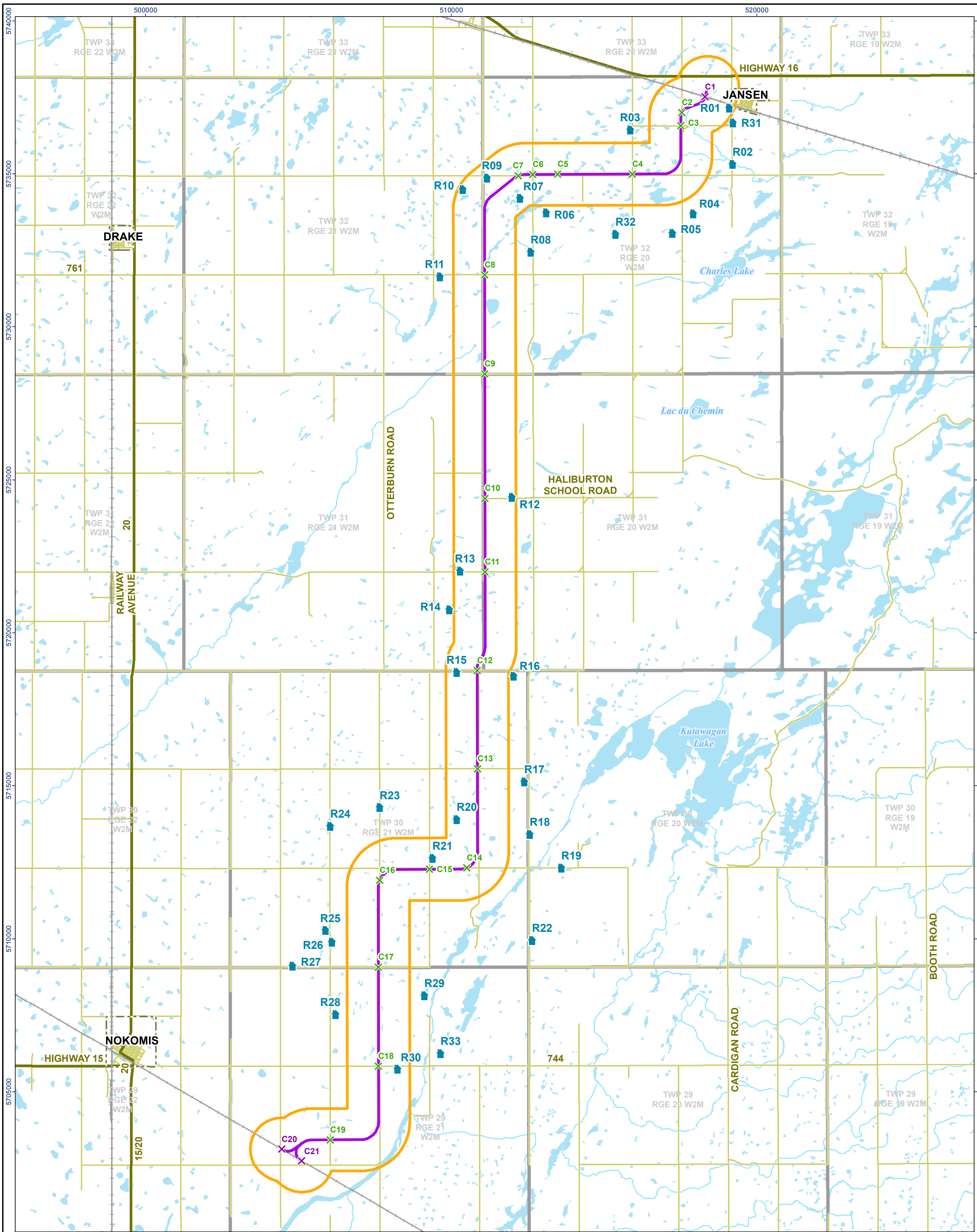
Energy Equivalent Sound Level (L_{eq})	An energy-average sound level taken over a specified period of time. It represents the average sound pressure encountered for the period. The time period is often added as a suffix to the label (e.g., L_{eq} (24) for the 24-hour equivalent sound level). L_{eq} is usually A-weighted. An L_{eq} value expressed in dBA is a good, single value descriptor of the annoyance of noise. Here is a list of L_{eq} used in this assessment: • $L_{eq,1hr}$ Hourly equivalent sound level • L_d Daytime period equivalent sound level (15 hours, 7:00 AM to 10:00 PM) • L_n Nighttime period equivalent sound level (9 hours, 10:00 PM to 7:00 AM) • L_{dn} day-night sound level (also see definitions for day-night Sound Level)
Frequency	Number of cycles per unit of time. In acoustics, frequency is expressed in hertz (Hz), i.e. cycles per second.
Hertz (Hz)	Unit of measurement of frequency, numerically equal to cycles per second.
Idle	The speed at which an engine runs when it is not under load.
Low Frequency Noise (LFN)	Noise in the low frequency range, 20 Hz up to 200 Hz: • where the difference between the overall C-weighted sound level and the overall A-weighted sound level exceeds 20 dB; or • ANSI 2005 indicates that sounds in the 16, 31.5 and 63-Hz octave bands greater than 70 dB may result in noise-inducted rattles, Low frequency noise can be associated with the introduction of noticeable vibrations and rattles in some structures.
Maximum Sound Level (L_{max})	The maximum value of the sound pressure level during a noise event, measured with a sound level meter using a Fast Time Weighting. This level can be applied to pass-by noise from transportation noise sources and impulsive noise events.
Nighttime	The hours from 10:00 PM to 7:00 AM.
Noise	Unwanted sound
Noise Level	Same as Sound Level, except applied to unwanted sounds.
Sound	A dynamic (fluctuating) pressure
Sound Exposure Level (SEL)	The 1-second equivalent continuous sound level that would be measured if the total energy in a noise event occurred during that one second. This level can be applied to pass-bys of transportation noise sources and impulsive noise events.

