Guidance for Evaluating Human Health Effects in Impact Assessment: NOISE

Health Canada Santé Canada

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Disclaimer:

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1 ACRONYMS

ACRONYM	MEANING
%HA	percent highly annoyed
%HSD	percent highly sleep disturbed
Agency	Impact Assessment Agency of Canada (also known as IAAC)
ANSI	American National Standards Institute
dB	decibel
dBA	A-weighted decibels
dBC	C-weighted decibels
dBZ	Z-weighted decibels
ERCB (EUB)	Energy Resources Conservation Board, Alberta (formerly Energy and Utilities Board, Alberta)
GBA Plus	gender-based analysis plus
HIA	health impact assessment
Hz	hertz
IA	impact assessment
IAA	*Impact Assessment Act*
IAAC	Impact Assessment Agency of Canada (also known as "the Agency")
IS	impact statement
ISO	International Organization for Standardization
Ld	daytime sound level
Ldn	day-night sound level
Leq	equivalent continuous sound level

Ln	night-time sound level
LAeq	A-weighted equivalent continuous sound level
LAmax	maximum A-weighted sound level
LFN	low-frequency noise
MNL	mitigation noise level
REDA	*Radiation Emitting Devices Act*
SEL	sound exposure level
TISG	tailored impact assessment guidelines
WHO	World Health Organization
US EPA	United States Environmental Protection Agency

2 PURPOSE OF THIS DOCUMENT

This document provides generic guidance on assessing potential human health risks related to levels and/or types of sound predicted in federal impact assessments (IAs) of proposed major resource and infrastructure projects in Canada. It presents the principles, current practices and basic information Health Canada looks for when it reviews the impact statement (IS) or other documentation submitted by project proponents as part of the IA process.

This document was prepared to support an efficient and transparent project review process. The foundational information described here should be supplemented appropriately with additional information relevant to proposed projects. The guidance was prepared for the Impact Assessment Agency of Canada (the Agency) and stakeholders involved in the IA process to communicate Health Canada's standard areas of engagement and priorities to help ensure that sufficient evidence is available to support sound decisions. As part of its review, Health Canada may suggest that the Agency, review panels or others collect information not specifically described in this document to assess the health effects of proposed projects. As the guidance provided here is generic and designed to support the IA process, the scope of Health Canada's review may also be amended to reflect project-specific circumstances.

Health Canada updates guidance documents periodically and, in the interest of continuous improvement, accepts comments and corrections at the following address: ia-ei@hc-sc.gc.ca.

In the same series, the following guidance documents are available:

- *Guidance for Evaluating Human Health Effects in Impact Assessment: AIR QUALITY*
- *Guidance for Evaluating Human Health Effects in Impact Assessment: COUNTRY FOODS*
- *Guidance for Evaluating Human Health Effects in Impact Assessment: DRINKING AND RECREATIONAL WATER QUALITY*
- *Guidance for Evaluating Human Health Effects in Impact Assessment: HUMAN HEALTH RISK ASSESSMENT*
- *Guidance for Evaluating Human Health Effects in Impact Assessment: RADIOLOGICAL IMPACTS*

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3 INTRODUCTION AND CONTEXT

The key objectives of Health Canada's IA program are to inform and improve understanding of the potential risks to human health associated with proposed projects, to help prevent, reduce, and mitigate negative impacts and foster positive impacts. Health Canada's expert information and knowledge are available to assist the Agency, review panels and others in assessing the potential project-related health effects.

As a federal authority, Health Canada provides specialist or expert information or knowledge in the Department's possession (expertise) to support the assessment of impacts on human health from projects considered individually and cumulatively under the *Impact Assessment Act* (IAA). This complement of expertise may change or evolve over time. The Department provides scientific expertise; it does not play a regulatory role. The use of expertise provided by Health Canada in the IA process will ultimately be determined by the reviewing body(ies).

In comparison to the *Canadian Environmental Assessment Act 2012*, the IAA expands the assessment of health to promote a broader understanding of the biophysical environment and supports assessment of the social and economic effects of projects. Among other things, the IAA includes specific requirements to consider positive and negative effects on the health, social and economic conditions of the public, including Indigenous peoples. In addition, the IAA includes the requirement for potentially affected Indigenous groups to be consulted during the planning phase of the project and incorporate Indigenous traditional knowledge, if provided, alongside other evidence. The IAA also requires consideration of the intersection of sex and gender with other identity factors.

Gender-Based Analysis Plus

Gender-based analysis plus (GBA Plus) identifies and analyzes the differential impacts of designated projects on diverse population groups. The "plus" in GBA Plus acknowledges that GBA goes beyond biological (sex[1]) and socio-cultural (gender[2]) differences. It highlights the pathways on which those differences develop and how they intersect with other determinants to shape health and well-being. It guides how we consider sex and gender when we frame, plan for, and implement the IA of designated projects. Gender-based analysis plus includes other individual and social identity factors such as race, religion, social position, income, age, ability, and education; this is called intersectionality[3]. The basic steps to applying GBA Plus include gathering appropriate data, understanding context, and asking analytical questions to determine whether the project is expected to have disproportionate effects on diverse populations. By working through a GBA Plus analysis, experts can better understand the possible differential effects of a project on distinct groups of people, including on disproportionately affected or impacted populations and populations identified by sex and gender. Considering how a program, policy, plan, or product might impact groups differently provides an opportunity for all those involved to help address potential pitfalls before they become a problem or to identify opportunities that would not have been otherwise considered.

1 Sex refers to physical and physiological features including chromosomes, gene expression, hormone levels and function, and reproductive/sexual anatomy. https://cihr-irsc.gc.ca/e/48642.html

2 Gender refers to the socially constructed roles, behaviors, expressions and identities of girls, women, boys, men, and gender diverse people. https://cihr-irsc.gc.ca/e/48642.html

3 Government of Canada's Approach Gender Based Analysis Plus. https://women-gender-equality.canada.ca/en/gender-based-analysis-plus/government-approach.html

Key GBA Plus considerations in IA of designated projects:

- Does the proposal identify the diverse communities of women, men and children who will be directly and indirectly affected by the proposed project's activities?
- Are the data about potential impacts disaggregated by sex, age, language and other social identities relevant to the local communities?
- Have the views of the affected women, men, Indigenous peoples and other disproportionately impacted groups been included in the proposed project's design?
- What are the implications of the proposed project's health and socio-economic effects on the well-being of women, men, Indigenous peoples and disproportionately affected populations?
- What types of measures are needed to ensure equitable representation during consultation processes and subsequent stages of the IA?
- What measures are needed to enhance the positive effects or mitigate any adverse effects of the designated project on women, men, children and other disproportionately affected groups?

Identifying the range of concerns and interests of, and impacts on, diverse groups based on social characteristics like gender, age, ethnicity, occupation, and length of residency, for example, can help foster the development of more comprehensive mitigation and enhancement strategies.

A health impact assessment (HIA) is a systematic, objective and yet flexible and practical way of assessing both the potential positive and negative impacts of a proposal on health and well-being. In the context of designated projects under the IAA, an HIA aims to characterize the anticipated health effects, both adverse and positive, and the distribution of those effects within the population. The Agency determines the scope of the factors taken into account, including their relevance to the IA, as outlined in the tailored impact assessment guidelines (TISG). The steps of an HIA include screening, scoping, assessment, recommendations, reporting, monitoring and evaluation of the effectiveness of the HIA process, and the impact on decision-making.

Health Canada has been working with key partners and rights holders, including Indigenous organizations, federal partners, provinces/territories, and other key stakeholders, to develop HIA guidance and tools for a more comprehensive assessment of potential health effects of proposed projects. The document provides guidance to scope and address the broader social and economic conditions underlying the health of potentially affected communities and Indigenous peoples. Health Canada has developed an interim HIA Guidance Document to bridge the gap between the IAA coming into force in August 28, 2019 and the planned publication by the Department of the guidance document and complementary materials on HIA. The interim guidance document is available upon request at the following address: ia-ei@hc-sc.gc.ca.

Health Canada provides its expertise in human health risks associated with air quality, drinking and recreational water quality, ionizing radiation, electromagnetic fields, noise, and country foods when it reviews and provides comments on information submitted by proponents in support of proposed projects. Health Canada also provides general information on the subject of health assessments in relation to proposed projects subject to the federal IA process.

This document concerns the assessment of human health risks associated with noise. It contains information on the division of roles and responsibilities for issues related to noise at various levels of government in Canada, health effects associated with noise, indicators of these effects, and steps in Health Canada's preferred approach to assessing noise-related health effects.

APPENDIX A provides a glossary that defines the technical terms used throughout.

APPENDIX B provides a checklist for verifying that the key elements of a noise impact assessment have been completed and where this information appears in the assessment document.

APPENDICES C through *H* contain additional technical and supplementary information related to noise assessment in IAs.

4 ROLES AND RESPONSIBILITIES

In Canada, noise is managed by different levels of government. Federal examples include Transport Canada (aircraft noise), the Canadian Transportation Agency (rail noise), and Employment and Social Development Canada (specifically the Labour Program: occupational noise in workplaces under federal jurisdiction). Health Canada has a regulatory role via the *Radiation Emitting Devices Act* (REDA) (1985). The REDA governs the sale (including re-sale), lease, advertising and importation of radiation emitting devices into Canada, including products emitting ionizing, non-ionizing and acoustical radiation (e.g., infrasound, sound and ultrasound). Outside of these specific federal mandates, noise may be regulated directly through provincial and territorial legislation and guidelines, or through municipal by-laws, which may apply broadly or only to specific project types or sectors. Provincial and/or municipal noise guidelines may include such factors as noise impacts on sleep and high annoyance in addition to occupational noise exposure, speech comprehension, and hearing loss.

In the context of IAs, one of Health Canada's roles concerning noise exposure is to review acoustical assessments for scientific validity and potential risks to human health from project-related changes in environmental noise. This role is fulfilled via leadership in science, research in the area of noise and health impacts, and involvement in committees nationally and internationally that develop noise-related standards (e.g., the Canadian Standards Association, the American National Standards Institute (ANSI), the International Organization for Standardization (ISO), the World Health Organization (WHO), and the International Electrotechnical Commission (IEC)).

Health Canada's scientists conduct, evaluate and remain current on domestic and international scientific research pertaining to the human health impacts of noise. Their expertise regarding the potential human health effects of noise is made available to support the assessment of impacts on human health from projects considered individually and cumulatively under the IAA. This document is an update of the 2017 guidance to reflect Health Canada's role in the IAA; however, the technical content remains consistent with the content of the 2017 document (Health Canada, 2017).

Health Canada does not enforce environmental noise thresholds or standards, but can make available information and knowledge acquired from Canadian and international sources regarding the potential adverse human health effects of noise. When noise levels have the potential to induce adverse human health effects, Health Canada may make available information or knowledge on mitigation measures in addition to those contained in this guidance document. Health Canada encourages proponents to consult with other government authorities to determine which enforceable standards for noise exist for specific provinces/territories and municipalities.

4.1 HEALTH CANADA'S APPROACH TO NOISE ASSESSMENTS IN IMPACT ASSESSMENTS

Noise is a somewhat special type of change to the environment, as it is an energy added to the air in the form of acoustical waves. Below the exposure threshold of biological damage to the ear, noise can also cause potential health impacts, such as sleep disturbance and/or cause long-term high annoyance, potential risk factors for other health impacts. These impacts depend on the interference of the noise with what one is trying to do (e.g., sleep, concentrate or communicate) and the expectation of peace and quiet during such activities (e.g., conducting traditional/recreational activities in a quiet rural area). Human response to noise varies among individuals, types of noise, and according to specific situations.

Different standards/guidelines may be designed for specific health endpoints, and therefore may not cover all possible impacts from noise exposure. For example, a guideline may be established to protect against hearing loss, but this guideline may not be protective against other human health endpoints, such as sleep disturbance. In addition, some guidelines and/or regulations are based on limiting absolute noise levels, whereas others emphasize the relative change in the noise environment and the effect of the change on human receptors.

This document provides general information on Health Canada's preferred methodology to use to determine the potential impacts for various human health endpoints with respect to noise exposure. The prediction of potential impacts is necessary to understand the nature, extent and severity of human health effects that may occur as a result of noise generated during various stages of a proposed project. These calculations also serve to evaluate the acceptability of the project proponent's planned mitigation measures in reducing human health effects and whether a specific mitigation measure is likely to achieve the desired result. Health Canada reviews the methodology and calculations provided in the noise assessment, as well as the subsequent discussion of potential noise-related impacts on health, for accuracy and completeness.

Depending upon the nature of the project, the Agency, review panels or others conducting the IA may want to consider the assessment of noise impacts (including annoyance and sleep disturbance) on off-duty workers residing in or near the project area. As health and safety of workers falls under provincial or territorial jurisdiction, Health Canada does not review this information in the context of IAs. Also, Health Canada does not possess information or knowledge on the impacts of noise on wildlife or ecosystems.

