DelDOT

Delaware Department of Transportation

SR 24 LONGITUDINAL EDGE LINE
RUMBLE STRIP NOISE STUDY

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INTRODUCTION

Delaware's Strategic Highway Safety Plan indicates that a high percentage of the fatal crashes in the state involve roadway departures with a disproportionately large percentage of the roadway departure crashes occurring on rural roadways. Studies have shown that the installation of longitudinal edge line rumble strips can significantly reduce the frequency of roadway departure crashes by alerting motorists through vibration and sound that their vehicle has left the travel lane. However, there are often concerns regarding noise impacts on surrounding residential land uses where rumble strips are being considered as a potential countermeasure to address roadway departure crashes. DelDOT's "Continuous Center Line and Longitudinal Edge Line Rumble Strips Design Guidance Memorandum" (effective May 16, 2011) states the following:

> *The intent of the rumble strip is to gain the attention of a driver. Naturally, the byproduct of this measure is noise. In isolated areas this is usually not a problem. However, when installed in a suburban or urban area, the noise from rumble strips may impact nearby residents. It is highly recommended to consider the noise implications of rumble strips if they are going to be located in a populated area.*
>
> *Generally, continuous or bicycle-friendly longitudinal edge line rumble strips should not be applied on the shoulders of roadways within urban areas. In urban areas, the designer should consult with Engineering Support and Public Relations to determine if noise will be a concern.*

The purpose of this noise study is to investigate the external noise impacts of edge line rumble strips on two-lane rural roadways to assist in identifying sections of roadway where rumble strips may be installed to mitigate crash trends without significantly impacting existing residents along these roadways. The study was performed in a rural area to provide generally a "worst-case" scenario with regards to noise impacts due to the limited amount of background noise and therefore, greater noise impact associated with the rumble strips. However, it is possible that some urbanized areas may generate greater rumble strip noise impacts than a rural area due to sound reverberation due to urban infrastructure.

PREVIOUS DELDOT RUMBLE STRIP NOISE STUDY

In 2006, DelDOT performed a noise study to evaluate the noise impacts of edge line rumble strips along a rumble strip test area on I-495 at the 12th Street interchange. This location was selected because it was surrounded by industrial land uses, was easily accessible compared to other locations along I-495, and was not heavily wooded or wet. The results of the previous study indicate the following:

- Noise level increases at the test area due to a vehicle striking the rumble strips were clearly perceptible at 100 feet from the source, barely perceptible at 250 feet from the source, and not readily perceptible at 400 feet from the source. The study concluded that it was not likely that the noise would be perceptible at a location 100 feet farther (i.e., 500 feet) from the rumble strips.

- The maximum ambient noise, which represented the noise readings throughout the study period excluding the ten-second intervals surrounding the period when the rumble strips were struck, exceeded the peak noise level when the rumble strip was struck, indicating that truck noise on the interstate was louder than the noise generated by rumble strips. However, spikes in the ambient noise level readings may have been attributed to trucks accessing the 12th Street ramps.
- DelDOT's Noise Policy (June 1995) at the time of the study stated that predicted exterior noise levels for a residence must approach or equal 67 dBA or experience a substantial increase (>10 dBA) to qualify as a traffic noise impact. Generally, peak noise levels at 400 feet did not approach or equal 67 dBA, nor was there a "substantial increase" in the noise levels at 250 feet or 400 feet.
- The study concluded that rumble strips should not be considered along I-495 where residences are located within 500 feet of the proposed rumble strips. For sections of I-495 with noise-sensitive adjacent land uses other than residences, proximity to rumble strips should be considered on a case by case basis.
- Highway traffic noise levels depend on several variables including traffic volumes, speeds, pavement type, percentage trucks, tires, horizontal and vertical roadway alignments, roadside terrain, vegetation, and other topography. For these reasons and due to the small sample size, the results of this study should not be applied to other roadways of varying characteristics.

