PORT of vancouver | Vancouver Fraser Port Authority

2021 annual noise monitoring report

The Vancouver Fraser Port Authority has a noise monitoring program in place to better understand the source and intensity of port-related noises and help respond to community concerns regarding noise. In late 2014, the port authority deployed a network of noise monitoring stations in the North Shore and South Shore trade areas of Burrard Inlet, and expanded the network to the Roberts Bank trade area in late 2015. A summary report has been prepared to provide general information and analysis of noise trends for December 1, 2018 through November 30, 2021 annual years.

Why monitor noise?

Port operations are industrial by nature and occur on a 24/7 basis. Local communities have raised concerns regarding noise impacts associated with port activities, such as ship engines, truck and rail movements, and normal terminal operations. Noise from horns, whistles, sirens and signals can be difficult to eliminate as they are often related to safety practices.

Monitoring is one of the ways the port authority is working with port users to minimize noise and other nuisances originating from the federal lands and waters that it manages. Actively monitoring, observing, and reporting on noise trends increases the visibility of concerns and highlights the importance of considering noise impacts in policy and planning decisions.

The noise monitoring program annual summary report answers the following questions:

- Are the noise levels getting louder or quieter over time?
- What are the nighttime noise trends?

Eleven noise monitoring terminals are located throughout the port, along the North and South Shores of Burrard Inlet and at Roberts Bank.

Who conducted the analysis and prepared the report?

BKL Consultants Ltd. (BKL) was retained to analyze recorded noise levels, prepare quarterly and annual summary reports, and provide general information and analysis of noise trends from 2018 through to 2021.

BKL was selected based on their expertise in terrestrial noise and their understanding of noise monitoring stations provided by Seti Media Inc.

What methods were used?

BKL applied industry best practices using the American National Standards Institute and European Commission Working Group Assessment of Exposure to Noise in the development of the methodology for data analysis and reporting.

Three noise metrics are applied in the report:

1. Day-evening-night equivalent sound level, Lden (dBA)
2. Nighttime equivalent sound level, Ln (dBA)
3. Noise event counts (daytime, evening, and nighttime)

What are the key findings and conclusions?

The report prepared by BKL found that:

- For the north shore NMTs (Locations 1 to 4), noise levels recorded in 2021 were similar to or slightly lower than those measured in 2020, except for CNV St Davids where noise levels have slightly increased. Minimal events were recorded, which is similar to 2020.
- For the south shore NMTs (Locations 5 to 8), noise levels recorded in 2021 were similar to or slightly lower than those measured in 2020. Minimal events were recorded, which is similar to 2020. Most events of the south shore were recorded at VAN Renfrew.
- For the Roberts Bank NMTs (Locations 9 to 11), noise levels recorded in 2021 were similar or slightly higher than those measured in 2020.

How are the results being used to manage noise?

The information gained from the noise monitoring program is used to inform our land use planning, project and environmental reviews, studies to assess opportunities for minimizing noise, and our engagement strategy with port users such as ship owners and rail operators. We also draw on the monitoring data to educate port users and communities about port-related noise issues and to support improved feedback on noise.

Contact us

To see noise levels in real-time, visit our online noise monitoring website hosted by Seti Media at

https://seti-media.com/infopopulation/port_vancouver. This information may help you identify noise levels and locations when notifying us of a noise concern.

Learn more about our noise monitoring program at https://www.portvancouver.com/port-dashboard/noise-monitoring.

If you have a concern about noise, please contact our community feedback line at 604.665.9004 or email community.feedback@portvancouver.com.

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Noise Monitoring Program

2021 Annual Noise Monitoring Report

Prepared for:

Vancouver Fraser Port Authority

2022-11-14

Prepared by:

BKL CONSULTANTS LTD.

File: 1924-22B-R0

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This document contains the expression of the professional opinion of BKL, at the time of its preparation, as to the matters set out herein, using its professional judgment and reasonable care. The information provided in this report was compiled from existing documents and data provided by the Client, site noise measurements and by applying currently accepted industry practice and modelling methods. Unless expressly stated otherwise, assumptions, data and information supplied by or gathered from other sources (including the Client, other consultants, testing laboratories and equipment suppliers, etc.) upon which BKL's opinion as set out herein is based has not been verified by BKL; BKL makes no representation as to its accuracy and disclaims all liability with respect thereto.

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Noise Monitoring Program
2021 Annual Noise Monitoring Report
Vancouver Fraser Port Authority
File: 1924-22B-R0
2022-11-14

Prepared by:

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List of Abbreviations

Abbreviation/Acronym	Definition
ANSI	American National Standards Institute
BKL	BKL Consultants Ltd.
BSI	British Standards Institute
dB	decibel
dBA	A-weighted decibel
Hz	hertz
ISO	International Organization for Standardization
Ld	daytime equivalent sound level (7 am to 7 pm)
Lden	day-evening-night equivalent sound level
Le	evening equivalent sound level (7 pm to 10 pm)
Leq	equivalent sound level
Ln	nighttime equivalent sound level (10 pm to 7 am)
LFN	low frequency noise
NMP	noise monitoring program
NMT	noise monitoring terminal

Introduction

Noise monitoring reports are produced annually as a part of Vancouver Fraser Port Authority's noise monitoring program. The purpose of this annual report is to provide the following:

- information on the noise monitoring program and latest improvements;
- documentation of noise levels and number of noise events recorded at each noise monitoring terminal (NMT) over the 36-month period from December 1, 2018, to November 30, 2021; and
- comments on any observable noise level or event trends at any of the NMTs.

A glossary covering relevant acoustical terminology is provided in Appendix A.

An introduction to sound and environmental noise assessment is provided in Appendix B.

Port Noise Monitoring Program

Local communities have raised concerns regarding noise impacts associated with port activities. Examples of port-related noise include ship engine noise, truck noise, rail noise, and safety sirens. The port recognizes that operations create noises that can negatively impact adjacent communities and has therefore invested resources into better understanding the operational conditions and types of noises that can disturb local communities.

The port implemented a long-term noise monitoring program (NMP) in 2014 that involved the installation of permanent noise monitoring terminals (NMTs) to continually record sound data in or near communities potentially affected by port noise. The port has retained Brüel & Kjær (2014 to 2019) and Seti Media (2019 to present) to provide noise monitoring instrumentation and support, and utilizes their web interfaces to manage both the field hardware and application software. Currently, the NMTs are connected to a Seti Media web console where NMTs are controlled and data is displayed, saved, and exported. The port uses noise monitoring data and the web-based system to improve its ability to work with port users and tenants to manage noise.

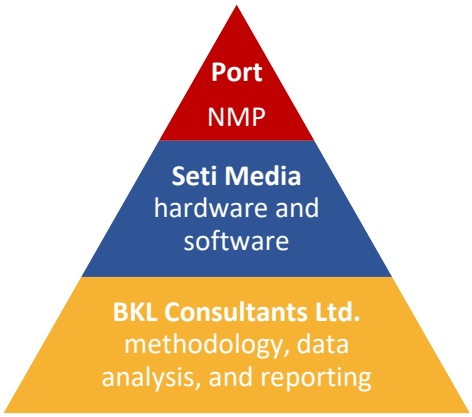


Figure 1 Roles and Responsibilities

BKL Consultants Ltd. (BKL), a Vancouver-based engineering firm that specializes in consulting services in acoustics, has been retained by the port to assist with managing and analyzing the data collected by the NMTs. BKL has been involved in developing the noise monitoring methodology, configuring the NMTs, exporting data from the web console, analyzing noise trends, and generating periodic noise reports.

Figure 2 illustrates some of the benefits of the NMP.

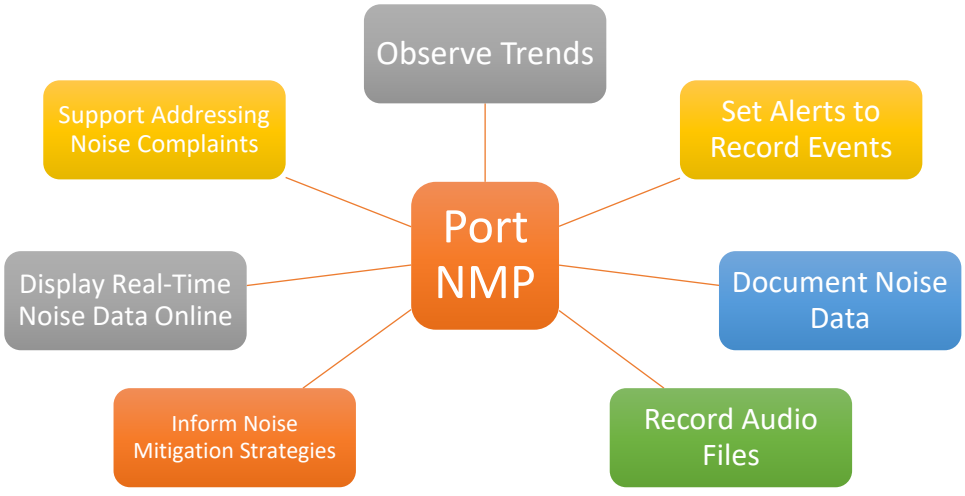


Figure 2 Noise Monitoring Program Benefits

Noise Monitoring Terminals

Noise Monitoring Terminals (NMTs) are sound level meters with the necessary accessories to allow for long term and continuous noise monitoring at a location. They have the following characteristics:

- acoustic conformance to class 1 requirements as defined by IEC 61672-1 (IEC 2013)
- a weather-proof and tamper-proof case that can be easily mounted to poles with a wide range of diameters
- a connection to permanent external power
- a battery that can provide temporary power during power outages
- a modem for data communications and streaming data to a web interface
- internal memory to back up most recent measurement data
- the capability of performing automatic internal calibration checks that include checking the microphone
- the capability of recording audio files to assist in remotely identifying noise events

In 2014, the port originally retained Brüel & Kjær to begin the installation of NMTs in select locations. 11 NMTs were installed at locations as shown in Figure 3 below. In summer 2019, all Brüel & Kjær NMTs were removed and the port retained Seti Media to install Larson Davis sound level monitors at the same locations, with the exception of two locations – CNV Queensbury and VAN Semlin. CNV Queensbury has been reinstalled and operational on July 21, 2020, at a new nearby location at the Spirit Trail approximately 125 metres southwest of the previous location. VAN Semlin has been reinstalled and operational on February 23, 2021 at the same location as it was at previously.

