Quantifying the ambient community noise environment for optimal industry siting

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Urban noise is an emerging nuisance issue for growing communities. The analysis method discussed herein can be used to industry's advantage. A road traffic noise model was developed by Conestoga-Rovers & Associates (CRA) to approximate the ambient community noise levels present within a 200 km² project area. Road corridors that included highways, city streets, and country side-roads were modeled to evaluate the existing road traffic generated ambient noise environment. An acoustical model and US Department of Transportation Federal Highway Administration Traffic Noise Model calculation standard was used to account for a variety of real-world variables such as Daily Average Traffic Counts, turning counts, speed limits, road composition, elevation, road width, and traffic composition. The model generated noise contours that were used to identify areas of elevated ambient noise levels within the project area that may prove suitable for a medium-sized industrial facility. This quantification of the ambient community noise environment allowed for the identification of optimal industrial sites within the project area. Locating new facilities within urbanized areas with elevated ambient conditions promotes complementary adjacent land use and sustainable urban densification by minimizing adverse community noise impacts and reducing post-construction noise abatement costs for industry.

Published by the Acoustical Society of America through the American Institute of Physics
INTRODUCTION

The global population surpassed 7 billion people in 2011 with 49% of us living in urban environments with an estimated annual urbanization growth rate of 2.2% (1990 to 2006). Industrialized nations such as the United States and Canada are comprised of a much higher urban population of over 80% with a greater than 1% annual growth rate. Such a high urban growth rate creates great demand to build and reduces undeveloped property that may provide a necessary buffer between less suitable adjacent land uses. Urban noise is an emerging nuisance issue for growing communities. Noise complaints are often the result when industry and suburbia converge and engineered noise controls offer a costly and reactive solution.

The background or ambient acoustic environment experienced in a community varies based on the location and over time. It is the composite of nearby and distant noise sources. Ambient noise includes single short-term events such as the pass-by of an airplane or car, the barking of a dog, or a thunderclap. Ambient noise also includes relatively steady residual or background sounds caused by distant traffic or industry.

CRA was retained to quantify the ambient noise environment for a community in Ontario, Canada, to determine an optimal site for the construction of an industrial facility with the purpose to minimize adverse noise impacts to the community.

METHODOLOGY AND MODELLING

The project area subject of this study was significant in geographic size and varied in acoustic character, which included a densely populated urban core and undeveloped agricultural land. CRA conducted a field survey and determined that vehicular road traffic was the predominant ambient noise source for the project area and identified the road corridors of environmental significance.

Six possible site locations were selected based on property availability within the 200 km² project area and were shortlisted from twenty available properties.

Geographical Information System (GIS) files were obtained and included in the acoustic model to identify major topographic features such as roads, intersections, and lots, which were necessary to establish basic site geometry for modeling purposes. The following details were collected for each road of interest:

1. Traffic Volumes
2. Road Conditions
3. Vehicle Distribution

An industry standard acoustical model and the US Department of Transportation Federal Highway Administration Traffic Noise Model (TNM) calculation standard was used to quantify the road traffic generated ambient noise.

Traffic Volumes

The traffic volumes were input to determine the potential sound energy of each road corridor. Detailed hourly traffic volume data was supplied by the local transportation authority for major roadways. For lesser travelled intersecting side roads, the Annual Average Daily Traffic (AADT) value was provided based on turning count information.

The hourly traffic data was averaged for the entire data set provided to determine a representative 24-hour traffic pattern. The average hourly traffic was then separated into the standard 16-hour daytime traffic volume (7:00 a.m. and 11:00 p.m.) and 8-hour nighttime traffic volume (11:00 p.m. and 7:00 a.m.) as a model input. Averaging the extensive data set for arterial roads normalized traffic lows that may be experienced during the late nighttime hours as well as peak activity during rush-hours. The 24-hour traffic pattern determined for the intersecting arterial road was applied to the AADT value for the side road to estimate the 16-hour daytime and 8-hour nighttime traffic volumes for input into the model.