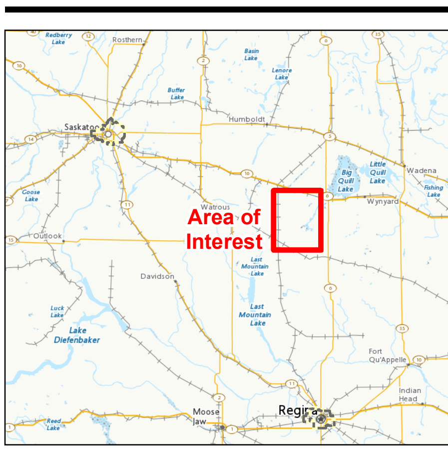
Sound Pressure Level (SPL)	The logarithmic ratio of the root mean square sound pressure to the sound pressure at the threshold of hearing. The sound pressure level is defined by equation below where P is the RMS pressure due to a sound and P_0 is the reference pressure. P_0 is usually taken as 2.0×10^{-5} Pascals. SPL (dB) = 20 $\log(P_{RMS}/P_0)$
Sound Power Level (PWL)	The logarithmic ratio of the instantaneous sound power of a noise source to that of the reference power. The sound power level is defined by equation below where W is the sound power of the source in watts, and Wo is the reference power of 10^{-12} watts. PWL (dB) = 10 $\log(W/W_0)$
Spectrum	The description of a sound wave's resolution into its components of frequency and amplitude.
Transmission Loss	The ratio of the sound energy striking an outside wall relative to the transmitted sound energy inside the wall, expressed in decibels.
Tonal Components	Often industrial facilities exhibit tonal components. Examples of tonal components are transformer hum, sirens, and piping noise. The test for the presence of tonal components consists of two parts (as per tonality prescribed in AUC Rule 012). The first part must demonstrate that the sound pressure level of any one of the slow-response, A-weighted, 1/3-octave bands between 20 and 16 kHz is 10 dBA or more than the sound pressure level of at least one of the adjacent bands within two 1/3-octave bandwidths. In addition, there must be a minimum of a 5 dBA drop from the band containing the tone within 2 bandwidths on the opposite side. The second part is that the tonal component must be a pronounced peak clearly obvious within the spectrum.
VdB – Decibel, Vibration Velocity	Vibration Velocity Level (VdB) Ten times the common logarithm of the ratio of the square of the amplitude of the root mean square vibration velocity to the square of the amplitude of the reference RMS vibration velocity. The reference velocity in the United States is one micro-inch per second. Abbreviated as VdB.
Vibration	An oscillation wherein the quantity is a parameter that defines the motion of a mechanical system.
Wheel Squeal	The noise produced by wheel-rail interaction, particularly on curves where the radius of curvature is smaller than allowed by the separation of the axles in a wheel set.

1.0 INTRODUCTION

The Canadian National Railway Company (CN) is proposing to construct and operate the CN Spur (the Project), that will connect BHP's Joint Access Spur (JAS) north of the Village of Jansen to the CN Watrous Subdivision east of the Town of Nokomis. The CN Spur will be 47 km in length and will have a 45 m wide right-of-way (RoW) within the spur corridor. The proposed Project RoW is shown in Figure 1.

BHP requested that Stantec collect environmental baseline data, including conducting an assessment of noise and vibration impact to support stakeholder engagement and construction and operation of the CN Spur. This assessment was completed to quantify the noise and vibration effects at the closest sensitive receptors along the Project RoW. The noise assessment approach follows the Canadian Transportation Agency (CTA) document, *Railway Noise Measurement and Reporting Methodology (August 2011)* guidance. The vibration assessment approach follows the methods recommended in the *United States (US) Federal Transit Administration (FTA) Transit Noise and Vibration Impact Assessment (FTA 2018)*.





Legend

- Jansen Spur Alignment
- General Study Area
- Noise and Vibration Receptor Location
- Rail Crossing
- Road Crossing
- Railway
- Watercourse
- Town/City
- Township
- Waterbody

0 2.5 5 Kilometers

(At original document size of 11x17)
1:130,000

N

Stantec BHP

Project Location
Jansen, SK

Prepared by MDW on 2020-06-26
TR by JH on 2020-06-26
IR Review by NC on 2020-06-26

Client/Project
BHP
CN SPUR

113254270-009 REVE

Figure No.
1

Title
Noise and Vibration Receptor Locations

1. Coordinate System: NAD 1983 UTM Zone 13N
2. Base features produced under license with the Government of Saskatchewan and the Government of Canada.

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2.0 PROJECT DESCRIPTION

The following sections provide descriptions of the noise activities during construction and operation phases that were used to inform the noise and vibration assessment.

2.1 CONSTRUCTION

Construction of the rail spur will include earthworks and rail track construction. It is currently anticipated that 2 construction seasons will be required for grade construction (May Year 1 through to October Year 2), with the second construction season also including the rail construction (May Year 2 to November Year 2). Approximately 1 km of earthworks and 2 km of rail track construction will be completed during each week of active construction period. Multiple crews are anticipated to be working at different locations simultaneously.

The construction hours will be typically 12 hours per day during daytime period (7:AM to 10PM). However, some isolated activities (e.g., install mainline switches) may be required during the nighttime period. Grading or track crews might desire to extend working hours beyond 12 hours per day to catch up on schedule due to delays. The equipment types and their quantity for the earthworks are summarized in Table 1.

Table 1 Earthworks Construction Equipment

Item	Equipment Type	Model	**Quantity**
1	Excavator	John Deere 350G LC	5
2	Dozer	Caterpillar D6R	3
3	Roller packer	Dynapac CA362	2
4	Haul Truck	Caterpillar 740	6
5	Grader	Caterpillar 160M	1
6	Skid steer	Caterpillar 242D	1
7	Water truck	--	1
Note: "--" information not available			

Rail track construction follows the completion of the earthworks at each construction area. Wherever possible, the rail track construction activities will be completed during the daytime period (7AM to 10PM). Rail track construction equipment is expected to operate 6 hours per day on average for each piece of equipment. The equipment types and their quantity for the rail track construction are summarized in Table 2.

Table 2 Rail Construction Equipment

Item	Equipment Type	Model	Quantity
1	Excavator	John Deere 350G LC	2
2	Dozer	Caterpillar D6R	1
3	Haul Truck	John Deere 300D	4
4	Rail tamper	Harsco Mark IV	1
5	Rail regulator/equalizer	Kershaw 4600	1
6	Spiker	Nordco CX Hammer	1
7	Mobile flash-butt welding system	Holland	1
8	Hi-rail 1-ton truck	--	1
Note: "--" information not available			

2.2 OPERATION

The operation phase will include two stages. Stage 1 is defined as the scenario where the yearly average may be up to 4 train movements per week (2 in and 2 out of Jansen). Stage 2 is defined as the scenario where the yearly average may be up to 8 train movements per week (4 in and 4 out of Jansen). Information for the operation activities are provided in Table 3. The assessment assumed a worst-case scenario for both Stage 1 and Stage 2 with a maximum of two train movement within a 24 hour period, one during the daytime and one during the nighttime.

Table 3 Train Description and Operation Summary

Item	Description
1	Locomotive type: diesel-electric
2	Locomotive quantity: 4 (maximum)
3	Locomotive model: EMD SD70, GE AC4400, GE ES44AC or GE ET44
4	Train speed: 25 miles/hr or 40 km/hr
5	Pass-bys frequency: maximum of two within a 24 hours period, one during the daytime (7AM to 10PM) and one during the nighttime (10PM to 7AM) representing a potential "worst case" scenario.
6	Rail car quantity: 177 (maximum)
7	Track condition: • Type: continuously welded • Number of road crossings: 15 • Number of rail diamond: one (CP Sutherland Subdivision) • Number of rail crossover (CN Watrous Subdivision) • No of turns: 10 • Rail curve radius: 280 m to 600 m

8	Locomotive Idling: 12 minutes (maximum) at the CP/CN diamond crossing near the Village of Jansen/south of the Sutherland mainline. For the connection to the CN Watrous subdivision, CN will not commonly dispatch trains from the Jansen mine site without a suitable block clear on their mainline.

Noise sources associated with the operation phase includes the following:

- Locomotive pass-by
- Rail car pass-by
- Wheel squeal
- Crossover/diamond/turnout noise
- Train whistle at road crossings
- Idling locomotive at diamond (CP/CN diamond crossing near the Village of Jansen)
- Noise effect due to train doubling, overloading, shunting would occur within the Jansen Mine Facility and would not occur on the proposed Project.