Study Challenges and Lessons Learned

- While noise monitoring was conducted during the evening hours when non-highway generated noise levels were at a minimum, the test area experienced noise from sources such as the Cherry Hill Landfill and other industrial buildings that may be higher than typical residential areas along I-495.
- Noise meters were located along I-495 at distances of 50 feet, 100 feet, 250 feet, and 400 feet from the outside rumble strips. The noise meters located at 250 feet and 400 feet from the source straddled the 12th Street on-ramp to northbound I-495 and large trucks using this ramp occasionally created spikes in the noise readings. While a 500-foot location was desirable, due to heavy vegetation and wetlands in the area, testing could only be conducted at maximum distances of 400 feet.
- The previous study was completed using a sedan (Honda Civic) for the test vehicle. However, it is likely that larger vehicles would have generated higher noise levels when striking the rumble strips.

RESEARCH

A review of recent studies and publications was conducted to obtain guidance on the installation of rumble strips in close proximity to residential areas. However, very little guidance exists regarding this topic other than to apply engineering judgment. The following guidance was found in FHWA's "Highway Traffic Noise: Analysis and Abatement Guidance":

> *Highway traffic noise is not usually a serious problem for people who live more than 500 feet from heavily traveled freeways or more than 100 to 200 feet from lightly traveled roads. In quiet settings, however, such as rural areas, people notice highway traffic noise over greater distances.*

Additionally, NCHRP Report 641 - "Guidance for the Design and Application of Shoulder and Centerline Rumble Strips" states:

> *It has been noted that some residents claim to be able to hear the noise generated from the rumble strips from up to 1.2 mi (2 km) away. Studies have also shown that when rumble strips are terminated 656 ft (200 m) prior to residential or urban areas, tolerable noise impacts are experienced; also at a distance of 1,640 ft (500 m), the noise generated from rumble strips is negligible.*

A study conducted for ITE, "Optimal Continuous Shoulder Rumble Strips and the Effects on Highway Safety and the Economy" (May 2003) measured noise levels 200 feet from the roadway. The study compared the noise level of a typical truck on the traveled way (69 dB) and the noise level of a testing van on a rumble strip (60 dB). The study concluded that the impact of rumble strip noise on the environment was minimal and could be ignored because it was a random event. The exterior sound level of rumble strips was 9 dB lower than that of a truck traveling on a highway. Although this study indicates that rumble strip noise does not exceed the noise created by typical trucks, several studies were found where rumble strips were either removed or moved farther from the travel lanes to reduce the frequency of vehicles striking the rumble strip and address residents' complaints.

A cooperative research project conducted by Kansas DOT, Kansas State University Transportation Center, and University of Kansas, "Promoting Centerline Rumble Strips to Increase Rural, Two-Lane Highway Safety" (December 2010) quantified the level of exterior rumble strip noise impacts on roadside residences and businesses. As part of this project, two different types of vehicles (a sedan and a 15-passenger van) were driven over two different types of center line rumble strips (rectangular and football-shaped), at several different locations, two different speeds (40 mph and 65 mph), and distances of 50, 100, and 150 feet from the center line. The study concluded that the difference between noise levels generated by vehicles driving over the rumble strips is at least 5 dB greater than the noise levels generated by vehicles driving over a smooth surface. Additional key findings include: the lower the speed of the vehicle, the lower the noise generated by the rumble strip, heavier vehicles produce more noise, and the greater the distance from the noise source, the lower the noise. A 5dB difference in noise is considered noticeable; therefore, installing rumble strips will affect the noise levels for residents located 50 feet, 100 feet, and 150 feet from the noise source. The project also included a residential survey, which indicated that 90 percent of respondents feel that the noise generated from center line rumble strips is noticeable but not a concern and 100 percent of respondents felt that the potential safety benefits of the rumble strips are worth some level of annoyance created by exterior noise impacts. Research and Innovative Technology Administration University Transportation Centers Program's "Use of Center Line Rumble Strips to Improve Safety on Two-Lane Highways" determined that distances within 200 feet from the center of the roadway with center line rumble strips are potential exterior noise concern areas for the conditions studied as part of the Kansas DOT study.