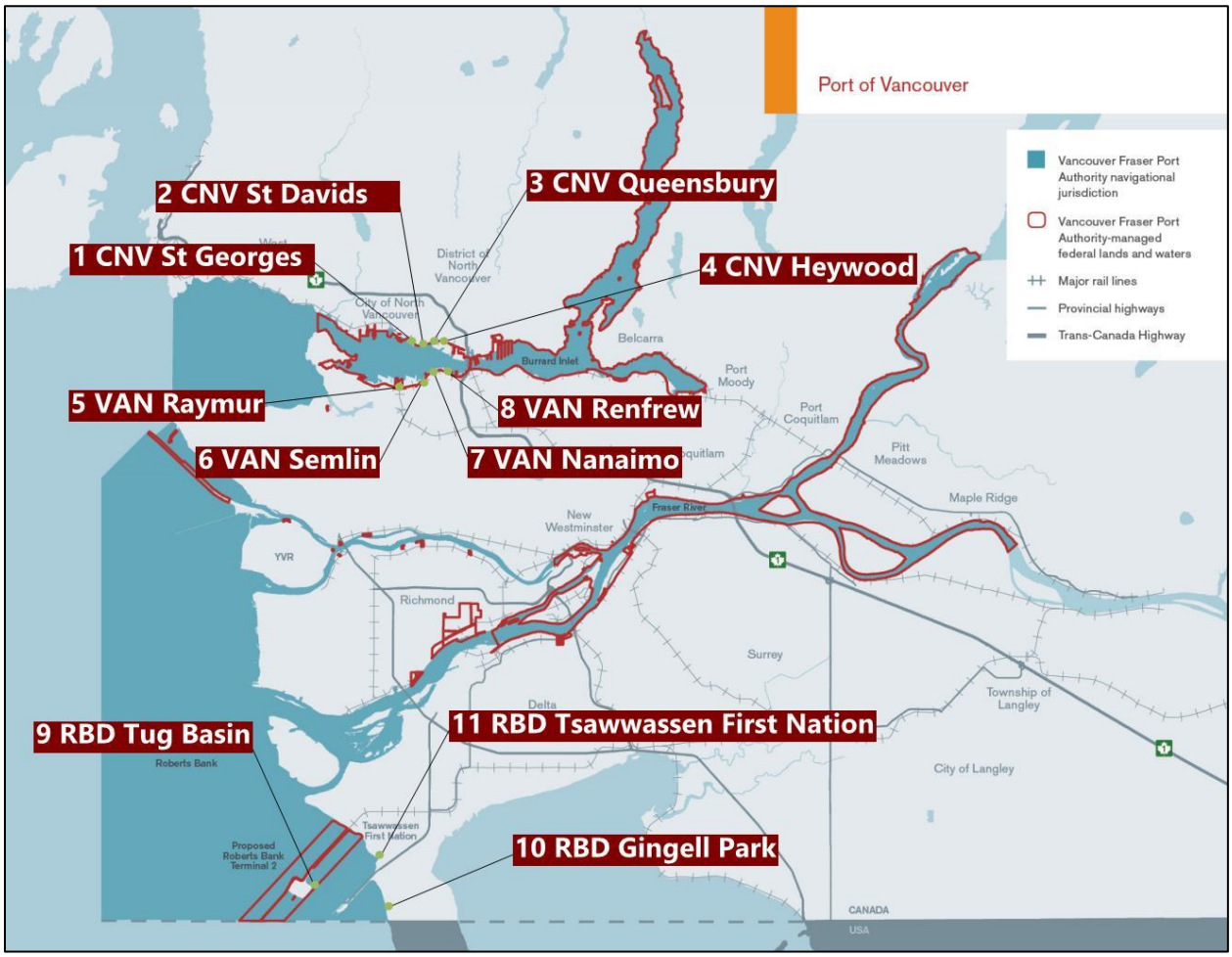


Figure 3 NMT Locations

Weather stations are also installed at CNV St Davids, VAN Nanaimo, and RBD Tug Basin.

Specific locations for each NMT were determined based on advice from technical experts along with community feedback. Efforts were made to locate each NMT to:

- be responsive to potential noise impacts identified by local residents and acoustical consultants; and
- meet operational constraints regarding land ownership, accessibility, site utilities, and security.

Some NMTs are not situated within the residential communities; the noise levels measured at these NMTs do not equate to noise levels experienced in the community. Each site is described in the Noise Monitoring Results section.

Seti Media Web Console

The Seti Media web console serves as the online control center for all the NMTs. Data from the NMTs are continuously streamed to the console. The application is used to view live and historical data, and export data.

While the web console is only accessible internally by the port, an online public website is available for viewing live and historical noise and weather data at each NMT, and listening to any audio clips recorded. Information about the web console and web access can be found at the following website: http://www.portvancouver.com/port-dashboard/noise-monitoring/.

Improvements are continually being made to the system to better track noise trends and events from port activities as the noise monitoring technology continues to be refined and developed.

Data Display

The Seti Media web console allows the user to select any NMT from a drop-down menu and display graphical information of the logged noise data. The details of the chart can be configured to show specific noise metrics, weightings, time range, and logging intervals.

Data Export

Additional details on noise and weather data that are not shown in the display can be exported to spreadsheet reports. These reports can be set up to be automatically generated at designated time intervals. While these data reports are only available internally to the port, upon request from the public or other stakeholders, they can be shared directly with interested parties.

Noise Alerts and Sound Clips

Noise alerts are set up internally by Seti Media. In the web console, noise alerts can only be reviewed. The alerts are set up to continually check the NMT data as it is logged for exceedances of particular static or dynamic noise thresholds. Alerts can be configured to monitor various noise metrics including equivalent, maximum, and minimum levels of broadband or frequency band-specific noise. When an exceedance occurs, an alert is created, and the alert name, time, location, exceeding value, and sound clip are recorded and documented. In this way, the web console can automatically log the occurrences of particular noise events, provided that it is adequately set up to flag the particular noise characteristics belonging to noise events of interest.

Noise Monitoring Reporting

Noise monitoring reporting includes the information summarized in Figure 4. The methodology used to define the noise levels and events are described in the sections below.

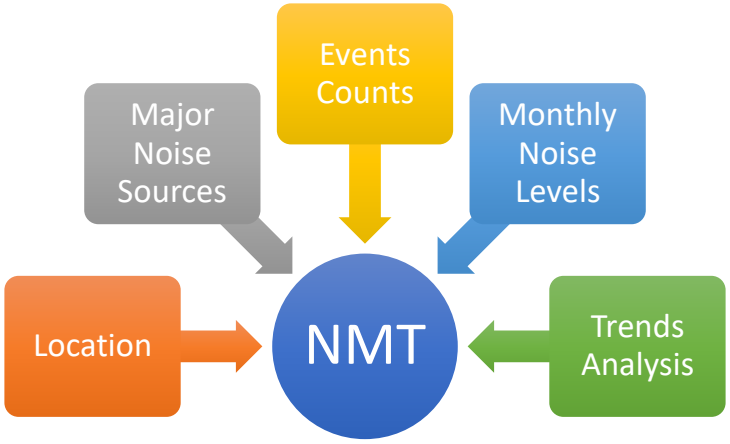


Figure 4 NMT Report Information

Noise Levels

While the decibel or A-weighted decibel is the basic unit used for noise measurement, specific sound metrics are used to appropriately quantify noise and its corresponding potential for disturbing the adjacent community. Figure 5 summarizes the two noise level metrics chosen for reporting in accordance with best practice (ANSI 2007, WG-AEN 2007). General noise theory and basic sound metrics can be found in Appendix B.

Day-Evening-Night Equivalent Sound Level, *Lden* (dBA)

- 24-hour time-averaged noise level commonly used to represent community annoyance when measured at community locations.
- 5 dBA penalty applied to evening period to represent increased community annoyance during evening periods (7 pm to 10 pm).
- 10 dBA penalty applied to night period to represent increased community annoyance during night periods (10 pm to 7 am).

Nighttime Equivalent Sound Level, *Ln* (dBA)

- Night period (10 pm to 7 am) time-averaged noise level commonly used to represent potential for sleep disturbance when measured at community locations.

Figure 5 Noise Monitoring Metrics

Noise Events

Alerts have been defined for each NMT for the purpose of warning against potential community noise complaints. The web console reviews the time-averaged noise data over 60-minute intervals during the day and over 15-minute intervals during the night, in accordance with British Standard BS 4142:2014, "Methods for rating and assessing industrial and commercial sound" (BSI 2014), and triggers alerts when higher-than-typical noise levels are recorded.

The alerts trigger when a noise level exceeds a pre-set threshold. The thresholds depend on the background noise level measured on different days of the week and times of the day. The process BKL used to calculate each threshold is summarized in Figure 6.

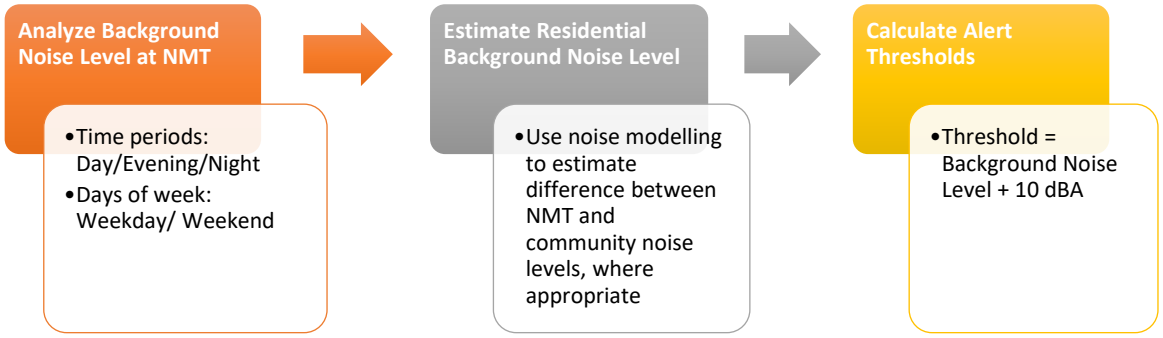


Figure 6 Process Used to Define Noise Events

At Roberts Bank, most port-related noise is quieter than local ambient noise levels in the nearest communities. Since high-frequency sound is more rapidly absorbed by the atmosphere compared to low-frequency sound, disturbance to these communities has typically been due to low-frequency noise (LFN) from sources such as shipboard generators. Hence, alerts for the Roberts Bank NMTs in the community are set to monitor LFN levels only and are validated by confirming that high levels of LFN were also measured simultaneously at the NMT located near the terminals.

