APPENDIX D – PRELIMINARY NOISE ASSESSMENT REPORT

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MEMORANDUM

DATE:	2025-03-07	**RWDI Reference No.:** 2401722
TO:	Nathan Farrell | Senior Environmental Planner, Egis Group	**EMAIL:** nathan.farrell@egis-group.com
FROM:	Alain Carrière | Senior Project Manager, RWDI Ayman Shaaban | Senior Noise Engineer, RWDI	**EMAIL:** Alain.Carriere@rwdi.com Ayman.Shaaban@rwdi.com
RE:	**MTO Rest Centres Class Environmental Assessment (MTO 5023-E-0006) Opasatika/Kapuskasing – White River – Wawa Preliminary Design – Environmental Noise Northeast Region, ON**	

Dear Nathan,

This memorandum details RWDI's environmental noise preliminary design assessment of three Ontario Ministry of Transportation (MTO) rest centres planned in the Northeast Region, ON. This assessment has been completed as per the Terms of Reference under MTO's assignment number: 5023-E-0006. The three proposed rest areas are proposed along Highway 11 at Opasatika/Kapuskasing (GWP 5133-22-00), along Highway 17 at White River (GWP 5134-22-00) and along Highway 17 at Wawa (GWP 5135-22-00). Multiple options (3 to 4) are currently proposed at each location. The objective of this study is to lay out the applicable noise criteria and MTO guidelines and further qualitatively assess the various proposed options from an environmental noise standpoint.

APPLICABLE GUIDELINES

The main applicable guidelines are the MTO Environmental Guide for Noise, 2022, and the MTO Environmental Reference for Highway Design, 2013, which are publicly available. The two main components of noise that have to be investigated are operational noise, and temporary construction noise.

Operational Noise

Sound impacts are assessed by comparing the future sound levels with and without the proposed rest areas. The rest areas are anticipated to be associated with stationary sources of noise, most notably truck idling. Moreover, it may impact the overall traffic volumes on the corresponding highways; however, that will be confirmed at a later stage of the project. Transportation sound levels are evaluated as 24-hour equivalent sound levels based on the Average Annual Daily Traffic (AADT) or Summer Average Daily Traffic (SADT), whichever is higher. If the predicted changes due to traffic and stationary sources result in difference in sound levels equal to or greater than 5 dB, or if the future sound levels with the undertaking are equal to or greater than 65 dBA, mitigation should be considered. Noise control measures have to be technically, economically and administratively feasible, as defined by the MTO Environmental Guide for Noise. Technically feasible barriers should achieve on average 5 dB noise reduction at the first-row receivers behind the noise barrier.

The stationary source of noise as a result of truck idling should be investigated as well according to part B of the NPC-300 publication by the Ontario Ministry of the Environment, Conservation and Parks (MECP). Northeast Region of Ontario is typically considered rural and would be classified as Class 3 as per NPC-300. This classification may be revisited based on the actual traffic volumes of the highways. As per NPC-300, the sound levels are assessed as one hourly equivalent. The exclusion (i.e. default) limit for a Class-3 area, during the most stringent evening and nighttime periods (7 pm – 7 am), is 40 dBA both at the façade and outdoor areas. The applicable limits could be raised to the minimum background sound levels by transportation sources, if it is modelled and found to be higher than the exclusion limits.

A plain language description of the terminology and relationships between everyday sounds to aid the non-technical reader is provided in **Appendix A**.

Construction Noise

Local Noise Control By-laws

The project lies within the local jurisdiction of the townships of Opasatika/Kapuskasing, White River and Wawa. No local noise control bylaws have been identified for the aforementioned townships except for the Town of Kapuskasing. Kapuskasing has Bylaw No. 1866-1982 to control noise. The bylaw prohibits the operation of any construction equipment in a residential area or a quiet zone without effective muffling devices. Quiet zones include areas zoned C5 (Funeral Homes) in addition to any hospital, senior citizen housing and nursing homes. Moreover, in residential areas and quiet zones the construction equipment is prohibited from 11 pm to 7 am Monday to Saturday, and from 11 pm to 9 am on Sunday. The bylaw indicates an exemption procedure for construction-related noise where an application has to be filed and potential exemptions may be granted for a temporary period.

MTO has reviewed and updated its practices related to obtaining noise bylaw exemption permits. Given that MTO is legally exempt from the requirements of municipal noise bylaws while working within MTO right-of-way, MTO will no longer be applying for these permits. MTO recognizes the impacts construction related noise can have on a community, and MTO will ensure clear and frequent communication with the municipality to work within the spirit of the municipal noise bylaw, if any. All reasonable attempts will be made including as appropriate, public notification and mitigation measures to reduce noise.

MECP Noise Control

The MECP (previously known as Ministry of the Environment (MOE)) stipulates limits on sound levels from individual items of equipment, rather than for overall construction noise. In the presence of persistent noise complaints, sound emission standards for the various types of construction equipment used on the project should be checked to ensure that they meet the specified limits contained in MOE Publication NPC-115 "Construction Equipment" (MOE, 1977b). Further information about the specified limits of NPC-115 would be provided in the detailed design study.

NOISE-SENSITIVE AREAS

A Noise Sensitive Area (NSA) is defined as the area where the MTO sound objectives apply and should be considered when investigating the sound levels associated with the operational noise of a roadway. The maximum area of investigation is 600 m perpendicular from the closest edge of pavement and forms the boundaries of this assessment. The NSAs are the areas that may eventually qualify to receive noise mitigation in the form of noise barriers if the sound levels exceeded the MTO criteria. Residential private homes (single family units and townhouses) come on the top of the list for NSAs to be considered. The list extends to multiple apartment buildings and hospitals given they common Outdoor Living Areas (OLAs).

For roadway improvement projects, similar to the current undertaking, special land use NSAs could be considered as a part of the community if they are next to a traditional NSA mentioned above. A special land use NSA may only receive noise mitigation if the traditional NSA beside it has a technically, economically, and administratively feasible noise mitigation. Special land use NSAs include:

- Schools, educational facilities, and daycare centres where there are outdoor living areas for students;
- Campgrounds that provide overnight accommodation;
- Hotels and motels with outdoor communal outdoor living areas (e.g., swimming pools) for visitors;
- Community centres with outdoor living areas (e.g., outdoor sports courts);
- Municipal parks (excluding golf courses and trails); and
- Places of worship with outdoor living areas.

However, MECP NPC-300, considers institutional buildings as typical noise-sensitive receivers if they got operable windows. Moreover, places of worship are considered as typical noise-sensitive receivers if they are not in commercially or industrially zoned lands.

The following land uses are generally not considered by either the MTO or the MECP to qualify as NSAs:

- Apartment balconies;
- Cemeteries;
- All commercial; and
- All industrial.

HIGHWAY 11 AT OPASATIKA/KAPUSKASING REST AREAS

Four different options have been considered for the rest area along Highway 11 at Opasatika/Kapuskasing. Options 3, 4, 6 and 7 have been communicated to RWDI as the four final options considered for this area as shown in Figures 1 through 4. Option 3 has four residential houses to the north at approximately 100 m setback. Option 4 has one residential house to the south at approximately 100 m setback, as well. Thus, both Options 3 and 4 are comparable from environmental noise perspective. 100 m is a reasonable setback distance for an idling truck sound impacts to drop within acceptable MECP levels specially given the absorptive grassy intervening ground. However, Option 4 is slightly favorable compared to Option 3 given the lower number of homes potentially impacted. Moreover, the backyard shielded from highway noise is also not facing the rest area. Option 6, shown in Figure 3, has a single identified noise sensitive receiver to the east at a setback distance beyond 240 m which is more than double the setback distances for either Options 3 or 4. Option 7 is proposed to the east of the Opasatika Municipal Complex with the residential houses only to the west at approximately 160 m setback, based on measurements from the property lines. The proposed rest area layout for Option 7, provided by Egis group, indicates the truck route is further to the east at a setback beyond 300 m from the west residences (See Figure 4b).

In conclusion, all the proposed alternatives for the rest area at Opasatika/Kapuskasing are anticipated to be feasible from environmental noise pending detailed modelling. However, the preference order would be for Option 7 (based on proposed layout), then Option 6 followed by Option 4 and finally Option 3, only if it was deemed favourable by other disciplines.

HIGHWAY 17 AT WHITE RIVER REST AREAS

Three different options have been considered for the rest area along Highway 17 at White River. Options 7, 8 and 9 have been communicated to RWDI as the three final options considered for this area as shown in Figures 5 through 7. Both Options 7 and 8 do not have any identified noise sensitive receiver within 600 m which is ideal from an environmental noise perspective. Option 9 has White River Motel, with operable windows, located approximately 30 m to the northwest with multiple homes at approximately 60 m to the east. The setback distances are based on measurements from the property lines of Option 9. These close setback distances have the potential to be problematic and feasible noise mitigation would be limited with receivers from multiple cardinal directions. Noise mitigation could be in the form of earthen embankments or berms which could be constructed using the excavated material onsite. Upon correspondence with Egis Group, the proposed layout of the lot indicates the truck route is at a further setback of 115 m from the White River Motel (See Figure 7b) with the corresponding truck parking spots strategically located further away from both the Motel and the residences to the east.