HIGHWAY NOISE FUNDAMENTALS

The extent to which individuals are affected by noise sources is composed of several factors, including:

- The duration and frequency of sound
- The distance between the source of the sound and the receptor
- The intervening natural or man-made barriers or structures
- The ambient environment

The level of highway traffic noise depends primarily upon:

- Traffic flow conditions (volume and speed)
- The number of trucks in the flow of traffic
- The distance of receptor to the noise sources
- Shielding effects from intervening terrain and vegetation

Hourly noise levels are given in equivalent hourly average (Leq) of "A-weighted decibels" (dBA), which is an average of the perceived sound level. Because noise levels in an area fluctuate dramatically over time and the human response to noise is frequency dependent, the actual measured time variant noise levels are compiled into a Leq. The Leq is a single representative noise level that contains the same amount of sound energy as the fluctuating noise levels measured over the same time period, generally one hour. To compensate for the frequency dependency of the "human" response, the contributions of different frequencies are adjusted to correspond to the human sensitivity to these frequencies. Sound data that has been adjusted using this method is reported as dBA. Throughout this study, all noise level measurements are given in Leq dBA. Table 1 provides examples of common outdoor and indoor noise levels and their corresponding noise levels in decibels.

Table 1: Common Outdoor And Indoor Noise Levels[1]

Common Outdoor Noise Levels	Noise Level Decibels	Common Indoor Noise Levels
	110	Rock Band
Jet Fly Over at 1,000 feet	100	Inside Subway Train (N.Y.)
Gas Lawn Mower at 3 feet		
Diesel Truck at 50 feet	90	Food Blender at 3 feet
Noisy Urban Daytime	80	Garbage Disposal at 3 feet/ Shouting at 3 feet
Gas Lawn Mower at 100 feet	70	Vacuum Cleaner at 3 feet
Commercial Area		Normal Speech at 3 feet
	60	
		Large Business Office
Quiet Urban Daytime	50	Dishwasher Next Room
Quiet Urban Nighttime	40	Small Theater, Large Conference Room (Background)
Quiet Suburban Nighttime		Library
	30	
Quiet Rural Nighttime		Bedroom at Night, Concert Hall (Background)
	20	
		Broadcast & Recording Studio
	10	Threshold of Hearing
	0	

1. Adapted from *Guide on Evaluation and Attenuation of Traffic Noise* AASHTO-1974

Typically, noise level changes between 2 and 3 dBA are barely perceptible, while a change of 5 dBA is readily noticeable by most people. A 10 dBA increase is usually perceived as a doubling of loudness, and conversely, noise is perceived to be reduced by one-half when a sound level is reduced by 10 dBA.

DELDOT'S NOISE POLICY

FHWA requires states to adopt their own policies on the abatement of highway traffic noise and provides guidance and criteria for the evaluation of traffic noise impacts and noise abatement opportunities for communities adjacent to highways. All federal or federal-aid highway projects authorized under Title 23, Unites States Code are subject to DelDOT's Highway Transportation Noise Policy, revised in July 2011. The policy is not mandatory for projects that are 100 percent State-funded or when FHWA approvals are not necessary.

Per DelDOT's Noise Policy, whenever traffic noise impacts are identified, DelDOT will consider and evaluate noise abatement for feasibility and reasonableness. The following conditions are identified as traffic noise impacts:

- Predicted (design-year) build condition noise levels approach or exceed the Noise Abatement Criteria levels shown in Table 2 (i.e., predicted exterior noise level for a ground-level residence must approach or equal 67 dBA to qualify as a traffic noise impact). DelDOT considers the noise abatement criteria to be approached if traffic noise levels are within one decibel of the values shown.
- Predicted (design-year) noise levels substantially exceed existing noise levels. DelDOT considers a substantial increase to be at least 12 dBA.