3.0 NOISE AND VIBRATION SENSITIVE RECEPTORS

A description of the noise and vibration sensitive receptors (i.e., collectively referred to as receptors) is discussed in this section. The assessment considered 33 residential dwellings closest to the Project RoW.

The receptor ID, description, location, and approximate distance to the Project RoW centerline are summarized in Table 4. The receptor locations are shown in Figure 1. The receptor (R21) closest to the rail spur is a single-storey residential building. Information on the number of stories for most receptors have been verified in the field for accuracy in modeling. No information is available for Receptor 32; therefore, it is conservatively assumed to be 2-storey dwellings. One-storey dwellings are modelled with a receptor height of 1.5 m above grade. One and a half-storey and 2-storey dwellings are modelled with a receptor height of 4.5 m above grade (i.e., highest window level). There are no schools, hospitals, daycare centers, or seniors' residences located within 1.5 km of the proposed spur. All facilities are located further than the receptors listed in Table 4.

Table 4 Receptor Location

Receptor ID	Description	Number of Stories	UTM [a] (easting)	UTM [a] (northing)	Distance to Project RoW Centerline (m)	Distance to Closest Road Crossing (m)
R01	Residential dwelling	1.5	519090	5737158	850	1670
R02	Residential dwelling	2	519202	5735324	1670	2080
R03	Residential dwelling	1	515860	5736446	1450	1470
R04	Residential dwelling	2	517920	5733702	1540	2340
R05	Residential dwelling	2	517236	5733069	1940	2290
R06	Residential dwelling	2	513100	5733735	1260	1320
R07	Residential dwelling	1	512248	5734207	635	890
R08	Residential dwelling	1.5	512601	5732450	1510	1680
R09	Residential dwelling	2	511163	5734866	550	1530
R10	Residential dwelling	2	510374	5734491	880	2360
R11	Residential dwelling	1	509630	5731650	1450	1460
R12	Residential dwelling	1	511984	5724439	890	890
R13	Residential dwelling	2	510285	5722023	810	810
R14	Residential dwelling	1	509936	5720757	1150	1740
R15	Residential dwelling	2	510182	5718714	650	690
R16	Residential dwelling	2	512037	5718592	1190	1160
R17	Residential dwelling	1.5	512386	5715136	1510	1540
R18	Residential dwelling	1	512562	5713413	1680	2300
R19	Residential dwelling	2	513595	5712313	2750	2990

Noise and Vibration Sensitive Receptors

Receptor ID	Description	Number of Stories	UTM [a] (easting)	UTM [a] (northing)	Distance to Project RoW Centerline (m)	Distance to Closest Road Crossing (m)
R20	Residential dwelling	2	510180	5713902	690	1600
R21 [b]	Residential dwelling	1	509381	5712633	396	396
R22	Residential dwelling	2	512638	5709951	3120	3120
R23	Residential dwelling	1	507653	5714291	2050	2330
R24	Residential dwelling	1.5	506033	5713684	2340	2400
R25	Residential dwelling	2	505882	5710273	1740	2130
R26	Residential dwelling	1	506095	5709895	1510	1750
R27	Residential dwelling	2	504803	5709114	2820	2820
R28	Residential dwelling	1	506213	5707524	1400	2070
R29	Residential dwelling	2	509115	5708145	1500	1740
R30	Residential dwelling	1	508245	5705741	620	620
R31	Residential dwelling	1	519213	5736677	1120	1690
R32	Residential dwelling	2	515376	5733027	1950	2018
R33	Residential dwelling	1	509650	5706247	2000	2035

Note:

[a] Coordinate System: NAD 1983 UTM Zone 13N

[b] closest receptor to the Project RoW

c Conservatively assumed two-storey houses (4.5 m window height)

4.0 METHODOLOGY

4.1 NOISE

4.1.1 Baseline

The baseline sound level at the receptors along the Project RoW are estimated by sound levels suggested for a quiet rural community as described in the CTA guidance (CTA 2011). Baseline sound level for a quiet rural area is less than or equal to 45 dBA during the daytime period (7:00 AM to 10:00 PM) and 35 dBA during the nighttime period (10:00 PM to 7:00 AM) as per CTA guidance.

4.1.2 Prediction Method

Project noise levels have been assessed using the A-weighted noise scale (dBA). The A-weighted noise scale is used for the prediction of noise effects as it is adjusted to reflect human hearing. The assessment is based on a day-night sound level (L_{dn}) calculated over a 24-hour period.

The noise assessment for the Project was completed based on the methods (both Methods A and B) recommended in the CTA noise guidance (CTA 2011). Noise effects due to locomotive pass-by, rail car pass-by, and locomotive whistle were predicted by using equations from the FTA 2018 guidance. Noise effects due to noise sources such as wheel squeal, rail crossovers, and locomotive idling were predicted by using commercial noise prediction software (CadnaA 2017). CadnaA 2017 is based on international standard ISO 9613-2, one of the recommended published noise models in the CTA noise guidance.

The following sections provide details on the prediction of noise effects from construction and various components of operations.

4.1.2.1 Construction Noise

Construction noise effects were predicted based on the method prescribed in the FTA noise guidance and the equations provided in the FTA guidance were used for the assessment. Noise emissions levels ($L_{emission}$) for the construction equipment were taken from the FTA guidance. Noise prediction equations based on the FTA guidance are summarized in Table 5.

Table 5 Construction Noise Level Prediction

Noise effect	Equation	Equation Reference (FTA 2018)
$L_{eq,equip\ (1hr)}$	$L_{eq,equip\ (1hr)} = L_{emission(1hr)} + 10\log(Adj_{usage}) - 20\log(D/50) - 10G\log(D/50)$	Eq. 7-1

Note:
$L_{eq,equip(1hr)}$ equivalent sound level at a receptor from the construction equipment over one hour period, dBA
$L_{emission\ (1hr)}$ is the noise emission level of the construction equipment at the reference distance of 50 ft, dBA
Adj_{usage} is the usage factor to account for the fraction of time that the equipment is in use over the specified time period. If the equipment are assumed to be operating continuous during the time period, the Adj_{usage} value is 1.
D is the distance from the receiver to the piece of equipment, ft
G is the constant that accounts for topography and ground effects, a value of 0.49 was used in the prediction

The construction equipment noise emission level at 15.2 m (50 feet) are based on reference levels (Table 7-1 FTA 2018) provided in the FTA noise guidance. The reference distance of 50 feet is prescribed in the prediction methods of the FTA guidance. The $L_{emission(1hr)}$ used for the prediction during earthworks and rail construction phases are summarized in Table 6.

Table 6 Construction Equipment Noise Emission at 50 feet

Earthworks			Rail Construction		
Equipment	Quantity	Noise Level at 50 ft [a], $L_{emission(1hr)}$ (dBA)	Equipment	Quantity	Noise Level at 50 ft [a], $L_{emission(1hr)}$ (dBA)
Excavators	5	82	Excavators	2	82
Dozers	3	85	Haul Trucks	4	84
Rollerpackers	2	85	Dozer	1	85
Haul Trucks	6	84	Tamper	1	83
Grader CAT 160M	1	85	Regulator	1	82
Skidsteer	1	80	Spiker	1	77
Water truck	1	84	Hi-rail 1-ton truck	1	84

Note:
[a] noise level value represents per unit of listed equipment

The detailed assessment in FTA Guidelines recommends combining one-hour L_{eq} noise levels from all the equipment, assuming they operate simultaneously.