Noise Monitoring Results

The data sheets on the following pages provide an overview of each NMT, a summary of the noise data and events logged since December 2018, a comparison of 2021[1] to 2020[2] noise levels, and commentary on any observable trends over the past 36 months. In 2021, VAN Semlin was offline between June 2019 and February 2021, due to delays in finding a suitable location for installation.

For the north shore NMTs (Locations 1 to 4), noise levels recorded in 2021 were similar to or slightly lower than those measured in 2020, except for CNV St Davids where noise levels have slightly increased. Minimal events were recorded, which is similar to 2020.

For the south shore NMTs (Locations 5 to 8), noise levels recorded in 2021 were similar to or slightly lower than those measured in 2020. Minimal events were recorded, which is similar to 2020. Most events of the south shore were recorded at VAN Renfrew.

For the Roberts Bank NMTs (Locations 9 to 11), noise levels recorded in 2021 were similar or slightly higher than those measured in 2020.

[1] The 2021 measurement period corresponds to noise levels measured from December 1, 2020, to November 30, 2021.
[2] The 2020 measurement period corresponds to noise levels measured from December 1, 2019, to November 30, 2020.

NMT Location 1: CNV St Georges

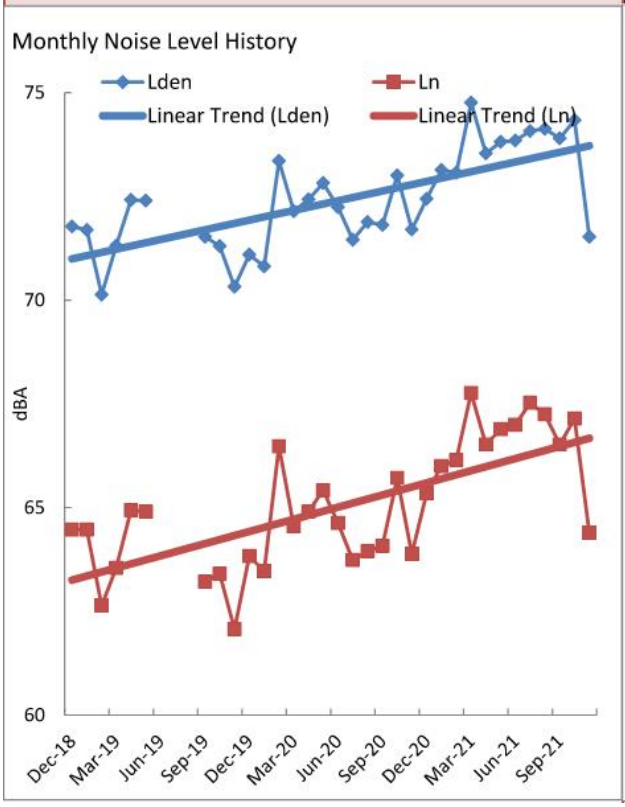
Location: Near intersection of St Georges Ave and Victory Ship Way, North Vancouver.
Dominant Noise Sources: Rail activity, substation fan, Esplanade Ave traffic, nearby trucks, and sandblasting at Vancouver Drydock.
Community Noise Levels Comparison: NMT noise levels are approximately four times (~20 dBA) louder than those experienced at nearest residences due to the close proximity of the rail line to the NMT and relative distance to nearest dwellings.

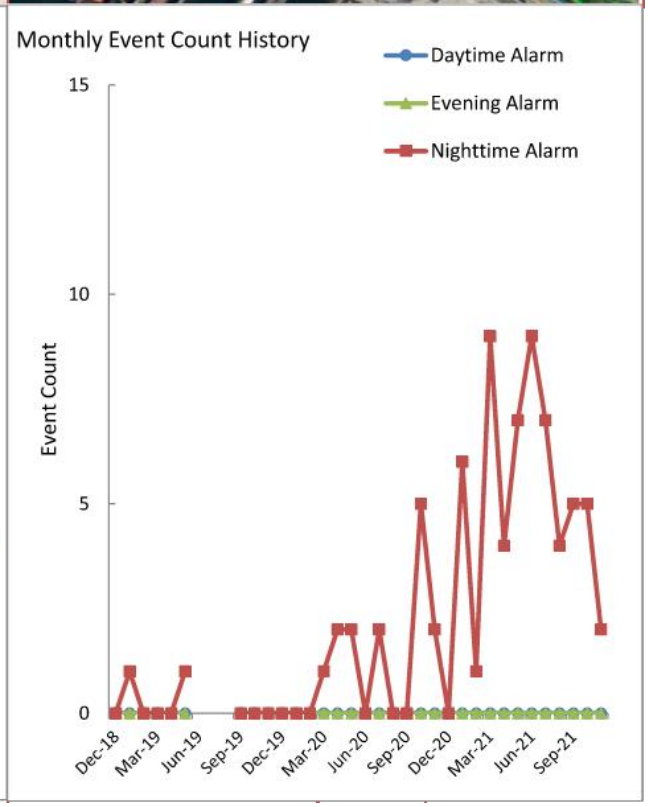
No data available between June and August 2019.

Event Commentary:
There were minimal alerts generated at this site and most alerts were generated during nighttime.

Noise Level Commentary:
In the past year, monthly noise levels had noticeable fluctuations. Compared to 2020 overall noise levels, the 2021 Lden increased by 1.5 dBA and Ln increased by 2 dBA.

From December 2018 to December 2021, the long-term trend in Lden increased by 3 dBA and Ln increased by 3.5 dBA.





NMT Location 2: CNV St Davids

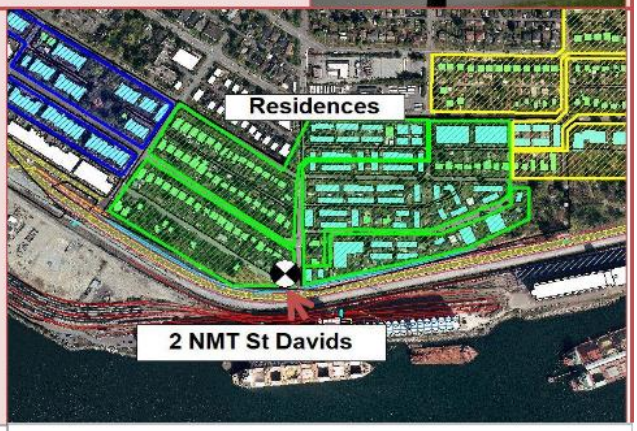
Location: Near intersection of St Davids Ave and Alder St, North Vancouver.
Dominant Noise Sources: Low Level Road traffic, rail activities (passbys, shunting, and rail squeal) and Richardson Terminal activity.
Community Noise Levels Comparison: NMT noise levels are very similar to those experienced at residences closest to the port.

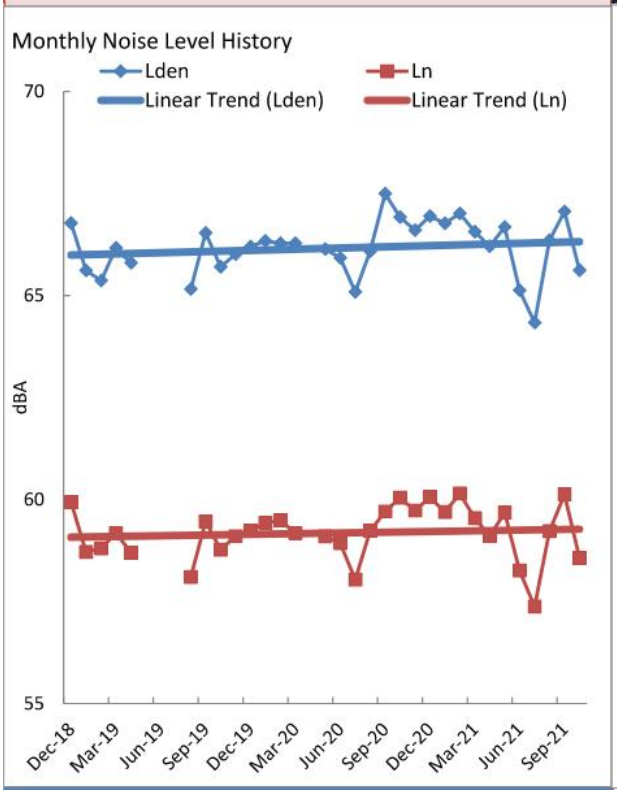
No data available between June and August 2019.

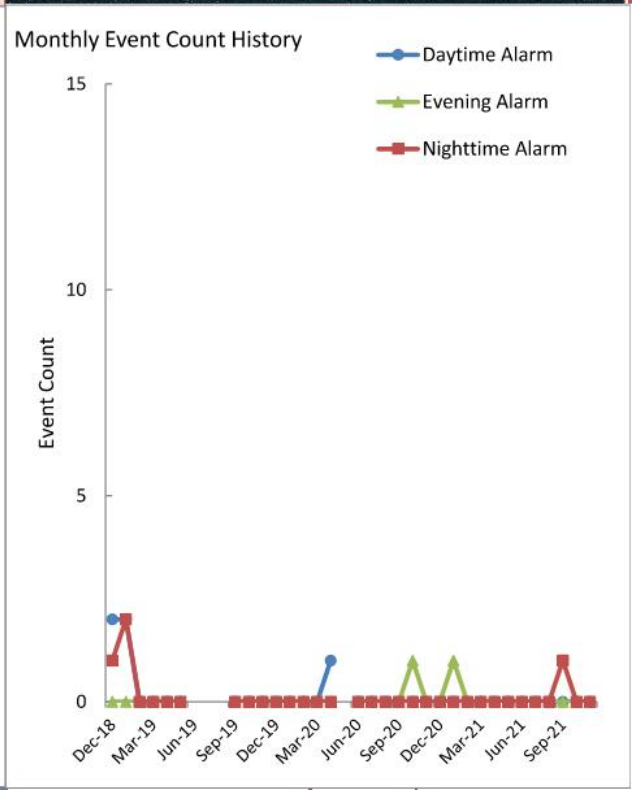
Event Commentary:
There were minimal alerts generated at this site and most alerts were generated in the daytime. There was no clear trend for any of the alerts.