5 IMPACTS ASSOCIATED WITH NOISE

In reviewing an IA, Health Canada emphasizes only those endpoints that have demonstrated a reasonable causal relationship between noise exposure and adverse human health effects. In the context of an IA, the associations that have been reported between noise exposure and hearing loss, sleep disturbance, interference with communication, noise complaints and a high level of annoyance are particularly relevant (WHO, 1999, 2009, 2011). The information and knowledge that Health Canada makes available is based on the following: the modelled changes between the existing and predicted daytime and night-time sound levels (for all project phases including construction, operation and decommissioning activities); predicted noise-level changes at specific receptor locations where people are or may be present (see *Appendix G*); the characteristics of the noise (e.g., impulsive, tonal); and/or the type of community (e.g., urban, suburban or quiet rural area).

5.1 NOISE-INDUCED HEARING LOSS

There is no known long-term risk of permanent hearing loss associated with sound levels below 70 A-weighted decibels (dBA), (ISO 1999:2013) and low risk below 85 dBA. However, as sound levels increase, the duration of daily exposure becomes an important risk factor for hearing loss. The time period before damage occurs shortens as the average sound level increases (WHO, 1999; Health Canada, 2012).

Hearing loss impacts are not typically considered in IAs because project-related sound levels rarely reach these high levels at the locations of off-site receptors. Noise-induced hearing loss would typically only become a consideration when receptors are on a construction site or are present for a substantial amount of time in the noisiest areas of the job site. These situations are typically considered under provincial/territorial occupational health and safety regulations and therefore are not evaluated by Health Canada. When considering impulsive noise, Health Canada suggests following the WHO (1999) recommendation to avoid hearing loss resulting from impulsive noise exposure and that peak sound pressures do not exceed 120 dBA for children and 140 dBA for adults.

5.2 NOISE-INDUCED SLEEP DISTURBANCE

Sleep disturbance encompasses the following: difficulty falling asleep; awakenings; curtailed sleep duration; alterations of sleep stages or depth; and increased body movements during sleep. The short-term effects of sleep disturbance have been shown to include, but are not limited to: increased fatigue; irritability; and decreased concentration and performance. These effects are generally experienced in the days subsequent to significant disturbances in sleep. Ongoing disturbed sleep has been reported to be linked to a wide variety of health effects, including, but not limited to cardiovascular effects, mental health issues and accidents (WHO, 2009; Zaharna and Guilleminault, 2010).

Project proponents may consider the WHO (2018) guidelines when evaluating project-related noise impacts in IA. The most recent guidelines are outdoor source-based sound level limits associated with an absolute prevalence of highly sleep disturbed (HSD) and high noise annoyance. For reasons discussed in Michaud *et al.* (2023), Health Canada continues to refer to the guidelines and recommendations of the WHO (1999, 2009) regarding sleep disturbance in IA. In particular, WHO guideline levels should not be exceeded for quiet rural areas and susceptible populations, such as daycare centres, schools, places of worship, hospitals and/or seniors' residences. For estimating the likelihood of sleep disturbance on any given night, the WHO (1999) reports a threshold for sleep disturbance as being an indoor sound level of no more than 30 dBA LAeq (A-weighted equivalent continuous sound level), for continuous noise during the sleep period. For individual noise events, the WHO (1999) has stated that: "*For a good night's sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dBA LAmax* [maximum A-weighted sound level] *more than 10–15 times per night....*". Health Canada recognizes that in many cases, people will want to keep windows at least partially open, depending on the season. Existing literature sources have indicated that an outdoor-to-indoor transmission loss with windows at least partially open is approximately 15 dBA (United States Environmental Protection Agency [US EPA], 1974; WHO, 1999) and fully closed windows are assumed to reduce outdoor sound levels by approximately 27 dBA (US EPA, 1974).

The WHO (2009) published night-time noise guidelines that are intended to protect the public, including the most vulnerable groups (e.g., children, the chronically ill, the elderly), from adverse health effects associated with sleep disturbance due to night-time noise. The recommended annual average is 40 dBA Ln (night-time sound level) outdoors at the most exposed façade. As this is an annual average, there may be times when the sound level is above or below 40 dBA; however, there should be no long-term impact on health if the annual average does not exceed 40 dBA.

Consistent with the view expressed above, when sensitive receptors may be present, such as in daycare centres, schools, places of worship, hospitals and/or seniors' residences, it is a good practice to consult with these facilities to determine whether certain sensitivities to sleep disturbance exist during the day. Should any such sensitivities be noted, the threshold levels for sleep disturbance specified in the WHO's Guidelines (1999, 2009, 2018) may be used to assess the severity of potential impacts on these receptors. Where there is interest in estimating the prevalence of sleep disturbance (expressed as %HSD), Miedema and Vos (2007) have published dose-response relationships for estimating %HSD by road, rail and aircraft noise.

5.3 INTERFERENCE WITH SPEECH COMPREHENSION

To maintain good speech comprehension, the recommended sound levels vary, depending on whether the noise from project activities is measured (or estimated) indoors or outdoors. For good speech comprehension, speech levels should exceed that of background noise by 15 dB. Normal indoor speaking levels are typically 55 to 58 dBA (Levitt and Webster, 1991), which is in line with the US EPA (1974) recommendation that indoor background noise levels should not exceed 40 dBA to achieve 100% sentence intelligibility. According to the WHO (1999), speech in relaxed conversation is 100% intelligible in background noise levels of about 35 dBA, and can be understood fairly well in background levels of 45 dBA. Therefore, Health Canada holds the view that background noise levels (i.e., noise due to project activities as measured indoors) be maintained below 40 dBA in order to sustain adequate speech comprehension.

People generally tend to speak in a louder voice when outdoors, where the separation between speakers is typically larger than indoors. In outdoor environments where distances of up to two metres exist between speakers, US EPA (1974) suggests that 95% sentence intelligibility is acceptable, and recommends a maximum background noise level of 55 dBA outdoors (i.e., 60 dBA with a 5 dBA margin of safety). To sustain good outdoor speech comprehension, recommended background outdoor noise levels at the most exposed façade for continuous noise should be below 55 dBA.

When a school is identified as a potentially impacted receptor, it is suggested that the IA address the special sensitivity of this type of receptor to daytime noise. The WHO (1999) recommends an ideal background noise level of 35 dBA in the classroom. This level is the threshold below which no impacts are expected and is based mainly on speech interference, but also on the impacts of interfering with message communication and the extraction of information (e.g., speech comprehension and reading).

5.4 INDICATORS OF POTENTIAL HUMAN HEALTH EFFECTS

Health Canada holds the view that certain community reactions to project-related noise represent potential indicators of adverse health; that is, if the noise is experienced over a long period of time, it could potentially increase one's risk of developing health effects. In the context of noise exposure, two of the most common community reactions are complaints and annoyance.

5.4.1 Noise Complaints

Many municipal policies concerning noise are based on the resolution of complaints. Reliance on noise complaints may only provide a partial indication of a noise problem (Michaud *et al.*, 2008) and when possible, the estimated magnitude of complaints should be supplemented with other measures, such as the calculated change in the percentage of highly annoyed (%HA) in an average community and/or estimated impacts on sleep (see *Appendix F* for details). In general, Health Canada recommends the following:

- The establishment of a complaint resolution process for all project phases and that information related to the complaint investigation process be provided to potentially impacted residents and communities;
- A commitment to address Project impacts on a case-by-case basis through community consultation, including possible additional noise monitoring; and
- A commitment to implement noise mitigation measures at specific receptor locations, if all other forms of mitigation have proven ineffective.

5.4.2 Long-term High Annoyance

The prevalence of community high noise annoyance (corresponds to %HA) can be thought of as an aggregate indicator of assorted noise effects, present to varying degrees, which are creating a negative effect on the community, and which may not be measurable when considered as separate negative effects.

High annoyance has been widely used as one way to estimate a community response to noise levels. High annoyance is an endpoint that is not directly measured but has been synthesized from self-reported annoyance in numerous large, community-based surveys. Although individual reaction varies greatly, the reported change in %HA among an average community in reaction to certain sound levels provides measurable and comparable exposure-response relationships (Michaud *et al.*, 2008). Health Canada is of the opinion that the change in %HA is an appropriate indicator of noise-induced human health effects from exposure to long-term construction noise (i.e., greater than one year) (see Section 6.3.1) and to project operational noise (see Section 6.3.2) exposure.

There have been more than 50 years of social and socio-acoustic research that either directly or indirectly studied the impact of noise on community annoyance. These studies have consistently shown that an increase in noise level is associated with an increase in the percentage of the community indicating that they are highly annoyed. The relationship between noise levels and high annoyance is stronger than any other self-reported measure, including complaints. Canadian research on road-traffic noise also shows that respondents highly annoyed by traffic noise are significantly more likely to perceive their annoyance as having a negative impact on their health (Michaud *et al.*, 2008).

To assess the impacts of noise from projects using this indicator, the project-related change in the sound environment and the related increase in %HA are evaluated. Using the dose-response relationship between noise levels and annoyance, as per ISO 1996–1:2003, one can calculate the percentage of a typical community that would report being "highly annoyed", expressed as %HA. In general, this dose-response relationship may be a useful tool in characterizing and quantifying average community response to noise levels and changes in noise levels.

Health Canada prefers that the increase in %HA per representative receptor (i.e., a group of residences in similar geographic proximity to the noise source) be evaluated and not the average increase in %HA for all receptors—which could underestimate the project-related impact on community annoyance.

Noise mitigation measures should be considered when a change in the calculated %HA at any given receptor location exceeds 6.5%. The ISO method does not characterize the nature of the increase in terms of severity of impact. However, the U.S. Federal Transit Administration describes a long-term increase of more than 6.5% HA as representing a severe project-related noise impact (Hanson *et al.*, 2006). This increase is based in part on the historical acceptability in the U.S. of no more than a 5 dBA increase in Ldn (day/night sound level) in an urban residential environment (not immediately adjacent to heavily travelled roads and industrial areas). Further justification for using an increase of 6.5% HA as a criterion for a severe noise-related impact can be found in Michaud *et al.* (2008), and Hanson *et al.* (2006). ISO 1996–1:2003 notes that there is a greater expectation for, and value placed on, "peace and quiet" in quiet rural areas, which may be equivalent to up to 10 dB in noise. Unless specified otherwise in an IA, this expectation is assumed by Health Canada to be equivalent to an adjustment of +10 dB (ISO 1996–1:2003). *Appendix F* presents the methodology and equations for calculating the change in %HA.

Note that the change in %HA is only one potential indicator of noise-related human health effects and that all possible human health endpoints should be considered in an assessment. In situations where baseline noise levels exceed an Ldn of 77 dBA, and project noise levels alone exceed an Ldn of 75 dBA, it may not be possible to meet the WHO guidelines for sleep disturbance (see Section 5.2). It may also not be possible to reduce these environmental noise levels to meet the levels suggested in Section 5.3 regarding adequate speech comprehension indoors for residents or students in classrooms. Therefore, Health Canada holds the view that mitigation of project noise be applied if it exceeds an Ldn of 75 dBA, even if the change in %HA does not exceed 6.5%. For example, if project noise alone exceeds an Ldn of 75 dBA, it may be that the levels noted in Sections 5.2 and 5.3 are not achievable in typical residences, even in situations where the highest level of outdoor-to-indoor transmission loss is achieved. In situations like this, project noise should be cautiously mitigated to a level below an Ldn of 75 dBA, which includes a consideration of both outdoor and indoor noise levels and uncertainty in predictions. Potential mitigation measures are presented in *Appendix H*.

6 AN APPROACH FOR ASSESSING THE HEALTH IMPACTS OF NOISE

The approach preferred by Health Canada for noise assessment involves obtaining a characterization of the acoustical exposure that may impact potential noise receptors, including sound level and duration, and noise characteristics, such as whether the noise is tonal, impulsive, highly impulsive, etc. (see *Appendix C*).

To obtain the highest quality data in acoustical studies, acoustical assessments should be completed by properly trained consultants, using equipment and methods that are recognized as the industry standard for acoustical measurements. Occasionally, limitations may exist in the technology and expertise available for some projects. Whenever uncertainty exists in the selection of appropriate monitoring equipment or in the application of standard techniques for noise characterization in IAs, Health Canada should be consulted for assistance or additional guidance.

The main steps in assessing the potential health impacts of changes in noise associated with a project are the following:

- Identify people (receptors) who may be impacted by the project-related noise, including current and reasonably foreseeable receptors (see *Appendix G* for examples);
- Determine the existing (baseline) noise levels at these receptor locations, by measurement or estimation;
- Predict project-related changes in noise levels for each phase of the project (construction, operation and decommissioning) and describe the sound characteristics;
- Compare predicted noise levels to relevant guidelines and/or standards;
- Identify and discuss the potential human health impacts associated with predicted changes in noise levels;
- Consider mitigation measures, their implementation, and any residual effects, after the measures are implemented;
- Consider community consultation and prepare a complaints-resolution plan; and
- Consider the need for monitoring of noise levels.