In conclusion, Option 9 is the least preferred option for the rest area at White River as noise mitigation measures may be challenging and potentially required towards different directions. On the other hand, no detailed noise modelling would be required for Options 7 and 8, as no sensitive receivers were identified in their vicinity.

HIGHWAY 17 AT WAWA REST AREAS

Three different options have been considered for the rest area along Highway 17 at Wawa. Options 2, 5 and 6 have been communicated to RWDI as the three final options considered for this area as shown in Figures 8 through 10. Option 2 does not have any identified noise sensitive receiver within 600 m which is ideal from an environmental noise perspective. Option 5 has one residential home at approximately 200 m to the northwest which is a fair setback distance with anticipated noise levels from the rest areas meeting the sound targets, pending detailed modelling. The area is close to Wawa Municipal Airport which suggests relatively higher ambient to mask potential truck idling at the rest areas. This should be confirmed in the next detailed design phase. Option 6 has one close by receiver which is the Highway 17 Hotel at a setback distance of 60 m from the edge of the rest area. This receiver will not be considered noise-sensitive as per MTO guidelines due to the lack of a common outdoor amenity area. However, it would be considered for stationary source assessment as per MECP NPC-300 since the guest rooms appear to have operable windows. Feasible noise mitigation measures could be investigated as the placement of the truck parking spots away from the southwest area of Option 6. Moreover, the effectiveness of a property line barrier could be examined in the detailed design phase, if needed.

In conclusion, Options 2 and 5 are anticipated to be feasible from environmental noise standpoint. No detailed modelling would be required for Option 2, while Option 5 feasibility should be confirmed with detailed modelling. Option 6 is the least favorable location for environmental noise; however, feasible noise mitigation measures could be investigated if this option is deemed favourable by other disciplines.

CLOSURE

Three planned MTO rest areas in Northeast Ontario has been investigated by RWDI from environmental noise standpoint. This assessment represents the preliminary design study and to be followed by a detailed design study as the project progresses. The applicable guidelines for both operational and construction noise have been detailed herein. Moreover, the various options for the rest area placement at each of the three locations have been qualitatively assessed and commented on regarding any potential noise impacts.

Yours truly,

Ayman Shaaban, PhD, P.Eng.

Senior Noise and Vibration Engineer

AS/klm

STATEMENT OF LIMITATIONS

This document entitled "MTO Rest Centres Class Environmental Assessment (Opasatika/Kapuskasing – White River – Wawa)", dated March 7, 2025, was prepared by RWDI AIR Inc., ("RWDI") for Egis Group (formerly McIntosh Perry) ("Client"). The findings and conclusions presented in this document have been prepared for the Client and are specific to the project described herein ("Project"). The conclusions and recommendations contained in this document are based on the information available to RWDI when it was prepared. Since the contents of this document may not reflect the final design of the Project or subsequent changes made after the date of this document, it is recommended that RWDI be retained by the Client during the final stages of the project to verify that the results and recommendations provided in this document have been correctly interpreted in the final design of the Project.

The conclusions and recommendations contained in this document have also been made for the specific purpose(s) set out herein. Should the Client or any other third party utilize the document and/or implement the conclusions and recommendations contained therein for any other purpose or project without the involvement of RWDI, the Client or such third party assumes any and all risk of any and all consequences arising from such use and RWDI accepts no responsibility for any liability, loss, or damage of any kind suffered by Client or any other third party arising therefrom.

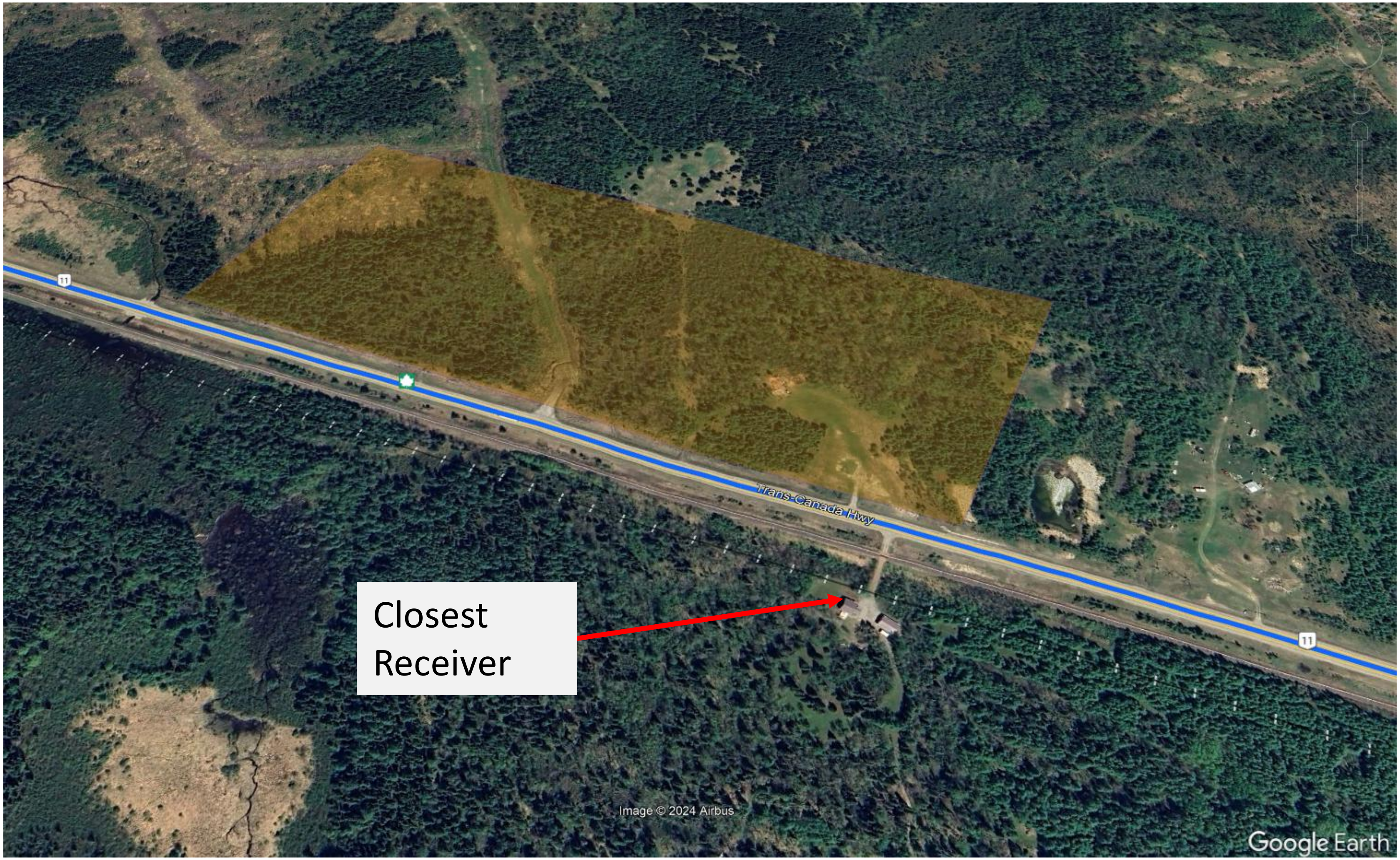
Finally, it is imperative that the Client and/or any party relying on the conclusions and recommendations in this document carefully review the stated assumptions contained herein to understand the different factors which may impact the conclusions and recommendations provided.