4.1.2.2 Train Pass-by and Locomotive Whistle Noise

Equations from the FTA guidance were used to predict the L_d, L_n, and L_{dn}, at the reference distance of 50 feet due to the locomotive, whistles, and rail cars. The reference distance of 50 feet is prescribed in the prediction methods of the FTA guidance. In addition, prediction equations for L_{max} at 50 feet due to the locomotive and rail car passbys were used. Distance correction was applied to the results to predict the

L_{dn} and L_{max} sound levels at the receptor locations. Distance used in the locomotive horn predictions was based on the distance between the receptor and the closest rail/road crossing (shown in Figure 1).

Prediction equations based on the FTA noise guidance are summarized in Table 7. The input values used in the equation parameters are summarized in Table 8.

Table 7 Day-night Sound Level Prediction

Noise effect	Equation	Equation Reference (FTA 2018)
Locomotive L_d or L_n at 50 ft	L_d or L_n = SEL_{ref} + 10 log(N_{loco})+ C_T + Klog(S/50) + 10 log(V) - 35.6	Eq. 4-25
Locomotive Warning Horns L_d or L_n at 50 ft	L_d or L_n = SEL_{ref} + 10 log(V) - 35.6	Eq. 4-26
Rail Cars L_d or L_n at 50 ft	L_d or L_n = SEL_{ref} + 10 log(N_{cars}) + 20log(S/50) + 10 log(V) - 35.6 + Adj_{track}	Eq. 4-27
Locomotive L_{max} at 50 ft	$L_{max,loco}$ = SEL_{locos} + 10log(S/50) – 10log(L/50) + 10log(2α) – 3.3	Eq. F-6
Rail cars L_{max} at 50 ft	$L_{max,Rcars}$= SEL_{Rcars} + 10log(S/50) – 10log(L/50) + 10log(2α+sin(2 α)) – 3.3	Eq. F-7
Rail Cars Passby Distance Correct $C_{distance}$	$C_{distance}$ = -10log(D/50) – 10Glog(D/42)	Eq. 4-46
Locomotive Passby and Horns Distance Correct $C_{distance}$	$C_{distance}$ = -10log(D/50) – 10Glog(D/29)	Eq. 4-47

Table 8 Day-night Sound Level Prediction Input Values

Symbol	Description	Values
SEL_{ref}	Reference sound exposure level at 50 feet, based on source reference SELs at 50 ft from Table 4-20, FTA 2018	92 dBA (locomotive – diesel) 82 dBA (rail cars) 113 dBA (locomotive horns at-grade crossing)
N_{loco}	Average number of locomotives per train	4
N_{cars}	Average number of cars per train	177
C_T	$C_T = 0$ for $T < 6$ $C_T = 2(T-5)$ for $T \geq 6$ where T is the throttle setting for diesel powered locomotive and DMU only	6 (based on T = 8)
K	-10 for passenger diesel 0 for DMU +10 for electric	-10
S	Train speed, miles per hour	25
V	Average hourly volume of train per hour	0.07 (daytime) 0.11 (nighttime)
Adj_{track}	+5 for joined track +4 for aerial structure with slab track +3 for embedded track on grade	+3
L	Total length of measured group of locomotives(s) or rail car(s), ft	297 (4x locomotive) 7965 (177x rail cars)
G	Ground absorption factor $G = 0.66$, $H_{eff} \leq 5$ ft $G = 0.75 (1 – H_{eff}/42)$, 5 ft < H_{eff} < 42 ft $G = 0$, $H_{eff} \geq 42$ ft	0.49 (locomotive and horn) 0.61 (rail cars)
H_{eff}	$H_{eff} = (H_s + H_b + H_r)/2$	14.8 ft (locomotive and horn) 7.9 ft (rail cars)
H_{eff}	where H_s, H_b, H_r is the source, barrier, and receptor height, respectively.	H_s = 14.8 ft (Locomotive or Horn), 1 ft (rail cars) H_b = 0 ft (barrier) H_r = 14.8 ft (receptor)
D	Closest distance between receptor and source	Varies (see Table 4)
α	Arctan (L/2D), rad	Varies

4.1.2.3 Idling Locomotive, Rail Crossover, and Wheel Squeal on Curved Tracks

CadnaA noise modeling software was used to predict noise effects at receptors due to noise sources such as, idling locomotives, rail crossover noise and wheel squeals. In addition, the maximum sound level from a train horn event at the rail and road crossing was predicted based on CadnaA model.

The CadnaA, a software package published by DataKustik (DataKustik 2017), incorporates ISO 9613 algorithms for sound propagation. ISO 9613 is commonly used among noise practitioners and is one of the recommended noise models in the CTA noise guidance for assessing noise sources. The noise model accounts for the following factors:

- Geometric spreading
- Ground absorption
- Screening effects
- Atmospheric absorption
- Noise source characteristics—sound power level, location, elevation, and directivity
- Atmospheric effects of downwind conditions and/or mild temperature inversion

Modelling parameters used in the noise model are summarized in Table 9.

Table 9 Noise Modelling Parameters

Model Parameters	CadnaA Noise Model Settings
Temperature	10°C
Relative Humidity	70%
Number of reflections	1
Propagation Standard	ISO 9613-1, ISO 9613-2
Ground Conditions and Attenuation Factor	The study area is predominantly rural land with soil and short grass; therefore, the ground absorption index is set to 0.75 (1 is absorptive and 0 is reflective)
Receptor Height	1.5 m above grade for 1-storey building 4.5 m above grade for 1.5-storey or 2-storey building
Topography	Ground terrain incorporated in model with 50 m by 50 m resolution

The sound power levels of the noise sources used in the CadnaA model are summarized in Table 10.

Table 10 Sound Power Levels used in CadnaA Model

Item	Noise Sources	Sound Power Level (dBA)	Reference
1	Idling locomotive (four engines)	113	CTA 2011
2	Rail Crossover	98	CTA 2011
3	Wheel Squeal at Curved Radius	134	CTA 2011
4	Locomotive Horn	124	CadnaA model database, based on FTA 2018 SEL of 113 dBA

4.1.2.4 Low Frequency Noise

Sounds with strong low frequency noise (LFN) effects may result in noise-induced rattles within buildings, resulting in greater annoyance. The difference between the C-weighted sound level (dBC) and A-weighted sound level (dBA) is determined to evaluate LFN impact at the receptor locations. The energy sum of linear individual octave band sound levels at 16, 31.5 and 63-Hz also is assessed for low frequency noise assessment as per the HC 2017 guideline.

4.1.3 Noise Impact Assessment Criteria

As a federally regulated railway, CN's proposed spur line will be subject to applicable federal legislation and is governed by the CTA with respect to noise and vibration from railway construction and operation.