Noise Level Commentary:
In the past year, monthly noise levels did not fluctuate significantly. Compared to 2020 overall noise levels, the 2021 Lden and Ln both did not change

From December 2018 to December 2021, the long-term trend in Lden increased by 0.5 dBA and Ln remained the same.







NMT Location 3: CNV Queensbury

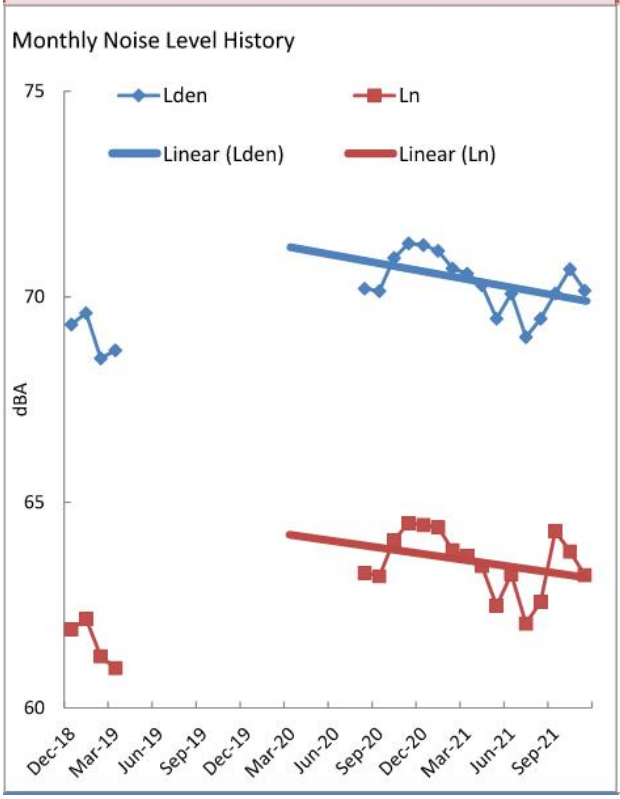
Location: Spirit Trail near E 3rd Street and Queensbury Avenue, North Vancouver.
Dominant Noise Sources: Cargill Terminal activity, rail activities (passbys and rail squeal), Low Level Road traffic, and East 3rd Street traffic.
Community Noise Level Comparison: Noise levels at NMT are slightly higher (~4 dBA) than experienced at nearest residences.

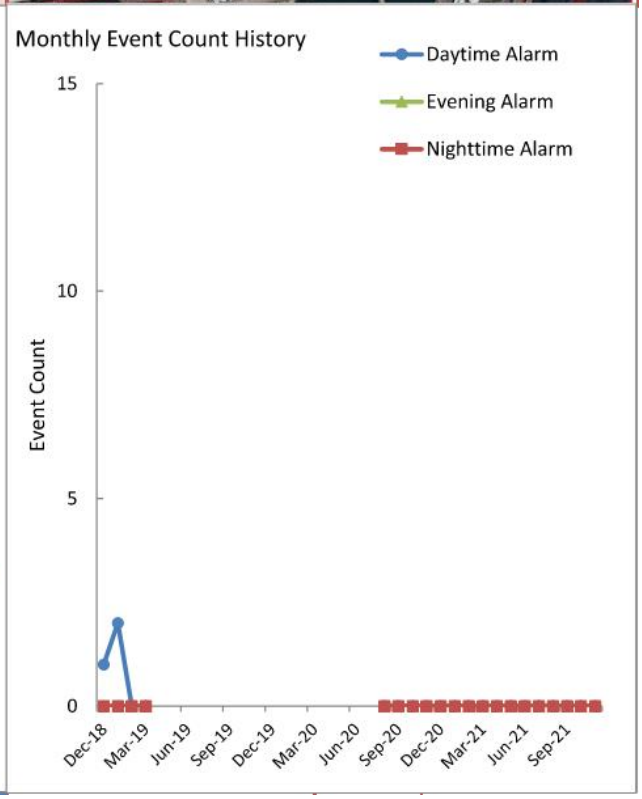
No data available between April 2019 and July 2020.
With NMT relocated to current location in July 2020, new trend line was established.

Event Commentary:
There were minimal alerts generated at this site and most alerts were generated in the daytime. There was no clear trend for any of the alerts.

Noise Level Commentary:
Since the NMT was reinstalled, monthly noise levels increased due to it being closer to Cargill Terminal and Low Level Road compared to the previous location.

From August 2020 to December 2021, the long-term trend in Lden decreased by 2.5 dBA and Ln decreased by 2 dBA.





NMT Location 4: CNV Heywood

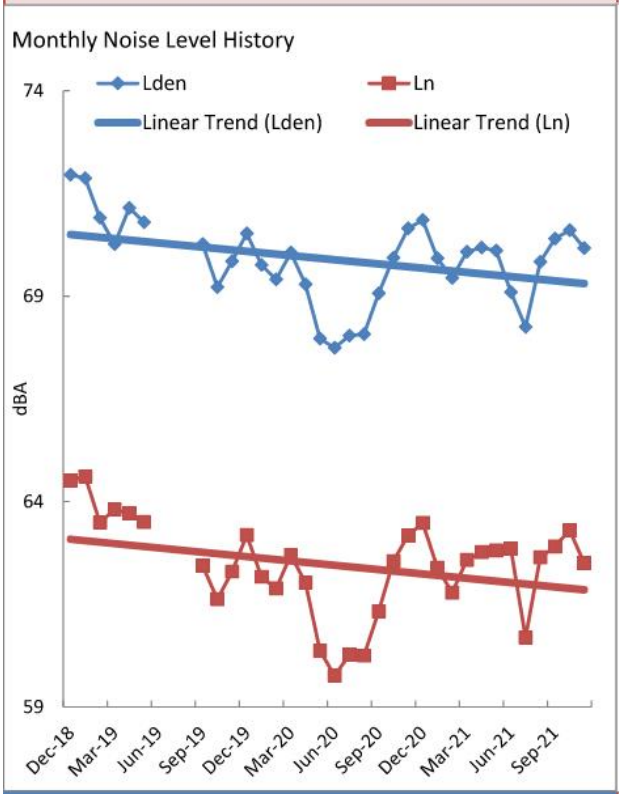
Location: Near intersection of Heywood St and 3rd St E, North Vancouver.
Dominant Noise Sources: East 3rd Street traffic, rail activities (shunts, rail squeal, passbys), Low Level Road traffic, Neptune Bulk Terminals and Cargill Terminal activity.
Community Noise Level Comparison: Noise levels at NMT are slightly higher (~3 dBA) than experienced at nearest residences.

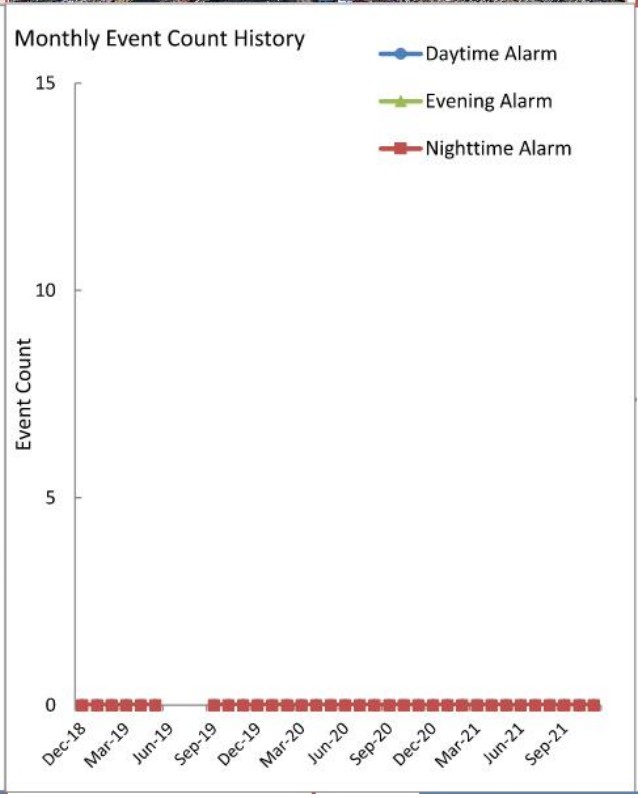
No data available between June and August 2019.

Event Commentary:
There were minimal alerts generated at this site. There was no clear trend for any of the alerts.

Noise Level Commentary:
In the past year, monthly noise levels did not fluctuate significantly. Compared to 2020 overall noise levels, the 2021 Lden increased by 0.5 dBA and Ln increased by 1 dBA

From December 2018 to December 2021, the long-term trend in Lden decreased by 1 dBA and Ln decreased by 1.5 dBA.