FIGURES

Opasatika/Kapuskasing MTO Rest Area Option 3

MTO 5023-E-0006 – Northeast Region, ON

Drawn by:	AFS	Figure:	1
Project #:	2401722		
Date:	2025-03-07		



Opasatika/Kapuskasing MTO Rest Area
Option 4

MTO 5023-E-0006 – Northeast Region, ON

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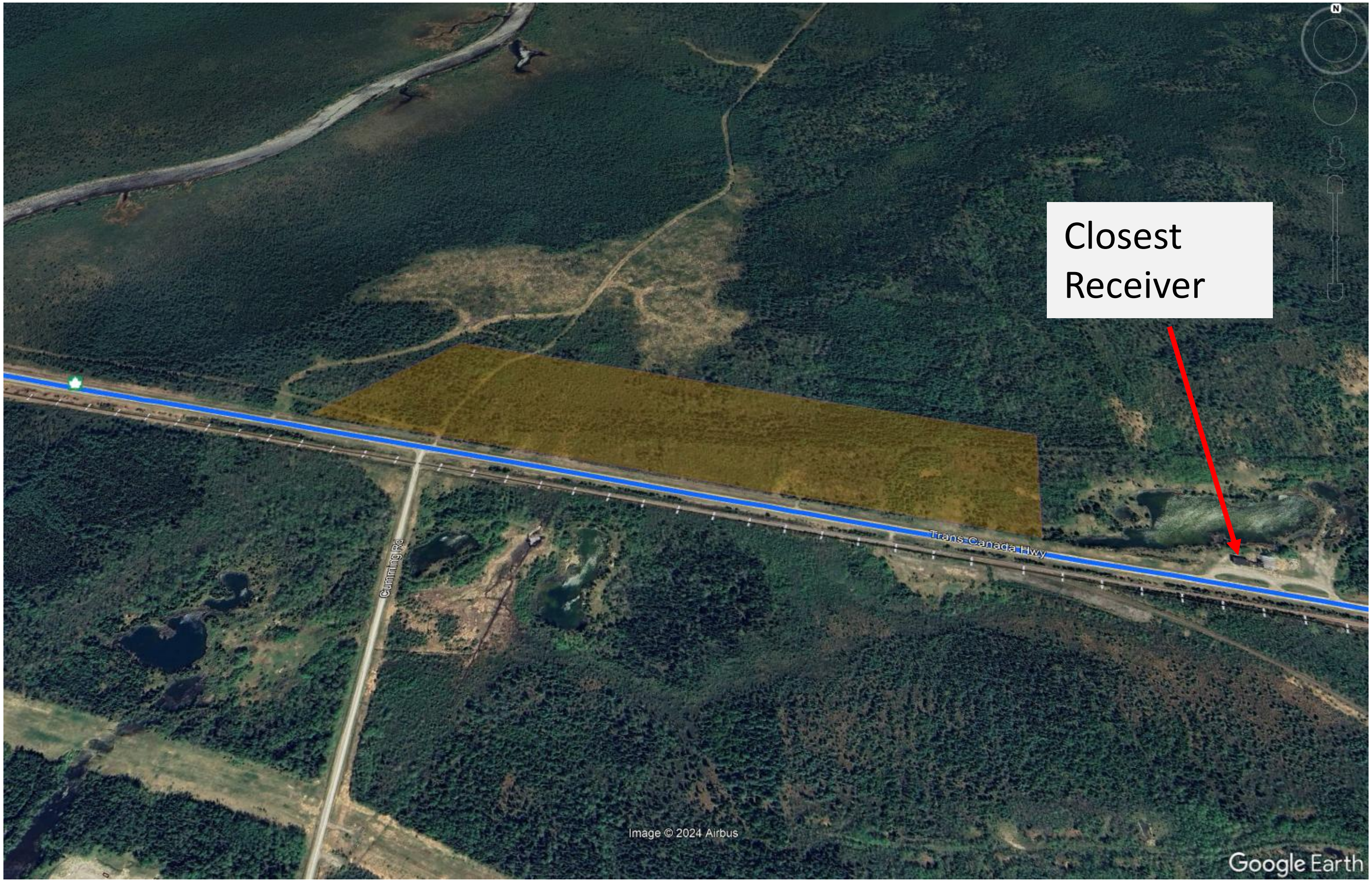

Opasatika/Kapuskasing MTO Rest Area Option 6

MTO 5023-E-0006 – Northeast Region, ON

Drawn by:	AFS	Figure:	3
Project #:	2401722		
Date:	2025-03-07		

Opasatika/Kapuskasing MTO Rest Area Option 7	Drawn by: AFS	Figure: 4a	
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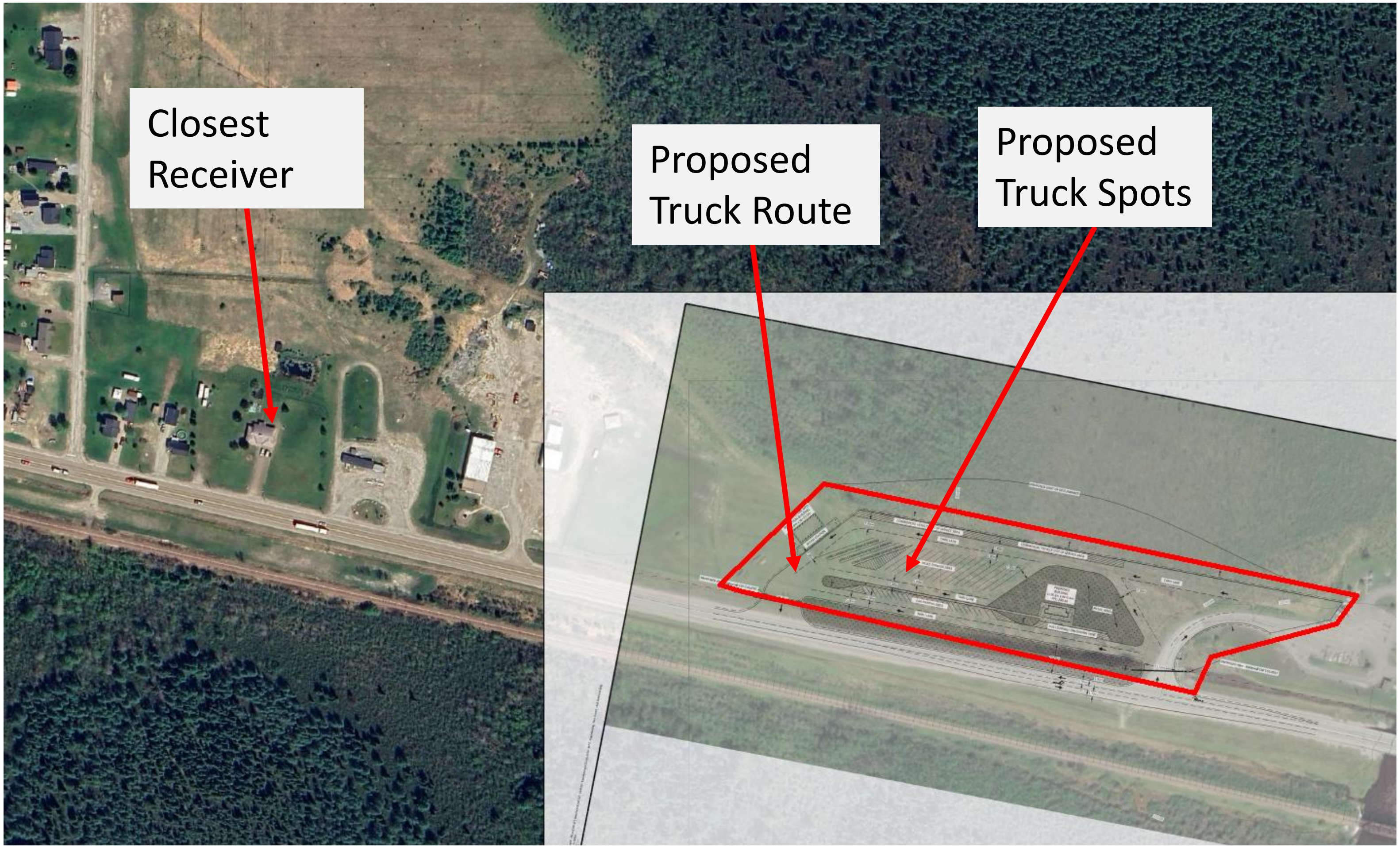
MTO 5023-E-0006 – Northeast Region, ON	Date:	2025-03-07	



Opasatika/Kapuskasing MTO Rest Area
Option 7 – Zoomed In Layout

MTO 5023-E-0006 – Northeast Region, ON

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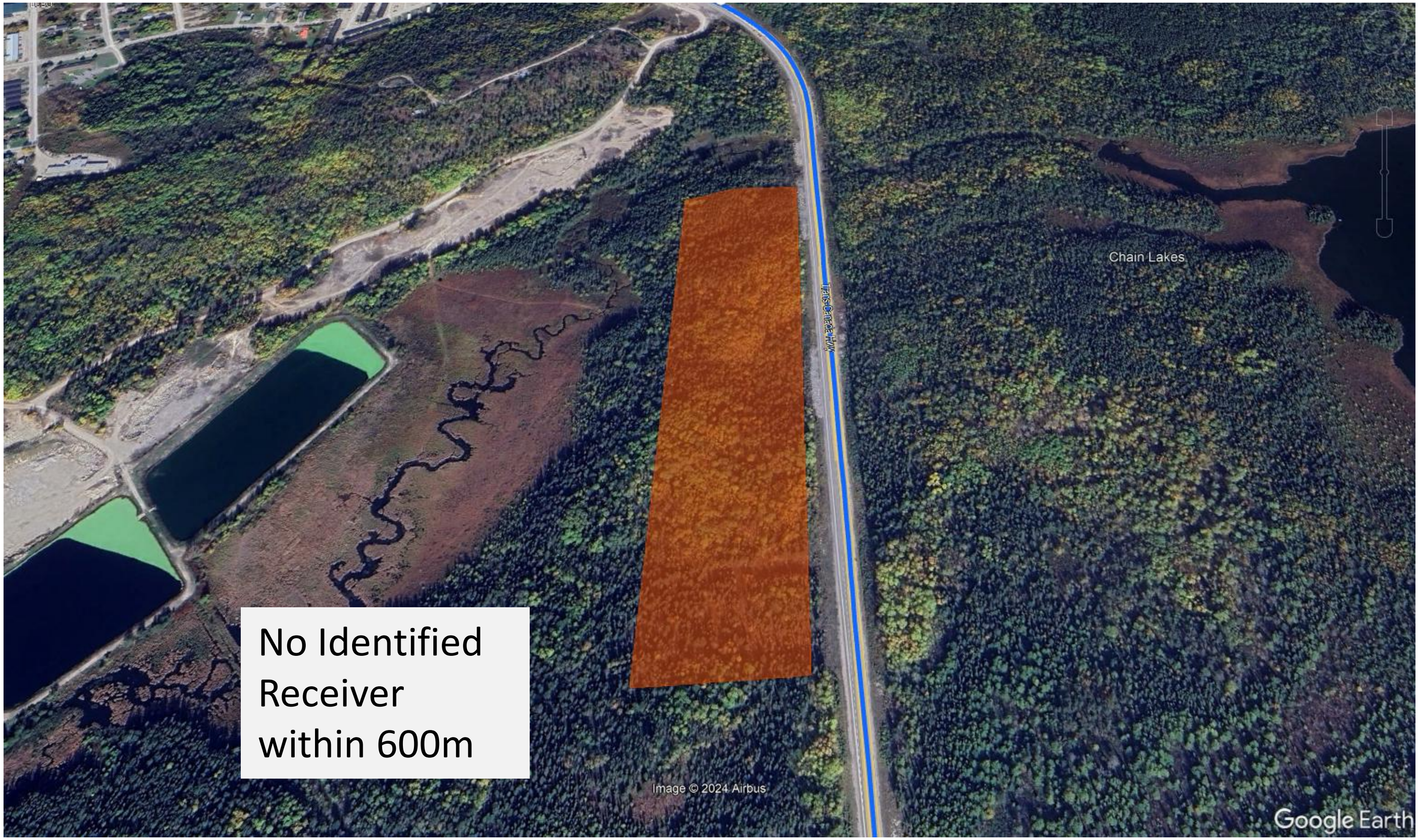
Date:	2025-03-07