Consistent with the CTA's methodology, the following criteria have been used for this assessment:

- FTA Guidelines; and,
- Heath Canada guidelines.

Both guidelines are relevant to evaluating the effects of changes in acoustical environments for the operations.

The assessment also considered noise effects such as annoyance, sleep disturbance, and low frequency noise at the receptors and they were assessed based on the following noise guidance:

- Health Canada Noise Guidance (Health Canada 2017)
- World Health Organization Guidelines (WHO 1999)

4.1.3.1 Construction Noise Criteria

The construction noise assessment is based on FTA 2018 general assessment noise criteria as shown in Table 11.

Table 11 Construction Noise Criteria

Land Use	$L_{eq,equip\ (1hr)}$ (dBA)	
	Daytime	Nightime
Residential (Category 2)	80	70

4.1.3.2 Health Canada Criteria (L_{dn} and %HA)

There are no federally regulated noise criteria from Environment and Climate Change Canada (ECCC); however, Health Canada (HC) has published a guideline (Health Canada 2017) that is commonly used by acoustic practitioners and accepted by regulators for noise assessment. HC guideline provides objectives for noise levels based on L_{dn} sound levels and %HA.

The HC noise guidance (Health Canada 2017) uses measurable parameters such as daytime or nighttime equivalent sound levels (L_d and L_n, respectively), adjusted day-night sound levels ($L_{dn, adjusted}$), percent highly annoyed (%HA), and mitigated noise level (MNL) to quantify noise effects.

The adjusted day-night sound level ($L_{dn, adjusted}$) is a 24-hour time-averaged L_{eq}, with a 10-dB penalty applied to nighttime hours and adjustments made for certain characteristics of sound such as expectation of “peace and quiet”, tonality, or impulsiveness.

The maximum allowable increase for change in %HA per HC is 6.5% recommended for activities at a location with duration more than one year. Therefore, this threshold is applicable to operation phase of the Project. If the change in %HA is exceeded, effects are of concern and may require mitigation. HC also recommends mitigation of Project noise if it exceeds L_{dn} of 75 dBA, even if the change in %HA does not exceed 6.5%.

4.1.3.3 CTA/HC Low Frequency Noise Criteria

Sounds with strong low frequency noise (LFN) effect may result in noise-induced rattles within buildings, resulting in annoyance. LFN is most typically associated with locomotive idling. The CTA 2011 and HC 2017 recommend two methods for determining if the noise under assessment has potential LFN effects:

- C-weighted sound level (dBC) is equal to or exceeds the A-weighted sound level (dBA) by approximately 20 dB; or
- The energy sum of the linear sound levels in the 16, 31.5 and 63-Hz octave bands greater than 70 dB may result in noise-inducted rattles.

4.2 VIBRATION

4.2.1 Prediction Method

The CTA 2011 does not provide any assessment method for vibration effects, but it refers to the FTA Transit Noise and Vibration Guideline. The prediction of vibration effect at the receptors and vibration threshold for the assessment were based on the FTA 2018.

Table 12 summaries the rail vibration prediction equation used for the assessment. The ground-borne vibration (GBV) due to rail operation is predicted by using Equation 6-1 of the FTA 2018 guidance based on the distance between the receptor and rail. A speed adjustment and a geological condition adjustment were applied to the GBV prediction. The speed adjustment of -6 VdB was based on the lower train speed of 25 mph as compared to the reference train speed of 50 mph. The geological adjustment of +10 VdB was based on the conservative approach for areas where efficient propagation is likely. The ground-borne noise (GBN) is estimated by using the conversion factor provided in Table 6-14 of the FTA 2018 guidance and is summarized in Table 13.

Table 12 Vibration Level Prediction

Vibration Effect	Equation	Equation Reference (FTA 2018)
Locomotive GBV, L_v	$L_v = 92.28 + 14.81\log(D) - 14.17\log(D)^2 + 1.65\log(D)^3$ where a speed adjustment of -6 VdB and a geological condition adjustment of +10 VdB were applied	Eq. 6-1
Locomotive GBN	GBV to GBN conversion factor • -50 dB (low frequency < 30 Hz) • -35 dB (mid frequency peak 30Hz to 60 Hz) • -20 dB (high frequency > 60 Hz)	Table 6-14

Notes:
L_v = vibration velocity level, VdB
D = distance from rail to receptor in ft

Due to large distance to receptor, vibration effect during the construction phase is not expected to have perception vibration level at the receptor locations. The closest receptor identified (R21) is at a distance of 396 m (see Table 4). The zone of influence of construction equipment such as a vibratory roller is less than 25 m for the annoyance threshold (80 VdB) and less than 10 m for structural damage threshold (0.2 PPV, in/sec for non-engineered timber and masonry buildings). Construction equipment listed in Table 6 are expected to have less vibration effect than a vibratory roller.

4.2.2 Vibration Impact Assessment Criteria

The vibration impact assessment criteria for infrequent events recommended in the FTA 2018 guidance is summarized in Table 13. The train pass-by events along the proposed spur line are considered as infrequent events as the occurrences are expected to be fewer than 30 events per day. Event frequency definitions are provided in Table 6-2 of the FTA 2018.

Table 13 Vibration Impact Criteria

Land Use Category	GBV Impact Levels [a] (VdB)	GBN Impact Levels [a] (dBA)
Category 2: Residences and buildings where people normally sleep	80	43

Note:
[a] Impact levels are based on Table 6-2 of the FTA 2018 guidance

In addition to the criteria, the FTA 2018 guidance provides information (Table 5-5 in FTA 2018 guidance) on human response to different levels of GBV and GBN and suggests the following approximate thresholds of perception for human:

- GBV level of 65 VdB
- GBN level of 25 dBA for low frequency sound (vibration spectrum peak is near 30 Hz)
- GBN level of 40 dBA for mid frequency sound (vibration spectrum peak is near 60 Hz)

5.0 MODELING RESULTS

5.1 NOISE

5.1.1 Construction

Construction noise effect prediction was assessed at the closest receptor R21. The one-hour equivalent noise level at R21 during earthworks and rail construction is presented in Table 14. The construction noise level at other receptors is expected to be less because they are located at further distance from the construction noise sources.

Table 14 Construction Equipment Noise at Closest Receptor R21

Construction Activities	Total Noise Level at 50 ft, $L_{emission(1hr)}$ (dBA)	Noise Level at R21 $L_{eq,\ equip\ (1hr)}$ (dBA)
Earthworks	97	61
Track construction	94	58

5.1.2 Operation

The day-night sound levels, maximum sound levels, idling locomotive sound levels in C-weighted and octave band linear decibel are summarized in the following sections for assessing various aspects of the operation phase of the Project.

5.1.2.1 Day-night Sound Level

The daytime, nighttime, and day-night sound levels were predicted at the receptors following the FTA guideline. Table 15 summarizes the prediction results due to noise effect from locomotive pass-by, rail car pass-by, locomotive whistle at road crossings, idling locomotive, rail crossovers and wheel squeal.