NMT Location 5: VAN Raymur

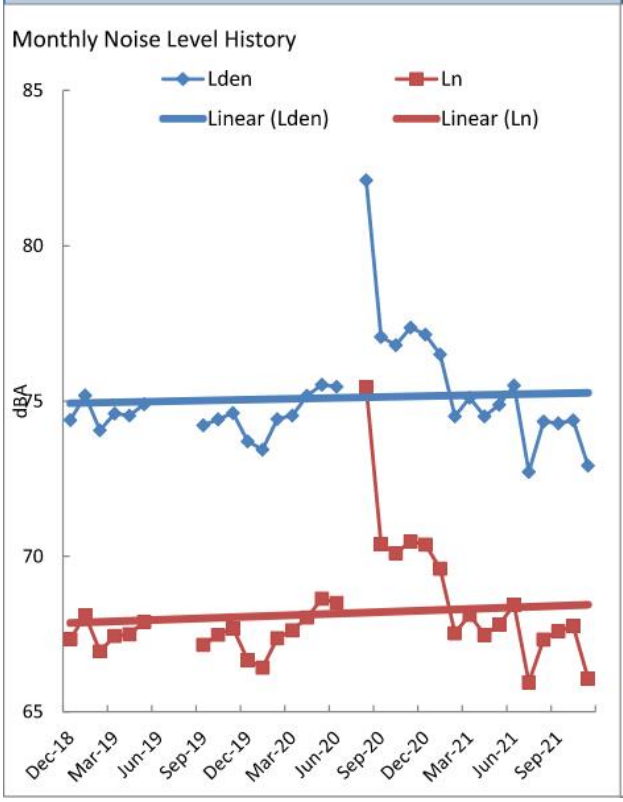
Location: Near Centennial Rd where it transitions to Stewart St, Vancouver.
Dominant Noise Sources: Rail activities (passbys, rail squeal) and Stewart St truck traffic.
Community Noise Level Comparison: Noise levels at NMT are approximately four times louder (~20 dBA) than those experienced at nearest residences due to the close proximity of Stewart Street and the rail lines to the NMT and relative distance to nearest dwellings.

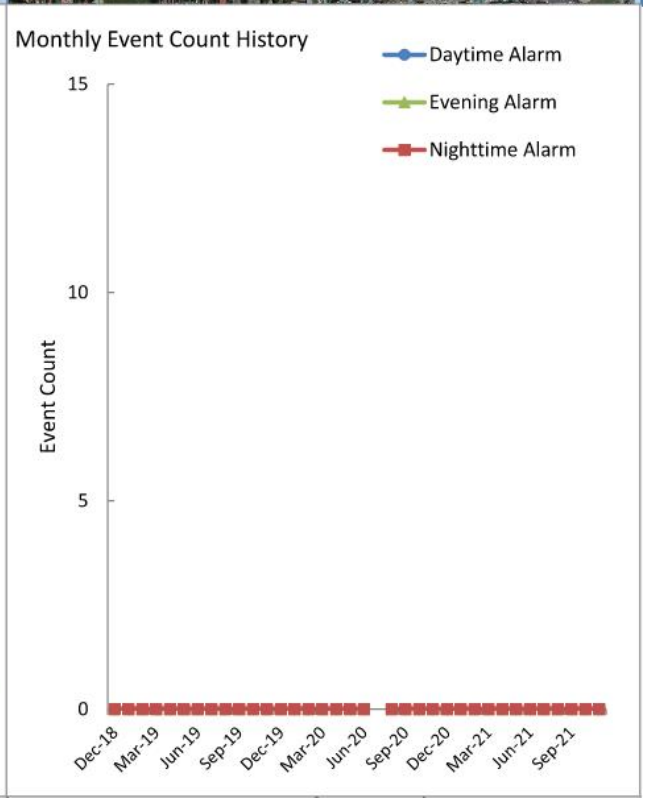
No data available between June and August 2019 and between June and July 2020.

Event Commentary:
There were no alerts generated at this site because measured noise levels never deviated from the typical noise levels estimated in the community.

Noise Level Commentary:
In the past year, monthly noise levels had noticeable fluctuations. Compared to 2020 overall noise levels, the 2021 Lden decreased by 1.5 dBA and Ln decreased by 2 dBA

From December 2018 to December 2021, the long-term trend in Lden increased by 0.5 dBA and Ln increased by 0.5 dBA. Ignoring the Augus 2020 outlier the long-term trend in Lden remained the same and Ln increased by 0.5 dBA.





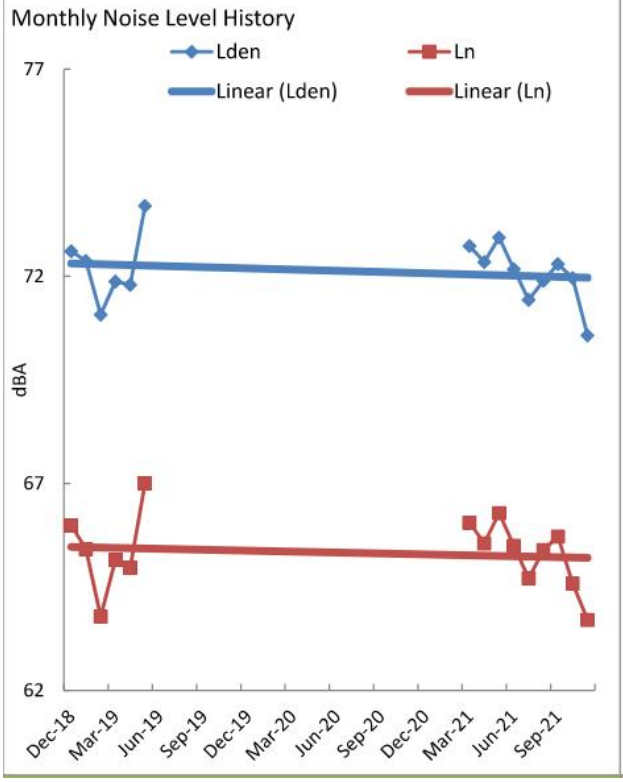
NMT Location 6: VAN Semlin

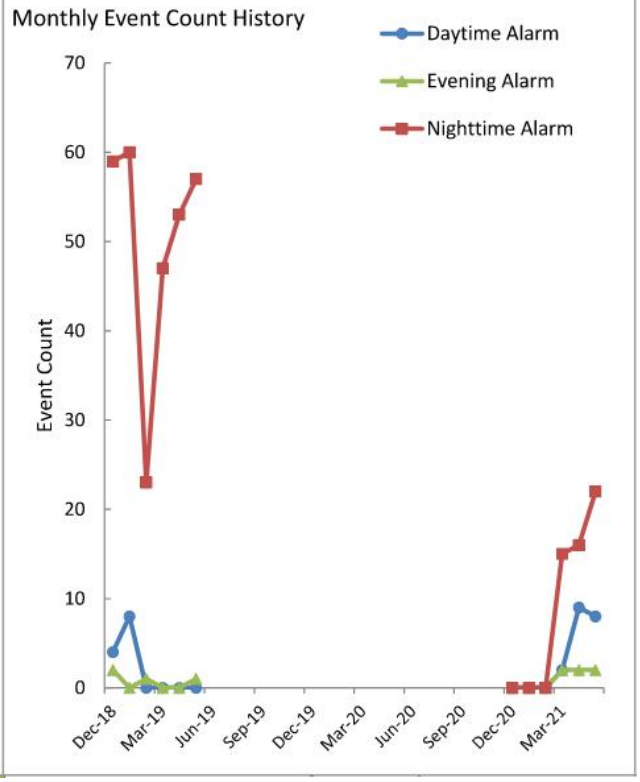
Location: Cambridge Park near Wall St, Vancouver.
Dominant Noise Sources: Rail activities (passbys, rail squeal) and Commissioner Street truck traffic.
Community Noise Level Comparison: Noise levels at NMT are very similar to those experienced at nearest residences.

No data available since June 2019, until February 2021, when the NMT was reinstalled.

Event Commentary:
There were minimal alerts generated at this site in 2021. Most Alertas were generated at night time.

Noise Level Commentary:
From December 2018 to December 2021, the long-term trend in Lden decreased by 0.5 dBA and Ln decreased by 0.5 dBA.





NMT Location 7: VAN Nanaimo

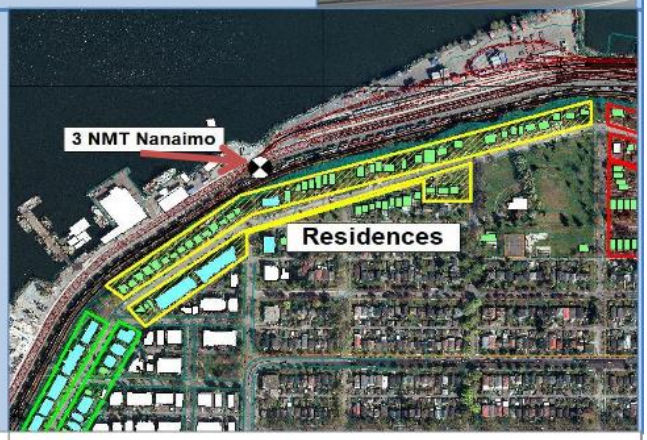
Location: Commissioner St near N Nanaimo St, Vancouver.
Dominant Noise Sources: Rail activities (passbys, rail squeal) and Commissioner Street truck traffic.
Community Noise Level Comparison: Noise levels at NMT are noticeably louder (~6 dBA) than those experienced at nearest residences.

Data between June-Aug 2019 unavailable due to switch over.

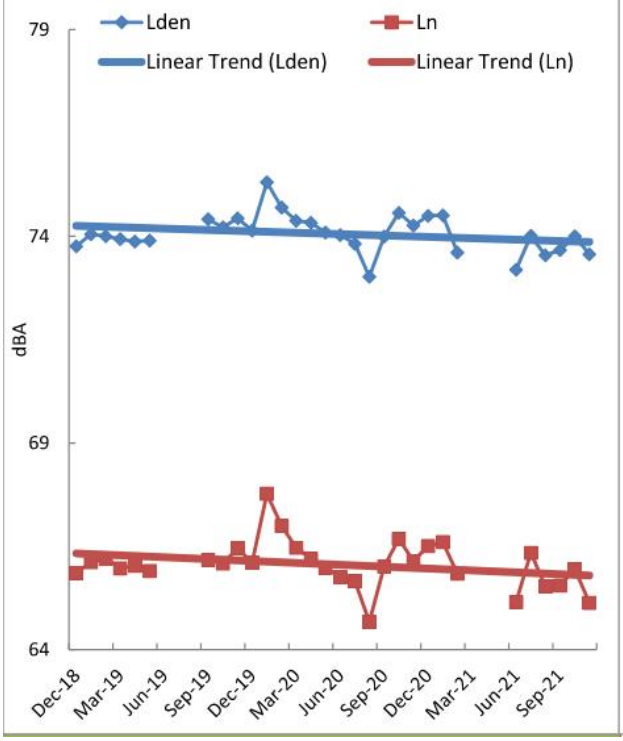
Event Commentary:
There were minimal alerts generated at this site. There was no clear trend for any of the alerts.