White River MTO Rest Area
Option 7

MTO 5023-E-0006 – Northeast Region, ON

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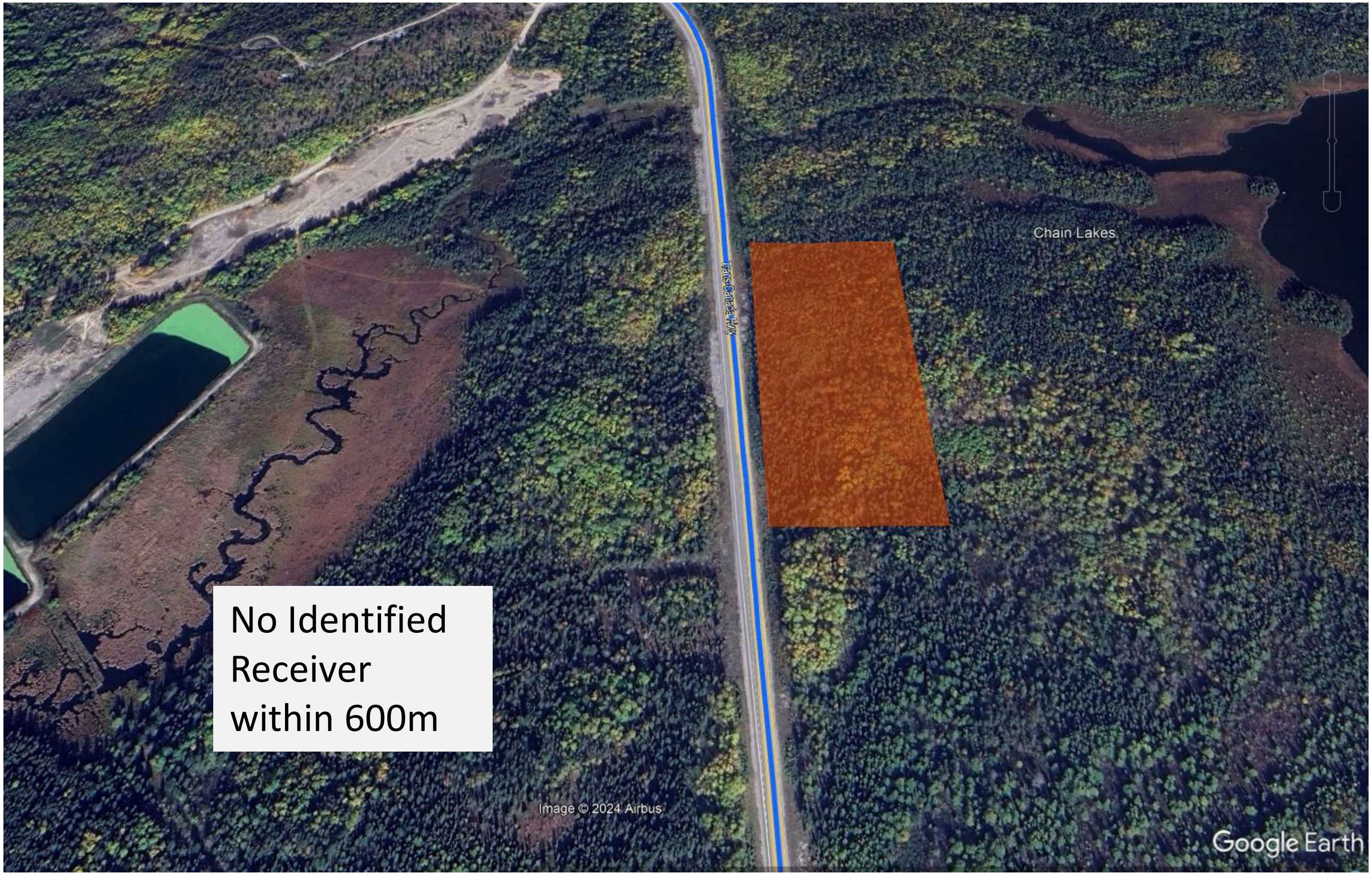

White River MTO Rest Area
Option 8

MTO 5023-E-0006 – Northeast Region, ON

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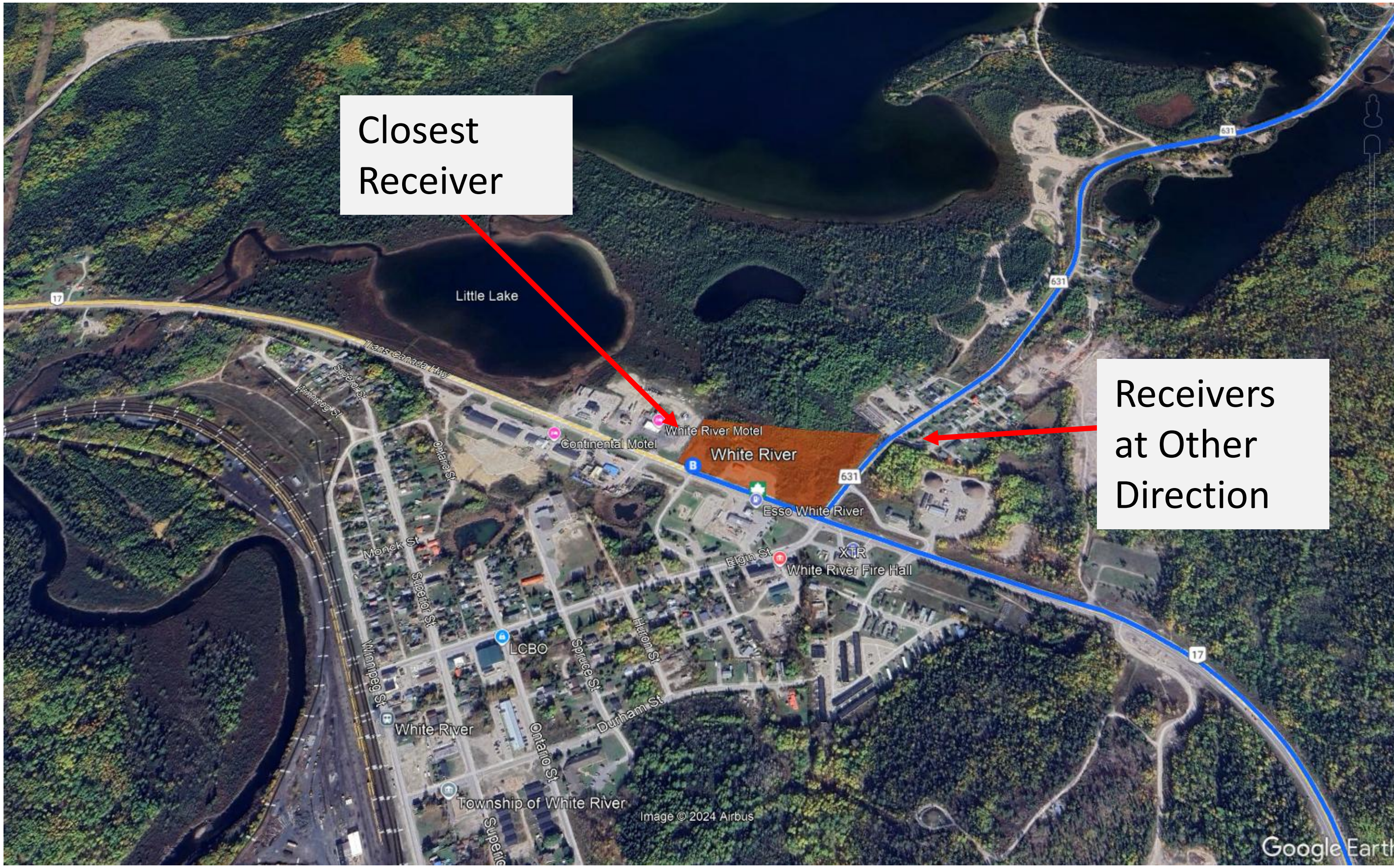
Date:			2025-03-07