6.1 IDENTIFICATION OF HUMAN RECEPTORS IN PROJECT AREAS

It is important to identify and describe all existing and reasonably foreseeable human receptors in the area that may be impacted by project-related noise—including a description of how the receptors were identified (e.g., recent land use maps, verification in person).

Noise assessments should also identify and describe any particular receptors that may have a heightened sensitivity to noise exposure (e.g., Indigenous peoples, daycare centres, schools, places of worship, hospitals, seniors' residences).

When identifying receptor sites at which noise impacts will be assessed, it is a good practice to consider and note the following:

- How the locations evaluated are representative of potentially impacted receptors;
- Any receptors who have seasonal/temporary residences or seasonal/recreational land-use; and
- Any receptors who live outside Canada that may be impacted by a project, if applicable.

If any receptors impacted by project noise are not assessed in the IA, there should be a rationale presented for their exclusion. If no human receptors are (or will be) present in the local or regional study area during the construction, operation, and decommissioning project phases, no further assessment with respect to noise and human health is necessary.

It is important to identify and describe any receptors in rural areas that may have a greater expectation of “peace and quiet” (i.e., quiet rural areas). Health Canada considers a “quiet rural area” to be a rural area with sound levels that do not exceed 45 dBA during the day and 35 dBA during the night (as per the Energy Resources Conservation Board (ERCB) Directive 038, 2007). For areas with the most stringent permissible noise levels, provincial regulatory criteria may also be used to define “quiet rural areas,” provided these areas are adequately described.

Due to the expected heightened sensitivity to noise, baseline levels in quiet rural areas should be adjusted by adding 10 dB (ISO 1996–1:2003; ANSI, 2005). This 10 dB adjustment also applies to the predicted project noise levels for all project phases (i.e., construction, operation, decommissioning) in determining %HA. The effect of this +10 dB adjustment in quiet rural areas is to produce a greater change in %HA than would occur with unadjusted noise levels. The exponential relationship between %HA and noise levels, as discussed in Section 5.4.2, produces increasingly larger changes in %HA for equal increases in project noise, compared to the baseline level.

An example follows:

If the initial baseline noise level is 45 dBA and the project-related noise level is 55 dBA, the unadjusted change in %HA would be 3.01 (using equations in Appendix F). When the +10 dB adjustment to both baseline and project-related noise is applied in a quiet rural area, the baseline rating level used to calculate the %HA becomes 55 dBA and the project-related noise rating level becomes 65 dBA in the calculation of %HA. At these rating levels, the resulting change in %HA is 9.79. Therefore, a 10-dBA project-related noise increase from a baseline of 45 dBA in a quiet rural area will result in exceeding the suggested mitigation level of 6.5%, while a 10-dBA increase in project-related noise from a baseline of 45 dBA in a more urbanized area would not exceed this level.

6.2 ASSESSMENT OF BASELINE NOISE

Baseline noise levels that are determined by measurement or estimation can be applied to noise impact assessments for all project phases (construction, operation and decommissioning). Measured or valid estimated baseline noise levels for both daytime (Ld) and night-time (Ln) at all representative receptor locations should be assessed and presented in the IA. It is a good practice to clearly indicate whether sound levels are measured or estimated, and to identify the exact location of any measured or modelled baseline levels (e.g., outdoors at the building facade, or on the lower level, upper level, property line).

6.2.1 Measuring Baseline Noise

When baseline measurement is conducted, measurements are to be completed in accordance with ISO 1996–2:2007 at each representative receptor (existing and reasonably foreseeable), and the reports include the dates and hours used to characterize these measurements. Non-anthropogenic sounds (e.g., ocean, wind and animal noises) should not be included in determining a baseline sound level. Wind and rain can also create false signals in the microphone used to measure sound levels. As a result, an appropriate windscreen must always be used and sound is not to be measured in the presence of precipitation or when wind speeds exceed 14 km/hr (3.9m/s) unless these effects can be shown to be negligible (ISO 1996–2:2007). The specific windscreen required will be dependent on atmospheric conditions including wind speed and air turbulence (Van den Berg, 2006). For wind speeds below 14 km/hr, outdoor measurements always require a minimum 70 mm diameter windscreen. For other conditions, including evaluating low frequency sounds (e.g., C-weighted decibels or dBC), larger windscreens may be required. Simultaneous measurements with different sized windscreens (e.g., at least a factor of two difference in size) can be used to show whether or not there is any effect of wind noise on the measurements.

To minimize uncertainty of the validity of measured baseline-sound-level data, the IA should include the following information:

- The number of hours or days used for measurement, and a rationale for why the reported sound levels can be considered representative;
- An estimate of seasonal differences and any differences between the weekend and weekday baseline noise levels;
- Where applicable, any differences due to weather conditions;
- All noise sources that contribute to the baseline, by type (e.g., vehicle traffic, aircraft, trains, other industrial sounds); and
- A characterization of each noise type described in the assessment using descriptors such as continuous, intermittent, regular impulsive, highly impulsive, high-energy impulsive, and continuous tonal and intermittent tonal.

6.2.2 Estimating Baseline Noise

Although the standard approach for baseline sound determinations is direct measurement, there may be situations where baseline measurement data are not available or not collected prior to project construction. In such cases, alternative approaches to estimating baseline levels exist. One conservative (i.e., most protective) approach is to consider a reasonable worst-case scenario and assume Ldn baselines of 35 dBA for rural areas and 45 dBA for urban/suburban areas (as per ERCB, 2007). However, defaulting to these lower baseline sound levels may result in greater values obtained for change in %HA when calculating project-related noise effects. Note that the estimate of an Ldn of 45 dBA for urban/suburban areas does not consider the inherent variability in baseline noise estimates based on population density, proximity to busy roads or adjacent industrial activity.

The use of alternative approaches to estimating baseline noise may yield higher baseline estimates than the reasonable worst-case scenario described above. To adequately review the reliability of such estimates, Health Canada prefers that sufficient supporting rationale is provided in the IA, particularly where the accuracy of the selected estimation approach decreases (see below).

Other approaches for estimating baseline noise (in order of decreasing accuracy) may include the following:

- Predictions based on computer models whose inputs, algorithms and outputs are based on accepted standards;
- Manual calculation procedures based on well-accepted models or standards;
- The use of known baseline levels from areas with very similar acoustical environments (e.g., very similar types of baseline noise sources, distances from sources to receptors, meteorological conditions, shielding); and/or
- Approximate values from Table 6.1 (see below).

Table 6.1 describes the estimation of baseline noise levels, based on a qualitative description of community characteristics and an average census-based population density (ERCB Directive 038, 2007). If this method (based on US EPA [1974] and ERCB [2007]) is used in a noise assessment, it is important to provide a rationale to support the validity of its use.

Table 6.1: Estimation of Baseline Noise Levels Using Qualitative Descriptions and Population Densities of Average Types of Communities

Community Type (Qualitative Description)	Average Census Tract Population Density, Number of People Per Square km	Estimated Baseline Sound Level[a], Ldn (dBA)
Quiet rural dwelling units more than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers	28	≤ 45[b]
Quiet suburban residential remote from large cities, industrial activity and trucking	249	48–52
Normal suburban residential not located near industrial activity	791	53–57
Urban residential not immediately adjacent to heavily travelled roads and industrial areas	2493	58–62
Noisy urban residential near relatively busy roads or industrial areas	7913	63–67
Very noisy urban residential	24,925	68–72

[a] Note that a range of values is provided and that selection of the appropriate estimated value would typically be based on the precautionary principle in the absence of adequate justification for a higher baseline. All day-night sound level (Ldn) values, except those of the quiet rural area community type, are based on US EPA I(1974).

[b] The quiet rural area (Ln = 35 dBA) estimated baseline noise level and population density were obtained from ERCB Directive 038 (revised Feb 16, 2007). The difference between Ld and Ln was obtained from ERCB and US EPA, and was approximated as 10 dBA. As such, quiet rural areas are considered to be less than or equal to 45 dBA Ldn.

6.3 ASSESSMENT OF PROJECT-RELATED NOISE

It is a good practice to document the criteria used to review the human health impacts of project-related noise and to characterize the potential for change in the sound environment due to any project activity, including construction, operation and decommissioning. In the noise assessment, it is important to compare predicted noise levels during construction, operation and decommissioning to the baseline noise levels at each representative receptor, as this will clearly demonstrate the predicted changes in noise levels experienced by each receptor. Health Canada suggests that the type of measurements used and the uncertainty associated with any sound-level monitoring, modelling or estimates be provided for all reported data.

It is important to consider that human health effects related to noise may be evaluated by a variety of endpoints and indicators, as discussed in Section 5. Health Canada holds the view that the evaluation of each potential noise-induced human health effect by one method alone is not necessarily representative of all possible human health effects related to noise exposure. For example, when using %HA as an indicator in a noise impact assessment, the change in %HA of receptors exposed to long-term noise may not exceed 6.5%, but these receptors may experience sleep disturbances due to an exceedance of the WHO indoor sleep-disturbance threshold limits discussed in Section 5.2. When changes in the sound environment have been characterized, Health Canada suggests that a discussion of the severity of these changes and how they impact human health be included in the noise assessment. Such an evaluation would typically describe all appropriate endpoints or indicators used to address potential impacts on human health, as described in this guidance. Alternative approaches to this evaluation may be acceptable, provided they are supported by adequate scientific justification.

In some cases, a less extensive assessment may be warranted. If noise levels at all receptors are not expected to approach the US EPA's mitigation noise levels (MNLs) (see Section 6.4.2) or to result in a change in %HA exceeding 6.5%, as discussed in Section 5.4.2, Health Canada suggests that a scientifically sound rationale be provided in the IA and/or supporting documentation to confirm that noise levels will be below the level where human health effects may occur (see Section 5) and that this rationale be provided in place of a complete noise impact assessment.

The results and conclusions of the noise assessment should be clearly documented in the IA and supporting documentation (as applicable). Health Canada suggests that the conclusion include a discussion of whether mitigation measures and/or a follow-up monitoring program is appropriate and include the rationale for why it is or is not appropriate (as applicable).

The following sections discuss the assessment of project-related construction noise of short- and long-term durations, as well as project-related operational noise.

6.3.1 Assessing Construction Noise

Noise from construction activities has the potential to negatively impact nearby receptors and can be the loudest source of project-related noise. Predicted construction noise levels for both daytime (Ld) and night-time (Ln) at all representative receptor locations should be reported in the IA. To permit a proper comparison of noise levels, the units, averaging times and other measurement parameters (including the uncertainty associated with any of the measurements) should be the same as those used in establishing the baseline.

The method for determining effects related to construction noise depends on the duration of the construction activities as follows:

i. Short-Term Construction Noise Exposure (< 1 year)

Health Canada suggests using the US EPA (1974) methodology that provides MNLs and associated adjustments for community types, to determine if adverse effects are likely and if mitigation is appropriate. This methodology is discussed in Section 6.4.2. Consideration should also be given to potential impacts on sleep, where adverse impacts are reported to begin when sound levels inside bedrooms exceed 30 dBA for continuous noise sources and 45 dBA LAmax for discrete noise events (WHO, 1999). With an estimated 15 dBA outdoor-to-indoor transmission loss, the equivalent outdoor levels should be 45 dBA and 60 dBA, respectively.

ii. Long-Term Construction Noise Exposure (≥ 1 year)

Health Canada suggests that construction noise lasting longer than 1 year be assessed as operational noise. This approach allows for an evaluation of the change in %HA at each receptor location, in accordance with ISO 1996–1:2003. *Appendix F* describes the methodology and equations related to calculating the change in %HA for projects. The appropriate adjustments (see *Appendix E*) should be applied to the A-weighted calculated or measured noise levels. This method of assessing construction noise is essentially identical to that of assessing operational noise, as discussed in Section 6.3.2 below. Also, potential impacts on sleep should be considered when construction activities may occur at night-time (as noted above in short-term construction).

There may be insufficient information concerning construction activities to permit an assessment of their potential impacts at the IA stage. Conservative assumptions based on similar projects and/or planned activities are often used in estimating noise levels and calculating impacts due to construction. An example of this estimation technique is to assume that all equipment is operating simultaneously, even though actual noise sources are not expected to occur simultaneously for any particular duration of time. In these cases, Health Canada suggests providing as much information as possible on construction activities, schedules, equipment use and any assumptions used, in addition to an explanation of why a more detailed assessment is not necessary.