Noise Level Commentary:
In the past year, monthly noise levels had noticeable fluctuations. Compared to 2020 overall noise levels, the 2021 Lden and Ln both decreased by 0.5 dBA

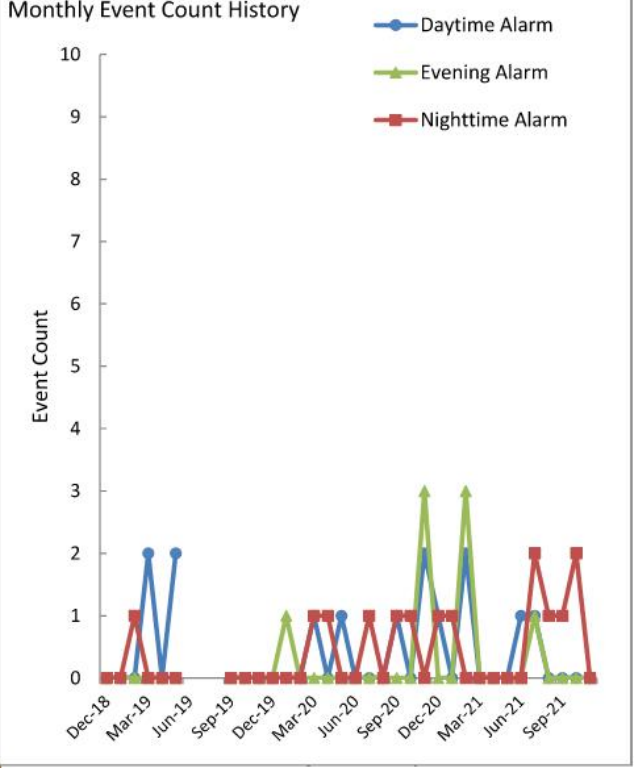
From December 2018 to December 2021, the long-term trend in Lden decreased by 1 dBA and Ln decreased by 1 dBA.



Monthly Noise Level History



Monthly Event Count History



NMT Location 8: VAN Renfrew

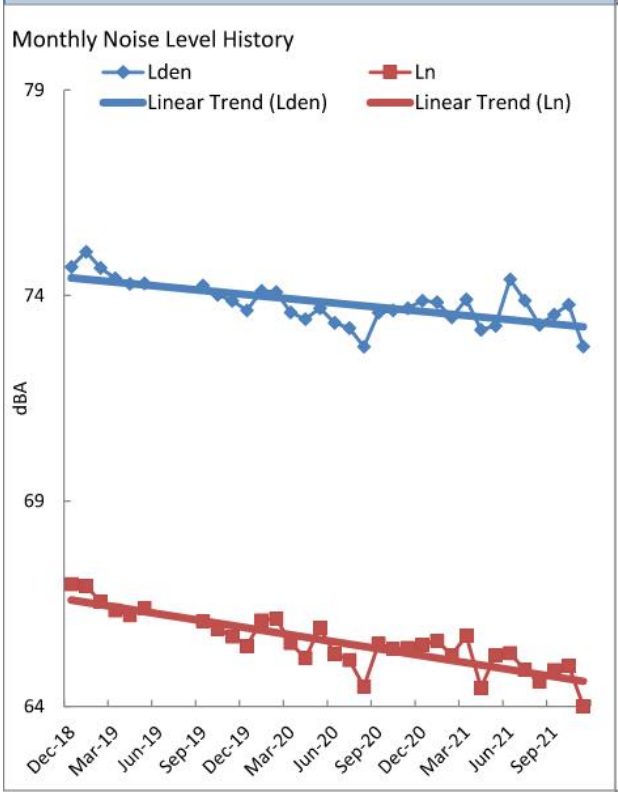
Location: Commissioner St near N Renfrew St, Vancouver.
Dominant Noise Sources: Commissioner Street truck traffic accelerating away from gates, rail activities (passbys and rail squeal).
Community Noise Level Comparison: Noise levels at NMT are slightly higher (~3 dBA) than experienced at nearest residences.

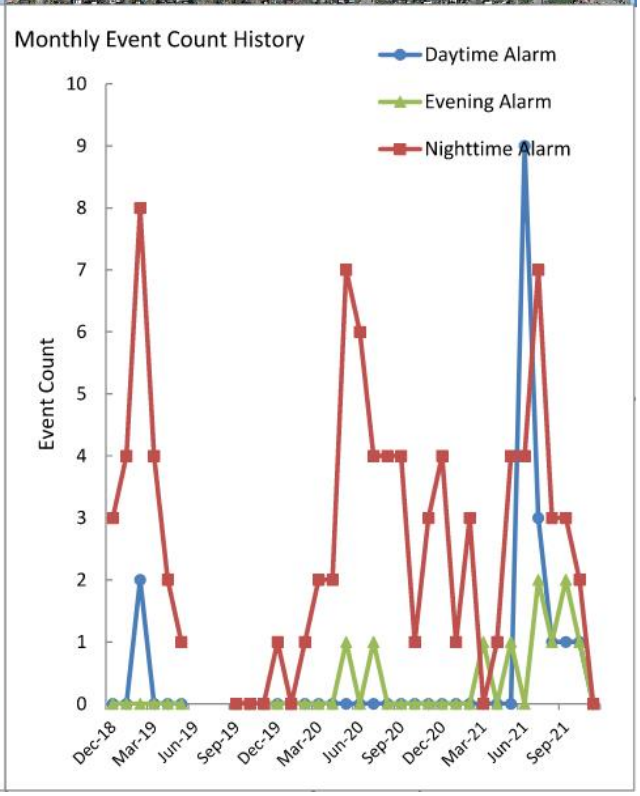
Data between June-Aug 2019 unavailable due to switch over.

Event Commentary:
There were minimal alerts generated at this site in 2021. Most Alertas were generated at night time.

Noise Level Commentary:
In the past year, monthly noise levels did not fluctuate significantly. Compared to 2020 overall noise levels, the 2021 Lden did not change and Ln decreased by 0.5 dBA

From December 2018 to December 2021, the long-term trend in Lden decreased by 1 dBA and Ln decreased by 2 dBA.





NMT Location 9: RBD Tug Basin

Location: Northeast corner of Deltaport Terminals, Delta. Monitoring analysis began in Dec 2015.
Dominant Noise Sources: Deltaport Terminals activity.
Community Noise Level Comparison: Noise levels at NMT are significantly higher than those experienced at nearest residences as this NMT is located at the terminal.

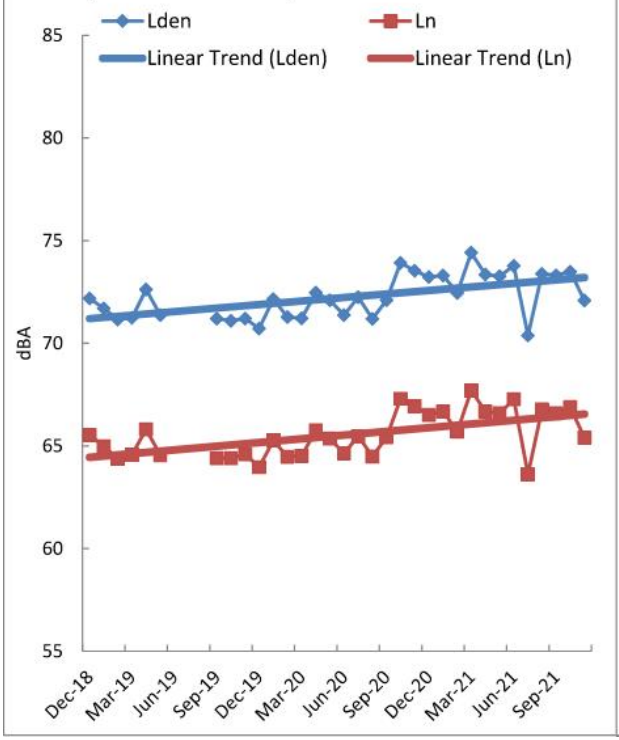
Data between June-Aug 2019 unavailable due to switch over.

Event Commentary:
Events are not counted at this NMT as it does not represent any residences. NMT is used to confirm port noise events for alerts generated at other RBD NMTs.

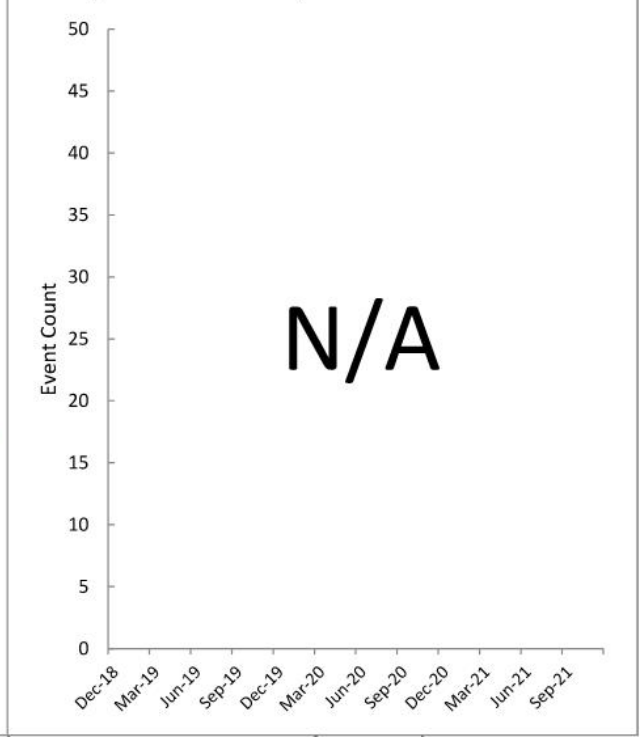
Noise Level Commentary:
In the past year, monthly noise levels had noticeable fluctuations. Compared to 2020 overall noise levels, the 2021 Lden and Ln both increased by 1 dBA

From December 2018 to December 2021, the long-term trend in Lden increased by 2 dBA and Ln increased by 2 dBA.