DelDOT Noise Abatement Criteria contained in DelDOT's Noise Policy apply to Type I projects, defined under 23 CFR 772 as:

(1) The construction of a highway on a new location; or,

(2) The physical alteration of an existing highway where there is either:

i. A substantial horizontal alteration; being a project that halves the distance between the traffic noise source and the closest receptor between the existing condition to the future build condition; or,

ii. A substantial vertical alteration; being a project that removes the shielding therefore exposing the line of sight between the receptor and the traffic noise source. This is done by either altering the vertical alignment of the highway or by altering the topography between the highway traffic noise source and the receptor.

(3) The addition of a through-traffic lane(s). This includes the addition of a through traffic lane that functions as a High Occupancy Vehicle lane, High Occupancy Toll lane, bus lane, or truck climbing lane; or,

(4) The addition of an auxiliary lane, except for when the auxiliary lane functions as a turn lane; or,

(5) The addition or relocation of interchange lanes or ramps added to a quadrant to complete an existing partial interchange; or,

(6) Restriping existing pavement for the purpose of adding a through-traffic lane or auxiliary lane, except for when the auxiliary lane functions as a turn lane; or,

(7) The addition of a new or substantial alteration of a weigh station, rest stop, ride-share lot, or toll plaza; or,

(8) If a project is determined to be a Type I project under this definition, then the entire project area as a defined in the NEPA environmental documentation is a Type I project.

Table 2: Noise Abatement Criteria (NAC) Hourly A-Weighted Sound Level in Decibels (dBA)				
Activity Category	Activity Criteria [1] Leq(h) [2]	DelDOT Approach Criteria	Evaluation Location	Activity Description
A	57	56	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B [3]	67	66	Exterior	Residential
C [3]	67	66	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, daycare centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings
D	52	51	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios
E [3]	72	71	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F
F	--	--	--	Agriculture, airports, bus yards, emergency services, industrial, logging maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G	--	--	--	Undeveloped lands that are not permitted

[1] The Leq(h) Activity Criteria values are for impact determination only, and are not design standards for noise abatement measures.
[2] The equivalent steady-state sound level which in a stated period of time contains the same acoustic energy as the time-varying sound level during the same time period, with Leq(h) being the hourly value of Leq.
[3] Includes undeveloped lands permitted for this activity category.

Since the installation of rumble strips does not meet the definition of a Type I project listed above, DelDOT's and FHWA's noise abatement criteria do not directly apply to this study, but do provide a basis for comparison. Under 23 CFR 772, the installation of rumble strips would be considered a Type III project and would not require a noise analysis. However, this does not preclude highway agencies from performing a noise analysis. 23 CFR 772 states that generally, if a project results in a new noise source, the highway agency should consider a noise analysis for the project.

STUDY METHODOLOGY AND RESULTS

Site Selection: As part of the 2007 High Risk Rural Road Program, a roadway departure crash problem was identified along SR 24 from 0.08 mile west of Warwick Road to 0.18 mile east of Gull Point Road. As a result, DelDOT installed bicycle-friendly edge line rumble strips within the outside shoulders of eastbound and westbound SR 24 from Williams Street Road to Bay Farm Road. As stated above, specific guidance regarding the placement of edge line rumble strips in relation to residences is not available. Therefore, this section of SR 24 was selected as a test location to measure exterior rumble strip noise impacts and to assist in developing guidance for installing rumble strips in relation to noise-sensitive land uses. Because of the agricultural, flat, and relatively unobstructed nature of the surrounding land uses, this section of SR 24 was selected as the test location.