It is a good practice to include a description of construction noise as it relates to exposure duration, rather than construction activity duration. The difference in these perspectives becomes apparent when considering the impacts of construction noise related to road projects. As a road project progresses, noise exposure continually varies from receptor to receptor as the geographic location of the construction equipment changes.

6.3.2 Assessing Operational Noise

Predicted operational noise levels for both daytime (Ld) and night-time (Ln) at all representative receptor locations should be reported in the IA. To permit a proper comparison of noise levels, the units, averaging times and other measurement parameters (including the uncertainty associated with any of the measurements) should be the same as those used in establishing the baseline.

As discussed previously, the determination of %HA is a widely accepted indicator of the human health effects of long-term noise exposure. Similar to comments in Section 6.3.1 (ii) (above), the assessment of project operational noise may include an evaluation of the change in %HA at each receptor site, in accordance with ISO 1996–1:2003. *Appendix F* describes the methodology and equations related to calculating the change in %HA for projects. The appropriate adjustments (see *Appendix E*) may be applied to the A-weighted, calculated or measured, noise levels. If noise from project operations may occur at night-time, the assessment of operational noise should also consider potential impacts on sleep.

Modelling sound levels (using appropriate software) is one method that is commonly used to estimate present or future operational sound levels. In the assessment, clearly identify the model(s) used and justify its/their suitability. Specific models may be selected on a site-by-site and/or project-by-project basis. Any assumptions used should be conservative (i.e., reasonable worst-case scenario) and be adequately described in the assessment.

In assessing impacts on human health, the baseline and project noise should be added together, as their sum represents what noise effects the receptors will actually experience. If project-related noise levels are provided without being added to the baseline sound levels, this must be clearly indicated. Other changes in the sound environment may also be characterized. If project-related operational noise includes audible tonal or impulsive noise (including regular impulsive, highly impulsive and high-energy impulsive types of noise [ISO 1996–1:2003] [e.g., blasting]), appropriate adjustments as presented in *Appendix E* should be made. Refer to ISO 1996–2:2007 for additional guidance on describing or measuring tonal and impulsive noise. These adjustments apply only when the noise under consideration is likely to be audible at receptor sites (i.e., audible based on human perception based on local surveys and/or ISO 1996–2 2007). Audible tones should be evaluated outdoors given the potential for unpredictable resonances indoors which may affect the audibility of tones indoors. In situations where more than one source characteristic adjustment is applicable (e.g., impulsive or tonal), only the higher of the adjustments should be used. However, all time-of-day adjustments (i.e., day-night adjustment of 10 dBA) and the quiet rural area adjustment (i.e., 10 dBA) are to be added to the highest of the applicable source adjustments when calculating change in %HA (as per ISO 1996–1:2003). Note that sound modelling can be more accurate than actual sound measurements given that any measurement taken over the short-term is conducted under certain atmospheric conditions which may not be representative of noise levels over longer durations (or worst-case conditions for sound propagation). As such, best-case and worst-case noise levels may not be captured with short-term monitoring. Monitoring and subsequent modelling is recommended to validate the monitoring results under the conditions when the monitoring was undertaken.

6.4 MITIGATION

Noise management and noise monitoring plans, including complaint resolution plans, are often incorporated as part of a management plan which considers impacts related to noise. When health effects from project-related noise are possible, Health Canada prefers that a management plan detailing the actions that will be taken to minimize human health impacts due to project noise (mitigation measures) be developed and included in the IA and/or supporting documentation. Special consideration should be given to mitigation measures for construction noise that occurs at night, in order to minimize impacts on sleep (e.g., avoiding tonal or impulsive noise sources at night). See *Appendix H* for specific construction-related noise mitigation measures, which may also be applicable to certain operational activities.

Due to the inherent uncertainty in both predicted and/or measured project noise levels, additional information should be provided to demonstrate that exceedances of the MNL or a 6.5% change in %HA are unlikely. Proposals for specific mitigation measures to limit noise at receptors where this uncertainty exists should be provided in the IA.

Health Canada prefers that any noise mitigation measures proposed for the project be described in sufficient detail to permit Health Canada to adequately review the measures' impacts on achieving noise reduction. When describing possible mitigation or other noise management measures, identify the conditions or circumstances under which various mitigation measures will be applied or implemented.

As it is more effective to use source controls, as a general rule, Health Canada recommends that mitigation measures be applied to the source rather than the receptor site, where this is technically and/or economically feasible. It should be noted that some estimates discussed in Section 5.2 (e.g., noise attenuation by closed windows or enclosed balconies) may not achieve the desired level of noise reduction, due to variability in construction techniques. While fully-closed windows are assumed to typically reduce outdoor sound levels by 27 dBA (US EPA, 1974), the type of enclosures that surround the windows or the presence of ventilation ducts may result in an outdoor-to-indoor noise transmission loss that is lower than 27 dBA.

6.4.1 Community Consultation

Developing a community consultation plan can be helpful to mitigate the impact of project-related noise on communities. The consultation process may assist in establishing feasible mitigation measures by targeting receptors that have the greatest potential for human health-related effects resulting from noise disturbance. Previous experience in assessing community reaction to noise impacts following community consultation has demonstrated that in these cases, a community is more likely to be understanding and accepting of noise, and more likely to make appropriate adjustments to limit noise exposure. This has been noted particularly when the information provided during the consultation process is accurate and does not attempt to misrepresent the likely noise level, and when commitments made by the proponent to limit noise during specific hours are respected.

The IA should specify whether community consultation with respect to noise has occurred, and whether any noise-related concerns have been expressed by potentially impacted receptors.

The comments or recommendations received during the consultation process may provide an indication of which project elements are likely to trigger the greatest level of opposition, particularly where noise issues are identified. Informing the public about project plans early in the IA process is encouraged, as this may provide additional options for mitigation measures, or at the very least, provide the opportunity to discuss the mitigation measures under consideration. It is a good practice to undertake community consultation prior to the creation of work schedules (e.g., continuous versus specific construction times) and to discuss the preferred means of informing the public of the time and duration of noisy activities. When construction delays or other problems result in extended construction schedules, Health Canada suggests that a plan for community consultation be implemented and that this consultation process is described in the IA, where applicable. When a project proponent deems it to be manageable, it may be preferable to consult with residents individually.

When the community receives information about expected changes in sound levels through a consultation process and feels that concerns with respect to noise may be addressed and resolved, the incidence of noise-related complaints is often reduced. Health Canada suggests that this approach be considered in managing both minor and major public concerns with respect to project-related noise. For more information, refer to ERCB Directive 38 (2007). For information specific to rail projects, refer to the Canadian Transportation Agency's *Guidelines for the Resolution of Complaints Over Railway Noise and Vibration* (2008).

6.4.2 Mitigating Short-Term Construction Noise Exposure (<1 year)

Health Canada often suggests mitigation measures, when the predicted construction noise level (construction lasting less than one year) exceeds the suggested MNL. To avoid widespread complaints regarding construction noise at any potentially affected receptor locations where the exposure duration is less than one year, the basic suggested MNL is 47 dBA (US EPA, 1974). This value was derived from the data presented in Figure D-7 and Table D-7 in US EPA (1974). The basic MNL is applicable for receptors in quiet suburban or rural areas, assuming that all of the construction noise is tonal and/or impulsive. In general, audible tones should be evaluated outdoors. The indoor environment can also be evaluated in the assessment; however, this should be addressed on a case-by-case basis given the uncertainty associated with specific resonances indoors that may affect the audibility of tones indoors. Due to the potential for masking by certain octave bands indoors, it is possible that certain tones may be audible indoors but not outdoors and vice versa.

In order to determine whether mitigation is advisable, consider the following:

- Use the data in Table 6.1 to characterize the community type based on average census tract population densities and community qualitative descriptions. Validating the community type may be accomplished by monitoring or calculating baseline noise levels.
- Use the data in Table 6.2 to identify the applicable correction factors for the relevant community type and additional corrections (e.g., construction duration, presence of tonal or impulsive noise, and whether windows are open), and then calculate the construction noise (less than one year) MNL.
- If the predicted construction noise levels exceed the MNL for the construction phase (less than one year), mitigation measures should be considered and described.

Table 6.2: Calculating Suggested MNL (as Ldn) for Construction Noise (Based on US EPA, 1974)

Suggested Basic MNL 47 dBA Ldn* Suggested MNL for various scenarios		
Community Description	**Applied Correction Factors**	**Suggested MNL**
Quiet suburban or rural	+0 dB	47 dBA
Normal suburban	+5 dB	52 dBA
Urban residential	+10 dB	57 dBA
Noisy urban	+15 dB	62 dBA
Very noisy urban	+20 dB	67 dBA
Additional Corrections If applicable, add any or all of the following corrections:		
Construction duration less than two months	+10 dB	
Winter (or windows always closed)	+5 dB	
Negligible tonal or impulsive noise§	+5 dB	

* Due to backup alarms, slamming tailgates, etc., construction noise normally contains both tonal and impulsive components. For the suggested basic MNL, the reasonable worst-case scenario is used and all of the construction noise is assumed to be due to tonal and/or impulsive noise.

§ When the contribution from tonal and/or impulsive noise may be negligible, +5 dB may be added to the suggested basic MNL. Health Canada prefers that a rationale be provided if this adjustment is applied.

Table 6.3 presents an example of how to establish a MNL. The final MNL is obtained through the application of several possible correction factors, as shown in Table 6.3. Calculated MNLs for other construction projects may vary, depending on the applicable correction factors specific to the project type, season and location.

Table 6.3: An Example of Applying Corrections to Establish a Suggested MNL (as Ldn) for a Project in a Very Noisy Urban Community

Description	Applied Correction Factors	Suggested MNL
Basic MNL	+0 dB	47 dBA
Project occurs in a very noise urban community	+20 dB	67 dBA
Construction duration is less than two months	+10 dB	77 dBA
Noise contains negligible tonal or impulsive noise	+5 dB	82 dBA
Project occurs during winter or in proximity to residences where windows cannot be opened	+5 dB	87 dBA
Final MNL		87 dBA

Widespread complaints tend to occur when the suggested MNLs in Table 6.2 are exceeded (US EPA, 1974). Therefore, Health Canada suggests the use of quieter technology or other mitigation measures, rather than lengthening construction duration (e.g., lowering the noise by having fewer pieces of equipment running at a time, thereby extending construction duration) to achieve a reduction in human health-related noise impacts.

Some examples of quiet technology and procedures are the following:

- Vibratory pile driving or boring, instead of impulsive pile driving; and
- Ambient-sensitive backup alarms, signal workers, machinery turning circles, and side loading/unloading trucks to reduce the impact of backup alarms.

If acceptable levels cannot be obtained with quieter technology, community consultation (as discussed in Section 6.4.1) is preferred, in order to seek consensus on construction operations (e.g., no activity during night-time or weekend hours). Some commonly applied construction noise mitigation measures and considerations for noise reduction are described in *Appendix H*.

6.4.3 Mitigating Long-Term Construction Noise Exposure (≥ 1 year)

Health Canada suggests that mitigation be implemented when noise levels during long-term construction result in a greater than 6.5% increase in %HA. If the change in %HA exceeds 6.5%, even when implementing quieter technology and construction methods as described in *Appendix H*, community consultation is important to establish mutually agreeable work schedules and is an acceptable means of informing the public of the time and duration of noisy activities.

Communication with potentially impacted residents is especially important when construction must occur outside daytime hours. Residents' concerns about blasting or other noisy activities can often be addressed through community consultation. Some flexibility among impacted residents may exist regarding construction noise levels, if demonstrable mitigation measures are used. Community consultation can be useful to determine whether the ability to avoid long periods of construction would result in greater community acceptance.

In addition to the consultative process, it is a good practice to consider technically and economically feasible mitigation measures (see *Appendix H*), in an attempt to reduce noise levels to levels that keep the change in %HA below 6.5% and protect against sleep impacts. In some cases, monitoring and working with the impacted community may address community reactions.

6.4.4 Mitigating Blasting Noise

Noise due to blasting has unique characteristics. Therefore, Health Canada holds the view that for blasting during short-term construction (< 1 year), limits on the number of blasts should be implemented irrespective of other noise levels due to background sources or construction activities. Noise effects due to blasting can be assessed in several ways. One approach for blasting exposures lasting less than one year is to use the US EPA (1974) criterion for sonic booms. The rationale for this approach stems from the findings of Schomer *et al.* (1997), whose research indicates that blasts and sonic booms create similar levels of annoyance for equal peaks.

According to US EPA (1974), little or no public annoyance is expected to result from any number of daytime sonic booms per day (N), if their measured or predicted peak value (in dB) is below 125–10 log N. In this case, dB is interpreted as meaning linear unweighted peak level for an instrument with a bandwidth of at least 0.1 Hertz (Hz) to 200 Hz. Health Canada prefers that the US EPA's sonic boom criterion be used as a blasting MNL for blasting events that occur over a period of less than one year.