Monthly Noise Level History

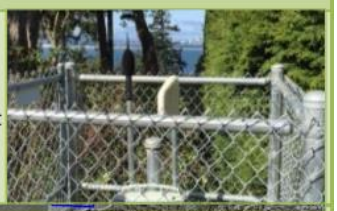


Monthly Event Count History



NMT Location 10: RBD Gingell Park

Location: Fred Gingell Park near English Bluff Rd, Delta. Monitoring analysis began in Dec 2015.
Dominant Noise Sources: Local sources such as traffic, Tsawwassen Ferry, and Deltaport terminals activity.
Community Noise Level Comparison: Noise levels at NMT are very similar to those experienced at nearest residences.

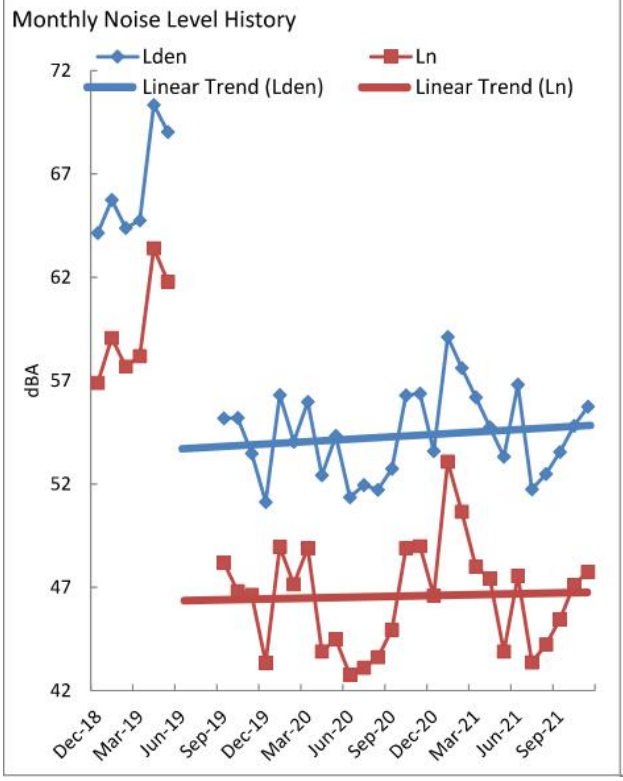


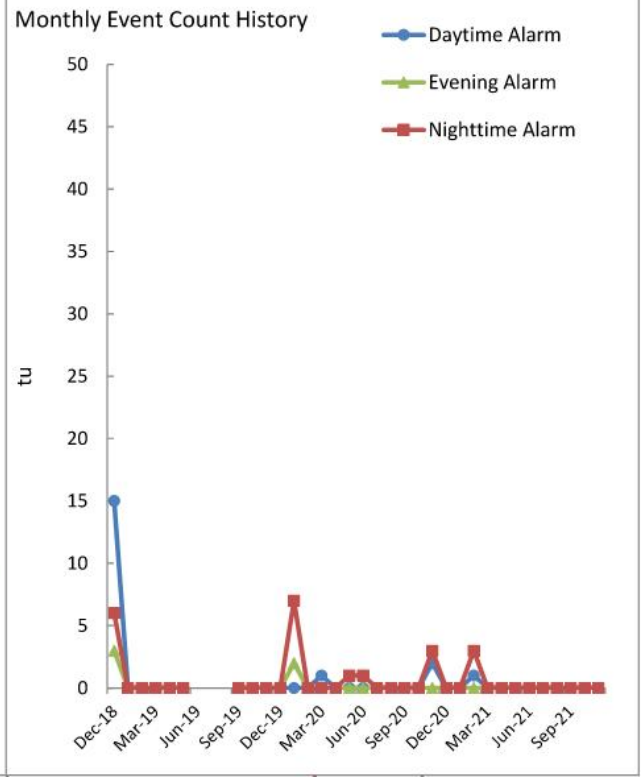
Data between June-Aug 2019 unavailable due to switch over. The loud period between August 2018 and May 2019 was not excluded from the trendline.

Event Commentary:
There were minimal alerts generated at this site. There was no clear trend for any of the alerts.

Noise Level Commentary:
In the past year, monthly noise levels had noticeable fluctuations. Compared to 2020 overall noise levels, the 2021 Lden and Ln both increased by 1.5 dBA.

From September 2019 to December 2021, the long-term trend in Lden increased by 1.5 dBA and Ln increased by 0.5 dBA.





NMT Location 11: RBD Tsawwassen First Nation

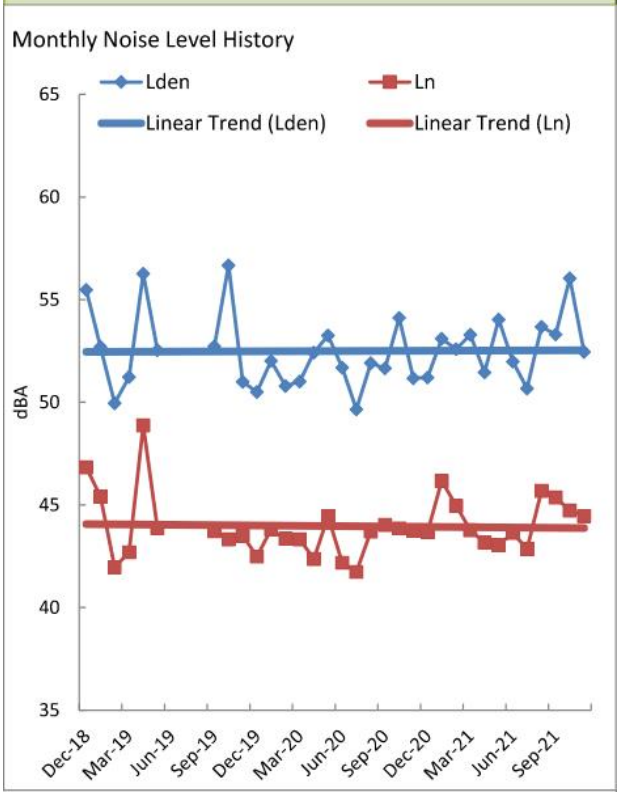
Location: Near intersection of Tsawwassen Dr N and Blue Heron Dr, Delta. Monitoring began in Feb 2016.
Dominant Noise Sources: Highway 17, Tsawwassen Ferry, and Deltaport terminals activity.
Community Noise Level Comparison: Noise levels at NMT are very similar to those experienced at nearest residences.

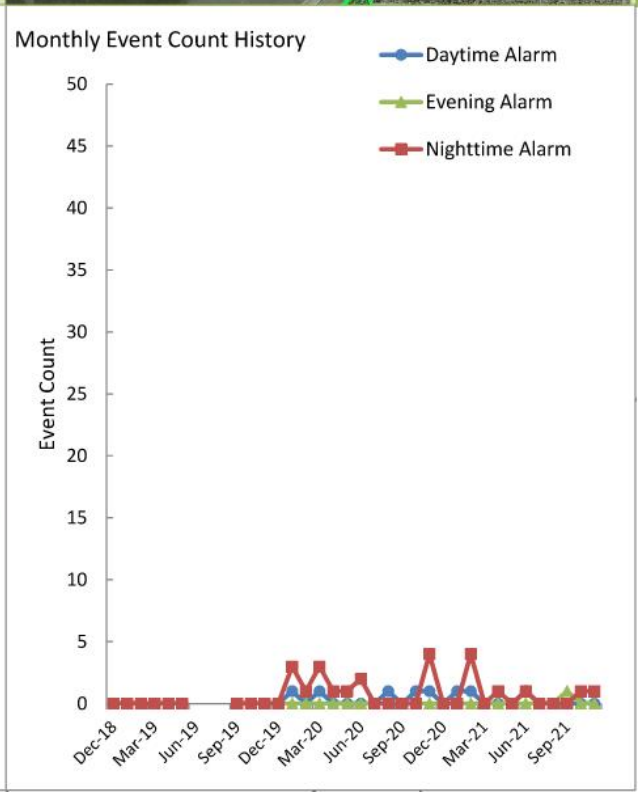
Data between June-Aug 2019 unavailable due to switch over.

Event Commentary:
There were minimal alerts generated at this site. There was no clear trend for any of the alerts.

Noise Level Commentary:
In the past year, monthly noise levels had noticeable fluctuations. Compared to 2020 overall noise levels, the 2021 Lden increased by 1.5 dBA and Ln increased by 1 dBA

From December 2017 to December 2021, the long-term trend in Lden and Ln remained the same





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Appendix A: Glossary

A-weighting (dBA) – A standardized filter used to alter the sensitivity of a sound level meter with respect to frequency so that the instrument is less sensitive at low and high frequencies where the human ear is less sensitive.

background sound level (L_{90}) - A-weighted sound level that is exceeded for 90% of a given time interval.

day-evening-night equivalent sound level (Lden) – The sound exposure level for a 24-hour day calculated by logarithmically adding the sound exposure level obtained during the daytime (*Ld*) (7 am to 7 pm) to 5 times the sound exposure level obtained during the evening (*Le*) (7 pm to 10 pm) and to 10 times the sound exposure level obtained during the nighttime (*Ln*) (10 pm to 7 am) to account for greater human sensitivity to evening and nighttime noise.

daytime equivalent sound level (Ld) - The equivalent sound level over daytime hours (7 am to 7 pm).

decibel (dB) – The standard unit of measurement for sound pressure and sound power levels. It is the unit of level which denotes the ratio between two quantities that are proportional to pressure or power. The decibel is 10 times the logarithm of this ratio. The reference pressure used for airborne sound is 20 µPa while the typical reference pressure used for underwater sound is 1 µPa.

equivalent sound level (Leq) - The steady level that, within a specified time interval, would contain the same amount of energy as the actual time-varying level. Although it is, in a sense, an "average", it is strongly influenced by the loudest events because they contain the majority of the energy.

evening equivalent sound level (Le) – The equivalent sound level over evening hours (7 pm to 10 pm).

frequency – Analogous to musical pitch, the basic unit for measuring frequency is the number of cycles per second, or Hertz (Hz), where bass tones are low frequency/low Hertz values and treble tones are high frequency/high Hertz values. Audible sound occurs over a wide frequency range, from approximately 15 Hz to 20,000 Hz.

frequency spectrum – Distribution of frequency components of a noise or vibration signal.