White River MTO Rest Area
Option 9

MTO 5023-E-0006 – Northeast Region, ON

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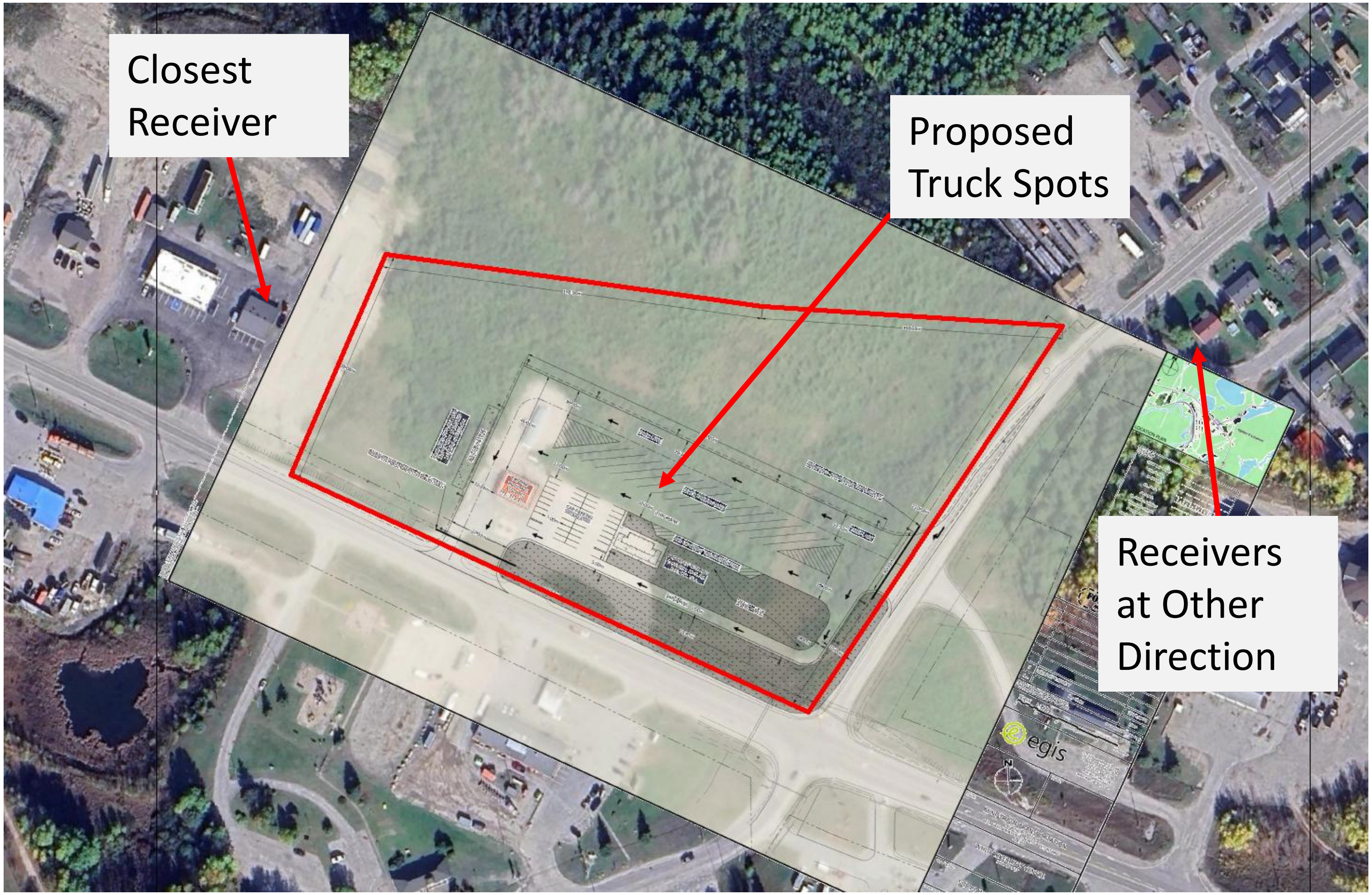
Date:			2025-03-07



White River MTO Rest Area
Option 9 – Zoomed In Layout

MTO 5023-E-0006 – Northeast Region, ON

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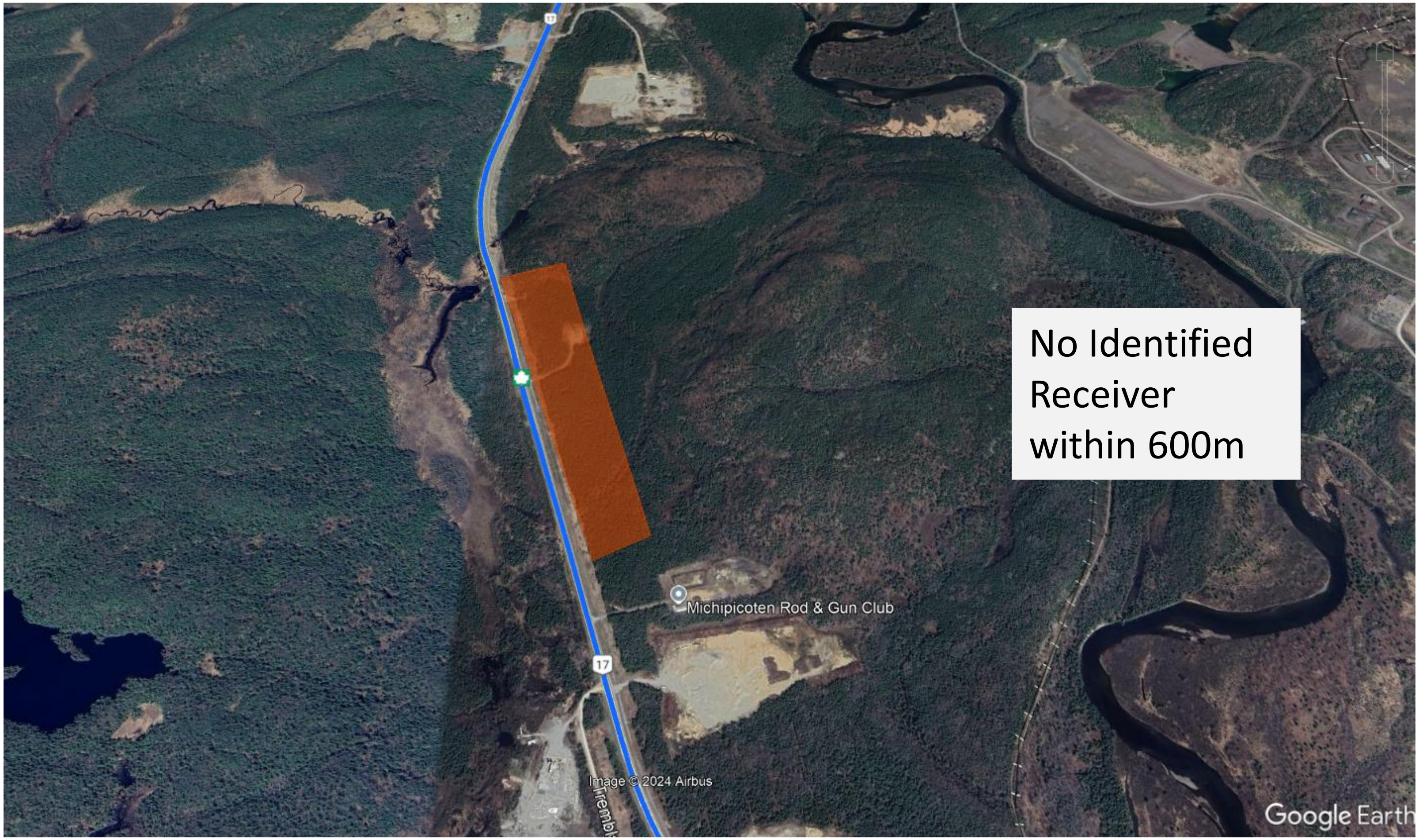


Wawa MTO Rest Area Option 2

MTO 5023-E-0006 – Northeast Region, ON

Drawn by: AFS	Figure: 8
Project #:	2401722
Date:	2025-03-07

Wawa MTO Rest Area Option 5

MTO 5023-E-0006 – Northeast Region, ON

Drawn by:	AFS	Figure:	9
Project #:	2401722		
Date:	2025-03-07		

Wawa MTO Rest Area
Option 6

MTO 5023-E-0006 – Northeast Region, ON

Drawn by:	AFS	Figure:	10
Project #:			2401722
Date:			2025-03-07

APPENDIX A

TRANSPORTATION SOUND BASICS

Sound Levels

Sound is, in its simplest form, a dynamic, fluctuating pressure, in a fluid medium. That medium can be air, other gases, or liquids such as water. These fluctuations are transmitted by pressure waves through the medium from the source to the receiver. For the majority of transportation engineering purposes, the primary interest is with sound waves in air, with human beings as the receptor. Noise is defined as unwanted sound. The standard practice within the acoustical industry is to use these two terms interchangeably.