Table 6.4 presents an example of the assessment technique of establishing an MNL based on a representative number of blasts.

Table 6.4: Mitigation Noise Levels Related to Number of Blasts

Number of Daytime Blasts per Day (N)	MNL (125–10 log N) (dB)
10	115
25	111
50	108
100	105

Health Canada suggests following the recommendations in ISO 1996–1:2003, as described in *Appendix E* and *Appendix F* of this guidance document, for blasting of duration of more than one year.

6.4.5 Mitigating Operational Noise

As with long-term construction noise, Health Canada considers high annoyance with noise generated during a project's operational phase to be an indicator of human health effects. If the change in %HA exceeds 6.5% or the suggested target values noted in Section 5.4.2 for project operational noise, Health Canada suggests that possible mitigation measures target the source, the propagation from source to receptor site and/or at the receptor site itself. These measures include, but are not limited to the following:

- Reducing noise output, such as using quieter machinery where technically and economically feasible;
- Implementing physical barriers, including acoustic shielding such as sound barriers (e.g., walls, berms or other artificial ridges or embankments), and windows with high soundproofing; and
- In some cases, changing project design (e.g., changing the proposed placement of an access road).

In general, implementing mitigation measures that further reduce noise impacts is always encouraged.

6.5 ASSESSMENT OF RESIDUAL IMPACTS

An assessment of any residual impacts of a project may include discussion of potential noise impacts arising from the project, after all proposed mitigation and management measures have been applied. It is a good practice for this discussion to include characterizing final maximum worst-case sound levels at representative receptor locations—in the same manner as is done in establishing the baseline sound levels—in addition to discussing the potential human health impacts that may be expected due to these changes.

Mitigating adverse noise effects can at times be technically challenging and costly. The severity of potential impacts on human health caused by noise is only one of many factors that may be considered in making an overall noise assessment of the project. When mitigation measures are judged to be not technically or economically feasible, a detailed discussion justifying the exclusion of these measures may be helpful in addressing potential concerns with respect to residual impacts of project-related noise. In such cases, the community consultation process discussed in Section 6.4.1 may offer alternative options for limiting complaints arising from excessive noise.

6.6 SOUND LEVEL MONITORING

The periodic monitoring of sound levels at representative receptor locations can be used to verify predictions made during the IA process. This monitoring is particularly important when predicted noise levels approach the level where adverse human health effects may occur and mitigation measures are being proposed. If the uncertainty related to predicted sound levels is large and the resulting impacts are more severe than expected, monitoring is considered particularly useful. It is also helpful to describe in the IA any commitments to evaluate the need for additional mitigation measures, if actual project-related noise levels are higher than predicted or if community reaction is stronger than expected.

If noise monitoring during project activities is not being undertaken when predicted noise levels are close to the suggested MNLs, Health Canada holds the view that the IA and supporting documentation should include a rationale explaining why monitoring is not considered appropriate or necessary.

7 ASSESSMENT OF CUMULATIVE EFFECTS

Under subsection 22(1)(a)(ii) of the IAA, an IA must take into account “any cumulative effects that are likely to result from the designated project in combination with other physical activities that have been or will be carried out.”

Assessing the cumulative effects of projects is a central element of the IA. The cumulative effects scenario represents the potential environmental effects of the existing baseline plus project scenario in combination with effects from reasonably foreseeable future projects within the same area of influence. Reasonably foreseeable future projects include those that are approved but not yet operating, and/or other proposed or likely developments within the potentially impacted area. The cumulative effect scenario provides an estimate of human health risks in the future when other facilities are also in operation.

In attempting to predict sound levels from the project when contributions from other sources are possible, Health Canada suggests that these sources be included in the modelling to establish potential cumulative effects.

In selecting a baseline sound level for a cumulative effects assessment, the pre-project baseline is the most appropriate comparison for noise-related human health impacts, as this comparison is predictive of the absolute change in the noise environment, when all project and additional noise sources are considered.

For guidance on assessing cumulative effects, consult the Agency’s website for up-to-date guidance materials at Canada.ca/iaac.

8 FOLLOW-UP PROGRAMS

Under Section 2 of the IAA, a follow-up program is defined as a program for:

a) Verifying the accuracy of the IA designated project; and

b) Determining the effectiveness of any mitigation measures.

It may be appropriate to consider a follow-up program for noise if one of the following applies (note that this is not a comprehensive list and is not a substitute for professional judgment):

- There is uncertainty about the modelling of ambient and project-generated noise at receptor locations;
- There is uncertainty whether proposed mitigation measures will be effective (e.g., the use of novel technologies or complex systems); or
- The project is located near a populated area where it is expected to generate a potentially significant, long-term increase in noise levels.

An effective method of verifying predicted increases in noise levels associated with the various project phases would be to:

- Monitor noise during the various project phases and compare to those predictions presented in the IA process; and
- Update predictive modelling based on known changes to input parameters and compare against monitoring results. These two comparisons can act to validate both modelling and monitoring results. In the event that measured levels are higher than the predictions and/or exceed the appropriate guideline/threshold values, additional mitigation and/or monitoring may be considered, particularly in the event of public complaints.

The effectiveness of mitigation measures can be evaluated based on the modelling and monitoring results as well as on the number of complaints received. If there are particular times or activities that result in increased complaints, additional mitigation targeting those times or activities may be implemented with the goal of reducing noise levels and the number of complaints.

Health Canada may make available expert health-related information or knowledge regarding a follow-up program upon request by the Agency, a review panel or others conducting the IA.

For further and up-to-date information on the need or requirements of follow-up programs, contact the Agency

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APPENDIX A | GLOSSARY

Term	Definition
Acoustics *(acoustique)*	The interdisciplinary science that deals with the study of sound, ultrasound and infrasound (all mechanical waves in gases, liquids and solids).
Ambient sensitive backup alarms *(avertisseur de recul qui s'adapte au bruit ambiant)*	Alarms that warn workers that a vehicle is backing up. These alarms increase or decrease in volume based on background noise levels to maintain a readily noticeable tone to workers, while reducing community noise annoyance. The alarms work best on small equipment such as backhoes and trucks. Note: The Construction Safety Association of Ontario notes that alarms offer the greatest benefit when traffic is limited to only one or two vehicles. The warning effect of the alarm is greatly reduced when it becomes part of the background noise on-site.
Annoyance *(gêne)*	A state, or adverse reaction, that may be referred to as being annoyed, disturbed, bothered or dissatisfied. *Noise annoyance:* A degree of annoyance measured by a subject's response to an annoyance questionnaire as part of a social survey on noise and annoyance. *High annoyance:* A degree of noise annoyance with a minimum cut-off of 71–73 on a scale of 0 to 100 (7–10 if the ISO-recommended scale of 0–10 is used) or the top two categories (very or extremely) of an adjectival scale (ISO/TS 15666:2003a)[4]
Average community *(collectivité typique)*	A community that would yield the same reaction to noise as that obtained from social surveys on noise in a large number of communities around the world (Michaud *et al.*, 2008).
Berm *(talus)*	An artificial ridge or embankment used to shield receptors from intruding noise.

[4] ISO. 2003a. ISO/TS 15666:2003. *Acoustics—Assessment of noise annoyance of social and socio-acoustic surveys.* www..iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=28630

Term	Definition
Community *(collectivité)*	An agglomeration of residents whose reaction to noise is being measured. *Very noisy urban residential community:* day-night sound level (Ldn) typical range 68–72 dBA, average 70 dBA; no qualitative characterization. *Noisy urban residential community:* Ldn typical range 63–67 dBA, average 65 dBA; qualitative characterization: near relatively busy roads or industrial areas. *Urban residential community:* Ldn typical range 58–62 dBA, average 60 dBA; qualitative characterization: not immediately adjacent to heavily travelled roads and industrial areas. *Normal suburban community:* Ldn typical range 53–57 dBA, average 55 dBA; qualitative characterization: not located near industrial activity. *Quiet suburban or rural community:* Ldn typical range 48–52 dBA, average 50 dBA; qualitative characterization: remote from large cities, industrial activity and trucking. (see Michaud *et al*., 2008 and US EPA, 1974 for more information).
Decibel *(décibel)*	A logarithmic unit of measurement that expresses the magnitude of a physical quantity (pressure, power or intensity) relative to a specified or implied reference level. Since it expresses a ratio of two quantities with the same unit, it is a dimensionless unit. The decibel is useful for acoustics and confers a number of advantages, such as the ability to conveniently represent very large or small numbers, and a logarithmic scaling that roughly corresponds to the human perception of sound. The decibel symbol is often qualified with a suffix, which indicates which reference quantity or frequency weighting function has been used.
Environmental noise *(bruit environnemental)*	Also called community noise, refers to non-occupational noise. The main sources of community noise include road, rail and air traffic, industries, construction and public works. In the context of this document, environmental noise refers almost always, if not entirely, to the above. In a more general context, the term may also refer to neighbourhood noise and indoor sources; primarily ventilation systems, home appliances and neighbours (e.g., in apartments) (Adapted from WHO, 1999).

Term	Definition
Equivalent continuous sound level Leq (t) *(niveau sonore continu équivalent Leq (t))*	A sound level obtained from energy averaging over a specified time interval (t). This level is obtained using an integrating averaging sound level meter, which determines the mean of the square of the sound pressure over a specified time interval (t), and expresses the result in decibels. *Day-night sound level (Ldn, also referred to as DNL)*: 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. *Daytime sound level (Ld):* An equivalent continuous sound level taken over 15 hours from 7 a.m. to 10 p.m. (In some jurisdictions, the start of daytime hours can be as early as 6 a.m. and the end of daytime hours can be as late as 11 p.m.) *Night-time sound level (Ln):* An equivalent continuous sound level taken over 9 hours from 10 p.m. to 7 a.m. (In some jurisdictions, the start of night can be as late as 11 p.m. As well, in some jurisdictions, the end of night can be as early as 6 a.m.) *Day-night rating level ($L_R dn$):* A day-night sound level to which an adjustment has been added. *Daytime rating level ($L_R d$):* A daytime sound level to which an adjustment has been added. *Night-time rating level ($L_R n$):* A night-time sound level to which an adjustment has been added. *LAeq (t):* An A-weighted equivalent continuous sound level in the denoted time interval. *LAeq (24):* An A-weighted equivalent continuous sound level for a specified 24-hour time interval. *LAeq (1):* An A-weighted equivalent continuous sound level for a specified 1-hour time interval.

Term	Definition
Frequency weighting *(pondération fréquentielle)*	A relative value applied to the spectrum of a sound in each defined frequency interval. *A-weighting (dBA):* A weighting of the frequencies in a sound that approximates the response of the human ear to frequencies in moderately loud sounds (sound pressure levels in the range of 45–65 dBA). *C-weighting (dBC):* A weighting of the frequencies in a sound that approximates the response of the human ear to frequencies in very loud sounds. It emphasizes the low frequencies of a sound much more than the Aweighting. *G-weighting (dBG):* A frequency weighting used for infrasound measurements. It is defined in ISO 7196 as 0 dB at 10 Hz. Between 1 and 20 Hz (the highest weighted frequency), the weighting approximates a straight line with a slope of 12 dB/octave. *Z-weighting (dBZ):* A frequency weighting defined in International Electrotechnical Commission (IEC) 61672–1:2002 with 0 dB weighting from 10 Hz to 20 kHz, within tolerances defined in the standard. (see ISO (1995) and IEC (2002) for more information)
Infrasound *(infrason)*	Like **Sound** but with frequency content below 20 Hz.
Maximum A-weighted sound level (LAmax) *(niveau maximal de pression acoustique pondéré A (LAmax))*	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.