Table 15 Predicted Sound Level at Receptors from Different Noise Sources

Receptor ID	Locomotive Pass-by (dBA)			Rail Cars Pass-by (dBA)			Locomotive whistle at Road Crossing (dBA)			Idling Locomotive (dBA)			Shunting (dBA)			Wheel Squeal and Rail Crossover (dBA)		
	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}
R01	32.6	34.8	40.9	25.5	27.7	33.9	34.7	36.9	43.1	22.9	25.1	31.2	9.4	11.7	17.8	34.4	36.6	42.8
R02	28.2	30.4	36.6	20.8	23.0	29.2	32.8	35.0	41.1	12.9	15.1	21.3	--	--	--	26.1	28.3	34.5
R03	27.2	29.4	35.5	20.0	22.2	28.4	33.0	35.3	41.4	11.1	13.3	19.5	--	--	--	26.3	28.5	34.7
R04	28.7	30.9	37.1	21.4	23.6	29.8	32.0	34.2	40.4	8.0	10.2	16.4	--	--	--	25.8	28	34.1
R05	27.2	29.5	35.6	19.8	22.0	28.1	32.1	34.4	40.5	6.2	8.4	14.5	--	--	--	21.8	24	30.2
R06	30.0	32.2	38.4	22.8	25.0	31.2	35.8	38.0	44.2	--	--	--	--	--	--	28.1	30.3	36.4
R07	32.8	35.0	41.2	26.1	28.3	34.5	37.7	40.0	46.1	--	--	--	--	--	--	36	38.3	44.4
R08	28.9	31.1	37.2	21.5	23.7	29.9	34.1	36.4	42.5	--	--	--	--	--	--	23.1	25.3	31.5
R09	35.4	37.6	43.7	28.6	30.8	36.9	37.0	39.2	45.4	--	--	--	--	--	--	36	38.3	44.4
R10	32.3	34.6	40.7	25.3	27.5	33.7	33.3	35.5	41.7	--	--	--	--	--	--	33.5	35.7	41.8
R11	27.2	29.4	35.5	20.0	22.2	28.4	33.1	35.3	41.5	--	--	--	--	--	--	16.4	18.6	24.8
R12	30.5	32.7	38.9	23.6	25.8	32.0	36.5	38.7	44.8	--	--	--	--	--	--	--	--	--
R13	32.9	35.1	41.2	25.9	28.1	34.2	38.8	41.1	47.2	--	--	--	--	--	--	16.1	18.3	24.4
R14	28.8	31.0	37.1	21.7	23.9	30.1	31.9	34.1	40.3	--	--	--	--	--	--	23.6	25.8	32.0
R15	34.3	36.5	42.7	27.4	29.6	35.8	39.9	42.1	48.3	--	--	--	--	--	--	33.4	35.6	41.7
R16	30.4	32.6	38.8	23.2	25.4	31.6	36.5	38.7	44.9	--	--	--	--	--	--	29.3	31.5	37.7
R17	28.9	31.1	37.2	21.5	23.7	29.9	34.7	36.9	43.1	--	--	--	--	--	--	15.5	17.7	23.8
R18	26.2	28.4	34.5	18.9	21.1	27.3	30.0	32.2	38.4	--	--	--	--	--	--	20.7	22.9	29.1
R19	25.0	27.2	33.4	17.3	19.5	25.7	30.4	32.6	38.8	--	--	--	--	--	--	15.8	18.1	24.2
R20	33.9	36.1	42.3	27.0	29.2	35.4	34.4	36.7	42.8	--	--	--	--	--	--	26.8	29.0	35.1
R21	36.0	38.3	44.4	29.6	31.8	37.9	42.0	44.2	50.4 [b]	--	--	--	--	--	--	29.6	31.8	38.0
R22	24.2	26.4	32.5	16.4	18.7	24.8	30.1	32.4	38.5	--	--	--	--	--	--	14.2	16.4	22.6
R23	24.8	27.0	33.2	17.4	19.7	25.8	29.9	32.1	38.3	--	--	--	--	--	--	20.3	22.5	28.7

Receptor ID	Locomotive Pass-by (dBA)			Rail Cars Pass-by (dBA)			Locomotive whistle at Road Crossing (dBA)			Idling Locomotive (dBA)			Shunting (dBA)			Wheel Squeal and Rail Crossover (dBA)		
	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}
R24	26.0	28.2	34.4	18.5	20.7	26.8	31.8	34.0	40.2	--	--	--	--	--	--	19.4	21.6	27.8
R25	27.9	30.2	36.3	20.5	22.7	28.9	32.6	34.8	41.0	--	--	--	--	--	--	18.0	20.2	26.4
R26	26.9	29.1	35.3	19.7	21.9	28.1	31.9	34.1	40.2	--	--	--	--	--	--	16.1	18.3	24.5
R27	24.8	27.0	33.2	17.1	19.4	25.5	30.8	33.0	39.2	--	--	--	--	--	--	8.9	11.1	17.2
R28	27.4	29.6	35.8	20.3	22.5	28.6	30.7	32.9	39.1	5.6	7.8	13.9	--	--	--	11.0	13.2	19.3
R29	28.9	31.1	37.3	21.6	23.8	29.9	33.9	36.1	42.3	--	--	--	--	--	--	12.2	14.4	20.6
R30	33.0	35.2	41.4	26.3	28.5	34.6	38.9	41.2	47.3	6.5	8.8	14.9	--	--	--	20.0	22.3	28.4
R31	28.9	31.2	37.3	21.9	24.1	30.3	32.1	34.3	40.5	18.6	20.8	27	2.9	5.1	11.3	30.3	32.5	38.7
R32	27.2	29.4	35.6	19.7	21.9	28.1	32.9	35.2	41.3	--	--	--	--	--	--	18.3	20.5	26.7
R33	25.0	27.2	33.3	17.6	19.8	26.0	30.8	33.0	39.2	--	--	--	--	--	--	12.0	14.2	20.4

Note:
"- -" negligible noise effect from sources due to long distance (i.e. greater than 5 km) from idling location
[b] highest level at a receptor in comparison to noise contribution from other sources

Table 16 summarizes the combined noise effects from different sources at each receptor. The results are determined by adding the noise effects (Table 15) from locomotive passby, rail car passby, locomotive horn at road crossing, idling locomotive, rail crossover and wheel squeal at each receptor.

Table 16 Combined Sound Level at Receptors from Train Passby

Receptor ID	Combined Sound Level (dBA)		
	L_d	L_n	L_{dn}
R01	39.1	41.3	47.4
R02	34.9	37.1	43.3
R03	34.9	37.1	43.3
R04	34.6	36.8	42.9
R05	33.8	36.0	42.2
R06	37.5	39.7	45.9
R07	40.9	43.1	49.3
R08	35.7	37.9	44.1
R09	41.1	43.3	49.5
R10	38.1	40.3	46.5
R11	34.3	36.5	42.7
R12	37.6	39.8	46.0
R13	40.0	42.2	48.4
R14	34.3	36.5	42.6
R15	41.6	43.8	50.0
R16	38.1	40.3	46.5
R17	35.9	38.1	44.3
R18	32.1	34.3	40.4
R19	31.8	34.0	40.2
R20	37.9	40.2	46.3
R21	43.4	45.6	51.7
R22	31.3	33.6	39.7
R23	31.6	33.8	40.0
R24	33.2	35.4	41.6
R25	34.2	36.4	42.6
R26	33.3	35.6	41.7
R27	31.9	34.2	40.3
R28	32.7	34.9	41.0
R29	35.3	37.5	43.7
R30	40.2	42.4	48.5

Receptor ID	Combined Sound Level (dBA)		
	L_d	L_n	L_{dn}
R31	35.7	37.9	44.0
R32	34.2	36.5	42.6
R33	32.0	34.2	40.4

5.1.2.2 Maximum Sound Level

Table 17 summarizes the predicted maximum sound levels (L_{max}) at the receptors due to the locomotive pass-by, rail car pass-by, whistle event, idling locomotive, wheel squeal, and rail crossover. The highest L_{max} value and the associated noise source for each receptor is also presented in Table 17.