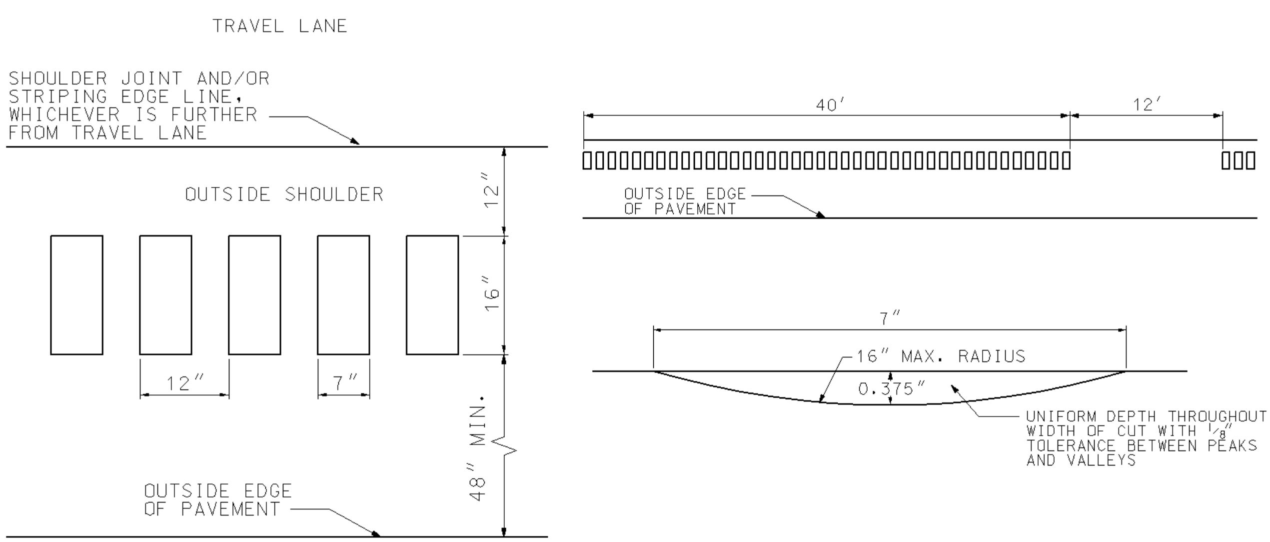
Four locations within the section of SR 24 with rumble strips were identified as potential locations for the noise measurements (see Figure 1). These locations were selected based on minimal background noise, continuous bicycle-friendly rumble strips for at least 400 feet (i.e., not broken for turn lanes or driveways) and relatively unobstructed land for distances a minimum of 1,000 feet from the edge of the rumble strip. Locations 1, 2, and 3 were selected for the noise study measurements and Location 4 was selected as an alternate location in the event that one of the other three locations were not available on the day of the study for any variety of reasons (e.g., problems coordinating with the property owners to obtain permission to access their property, significant background noise present at the time of the study, etc.). The parcel numbers and land owner information for each location was obtained from the Sussex County Online Mapping website, as shown below. Prior to conducting the noise study measurements, DelDOT contacted the property owners to obtain permission to access their property and set up the noise meters.

- **Location 1:** South side of SR 24, approximately 300 feet east of Tecumeh Pass – Parcels 234-28.00-172.00 (property owners: Frank Calhoun and Frances Dawson) and 234-29.00-51.00 (property owners: Margaret Shroeder)
- **Location 2:** South side of SR 24, approximately 900 feet east of Layton Davis Road – Parcels 234-29.00-66.00, 234-29.00-66.01, and 234-29.00-66.02 (property owners: William and Joan Norwood)
- **Location 3:** North side of SR 24, approximately 1,250 feet east of Mount Joy Road – Parcel 234-29.00-263.01 (property owners: Moore's Cloverleaf Farm, LLC) *Ball bank indicator tests were performed to confirm that the slight horizontal curvature just east of the location can be driven safely at the speed limit.*
- **Location 4 (alternate):** South side of SR 24, approximately 1,500 feet west of Mount Joy Road – Parcels 234-29.00-67.00 and 234-29.00-67.04 (property owners: Nentego Properties, LLC)

Per DelDOT's "Continuous Center Line and Longitudinal Edge line Rumble Strips Design Guidance Memorandum" (effective May 16, 2011), continuous, milled, bicycle-friendly edge line rumble strips consist of 40-foot rumble strip segments with 12-foot "gap" segments without rumble strips, as shown in Figure 2. Bicycle-friendly edge line rumble strip are installed 12 inches from the edge line and with a 3/8th-inch depth.