Term	Definition
Noise *(bruit)*	Unwanted sound. *Low-frequency noise* (LFN)*:* Noise with frequency content in the range of 20–200 Hz. Where it produces a 16, 31.5 or 63 Hz octave band sound-pressure level of more than 65, 65 or 70 dBZ, respectively, low frequency noise can be associated with the introduction of noticeable vibrations and rattles in some structures (e.g., as from a nearby idling locomotive). *Tonal noise:* Noise containing prominent (audible) tones such as backup alarms on trucks. Here “tones” refers to tonal sound, defined in ISO 1996–1:2003 as sound characterized by a single frequency component or narrow-band components that emerge audibly, **at the receptor position**, from the total sound. If the audibility is in dispute, ISO 1996–2:2007 contains a method for analyzing a spectrum to determine audible tonality. *High-energy impulsive noise:* Impulsive noise from any high-energy impulsive sound source, including any explosive source in which the equivalent mass of TNT (trinitrotoluene) exceeds 50 g, or sources with comparable characteristics and degrees of intrusiveness. Internationally agreed upon examples are listed in ISO 1996–1:2003 and include sonic booms, blasting, quarry and mining explosions, demolition or industrial processes that use high explosives, explosive industrial circuit breakers and military ordnance (e.g., armour, artillery, mortar fire, bombs, and the explosive ignition of rockets and missiles). *Highly impulsive noise:* Impulsive noise from any noise source with highly impulsive characteristics and a high degree of intrusiveness. Internationally agreed upon examples of sources are listed in ISO 1996–1:2003 and include impact pile driving, small arms firing, hammering on metal or wood, nail guns, drop-hammering, drop forging, punch pressing, pneumatic hammering, pavement breaking, or metal impacts in rail-yard shunting/coupling operations. *Regular impulsive noise:* Impulsive noise from sources that are neither highly impulsive nor high-energy impulsive. Internationally agreed upon examples of these sources are listed in ISO 1996–1:2003 and include slamming car doors and truck tailgates.
Noise Impact Assessment *(évaluation des effets du bruit)*	A formalized process that provides information on the sources and expected loudness from individual sources and all sources collectively for all project phases. It can also evaluate the change in noise levels from baseline for each project phase (which can be modelled and then validated through field measurements). Both positive effects of controlling noise against the costs and technical feasibility of achieving effective noise control should be considered. Based on the analysis, appropriate noise management and noise mitigation measures can be identified to be protective against any potential adverse health consequences resulting from exposure to increased noise levels.

Term	Definition
Normalized Ldn *(Ldn normalisé)*	A calculated day-night sound level that is used to determine the potential for widespread complaints. The normalized Ldn is obtained from the measured value and the addition of various corrections in dB (as per US EPA, 1974).
Octave band *(bande d'octave)*	A section (band) of a sound spectrum where the ratio of the maximum to minimum frequency in the band is 2. Nominal centre frequencies (in Hz) of noise octave bands have been standardized as 16, 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000, and 16000.
Sentence intelligibility *(intelligibilité du message)*	The ability to recognize key words in a sentence using full concentration in a laboratory setting. Due to redundancy in normal conversation, all words in the sentence may not have been understood.
Sleep disturbance *(perturbation du sommeil)*	Any of: (i) interfering with falling asleep, (ii) shortening sleep stage duration, (iii) lessening perceived quality of sleep, (iv) awakening people from sleep, or (v) increasing body movements (motility) during sleep. *Awakenings:* A transient or indeterminate end of sleep. Awakenings can be measured: (i) behaviourally, by a subject pushing a button upon finding that they are aware of awakening, (ii) when a certain threshold of body movement (motility threshold) is exceeded from a previous low level of body movement (sleep), and (iii) by an objectively defined change in brain wave pattern measured by an electroencephalograph (EEG) (Michaud *et al.*, 2008). *Percent awakenings due to noise:* Awakenings attributed to noise events divided by the total number of awakenings multiplied by 100 (normally the totals are taken for all subjects in the study). *Sleep stage:* A stage of sleep with a well-defined brain wave pattern measured with an EEG. There are 5 stages of sleep. Sleep stage is also related to muscle activity and eye movements.
Sound exposure level (SEL) *(niveau d'exposition au bruit (NEB))*	The 1-second equivalent continuous sound level (Leq) 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. Note: The Leq for an extended time period that contains a number of noise events can be obtained by energy averaging the SEL values over the time period.
Time weighting *(pondération temporelle)*	*Fast weighting:* A time constant of 0.125 second in a sound-level meter used to smooth the square of the measured sound pressure prior to the expression of the sound pressure level in decibels. *Slow weighting:* A time constant of 1 second used to smooth the square of the measured sound pressure prior to the expression of the sound pressure level in decibels.

Term	Definition
Transmission loss *(perte de transmission)*	In environmental noise, the ratio of the sound energy striking a wall (e.g., the outside of a residence) relative to the transmitted sound energy (e.g, into a living room or bedroom), expressed in decibels.
Vibratory pile driving or boring *(vifrofonçage de pieux)*	A pile driving system that does not rely on an impact hammer but on a rapidly vibrating hammer that transfers its vibrational energy to the pile to drive it in.
Wind screen *(écran antivent)*	A screen, commonly a porous sphere or an egg-shaped structure of open cell foam, to protect a microphone's protective grid from turbulence produced by the passage of wind.

APPENDIX B | NOISE IMPACTS CHECKLIST

This checklist can be used to verify that the main components of a noise impact assessment have been completed. It is helpful to include this checklist with the IS (or equivalent document) to show where the components of the noise impact assessment are located in the document. This is especially helpful if the components are located in more than one section of the document.

OVERALL (THROUGHOUT THE IA)	
✓	**Item**
	1. In addition to the construction phase, are all other project phases, including operation and decommissioning, included in the IA?
	2. Has modelling been undertaken, and if so, is there an intention to validate the modelling with actual sound level measurements? If sound level measurements have been conducted, has modelling been used to validate the measurements?
	3. When modelling techniques are used to estimate present (baseline) or future (construction, operation and decommissioning) sound levels, are these techniques and any assumptions documented and appropriately justified?
	4. Is information provided that describes any tonal, regularly impulsive, highly impulsive or high-energy impulsive noise at receptors during the construction, operation, decommissioning project phases? Is information provided that describes the potential for LFN?
	5. Does the IA avoid statements relating to the perceptibility or whether changes in noise are noticeable, list dominant noise sources and justify that the measurements made are under reasonable worst-case scenarios based on existing national and international guidance?

RECEPTOR IDENTIFICATION AND CHARACTERIZATION		
✓	**Item**	**Section in IA**
	6. Are all currently impacted receptors (including Indigenous peoples) and potential reasonably foreseeable future receptors, clearly identified?	
	7. Is information on all noise-sensitive receptors in the area (including any foreseeable future receptors) and on distances of receptors from the project, included?	
	8. Are maps identifying receptor locations relative to the project site, including noise contour diagrams (all to scale), provided?	
	9. Is justification provided for any excluded receptors (if applicable)?	

	10. Are receptors identified in "quiet rural areas" assigned a +10 dB adjustment (if applicable) (as described in Section 6.2 of this Guidance Document)?	
	11. Is a description provided of any community consultation that may have occurred concerning noise impacts, including any human health concerns expressed by potential receptors?	

IMPACTS ASSOCIATED WITH NOISE

✓	Item	Section in IA
	12. Does the outdoor annual average for night-time (Ln) exceed 40 dBA?	
	13. Do predicted indoor night-time sound levels (or sound levels when nearby receptors are expected to be sleeping) exceed 30 dBA LAeq from continuous noise sources at any representative receptors?	
	14. Are more than 15 night-time individual noise events above 45 dBA LAmax indoors predicted at any representative receptor?	
	15. Is an evaluation of the severity of residual impacts (post-mitigation) on sleep disturbance included?	
	16. Is any interference with daytime speech comprehension (indoor sound levels greater than or equal to 40 dBA or outdoor sound levels greater than 55 dBA) predicted?	
	17. Is an evaluation of the severity of residual impacts (post-mitigation) on speech comprehension provided in the IA?	

ASSESSMENT OF BASELINE NOISE LEVELS

✓	Item	Section in IA
	18. Are measured or valid estimates of baseline noise levels provided, including any uncertainties for both daytime (Ld) and night-time (Ln) at receptors?	
	19. When measured baseline noise levels are provided, are the hours during which the measurements were obtained and the exact locations of the measurements provided?	
	20. Is a rationale provided explaining why the baseline is considered representative, including the days, weather conditions and any seasonal variations when monitoring occurred?	

	21. Are all noise sources that contribute to the baseline identified, including a description of the specific noise character(s), and appropriate adjustments made?	
	22. When baseline noise is estimated, are the estimation method and rationale for using this method provided?	
	23. Is a calculation of baseline percent highly annoyed (%HA) at receptors provided?	

ASSESSMENT OF CONSTRUCTION NOISE LEVELS

✓	Item	Section in IA
	24. Are valid estimates (predictions) of construction noise levels provided for both daytime (Ld) and night-time (Ln) at receptors, including any uncertainties?	
	25. Are the duration of construction activities impacting each receptor and the method of noise assessment (based on the construction duration) provided?	
	26. Are construction noise-related impacts and an associated management plan (if applicable) included?	
	27. Are construction noise levels estimated or modelled for each receptor, and are appropriate adjustments identified?	
	28. When short-term (<1 year) construction noise levels are expected to approach a suggested mitigation noise level (MNL), are mitigation measures and an associated management plan provided?	
	29. If an assessment of construction noise impacts is not conducted because the noise levels are predicted to be below the level for widespread complaints at all receptors, is a rationale provided?	
	30. When construction noise is expected to last longer than 1 year at any given receptor, is an evaluation of the change in %HA (from baseline) at these receptors provided? Are all applicable adjustments identified in estimating %HA?	

ASSESSMENT OF PROJECT OPERATIONAL NOISE

✓	Item	Section in IA
	31. Are predicted future (operation) daytime (Ld) and night-time (Ln) sound levels provided for all receptors, using the same parameters that were used to establish the baseline (e.g., units and averaging times)? Are appropriate adjustments identified?	
	32. Is an evaluation of the change in %HA (from baseline) at each receptor provided for operational noise?	
	33. Are the results and conclusions of the operational noise assessment clearly documented?	

MITIGATION MEASURES

✓	Item	Section in IA
	34. If applicable, is a discussion of whether mitigation measures or follow-up monitoring are warranted included?	
	35. When noise is expected to approach suggested mitigation levels either during project construction or operations, is a discussion of planned or conditional mitigation measures included?	
	36. Is a residual impacts assessment discussing noise impacts following mitigation included?	
	37. When LFN is emitted, is information describing impacts of any anticipated effects (e.g., rattling) and related mitigation measures included?	
	38. After all of the noise mitigation measures are applied, does the calculated change in %HA (from baseline) at any of the representative receptors exceed 6.5%?	
	39. Is information provided on how the noise-related complaints will be addressed, including a description of a complaint resolution process?	

ASSESSMENT OF CUMULATIVE EFFECTS		
✓	**Item**	**Section in IA**
	40. When other ongoing or reasonably foreseeable future projects in the region may contribute to noise levels, is a cumulative effects assessment included?	

FOLLOW-UP PROGRAM		
✓	**Item**	**Section in IA**
	41. Has a follow-up program been developed to evaluate the accuracy of the noise predictions?	

APPENDIX C | NOISE CHARACTERISTICS

C.1 TONAL AND IMPULSIVE NOISE

Tonal (e.g., backup alarms on trucks) and impulsive noise (e.g., hammering on metal) are often perceived as annoying and may have a high potential to disturb receptors (US EPA, 1974; ISO 1996–1:2003; ANSI, 2005; WHO, 1999). Therefore, providing information on tonal, regular impulsive, highly impulsive or high-energy impulsive project noise that is audible at receptors is suggested. This characterization of noise is also important in selecting the appropriate corrections and adjustments in the calculation of noise impacts for construction, operations, and decommissioning noise.

As described in ISO 1996–1:2003, regular impulsive noise is sometimes characterized as intrusive but not as intrusive as highly impulsive noise. Examples of regular impulsive noise include the slamming of car doors, outdoor recreational activities such as sporting events (e.g., soccer games), and church bells. Very fast pass-bys of low-flying military aircraft may also fall under this category.

Impulsive noise sources that have a high degree of intrusiveness may be characterized as either highly impulsive or high-energy impulsive, although adjustments for such sounds are described in ISO 1996–1:2003. See *Appendix A* for more information.

ISO 1996–1:2003 recommends making a +5 dB adjustment to tonal and regular impulsive noise sources and a +12 dB adjustment to highly impulsive noise sources. The expected contribution of project noise and details on how tonality and impulsiveness were accounted for are important elements of the noise assessment. See *Appendix F* for more information.

C.2 LOW-FREQUENCY NOISE

Noise occurring at frequencies below 200 Hertz (Hz) is generally defined as LFN. Low-frequency noise is commonly not well perceived by the human ear but may induce vibrations in buildings that may be perceptible or cause a “rattle” in these environments. Research indicates that annoyance related to noise is greater when LFN is present (ISO 1996–1:2003) and one of the main reasons is the annoyance caused by rattles (Schomer and Neathammer, 1987; Schomer and Averbuch, 1989). As sound environments are usually characterized using dBA that reflect the frequencies most audible to the human ear, the impacts of LFN may need to be assessed separately using another noise weighting system (such as dBC or dBZ).

Guidance for low-frequency sound (or infrasound) in the 16–63 Hz octave bands stems from the ANSI standard on environmental sound regarding noise assessment and the related prediction of long-term community response (ANSI, 2005). Where standards or acceptable procedures for the measurement of these frequencies exist, it is suggested that the IA include a description of the potential impacts and any mitigation measures concerning potential effects at these frequencies.