Table 17 Maximum Sound Level at Receptors

Receptor ID	Locomotive Pass-by (dBA)	Rail Cars Pass-by (dBA)	Locomotive whistle at Road Crossing (dBA)	Idling Locomotive (dBA)	Shunting (dBAi)	Wheel Squeal (dBA)	Rail Crossover (dBA)	Highest L_{max} (dBA)
R01	68.2	58.2	43.4	41.6	50.0	58.0	20.5	68.2
R02	65.3	57.1	40.1	31.7	29.0	46.6	7.1	65.3
R03	65.9	57.4	45.9	29.9	25.9	49.3	5.5	65.9
R04	65.6	57.3	38.4	26.7	19.8	49.1	0.4	65.6
R05	64.6	56.7	38.8	24.9	17.5	43.0	--	64.6
R06	66.5	57.7	46.6	--	--	51.8	--	66.5
R07	69.5	58.4	49.9	--	--	59.8	--	69.5
R08	65.7	57.3	43.4	--	--	42.7	--	65.7
R09	70.1	58.5	44.5	--	--	59.8	--	70.1
R10	68.1	58.2	38.3	--	--	57.2	--	68.1
R11	65.9	57.4	43.8	--	--	--	--	65.9
R12	68.0	58.2	50.4	--	--	--	--	68.0
R13	68.4	58.3	52.4	--	--	--	--	68.4
R14	66.9	57.9	43.2	--	--	46.1	--	66.9
R15	69.4	58.4	54.9	--	--	57.1	--	69.4
R16	66.8	57.8	48.9	--	--	53.0	--	66.8
R17	65.7	57.3	44.7	--	--	--	--	65.7
R18	65.3	57.1	36.7	--	--	42.9	--	65.3
R19	63.1	55.6	34.1	--	--	--	--	63.1
R20	69.1	58.4	47.6	--	--	50.1	--	69.1
R21	71.5	58.6	59.3	--	--	53.3	--	71.5
R22	62.6	55.2	33.7	--	--	--	--	62.6
R23	64.4	56.6	36.3	--	--	40.0	--	64.4
R24	63.8	56.2	38.1	--	--	--	--	63.8
R25	65.1	57.0	42.2	--	--	--	--	65.1
R26	65.7	57.3	41.1	--	--	--	--	65.7
R27	63.0	55.5	35.5	--	--	--	--	63.0
R28	66.1	57.5	41.1	24.0	16.2	--	--	66.1
R29	65.8	57.4	43.0	--	--	--	--	65.8
R30	69.6	58.4	54.4	25.0	17.8	40.3	--	69.6
R31	67.0	57.9	41.6	37.3	43.4	53.9	15.0	67.0
R32	64.6	56.7	40.8	23.3	16.2	--	--	64.6

Receptor ID	Locomotive Pass-by (dBA)	Rail Cars Pass-by (dBA)	Locomotive whistle at Road Crossing (dBA)	Idling Locomotive (dBA)	Shunting (dBAi)	Wheel Squeal (dBA)	Rail Crossover (dBA)	Highest L_{max} (dBA)
R33	64.5	56.6	38.9	22.3	--	--	--	64.5
Note: "- -" negligible noise effect from sources due to long distance (i.e. greater than 5 km)								

5.1.2.3 Low Frequency Noise

For assessing low frequency noise from an idling locomotive, the overall sound levels were predicted in A-weighted and C-weighted scale, and spectral linear sound levels at 16 thru 63 Hz. Locomotive idling is expected at the CP Sutherland Subdivision rail diamond. The closest receptor (R01) located approximately 850 m east of the crossover was considered for the LFN assessment.

The predicted idling locomotive sound levels at R01 in A-weighted, C-weighted, and linear (in 16 Hz, 31.5 Hz, and 63 Hz octave bands) decibel sound levels are presented in Table 18. The sound level at the 16 Hz band was assumed to be the same as at the 31.5 Hz band as the noise model does not predict noise level in the 16 Hz band. The sum of linear decibel sound levels for the three octave bands are presented in LFN analysis.

Table 18 Low Frequency Noise Results at R01

Receptor ID	Predicted Sound Level			Predicted Octave Band Sound Level (dB)			
	dBA	dBC	dBC minus dBA	16 Hz	31.5 Hz	63 Hz	Sum of 16 Hz, 31.5 Hz, and 63 Hz
R01	41.6	64.4	22.8	60.1 [a]	60.1	64.3	67
Note: [a] assumes same value as 31.5 Hz octave band							

5.2 VIBRATION

Due to large distance to the receptor, vibration effect during the construction phase is not expected to be perceptible at the receptor locations. The closest receptor identified (R21) is at a distance of 396 m (see Table 4).

The predicted GBV and GBN result for all receptors during the operation phase is summarized in Table 19.

Table 19 Ground-borne Vibration and Ground-borne Noise Results

Receptor ID	Ground-borne Vibration, GBV (VdB)	Ground-borne Noise, GBN (dBA)
R01	47	12
R02	40	5
R03	41	6
R04	41	6
R05	38	3
R06	43	8
R07	50	15
R08	41	6
R09	51	16
R10	46	11
R11	41	6
R12	46	11
R13	47	12
R14	43	8
R15	49	14
R16	43	8
R17	41	6
R18	40	5
R19	35	0
R20	49	14
R21 [a]	55	20
R22	34	0
R23	38	3
R24	37	2
R25	39	4
R26	41	6
R27	35	0
R28	41	6
R29	41	6
R30	50	15
R31	44	9
R32	38	3
R33	38	3

6.0 PROJECT EFFECTS

6.1 NOISE

6.1.1 Construction

The construction noise level at the closest receptor R21 is compared to the FTA 2018 criteria in Table 20. The result indicates noise level well below the FTA threshold of 80 dBA daytime and 70 dBA nighttime. Lower construction noise levels are expected at other receptors given that they are located at further distances from the Project RoW.

Table 20 Construction Activities Impact

Receptor ID	Hourly Sound Level, $L_{eq,1hr}$ (dBA)		FTA Threshold, $L_{eq,equip\ (1hr)}$ (dBA)	
	Daytime	Nighttime	Daytime	Nighttime
R21	61 (earthworks) 58 (track construction)	--	80	70
Note: "- -" not applicable because no nighttime construction activities are planned				

6.1.2 Operation

6.1.2.1 Health Canada

HC recommends mitigation of project noise if it exceeds L_{dn} of 75 dBA and if the change in %HA exceed 6.5%.Table 21 presents the Project sound levels, baseline %HA, cumulative %HA, and change in %HA at the receptors for the operations phase. The baseline %HA is determined by the existing L_{dn} of 45 dBA . A sample calculation of %HA at receptor (R21) is shown in Appendix A.