Decibels

A decibel (dB) is a logarithmic ratio of a value to a reference level. The general mathematical format is:

Level in dB = 10 log (Value / Reference)

Any value can be expressed in decibels. Decibels are very useful in performing comparisons where there are huge ranges in levels. For example, an acoustical engineer can expect to deal with acoustical energy values ranging from 0.00001 W to 100 W (sound power), and pressures ranging from 0.002 Pa to 200 Pa (sound pressure).[1] For completeness, decibels should always be stated with their reference level (e.g., 20 dB re: 20 μPa). However, in practice the reference level is often left out.

Sound Pressure Level

Sound pressure level is what humans experience as sound. Sound waves create small fluctuations around the normal atmospheric pressure. These pressure fluctuations come into contact with eardrums and create the sensation of sound. Sound pressure is measured in decibels, according to the following equation:

$$\text{Sound Pressure Level, dB} = 10 \log (p^2 / p_o^2)$$

Where: p = root mean square (r.m.s.) sound pressure, in Pa
p_o = reference sound pressure, 20 μPa

The reference pressure represents the faintest sound that a "typical" human being can hear. The typical abbreviation for sound pressure level is SPL, although L_p is also often used in equations. "Sound level" or "noise level" are also sometimes used.

[1] Equivalent to Sound Power Levels ranging from 70 to 140 dB and Sound Pressure Levels ranging from 20 dB to 140 dB

Octave Bands

Sounds are composed of varying frequencies or pitches. Human sensitivity to noise varies by frequency, with a greater sensitivity to higher frequency sounds. The propagation of sound also varies by frequency. The unit of frequency is Hertz (Hz), which refers the number of cycles per second (number of wave peaks per second of the propagating sound wave). The typical human hearing response runs from 20 Hz to 20,000 Hz. Frequencies below 20 Hz are generally inaudible, although response is variable, and some individuals may be able to hear or perceive them.

Sound is typically analysed in octave bands or 1/3-octave bands. An octave band is defined as a band or range of sound frequencies where the frequency range doubles for succeeding octave (alternately, the highest frequency in the range is twice the value of the lowest frequency). Octave band and 1/3-octave band frequencies of interest frequencies of interest are shown in the table on the following page. Road and rail transportation noise sources tend to be broadband in nature, having roughly equal sound energy in many octave bands. Heavy rail traffic and heavy truck traffic may produce significant noise in lower frequencies < 200 Hz.

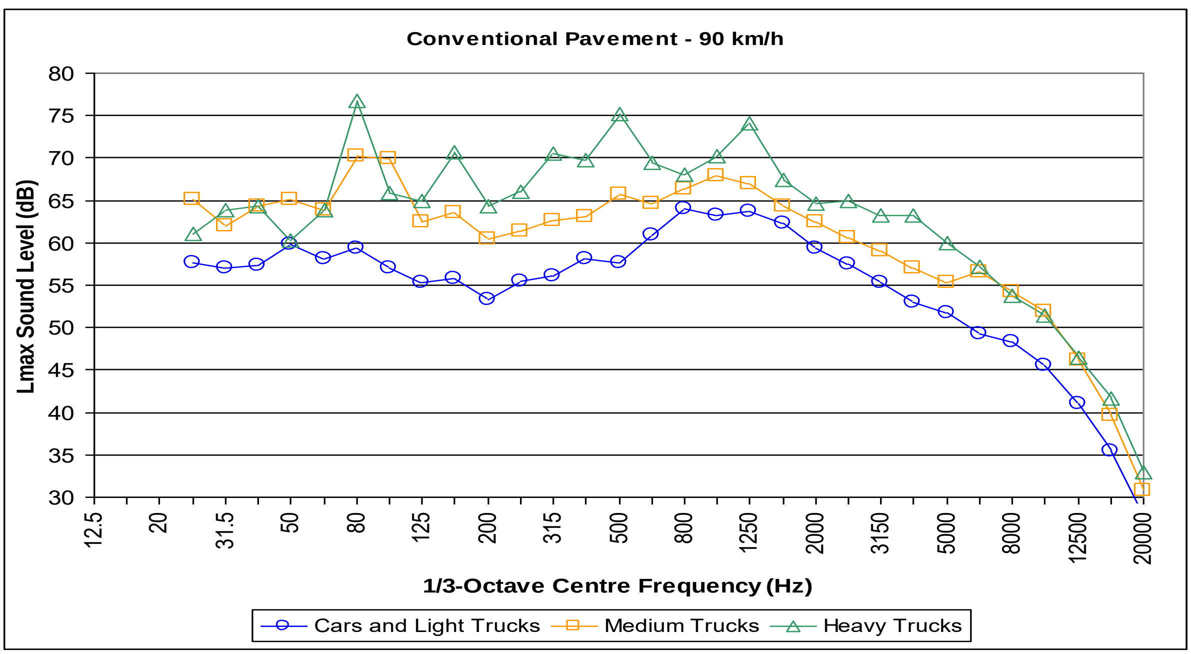
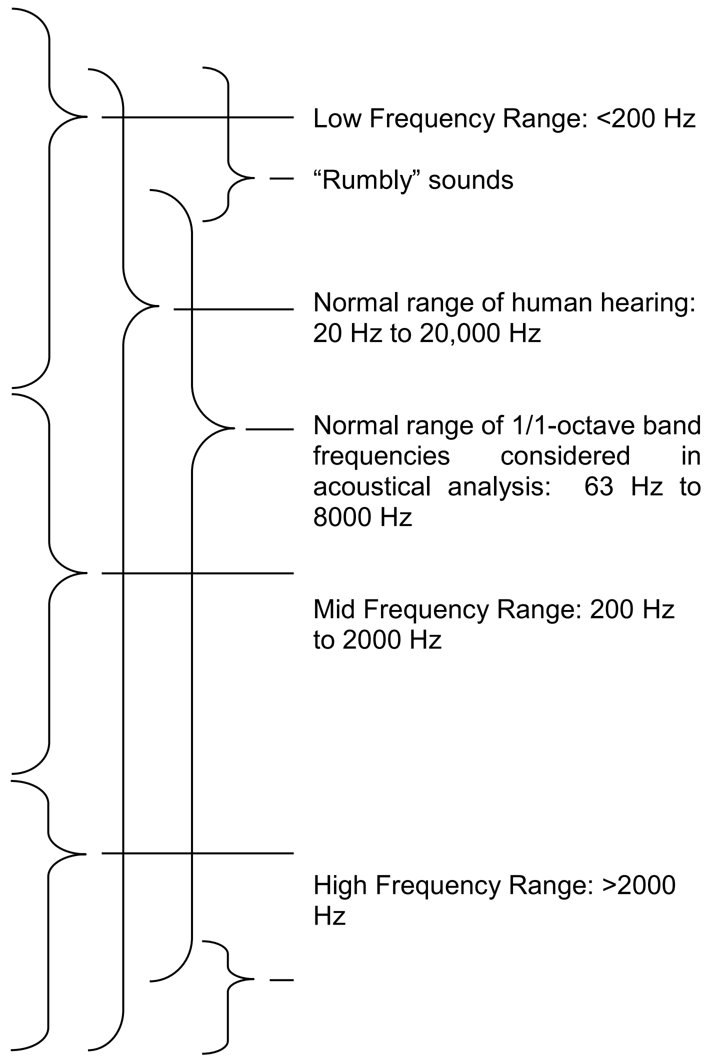


Figure 1: Typical Frequency Spectra of Traffic Noise - Vehicle Pass-bys at 90 km/h

Table 1: Octave Band Frequencies of Interest

Centre-Frequency (Hz)		Band No.	Frequency Range (Hz)
1/3-Octave	1/1-Octave		
12.5			
16	16	N/A	11 to 22
20			
25			
31.5	31.5	0	22 to 45
40			
50			
63	63	1	45 to 89
80			
100			
125	125	2	89 to 177
160			
200			
250	250	3	177 to 345
315			
400			
500	500	4	345 to 707
630			
800			
1,000	1,000	5	707 to 1,414
1,250			
1,600			
2,000	2,000	6	1,414 to 2,828
2,500			
3,150			
4,000	4,000	7	2,828 to 5,657
5,000			
6,300			
8,000	8,000	8	5,657 to 11,314
10,000			
12,500			
16,000	16,000	N/A	11,314 to 22,627
20,000			



Note: Per ISO 266-1975

A-Weighting

When the overall sound pressure level is expressed as a single value (i.e., not expressed in frequency band levels) the variation in human frequency response must be accounted for. People do not hear low frequency noise as well as noise in mid or high frequencies. To account for this, frequency-weighting networks have been developed to better account for human hearing response. The most frequently used networks are the A-Weighting and C-Weighting.

The A-Weighting network was developed to correspond to how humans hear low to medium levels of noise. The A-Weighting is the most frequently used scheme, and the majority of noise guidelines are expressed in A-Weighted decibel values, denoted as “dBA” levels. C-Weighted “dBC” values are sometimes used in assessing low-frequency noise impacts, which are generally not of concern in transportation noise impact assessment. The A-Weighting and C-Weighting values are shown in the following table and figure.