The ANSI standard concerns essentially continuous sounds with strong low-frequency content. To prevent rattles from LFN and the associated annoyance from this effect, ANSI indicates that the (energy) sum of the sound levels in the 16-, 31.5- and 63-Hz octave bands be less than 70 dBZ. If this 70-dBZ "rattle criterion" is exceeded, Health Canada may suggest the implementation of feasible mitigation measures. ANSI (2005) indicates that there is evidence that noise-induced rattles are very annoying, and this annoyance may be independent of the number or duration of events.

Additionally, ANSI (2005) provides a more sophisticated mathematical procedure for assessing %HA when LFN is present. Health Canada prefers using this procedure when the C-weighted Ldn exceeds the A-weighted Ldn by more than 10 dB. This is further outlined in *Appendix D* of ANSI (2005).

Broner (2011) has provided simplified outdoor dBC LFN criteria based on the type of receptor (i.e., residential and commercial) and time of day. Based on these criteria, LFN does not generally require further consideration if outdoor Ld is ≤ 60 dBC, and Ln ≤ 55 dBC. At 10 Hz, 60 dBC is approximately 69 dBZ. Health Canada's 70 dBZ rattle criterion limit is based on unsteady noise, where rattles may intermittently exceed the criteria, but overall levels are below a long-term average of of less than 70 dBZ.

C.3 PERCEPTIBILITY

It is important to consider that people respond to sound characteristics that do not necessarily appreciably increase the sound level. Therefore, in the context of an IA, statements relating to perceptibility or whether changes in noise are noticeable are to be avoided, as these statements are misleading and may result in increased complaints if people are told they will not hear these sounds when they are clearly audible but below acceptable guideline values referenced in the IA.

APPENDIX D | INTRODUCTION TO NOISE

SOUND AND NOISE

Sound is defined as mechanical vibrations travelling through the air or other media.

Noise is most simply defined as unwanted sound.

Sound is measured using a calibrated microphone to determine the rapid cyclical changes in pressure (force per unit area) of the sound wave from the normal atmospheric pressure of about 101,325 Pascals (Pa). As the human ear is sensitive to sound waves over a very wide range of maximum changes in sound pressure, for convenience, this range is compressed by using a logarithmic scale, and the resulting sound unit used is called a "decibel" (dB). A logarithmic scale is non-linear; as one moves up the scale, the same change in decibels represents a larger and larger increase in sound pressure. This means that decibels cannot be added or averaged in the same way as other linear measurements such as distance or weight.

D.1 WEIGHTING

People do not perceive all sound frequencies equally, and as such, decibel levels are modified (weighted) according to the frequencies present in the sound. The typical modified levels that are related to human hearing are termed "A-weighted" and are reported as dBA rather than dB. The A-weighting reduces the contribution from low and high frequencies to capture the mid-frequency range to which the average human ear is most sensitive. Note that LFN is de-emphasized by A-weighting as its impacts are not perceived as well by the human ear. However, these low frequencies are factors that can induce rattles and vibrations that can be heard and/or felt. Given the logarithmic system of measuring sound, decibels can be measured in many ways. These include dBC-, G- and Z-weighting. C-weighting is appropriate when assessing the %HA from exposure to frequent blasting (a high-energy impulsive noise) or, potentially, other project noise sources in which LFN dominates.

D.2 ADDING DECIBELS

Sounds often need to be added together to determine total sound (or adjusted sound) levels (expressed in decibels) The known/measured/predicted values characterizing the sound are also normally expressed as sound levels in decibels. As a quick rule of thumb, if two sound levels are added, the final value will be at most (i.e., no more than) 3 dB greater than the highest of the two values. However, a more formalized equation that can be used to add sounds, where the starting sound levels (L_i) are changed to mean square sound pressures which are added; this sum is then changed back to decibels (L_{sum}):

$$L_{sum} = 10 \log_{10}[\Sigma_i 10^{(0.1\, L_i)}] \qquad (1)$$

D.3 AVERAGING DECIBELS

In calculating an average sound level over a certain time period, the measured sound pressure at each time is squared and then averaged over time (mean square sound pressure). The mean square sound pressure is then converted to decibels. Occasional loud sound events (e.g., a bird landing on a microphone) may inappropriately influence an average. Events unrelated to the assessment are, after being identified, commonly excluded from the calculation of average sound pressure level.

D.4 MEASUREMENTS ASSOCIATED WITH SOUND LEVELS REPORTED IN IAs

In the context of evaluating noise for future proposed projects under the IAA, sound levels are typically reported in average decibel level over a defined time period. The measurement used to describe the sound level indicates the duration and time of day of the sound, and whether any weighting was applied.

APPENDIX E | SOUND SOURCES AND SOUND CHARACTER

Appendix F lists equations that show how to obtain %HA values from daytime and night-time rating levels. The rating levels can be estimated from the application of adjustments to the applicable daytime (Ld) and night-time (Ln) sound levels for the noise environments with and without the project. The Ld and Ln are obtained by an appropriate combination of predictions and measurements.

The values of the daytime rating levels $L_R d_i$ and the night-time rating levels $L_R n_i$ for any applicable noise source are obtained by applying adjustments to the sound levels that are energy-averaged to obtain Ld and Ln for the given (i-th) noise source. Adjustments may pertain to a particular type of source or to a particular character of the noise from a source or to the receiver characteristics.

When adjustments to project or baseline noise are necessary, Health Canada prefers that adjustments be made by following ISO 1996–1:2003. Details of how to apply adjustments are given in Section 6 of ISO 1996–1:2003, in particular, for situations where noise sources of a specific character are audible and either distinguishable from noise from other sources, or indistinguishable from noise from other sources. Furthermore, this section of the ISO standard indicates how to determine the rating level from combined sources.

With respect to receptor characteristics, an adjustment is made for a “quiet rural area,” where a noise receptor (or group of receptors) has a greater expectation for and value placed on “peace and quiet”. ISO notes that a +10 dB adjustment should be applied in this situation. In the absence of further information, Health Canada will assume that receptors with a LAeq (7 a.m.–10 p.m.) of 45 dBA or less and a LAeq (10 p.m.–7 a.m.) of 35 dBA or less are in a quiet rural area, and warrant a +10 dB adjustment in the calculation of the change in %HA.

For **air traffic** sources of noise, Health Canada prefers that a +5 dB adjustment be applied. For **rail traffic**, either a -5 dB (note this is a negative adjustment) or 0 dB adjustment should be applied, as applicable. The -5 dB rail traffic adjustment is not applicable to long diesel trains, or to trains operating at speeds in excess of 250 km/hr. These specific adjustments fall within the ranges given in ISO 1996–1:2003.

Road traffic noise and industrial-type noise (including construction noise for the purposes of this guidance) have a 0 dB adjustment, as specified in ISO 1996–1:2003. The 0 dB adjustment for industry/construction noise applies to only two types of sound levels: (i) from noise sources which are not audibly tonal at the receptor and (ii) from non-impulsive sources.

Certain **other noise sources**, as per ISO 1996–1:2003, are considered regular impulsive (+5 dB adjustment), highly impulsive (+12 dB adjustment) or high energy impulsive (the adjustment may vary based on the type of high energy impulsive sound and is based on the C-weighted values; see *Appendix B* of ISO 1996–1:2003 for details). Tonal sound is also addressed in the ISO standard. Health Canada prefers that a +5 dB adjustment be applied to noise which is audibly tonal at the receptor. This value falls within the range specified in the standard.

As per ISO 1996–1:2003, if more than one adjustment applies for the source type or character of a given **single sound source**, only the largest adjustment is applied. However, time period adjustments are always added to the otherwise adjusted levels. Also, the adjustment for receiver characteristics in a quiet rural area is added to any other adjustments.

ISO 1996–1:2003 also explicitly states that adjustments for tonal character should only be applied when the "sound is audibly tonal at the receiver location". The standard also indicates that adjustments for impulsive source character should only be applied to "impulsive sound sources that are audible at the receiver location." The subtle distinction made in ISO 1996–1:2003 between audibly tonal versus audible sources may only be relevant in consideration of high energy impulsive noise. At long distances, high energy impulsive artillery fire can change from an impulse to a rumble without substantially affecting the magnitude of the required adjustment. For more common sources, a source is still impulsive even if it loses the high frequencies at long distances (e.g., ISO 1996–1:2003 identifies the predominantly low-frequency car door slam as regular impulsive).

E.1 EXAMPLES

Aircraft noise: Although an aircraft can create prominent tones during aircraft noise events, which would normally get a +5 dB adjustment, the adjustment for the air traffic type is also +5 dB. Therefore all air traffic noise receives a +5 dB adjustment.

Shunting of rail cars: The sound sources that are identified as highly impulsive in ISO 1996–1:2003 are the "metal impacts in rail-yard shunting operations". Thus, only the sound level during the time that the metal impacts are audible should receive the +12 dB adjustment; not the rest of the noise associated with the shunting activity. The noise due to the engine and motion of the rail cars during shunting is separate from the impact noise and is thus a separate component with a 0 dB adjustment.

Rail wheel squeal: There are times at the receptor when the noise from the train is audibly tonal, due to wheel squeal, and the +5 dB adjustment applies. However, for that portion of time where the sound is no longer audibly tonal at the receptor, the noise from the train receives either 0 or -5 dB adjustment for source type.

APPENDIX F | DETERMINATION OF PERCENT HIGHLY ANNOYED (%HA)

INTRODUCTION

Appendix F presents the methodology and equations for calculating (the change in) percent highly annoyed (%HA): using Ld and Ln to calculate rating levels $L_R d$ and $L_R n$; and using rating levels in the equations below to determine %HA. These calculations are applicable to projects where the construction phase is ≥ 1 year in duration, and for projects in the operational phase.

Note: Rating levels are an intermediate step in the calculations of %HA, but are generally not reported in an IA. The various details about Ld, Ln and the adjustments applied should be reported.

Refer to Section 5.4 for a discussion about complaints and %HA, and consult *Appendix A* for definitions.

CALCULATION OF BASELINE, CONSTRUCTION ≥ 1 YEAR DURATION, AND OPERATION DAYTIME (7 A.M.–10 P.M.) AND NIGHT-TIME (10 P.M.–7 A.M.) RATING LEVELS

Energy summation of applicable daytime rating levels from each noise source will result in a daytime rating level that can be used to calculate %HA.

Daytime rating level

$$L_R d = 10 \log_{10}[\Sigma_i 10^{(0.1\ L_R d_i)}] \qquad \text{(F1)}$$

For a quiet rural area, the daytime rating level

$$L_R d = 10 + 10 \log_{10}[\Sigma_i 10^{(0.1\ L_R d_i)}] \qquad (\text{F1}_{\text{quiet\_rural\_area}})$$

Where $L_R d_i$ = any applicable daytime rating level and a quiet rural area is considered an area where a noise receptor (or group of receptors) has a greater expectation for and value placed on “peace and quiet”. In the absence of further information, Health Canada will assume that receptors with a LAeq[5] (7 a.m.–10 p.m.) of 45 dBA or less and a LAeq (10 p.m.–7 a.m.) of 35 dBA or less are in a quiet rural area and warrant a +10 dB adjustment.

The same calculation (using Equations F1 or $\text{F1}_{\text{quiet rural area}}$) is also applicable to determine the night-time rating level ($L_R n$) needed to calculate %HA.

5 LAeq is an A-weighted equivalent of continuous sound level in the denoted time period.

CALCULATION OF %HA

The rating level used to calculate %HA is the day-night rating level (L_Rdn). In general, to calculate the relevant change in %HA values due to the project noise, (e.g., construction, or operation), L_Rdn values are needed for baseline, construction ≥1 year, and operation. The energy summation of baseline and construction L_Rdn values (L_Rdn (baseline and construction)) is needed for the construction phase. The energy summation of baseline and operation L_Rdn values (L_Rdn (baseline and operation)) is needed for the operation phase. L_Rdn is a 24-hour energy averaged rating level in which the contribution from the night-time rating level is artificially increased by 10 dB and is calculated using Equation F2.

$$L_Rdn = 10\log_{10}[((15 \times 10^{(0.1 \times L_Rd)}) + (9 \times 10^{(0.1 \times (L_Rn + 10))}))/24] \quad \text{(F2)}$$

$$L_Rdn_{(\text{baseline and construction})} = 10\log_{10}(10^{(0.1 \times \text{construction } L_Rdn)} + 10^{(0.1 \times \text{baseline } L_Rdn)}) \quad \text{(F3a)}$$

$$L_Rdn_{(\text{baseline and operation})} = 10\log_{10}(10^{(0.1 \times \text{operation } L_Rdn)} + 10^{(0.1 \times \text{baseline } L_Rdn)}) \quad \text{(F3b)}$$

The %HA is calculated using Equation F4:

$$\%HA = 100/[1 + e^{(10.4 - 0.132 \times L_Rdn)}] \quad \text{(F4)}$$

The %HA (baseline), %HA (baseline and construction), %HA (construction), %HA (baseline and operation) and %HA (operation) can be obtained by substituting the appropriate L_Rdn into Equation F4.