The results indicate that the Project cumulative L_{dn} is below 75 dBA and the change in %HA are below the limit of 6.5% at all receptors (Table 21).

Table 21 Day-night Sound Levels and Change in %HA at Receptors

Receptor ID	Cumulative L_{dn} (dBA)	Baseline %HA [a]	Cumulative (Project + Existing) %HA	Change in %HA
R01	49.4	1.1	2.0	0.9
R02	47.2	1.1	1.5	0.4
R03	47.2	1.1	1.5	0.4
R04	47.1	1.1	1.5	0.4
R05	46.8	1.1	1.5	0.4
R06	48.5	1.1	1.8	0.7
R07	50.7	1.1	2.4	1.3
R08	47.6	1.1	1.6	0.5
R09	50.8	1.1	2.4	1.3
R10	48.8	1.1	1.9	0.8
R11	47.0	1.1	1.5	0.4
R12	48.5	1.1	1.8	0.7
R13	50.0	1.1	2.2	1.1
R14	47.0	1.1	1.5	0.4
R15	51.2	1.1	2.5	1.4
R16	48.8	1.1	1.9	0.8
R17	47.7	1.1	1.6	0.5
R18	46.3	1.1	1.4	0.3
R19	46.2	1.1	1.3	0.2
R20	48.7	1.1	1.9	0.8
R21	52.6	1.1	3.0	1.9
R22	46.1	1.1	1.3	0.2
R23	46.2	1.1	1.3	0.2
R24	46.6	1.1	1.4	0.3
R25	47.0	1.1	1.5	0.4
R26	46.7	1.1	1.4	0.3
R27	46.3	1.1	1.3	0.2
R28	46.5	1.1	1.4	0.3
R29	47.4	1.1	1.6	0.5
R30	50.1	1.1	2.2	1.1
R31	47.6	1.1	1.6	0.5
R32	47.0	1.1	1.5	0.4
R33	46.3	1.1	1.4	0.3

6.1.2.2 Low Frequency Noise

Low frequency noise (LFN) effect is assessed at the receptor R01 closest to the locomotive idling location at the CP Sutherland Subdivision crossing. The difference in C-weighted and A-weighted sound level at R01 is 22.8 dB, higher than the recommended threshold of 20 dB (Table 18). However, further analysis indicates that the energy sum of linear sound levels (unweighted) in the 16 Hz, 31.5 Hz, and 63 Hz band at the closest receptor R01 is 67 dB, below the threshold of 70 dB limit. Therefore, this assessment concludes that LFN effect at R01 closest to the locomotive idling location is not expected.

6.2 VIBRATION

Construction vibration is not expected to impact the receptors in the area as there are no receptors within the zone of influence of any construction equipment.

The results during operation are compared to the vibration impact criteria recommended Table 6-3 of the FTA 2018 guidance. All residential receptors (i.e., R01 to R30) are considered as Category 2 for residences and buildings where people normally sleep. The predicted vibration levels are below the impact criteria thresholds of 80 VdB ground-borne vibration and 43 dBA ground-borne noise at all residential receptors. The highest results are predicted at the closest receptor R21. The predicted GBV of 55 VdB and GBN of 20 dBA at the closest receptor R21 are below the perception thresholds of 65 VdB and 25 dBA.

7.0 RECOMMENDATIONS

The noise and vibration effects at all receptors are predicted to meet the assessment criteria. Based on the results, no mitigation measures are required for the proposed Project design.

8.0 CONCLUSION

This assessment was completed to quantify the noise and vibration effects at the closest sensitive receptors for the Project.

Noise effects due to locomotive pass-by, rail cars pass-by, locomotive whistle, wheel squeal, rail crossover, locomotive idling, and construction were assessed. The predicted noise levels at all receptors are considered to meet the HC change in percent highly annoyed threshold (%HA) of 6.5%. The results indicate that noise effects are below the thresholds at all receptors.

Vibration effects due to locomotive pass-by and rail cars pass-by were also assessed. The results at all receptors were below the threshold recommended in the FTA 2018 noise and vibration guidance. Therefore, no noise and vibration mitigation measures are required for the proposed Project design.

9.0 REFERENCES

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Appendix A HEALTH CANDA PERCENT HIGHLY ANNOYED CALCULATION EXAMPLE

This section presents detailed sample calculation for the change in %HA at receptor R21. The %HA is calculated using equation F4 in Appendix F of Health Canada 2017:

$$\%HA = 100 / [1 + e^{(10.4 - 0.132* Ldn}] \qquad [F4]$$

Baseline Day-night Sound Level (Ldn)

At R21, the L_d of 45 dBA and L_n of 35 result in the day-night sound level (L_{dn}) value of 45 dBA. The Day-night Sound Level L_{dn} is calculated by using equation F2 in Appendix F of Health Canada 2017 as follows:

$$L_Rdn = 10 \log10 [((15 \times 10^{(0.1 \times Ld)} + (9 x 10) / 24)^{(0.1 \times (Ln + 10))}] \qquad [F2]$$

$$\text{Baseline } L_Rdn = 10 \log10 [((15 \times 10^{(0.1 \times 45 dBA)} + (9 x 10) / 24)^{(0.1 \times (35 dBA + 10))}] = 45 dBA$$

Baseline %HA

The baseline %HA of 1.1 % is based on the equation F4 as follows:

$$\text{Baseline } \%HA = 100 / [1 + e^{(10.4 - 0.132* 45 dBA)}] = 1.1 \%$$

Project Day-night Sound Level

The Project daytime sound level L_d is 43.4 dBA and Project nighttime sound level L_n is 45.6 dBA., resulting in the L_{dn} of 51.7 dBA.:

$$L_{dn} = 10 \log10 [((15 \times 10^{(0.1 \times L_Rd)} + (9 x 10) / 24)^{(0.1 \times (L_Rn + 10))}] \qquad [F2]$$

$$\text{Project } L_{dn} = 10 \log10 [((15 \times 10^{(0.1 \times 43.4 dBA)} + (9 x 10) / 24)^{(0.1 \times (45.6 dBA + 10))}] = 51.7 dBA$$

Cumulative Day-night Sound Level

The cumulative day-night sound level is determined by adding the baseline sound level of 45 dBA and adjusted Project sound level of 51.7 dBA, calculated as follows:

$$\text{Cumulative } L_Rdn = 10 \log[10^{(0.1 \times 45 dBA)} + 10^{(0.1 \times 51.7dBA)}] = 52.6 dBA$$

Cumulative (Baseline and Project) %HA

The cumulative (Baseline and Project) %HA of 3.0 % is based on equation F4 as follows:

$$\text{Cumulative } \%HA = 100 / [1 + e^{(10.4 - 0.132* 52.6 dBA)}] = 3.0 \%$$

Change in %HA

The change in %HA of 1.9 % is determined by the different in the cumulative (Baseline and Project) %HA of 3.0 % and Baseline %HA of 1.1 %.