Table 2: A- and C-Weighting Values

1/1-Octave Frequency (Hz)	A-Weighting Value (dB)	C-Weighting Value (dB)
31.5	-39.4	-3.0
63	-26.2	-0.8
125	-16.1	-0.2
250	-8.6	0
500	-3.2	0
1,000	0	0
2,000	1.2	-0.2
4,000	1.0	-0.8
8,000	-1.1	-3.0

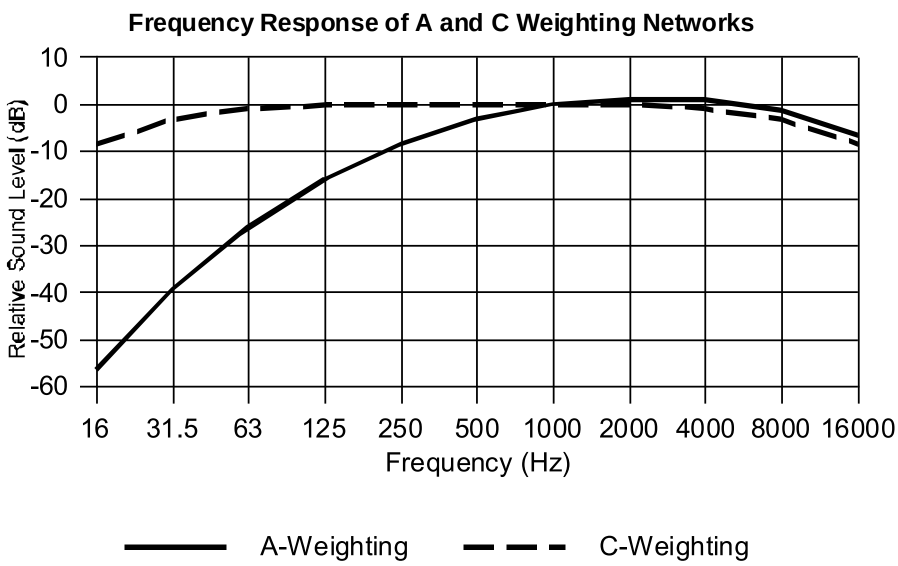


Figure 2: A-Weighting and C-Weighting Networks

Ranges of Sound Levels

People experience a wide range of sound levels in their daily activities. The table below presents a graphical comparison of "typical" noise levels which might be encountered, and the general human perception of the level.

Table 3: Ranges of Sound Levels

Sound Levels		Sources of Noise
Human Perception	**SPL, in dBA**	
Deafening	125	Sonic booms
	120	Threshold of Feeling / Pain
	115	Maximum level, hard rock band concert
	110	Accelerating Motorcycle at a few feet away
Very Loud	105	Loud auto horn at 3 m (10 ft) away
	100	Dance club / maximum human vocal output at 1 m (3 ft) distance
	95	Jack hammer at 15 m (50 ft) distance
	90	Indoors in a noisy factory
Loud	85	Heavy truck pass-by at 15 m (50 ft) distance
	80	School cafeteria / noisy bar; Vacuum Cleaner at 1.5 m (5 ft)
	75	Near edge of major Highway
	70	Inside automobile at 60 km/h
	65	Normal human speech (unraised voice) at 1 m (3 ft) distance
Moderate	60	Typical background noise levels in a large department store
	55	General objective for outdoor sound levels; typical urban sound level
	50	Typical suburban / semi-rural sound level (24h)
	45	Typical noise levels in an office due to HVAC; typical rural levels (24h)
Faint	40	Typical background noise levels in a library
	35	
	30	Broadcast Studio
	25	Average whisper
Very Faint	20	Deep woods on a very calm day
	15	
	10	
	5	Human breathing
	0	Quietest sound that can be heard

Sound levels from 40 to 65 dBA are in the faint to moderate range. The vast majority of the outdoor noise environment, even within the busiest city cores, will lie within this area. Sound levels from 65 to 90 are perceived as loud. This area includes very noisy commercial and industrial spaces. Sound levels greater than 90 dB are very loud to deafening, and may result in hearing damage.

Transportation noise events, which vary with time, can also be considered in terms of their maximum noise level (L_{max}) during a vehicle pass-by, as shown in the following table:

Table 4: Typical Pass-By Noise Levels at 15 m from Noise Source

Event	Range of Noise Levels (dBA) at 15 m
Semi-Trailer Trucks	75 - 85
Aircraft	69 – 85 [1]
Conventional Light Rapid Transit (Streetcars)	72 – 80 [2]
Large Trucks	71 - 78
Street Motorcycle	76
Diesel or Natural Gas Bus	70 - 78
Trolley Bus	69 - 73
Small Motorcycle	67
General Busy Auto Traffic	66 - 70
Individual Automobiles	63 - 69

Notes: Source: BKL Consultants Ltd.

[1] Aircraft flyover not at 15 m distance

[2] Based on data provided for the Calgary, Edmonton and Portland LRT systems.

Noise Descriptors – Leq Values

At this time, the best available research indicates that long-term human responses to noise are best evaluated using energy equivalent sound exposure levels (L_{eq} values), in A-Weighted decibels (L_{eq} values in dBA)[2, 3] including adjustments to account for particularly annoying characteristics of the sounds being analyzed.

Sound levels in the ambient environment vary each instant. In a downtown urban environment, the background noise is formed by an "urban hum", composed of noise from distant road traffic and from commercial sources. As traffic passes near a noise receptor, the instantaneous sound level may increase as a vehicle approaches, and then decrease as it passes and travels farther away. The energy equivalent sound exposure level L_{eq} is the average sound level over the same period of time with same acoustical energy as the actual environment (i.e., it is the average of the sound energy measured over a time period T). As a time-average, all L_{eq} values must have a time period associated with them. This is typically placed in brackets beside the L_{eq} tag. For example, a thirty-minute L_{eq} measurement would be reported as an L_{eq} (30 min) value.

The L_{eq} concept is illustrated in Figure 3, showing noise levels beside a small roadway, over a 100 second time period, with two vehicle pass-bys:

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2 Berglund and Lindvall, Community Noise, 1995.

3 ISO 1996:2003(E), *Acoustics – Description, measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures*.

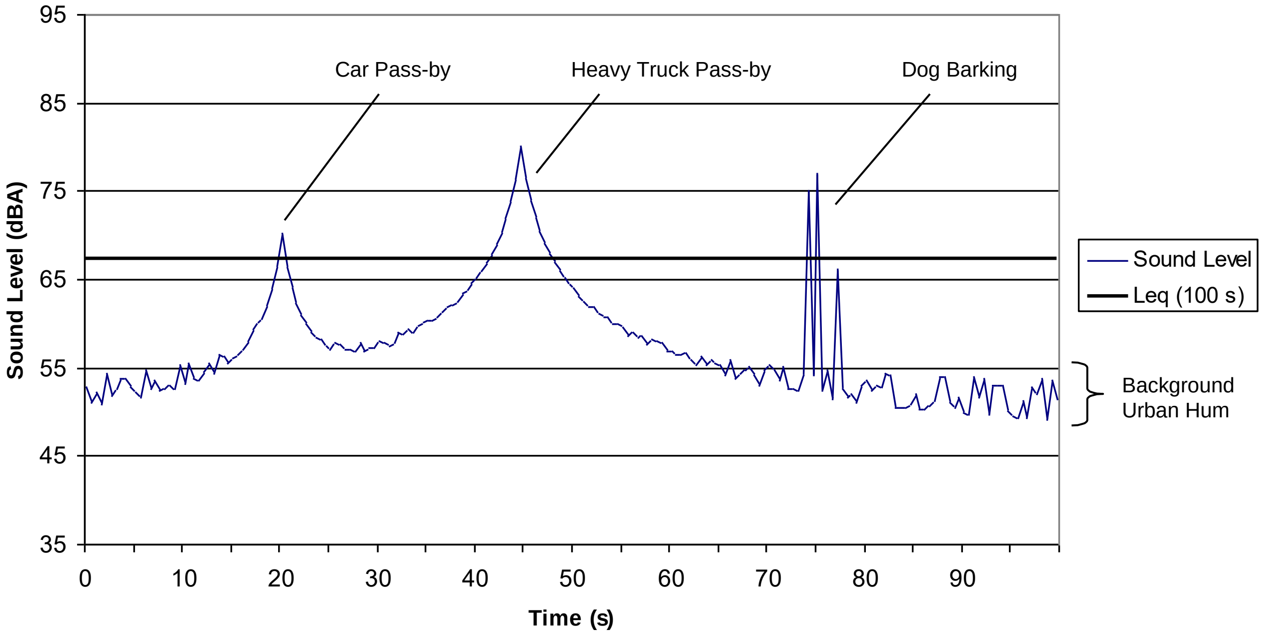

Figure 3: Example of the L_{eq} Concept

In this example, the background "urban hum" is between 47 and 53 dBA. A car passes by at 20 seconds. As it approaches, the noise level increases to a maximum, and then decreases as it speeds away. At 45 seconds, a heavy truck passes by. Near 75 seconds, a dog barks three times. The maximum sound level (L_{max}) over the period is 80 dBA and the minimum is 47 dBA. For almost 50% of the time, the sound level is lower than 55 dBA.