As expected, the sites that are closer to the urban core experienced greater 24-hour road traffic volumes and therefore higher ambient noise conditions. CRA considered the noise influence for each street adjacent to the sites of interest. Those streets that were concluded to have an insignificant influence on the ambient noise (i.e. 10 dBA...
lower than the applicable regulatory limit or the adjacent road generated sound level) were eliminated from the model to reduce processing times.

**Road Conditions**

The following road conditions were collected and input to accurately model each road corridor:

1. **Width of Road** – establishes source geometry and that sound propagation begins over a reflective pavement surface
2. **Surface Type** – reflective or porous ground was established for both the road and non-road surfaces, respectively
3. **Speed Limit** – the posted speed limit was input for each road

![Figure 1. Influence of Speed on Noise Contours](image)

The posted speed limit of each road plays a vital role in determining the noise dispersion due to the effects of the engine, tire noise and aerodynamic noise generated at different speeds. Figure 1 presents the influence of speed on noise propagation from a road corridor. On the north end of this stretch of road, the speed limit is 80 kilometers / hour (km/h), whereas a speed limit of 60 km/h is enforced approaching the intersection. The 45 dBA contour extends 140 meters (m) from the road at a speed of 80 km/h and was reduced to 100 m when speed is reduced to 60 km/h. The speed limits throughout the project area were included for accuracy of the model results.

**Vehicle Distribution**

The traffic volumes were distributed based on the type of vehicle and were defined as either a heavy truck or car. Since vehicle distribution was not available from the transportation authority, a 5% heavy truck distribution was estimated to be conservative. Vehicle distribution is a critical detail as trucks generate a significantly higher sound power in comparison to a car.

**Stationary Influences**

CRA reviewed over 100 publically available environmental permits for industrial facilities in the project area that may contribute to the ambient acoustic environment. The facilities were evaluated based on the physical size, the noise sources, and controls documented in each permit. No facilities were identified as environmentally significant.
ANALYSIS

Sound Level Contours

The model was used to generate sound level contours for each site of interest. The contours provide a visual representation of how the traffic generated sound propagates from the road source. Figure 2 provides the sound level contour composite map generated for the daytime period for the six sites. The major highway was a visible and predominant environmental noise source of influence up to one kilometer away.

Applicable Noise Limits

The applicable minimum regulatory noise limits for industry in Ontario are defined based on the acoustic character for the area of interest. The project area spans over 200 km² and includes rural as well as developed urban space. Urban sites benefit from elevated ambient conditions and higher allowable noise limits are established, such as 50 dBA during daytime and 45 dBA during the nighttime. Rural sites are predominantly influenced by natural noises and the absence of human activity generated noise. Rural areas experience lower ambient conditions and much stricter noise limits of 45 dBA during the daytime and 40 dBA during the nighttime apply.

Site Comparison

The sound level contours for the sites of interest were compared to one-another. The primary criterion for each site was an elevated ambient environment above the regulatory limits. The proximity to any surrounding sensitive land uses, such as a residential or institutional zone, was secondary.
Site 1 and 2 are adjacent and yet contrasting properties subject of the following discussion. Figure 3 presents the noise contours generated for Site 1 during the daytime. Site 1 is located near a minor side road and a moderately travelled country road. Figure 4 presents the noise contours generated for Site 2 during the daytime. Site 2 is adjacent to two county highways with significant 24-hour traffic volumes.

For both Figures 3 and 4, the property under consideration for the industry is hatched in green and the existing residential areas are indicated in red. Site 1 (Figure 3) is adjacent to two residential areas to the north and south of
the property. Site 2 (Figure 4) is immediately adjacent to an established residential zone on the opposite side of the road and a second residential area is located further north of the property.