Hertz (Hz) – The unit of acoustic or vibration frequency representing the number of cycles per second.

low frequency equivalent sound level (LLF) – The low frequency equivalent sound level as defined in ANSI S12.9 Part 4 – 2005 (ANSI 2005).

low frequency noise (LFN) – Sound containing frequencies of interest within the range covering the one-third octave bands from 10 Hz to 200 Hz.

metric – Measurement parameter or descriptor.

nighttime equivalent sound level (Ln) - The equivalent sound level over the nighttime hours (10 pm to 7 am).

noise - Noise is unwanted sound, which carries no useful information and tends to interfere with the ability to receive and interpret useful sound.

octave bands – A standardized division of a frequency spectrum in which the interval between two divisions is a frequency ratio of 2.

one-third octave bands – A standardized division of a frequency spectrum in which the octave bands are divided into thirds for more detailed information. The interval between center frequencies is a ratio of 1.25.

overall or total sound – Totally encompassing sound in a given situation at a given time, usually composed of sound from many sources near and far, see below figure.

receiver – A noise-sensitive stationary position at which noise levels are received.

reference time interval – Time interval to which the rating level is referred, e.g., the reference time interval for the *Lden* is 24 hours.

residual sound – Sound remaining at a given position in a given situation when the specific sounds under consideration are suppressed, see below figure.

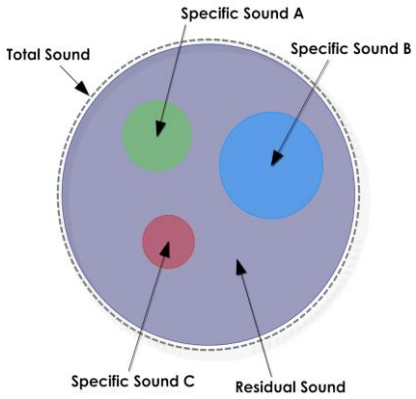
sound – The fluctuating motion of air or other elastic medium which can produce the sensation of sound when incident upon the ear.

sound level – The level of sound pressure measured with a sound level meter and one of its weighting networks. When A-weighting is used, the sound level is given in dBA.

sound level meter – An electronic instrument for measuring the sound level in accordance with accepted national or international standards.

sound source – The means by which a sound is produced through the vibration of a physical object.

specific sound – Component of the total sound that can be specifically identified and which is associated with a specific sound source, see below figure.



Relationship between Total, Specific, and Residual Sound

Appendix B: Introduction to Sound and Environmental Noise Assessment

General Noise Theory

The two principal components used to characterize sound are loudness (magnitude) and pitch (frequency). The basic unit for measuring magnitude is the decibel (dB), which represents a logarithmic ratio of the pressure fluctuations in air relative to a reference pressure. The basic unit for measuring pitch is the number of cycles per second, or hertz (Hz). Bass tones are low frequency and treble tones are high frequency. Audible sound occurs over a wide frequency range, from approximately 20 Hz to 20,000 Hz, but the human ear is less sensitive to low and very high frequency sounds than to sounds in the mid frequency range (500 to 4,000 Hz). “A-weighting” networks are commonly employed in sound level meters to simulate the frequency response of human hearing, and A-weighted sound levels are often designated “dBA” rather than “dB.”

If a continuous sound has an abrupt change in level of 3 dB it will generally be noticed while the same change in level over an extended period of time will probably go unnoticed. A change of 6 dB is clearly noticeable subjectively and an increase of 10 dB is generally perceived as being twice as loud.

Sound levels theoretically reduce by 6 dB every time the distance from a point source to the receiver is doubled due to geometric spreading of the sound energy. In practice, the propagation of sound can also be affected by the nature of the intervening terrain and ground cover, weather effects, sound reflections, etc.

Basic Sound Metrics

While the decibel or A-weighted decibel is the basic unit used for noise measurement, other indices are also used to describe environmental noise. The Equivalent Sound Level, abbreviated Leq, is commonly used to indicate the average sound level over a period of time. The Leq represents the steady level of sound which would contain the same amount of sound energy as the actual time-varying sound level. Although the Leq is an average, it is strongly influenced by the loudest events occurring during the time period, because these loudest events contain most of the sound energy. Another common metric used is the L90, which represents the sound level exceeded for 90% of a time interval and is typically referred to as the background noise level.

The Leq can be measured over any period of time using an integrating sound level meter. Some common time periods used are 24 hours, noted as the Leq24, daytime hours (07:00 to 19:00), noted as the Ld, evening hours (19:00 to 23:00), notes as the Le, and nighttime hours (23:00 to 07:00), noted as the Ln. As the impact of noise on people is judged differently during the daytime, evening and nighttime, 24-hour noise metrics have been developed that reflect this.

The day-evening-night equivalent sound level (Lden) is one metric commonly used to represent community noise levels. It is derived from the Ld, Le and Ln with a 5 dB penalty applied to the Le and a 10 dB penalty applied to the Ln to account for increased sensitivity to evening and nighttime noise.

Human Annoyance to Noise

Noise is generally defined as "unwanted sound", which carries no useful information and tends to interfere with activities or the ability to receive and interpret useful sound. The intrusiveness and potential disturbance caused by noise depends largely upon the background noise level that exists when the noise occurs. However, the response to noise is subjective and depends on other factors such as the absolute level of sound, the time of day, local attitudes to the premises and expectations for quiet by the individual.

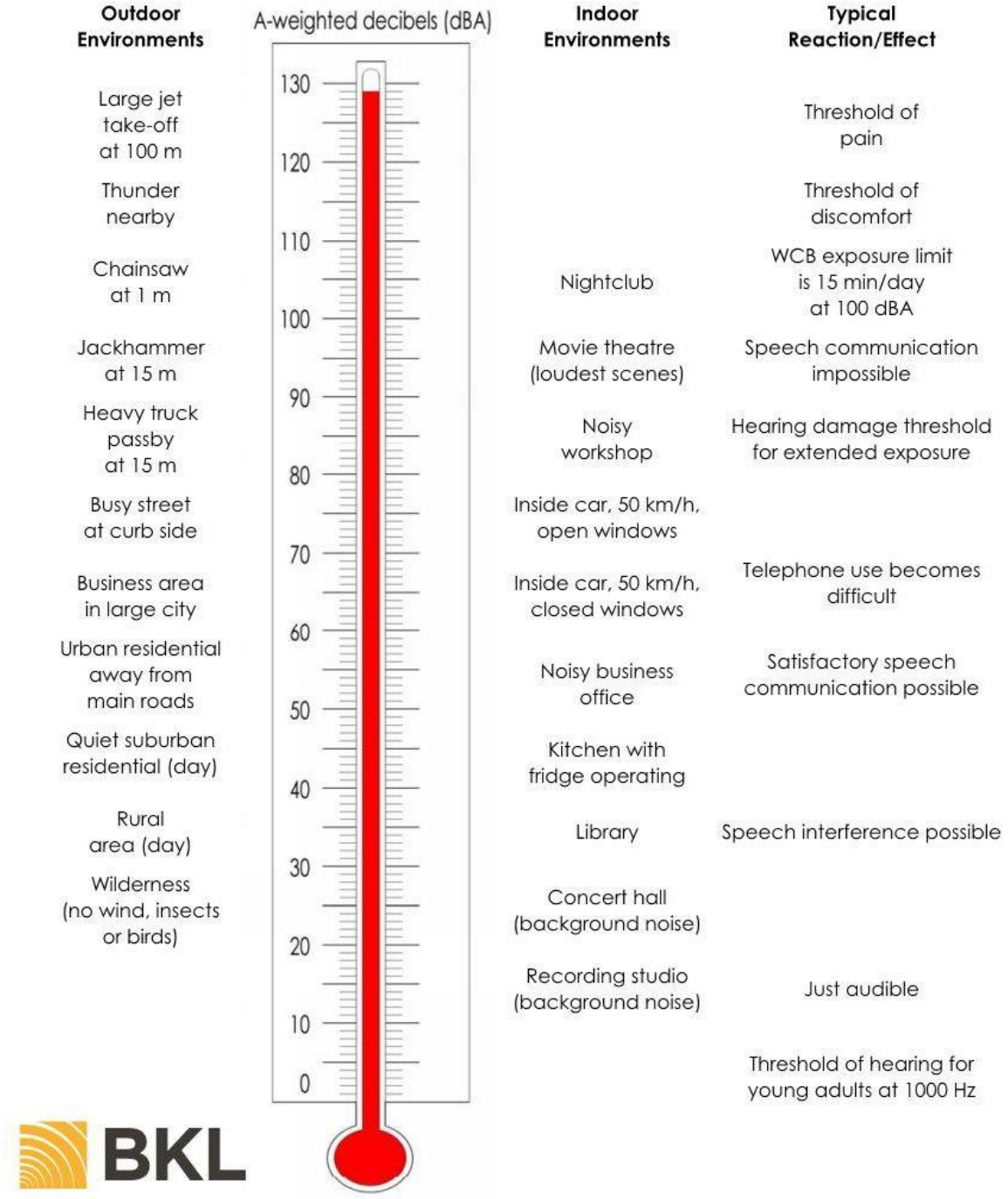
Studies have consistently shown that an increase in noise in a community will bring an increase to the amount of people who are highly annoyed (ISO 2016). However, the sound pressure level is not the only factor in how annoying noise is. The type of noise, or the quality of it, can also greatly affect how annoying the sound is perceived. In general, tonal, impulsive or sounds with excessive low frequency content can all increase the level of annoyance. These characteristics are often referred to as intrusive noise characteristics.

Reference Sound Levels

Commonly heard sound sources and associated typical sound levels are shown in the figure below:

Noise Thermometer

Common Noise Levels and Typical Reactions



Note: The sound levels shown are intended as a guide to allow the lay person to gauge the loudness, in a very approximate manner, of a particular noise level. The information provided is not intended to be used, and should not be used, to judge noise levels for the purpose of establishing compliance with standards or regulations, or in any legal proceedings.