The L_{eq} (100s) for the above example is 67 dBA, which is much higher than the statistical mean sound level of 55 dBA. This illustrates that the L_{eq} value is very sensitive to loud noise events, which contain much more sound energy (as sound is ranked on a logarithmic scale) than the normal background. It is also sensitive to the number of events during the time period, and the duration of those events. If only the truck had passed by during the measurement (no car and no dog barks), the L_{eq} (100s) would be 66 dBA. If only the car and dog barks had occurred, the L_{eq} (100s) would have been 61 dBA. This shows that the truck pass-by is the dominant event in our example, due to its level and duration.

The ability of the L_{eq} metric to account for the three factors of level, duration and frequency of events makes it a robust predictor of human response to noise. It is for this reason that the vast majority of noise standards are based on L_{eq} values.

Typical Durations for Leq Analyses

For transportation noise impact analyses, the following durations are typically used:

L_{eq} (24h) – The sound exposure level over then entire 24-hour day

L_{eq} Day – Either: L_{eq} (15h), from 7am to 10 pm; or
L_{eq} (16h), from 7am to 11 am

L_{eq} Night – Either: L_{eq} (9h), from 10 pm to 7 am; or
L_{eq} (8h), from 11 pm to 7 am

L_{dn} – A special L_{eq} (24h) value with a 10 dB night-time penalty applied to overnight sound levels (10pm to 7am)

L_{eq} (1-h) – The sound exposure over a 1-hour time period

L_{eq} (24h) values are appropriate for examining impacts of transportation noise sources with small changes in sound exposure levels over the 24-hour day. For example, freeway noise levels are generally consistent over the 24-hour day. Therefore, for freeways, there is little difference between L_{eq} (24h) values and the corresponding L_{eq} Day and L_{eq} Night values.

L_{eq} Day values, covering off the AM-peak and PM-peak travel periods, are generally appropriate for examining the impacts of non-freeway highways and municipal arterial roadways. The vast majority of noise associated with these sources is concentrated in the daytime hours, where typically, 85% to 90% of the daily road traffic will occur.[4] Thus, if reasonable sound levels occur during the daytime (and appropriate guideline limits are met), they will also occur (and be met) at night.

To account for increased annoyance with noise overnight in a single value, the U.S. Environmental Protection Agency (U.S. EPA) developed the L_{dn} metric. It is a special form of the L_{eq} (24h) with a +10 dB night-time penalty. L_{dn} values and a related metric, the day-evening-night level (L_{den}) are also used in some European guidelines. L_{dn} values are not used in Canadian Provincial jurisdictions in evaluating transportation noise. Instead, guideline limits for separate L_{eq} Day and L_{eq} Night periods are generally used.

L_{eq} (1-h) values are the average sound levels over a one-hour time period. These tend to fluctuate more over the day, as traffic levels can fluctuate significantly hour to hour. L_{eq} (1-h) values are useful in assessing the impact of transportation sources which also vary hourly, and which may vary in a different manner than the background traffic. These values are often used to assess haul route noise impacts, for example.

4 Based on research conducted by Ontario Ministry of Transportation, and provided in the *MTO Environmental Office Manual Technical Areas – Noise*. Daytime refers to a 16 hour day from 7am to 11 pm.

Some transportation noise sources may have significant traffic levels occurring over-night. For example, freight rail traffic in heavily used corridors can be shifted to over-night periods, with daytime track use being reserved for freight switcher traffic and passenger traffic. In situations such as this, an assessment of both daytime and night-time noise impacts may be appropriate.

Decibel Addition

Decibels are logarithmic numbers, and therefore have special properties of addition. Decibel values must be added logarithmically. If two sources, each emitting the same amount of sound energy, are placed side-by-side, then the total increase in sound level will only be 3 dB. If the difference in sound energy emitted is greater than 10 dB, then effectively the sound level will be the same as for the loudest unit (i.e., the increase in noise will be less than a decibel). This is shown in Table 5.

Table 5: Decibel Addition Chart

dB Difference Of	dB Value to Add to Highest Number
0	3.0
1	2.5
2	2.1
3	1.8
4	1.5
5	1.2
6	1.0
7	0.8
8	0.6
9	0.5
10	0.4

This affects transportation noise from projects, as noise emission is logarithmically related to traffic volume. Doubling the traffic volume (essentially the same as adding a source with the same sound emission) will only result in a 3 dB increase over the original levels. The decibel increase in noise due to the increase in traffic volume, assuming all other factors remain the same, can be estimated by:

dB increase = 10 log (new volume / original volume).

Human Response to Changes in Sound Levels

The human ear does not interpret changes in sound level in a linear manner. The general subjective human perception of changes in sound level is shown in the following table.

Table 6: Subjective Human Perception of Changes in Sound Level [5,6]

Change in Broadband Sound Level (dB)	Human Perception of Change
< 3	Imperceptible change
3	Just-perceptible change
4 to 5	Cleary noticeable change
6 to 9	Substantial change
> 10 and more	Very substantial change (half or twice as loud)
> 20 and more	Very substantial change (much quieter or louder)

Notes: Adapted from Bies and Hansen, p53, and MOE Noise Guidelines for Landfill Sites, 1998. Applies to changes in broadband noise sources only (i.e., increases or decreases in the same noise or same type of noise only). Changes in frequency content or the addition of tonal or temporal changes would affect the perception of the change.

The above table is directly applicable to changes in sound level where the noise sources are of the same general character. For example, existing road traffic noise levels can be directly compared to future road traffic noise levels, using the above relationships. In comparing road traffic noise to road plus rail traffic noise, the different frequency and temporal nature of the noise means that the rail noise may be more noticeable. Adjustments for the nature of the new sound can be applied to better account for temporal and frequency differences.

For transportation noise sources, research conducted by the U.S. Environmental Protection Agency indicates that a 5 dB change in sound levels is required to trigger a change in large-scale community response to noise. This correlates to a clearly noticeable increase in noise levels.

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5 Bies, D.A., and C.H. Hansen 1988. *Engineering Noise Control – Theory and Practice, 2nd Ed.* E & FN Spon, London, p 53.

6 Ontario Ministry of the Environment 1998. Noise Guidelines for Landfill Sites. Queen's Printer for Ontario.

Decay of Noise with Distance

Noise levels decrease with increasing distance from a source of noise. The rate of decay is partially dependent on the nature of the ground between the source: whether it is hard (acoustically reflective) or soft (acoustically absorptive). Transportation noise sources in general act as *line sources* of sound. For line sources, the rate of decay is approximately:

- Hard ground: 3 dB for each doubling of distance from the source
- Soft ground: 5 dB for each doubling of distance from the source

This is shown graphically in Figure 6, based on a reference distance of 15 m from the source:

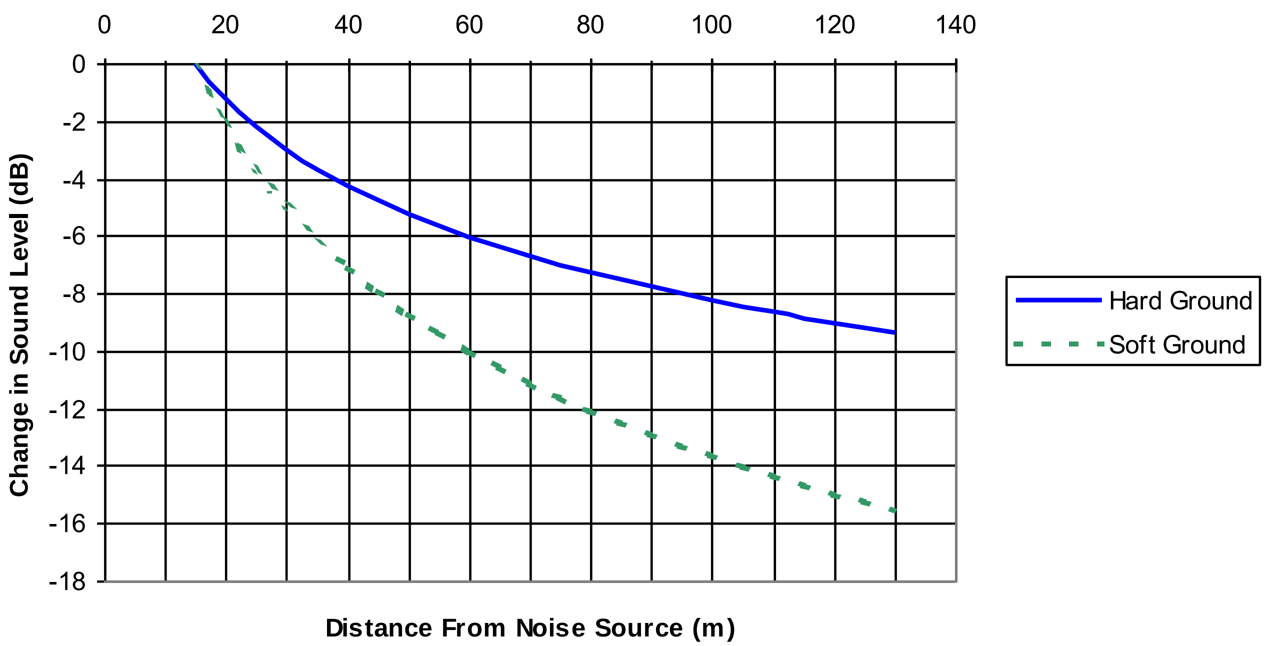

Figure 4: Decay of Noise Versus Distance for Line Sources