Site 1 does not benefit from significantly elevated ambient noise. Figure 3 shows the 45 dBA contour projected approximately 120 m from the moderately travelled country road and 12 m away from the side road. The same figure shows the 40 dBA contour being projected 260 m away from the moderately travelled road and 20 m away from the side road. Alternatively, Figure 4 shows that the 45 dBA contour extends 280 m from the county highway and well into the adjacent south residential area for Site 2. The 40 dBA contour is projected 500 m from the road. The reflective quality of the urban surface to the south side of Site 2 propagates the 45 dBA contour 450 m from the road into the residential area of interest and the 40 dBA contour is projected 900 m.

The road traffic modeling results for Site 1 suggests the area is rural in character. The majority of the site is predicted to experience ambient noise conditions that are below the rural regulatory daytime limit of 45 dBA. Future industrial development on this site would prove challenging and requires costly engineered noise control measures to meet the applicable rural limits. This site can therefore be qualified as unsuitable for industrial development.

Site 2 can be classified as a potentially suitable site given the significant ambient sound levels generated from the adjacent county highways.

Sites 3, 4 and 5 can also be qualified as unsuitable for future industrial development based on visual inspection of the daytime noise contour predictions below. Similar to Site 1, these three sites do not benefit from elevated ambient sound levels and are rural in acoustic character.

Site 6 is surrounded by two country roads. However, the 45 dBA contour line does not extend as far from the road corridor due to the lesser traffic volumes and absorptive nature of the undeveloped surface. The road traffic modeling demonstrated that the majority of this site also experiences rural ambient conditions.

**Community Reaction and Predicted Noise Impact**

The audibility and potential community reaction to a change in the ambient noise conditions will be a function of how much, if at all, the new noise level exceeds the existing or baseline noise conditions. The Minnesota Pollution Control Agency defines the thresholds of audibility as follows:

- 1 dBA = not noticeable
- 3 dBA = threshold of perception
- 5 dBA = clearly noticeable
- 10 dBA = perceived as twice as loud / half as loud

The threshold of audibility scale demonstrates the typical community reaction to changes in sound level. A nearby resident may perceive a sound that is 3 dBA or more above typical ambient conditions.

To further enhance the site analysis and finalize the selection process, a simplified industrial facility was modeled based on a representative total sound power and point source placed at the centroid of each property to evaluate the potential off-site environmental noise impact for potential Sites 1, 2 and 6. The current ambient noise conditions and the post construction industrial noise impact predictions are presented in Annex A.

The post construction industrial noise impact predicted for Site 1 shows that the 40 dBA contour shifts 10 m further north from the road. There is an existing residential receiver located approximately 16 m north of the road that also intersects with the original 40 dBA ambient noise contour line. The new predicted post construction noise impact is 46 dBA at this location. A 6 dBA change to the ambient sound level conditions would be considered clearly noticeable by the adjacent community based on the threshold of audibility scale.

Site 2 does not exhibit a significant change in the overall noise levels. The predicted post construction impact is 45.6 dBA at the location of the original 45 dBA ambient noise contour line. A 0.6 dBA change to the ambient sound level would not be noticeable and considered environmentally insignificant.
Site 6 experiences a 3.5 dBA increased overall sound level at the reference 40 dBA traffic only contour line, which is considered above the threshold of perception and maybe audible to the community based on the audibility scale.

CONCLUSIONS

The road traffic modeling results demonstrate that Site 2 is the most suitable location for the construction of a medium sized industrial facility and meets the purpose of the study. A noise impact study based on a detailed site design would be completed to determine the off-site environmental noise impact and potential for adverse impacts to the community.

Environmental noise consulting is often reactive to community noise complaints and to mitigate problematic noise sources for an existing industry. CRA used an acoustical model and calculation standard to quantify the existing ambient community noise environment for a defined project area based on actual traffic volumes and road conditions to identify potential sites for a future medium sized industry. This modeling technique can be used to optimize future industrial site selection to the benefit of industry and to the community. Locating new facilities within urbanized areas with existing elevated ambient conditions promotes complementary adjacent land use and sustainable urban densification by minimizing adverse community noise impacts and reducing post-construction noise abatement costs for industry.

REFERENCES