The **change in %HA for project construction** is calculated by subtracting %HA (baseline) from %HA (baseline and construction).

The **change in %HA for project operation** is calculated by subtracting %HA (baseline) from %HA (baseline and operation).

Table F.1 is a worked example showing the project noise levels (i.e., construction phase [≥1 year] or during the operational phase) that would result in a change of 6.5%HA from the baseline to project scenario. Use this table as a reference to check calculations carried out for a proposed project. This table presents rating levels, but note that rating levels are not commonly reported in an IA as they are an intermediate step in calculating %HA (see above).

The table ranges from a baseline of 20 dB (i.e., quiet rural area) up to a project level of 75 dB.

Table F.1: Worked example showing baseline and project rating levels associated with a 6.5% increase in %HA due to a project's noise.

			Change in %HA between baseline and project equals 6.5%	
$L_R$dn baseline (dB)	$L_R$dn project (dB)	total $L_R$dn (dB)	%HA baseline (%)	%HA total (%)
<20	58.6	58.6	0.0	6.5
35	58.9	59.0	0.3	6.8
42	59.4	59.5	0.8	7.3
46	59.9	60.1	1.3	7.8
48	60.2	60.5	1.7	8.2
50	60.6	61.0	2.2	8.7
52	61.1	61.6	2.8	9.3
53	61.3	61.9	3.2	9.7
55	61.9	62.7	4.1	10.6
56	62.2	63.1	4.7	11.2
57	62.5	63.6	5.3	11.8
58	62.8	64.1	6.0	12.5
59	63.2	64.6	6.8	13.3
60	63.6	65.2	7.7	14.2
61	64.0	65.8	8.7	15.2
62	64.5	66.4	9.8	16.3
63	64.9	67.1	11.1	17.6
64	65.4	67.8	12.4	18.9
65	65.9	68.5	13.9	20.4
66	66.5	69.2	15.6	22.1
67	67.0	70.0	17.4	23.9
68	67.6	70.8	19.4	25.9
69	68.3	71.7	21.6	28.1
70	68.9	72.5	23.9	30.4
71	69.6	73.4	26.3	32.8
72	70.3	74.3	29.0	35.5
73	71.1	75.2	31.8	38.3
74	71.9	76.1	34.7	41.2
75	72.8	77.0	37.8	44.3
76	73.7	78.0	40.9	47.4
77	74.6	79.0	44.1	50.6

APPENDIX G | IDENTIFICATION AND CHARACTERIZATION OF SOME COMMON RECEPTOR LOCATIONS

Receptor location	Characterization	Comments/Considerations
Commercial premises	Retail stores, offices, research facilities and laboratories	Noise effects during business hours
Daycare centres	Highly sensitive receptors (children)	Noise effects considered during occupied periods
Entertainment establishments	Film and television studios, theatres, restaurants, etc.	Noise effects during periods of operation
Hospitals	Highly sensitive receptors (sick people)	Noise effects over a 24-hour period
Industrial premises	Factories and other industrial plants	Potential for additive noise in cumulative effects assessment
Places of worship and cemeteries	Churches, mosques, synagogues, temples, locations where Indigenous Peoples' cultural or religious ceremonies occur, etc.	Noise effects during religious services, meetings or processions
Recreation areas: Active	Parks and sports grounds	Noise effects considered during occupied periods
Recreation areas: Passive	Outdoor grounds used for hunting, fishing, teaching, etc.; includes locations where Indigenous Peoples may hunt, fish or gather country foods	Noise effects considered during activity periods
Residences: Permanent	Urban, suburban and rural locations containing houses, mobile homes and/or multilevel dwellings	Noise effects over a 24-hour period with particular emphasis on night-time noise levels
Residences: Seasonal	Cottages, campgrounds and RV parks; includes Indigenous hunting and fishing cabins, and seasonal camps	Noise effects considered during occupied periods
Schools	Education facilities from pre-school to universities; highly sensitive receptors	Noise effects during regular hours of operation, which may include evenings and the possibility of schools being used during summer
Seniors' residences	Highly sensitive receptors (elderly)	Consideration of noise effects over a 24-hour period with particular emphasis on night-time noise levels
Workers' living quarters[6]	Locations may be on or off the project site	Mitigation measures in the design of temporary living quarters for workers to limit noise

[6] Occupational exposure and health issues are typically under provincial or territorial jurisdiction, and Health Canada does not review this information in the context of IAs.

APPENDIX H | COMMONLY APPLIED CONSTRUCTION NOISE MITIGATION MEASURES AND CONSIDERATIONS FOR NOISE REDUCTION

The measures below have been adapted from the New South Wales Interim Construction Noise Guideline (July 2009), Department of Environment and Climate Change, New South Wales, Australia. Available at: www.epa.nsw.gov.au/noise/constructnoise.htm

GENERAL MITIGATION MEASURES

- Regularly train workers and contractors to use equipment in ways that minimize noise.
- Ensure that site managers periodically check the site, nearby residences and other sensitive receptors for noise problems so that solutions can be quickly applied.
- Include in tenders, employment contracts, subcontractor agreements and work method statements, clauses that assure the minimization of noise and compliance with directions from management to minimize noise.
- Avoid the use of radios and stereos outdoors and the overuse of public address systems where neighbours can be affected.
- Avoid shouting and minimize talking loudly and slamming vehicle doors.
- Keep truck drivers informed of designated vehicle routes, parking locations, acceptable delivery hours and other relevant practices (e.g., minimizing the use of engine brakes and periods of engine idling).

NIGHT-TIME MITIGATION MEASURES

- Avoid the use of equipment that generates impulsive noise.
- Minimize the need for reversing alarms.
- Avoid dropping materials from a height.
- Avoid metal-to-metal contact on equipment.
- If possible, schedule truck movements to avoid residential streets.
- Avoid clustering of equipment near residences and other sensitive receptors.
- Ensure that periods of respite are provided in the case of unavoidable maximum noise level events.

CONSULTATION AND NOTIFICATION

- The community is more likely to be understanding and accepting of project noise if related information is provided and is frank, and does not attempt to understate the likely noise level, and if commitments are respected.

NOTIFICATION BEFORE AND DURING CONSTRUCTION

- Provide advance notification to people concerning construction duration, defining activities that are expected to be noisy and their expected duration, what noise mitigation measures are being applied, and when noise respite periods will occur.
- For night-time work, receptors may be informed in two stages: two weeks prior to construction and then two days before commencement.
- Provide information to neighbours before and during construction through media such as letterbox drops, meetings or individual consultation. In some areas, the need to provide notification in languages other than English may be considered. A website may also be established for the project.
- Use a site information board at the front of the site with contact details, hours of operation and regular information updates.
- Facilitate contact with people to ensure that everyone can see that the site manager understands potential issues, that a planned approach is in place, and that there is an ongoing commitment to minimize noise.

WORK SITE AND EQUIPMENT

- In terms of both cost and results, controlling noise at the source is one of the most effective methods of minimizing the noise impacts from any construction activities

QUIETER METHODS

- Examine and implement, where feasible and reasonable, alternatives to rock-breaking work methods, such as hydraulic splitters for rock and concrete, hydraulic jaw crushers, chemical rock and concrete splitting, and controlled blasting, such as penetrating cone fracture.
- Consider alternatives to diesel and gasoline engines and pneumatic units, such as hydraulic or electric-controlled units, where feasible and reasonable. When there is no electricity supply, consider using an electrical generator located away from residences.
- Examine and implement, where feasible and reasonable, alternatives to transporting excavated material from underground tunnelling off-site at night-time (e.g., stockpile material in an acoustically treated shed during the night and load out the following day).

QUIETER EQUIPMENT

- Examine different types of machines that perform the same function and compare the noise level data to select the least noisy machine (e.g., rubber-wheeled tractors can be less noisy than steel-tracked tractors).
- Pneumatic equipment is traditionally a problem. Consider selecting super-silenced compressors, silenced jackhammers and damped bits, where possible.
- When renting (or purchasing) equipment, select quieter pieces of machinery and construction equipment, where feasible and reasonable. As well, select the most effective mufflers, enclosures and low-noise tool bits and blades. Always seek the manufacturer's advice before making modifications to any equipment to reduce noise.
- Reduce throttle settings and turn off equipment when it is not being used.

- Examine and consider implementing, where feasible and reasonable, the option of reducing noise from metal chutes and bins by placing damping material in the bin.

EQUIPMENT MAINTENANCE

- Regularly inspect and maintain equipment to ensure that it is in good working order, including the condition of mufflers.
- For machines with enclosures, verify that doors and door seals are in good working order and that the doors close properly against the seals.
- Return any leased equipment that is causing noise that is not typical for the equipment. The increased noise may indicate the need for repair.
- Ensure that air lines on pneumatic equipment do not leak.

SITE MITIGATION MEASURES

- Barriers and acoustic sheds are most suited to long-term fixed works, as in these cases, the associated cost is typically outweighed by the overall time savings.

WORK SITE LOCATION

- Place as much distance as possible between the machinery or equipment, and residences and other sensitive receptors.
- Restrict areas in which mobile equipment can operate, so that they are away from residences and other sensitive receptors at particular times.
- Locate site vehicle entrances away from residences and other sensitive receptors.
- Carry out noisy fabrication work at another site (e.g., within enclosed factory premises) and then transport products to the project site.

ALTERNATIVES TO REVERSING ALARMS

- Avoid the use of reversing alarms by designing the site layout to avoid reversing, such as by including drive-through for parking and deliveries.
- When applicable legislation permits, consider less annoying alternatives to the typical “beeper” alarms. Examples include smart alarms that are adjustable in volume depending on the ambient level of noise, and multi-frequency alarms that emit noise over a wide range of frequencies.

MAXIMIZE SHIELDING

- Re-use existing structures rather than demolishing and reconstructing.
- Use full enclosures, such as large sheds, with good seals fitted to doors to control noise from nighttime work.
- Use temporary site buildings and material stockpiles as noise barriers.
- Schedule the construction of permanent walls so that they can be used as noise barriers as early as possible.
- Use natural landform as a noise barrier. Place fixed equipment in cuttings or behind earth berms.

- Take note of large reflecting surfaces on- and off-site that might increase noise levels, and avoid placing noise-producing equipment in locations where reflected noise will increase noise exposure or reduce the effectiveness of mitigation measures.

PROVIDE RESPITE PERIODS

- Consult with schools to ensure that noise-generating construction works in the vicinity are not scheduled to occur during examination periods, unless other acceptable arrangements (such as relocation) can be made.
- When night work near residences cannot be feasibly or reasonably avoided, restrict the number of nights per week and/or per calendar month that the work is undertaken.

WORK SCHEDULING

- Schedule noisy work during periods when people are least affected.

SCHEDULE ACTIVITIES TO MINIMIZE NOISE IMPACTS

- Organize work to be undertaken during the recommended standard hours, where possible.
- If the construction site is in the vicinity of a sports venue, consider scheduling work to avoid times when there are special events.
- When work outside the recommended standard hours is planned, avoid scheduling it on Sundays or public holidays.
- Schedule work when neighbours are not present (e.g., outside business hours or on weekends, when commercial neighbours, college students and school students may not be present).
- Schedule noisy activities around times of high background noise (i.e., when local road traffic or other local noise sources are active) where possible, to provide masking or to reduce the amount that the construction noise intrudes above the background noise

DELIVERIES AND ACCESS

- Nominate an off-site truck parking area away from residences for trucks arriving prior to gates opening and schedule deliveries only during specified periods.
- Optimize the number of vehicle trips to and from the site. Movements can be organized to amalgamate loads rather than using a number of vehicles with smaller loads.
- Designate access routes to the site through consultation with potentially noise-affected residences and other sensitive receptors, and inform drivers of nominated vehicle routes.
- Provide on-site parking for staff and on-site truck waiting areas away from residences and other sensitive receptors. Truck waiting areas may require walls or other barriers to minimize noise.

NOISE TRANSMISSION PATH

- Physical methods to reduce the transmission of noise between construction locations and residences or other sensitive receptors are generally suited to construction projects in which there is long-term noise exposure.
- Reduce the line-of-sight noise transmission to residences and other sensitive receptors using temporary noise barriers.
- Temporary noise barriers can be constructed from boarding (plywood boards, panels of steel sheeting or compressed fibre cement board) with no gaps between the panels at the site boundary. Stockpiles and shipping containers can be effective noise barriers.
- Erect temporary noise barriers before work commences to reduce noise from construction as soon as possible.
- Where high-rise dwellings adjoin the construction site, the height of a barrier may not be sufficient to effectively shield the upper levels of the residential building from construction noise. Find out if this is a consideration for the project and examine alternative mitigation measures, where needed.