Figure 1 – Location Map

Figure 2 – Rumble Strip Details



Noise Measurements: Noise measurements were conducted to quantify the noise generated by vehicles striking the edge line rumble strips at Locations 1, 2 and 3, as discussed above. Since residents are most aware of the noise produced by rumble strips during periods when background traffic noise levels are lowest, testing was performed during off-peak hours (i.e., between 9 AM and 3 PM). Noise measurements were conducted at Location 1 between 10:20 AM and 11:10 AM, Location 2 between 11:40 AM and 12:45 PM, and Location 3 between 1:15 PM and 2:15 PM. Two test vehicles were used for the noise measurements – a Honda Odyssey minivan and a large 3-axle DelDOT dump truck. Test vehicles were driven at the posted speed limit of 50 miles per hour. The study was conducted using ANSI S 1.4-1983 Type II noise level meters, which record noise levels in a variety of formats, including Leq dBA.

Based on the findings from the previous studies discussed above, noise meters were positioned at 50 feet, 250 feet, 500 feet, and 1,000 feet distances from the outside of the rumble strips at each of the three study locations to assess the exterior noise impacts of the rumble strips on the surrounding areas. The positions of the four noise meters could have been relocated to different distances than those discussed above based on preliminary findings in the field. For example, if the noise meters were unable to detect rumble strip noise at distances of 1,000 feet, the farthest meter could have been moved to 750 feet, or if rumble strip noise is readily noticeable at 1,000 feet, the farthest meter could have been moved to 1,500 feet. However, relocating the noise meters was not necessary based on the preliminary findings while performing the study. The noise measurements were conducted on a dry day with low winds and the sound meters were placed orthogonally from the edge line rumble strips.

The noise meters placed at the distances discussed above were used to record the exterior noise levels during at least five base runs and five rumble strip runs at each location. The base runs involved the test vehicles traveling over smooth asphalt pavement through approximately 400-foot segments along SR 24 at the locations discussed above. The rumble strip runs involved the test vehicles traveling over the edge line rumble strips through the 400-foot test segments along SR 24 at the same locations. The 400-foot test segments along SR 24 were marked with cones. Runs with increased background noise, such as when a tractor trailer was present within the marked test segments during the run, were discarded from the data set. For future studies, a flagger or rolling road block could be used to eliminate any other vehicle from being present within the marked test segments during each run to further isolate the noise generated by the rumble strip; however, based on the study findings, relatively consistent data was obtained; therefore, this was not necessary.

Study Results: Noise levels were measured in one second intervals at all three study locations. The five one-second intervals during the time the test vehicles were driven across the rumble strips were averaged for each rumble strip run. Similarly, the five one-second intervals were averaged for each base run as the test vehicle traveled through the marked test segments. Table 3 shows the average noise levels for the base runs and the rumble strip runs for each test vehicle and at 50, 250, and 500 feet from the outside of the rumble strip. The noise levels recorded by the meter located 1,000 feet from the outside of the rumble strip were indistinguishable between the background noise (the person monitoring this meter confirmed that rumble strip runs could not be audibly identified at this distance). During the study, the noise meter located 500 feet from the outside of the rumble strip lost power at Locations 1 and 2; therefore, the number of runs used in the average noise measurement for this meter was significantly less than the other meters. However, the available data from this meter is consistent with the other readings. The average noise level during the rumble strip run was compared to the average noise level during the base run for each vehicle and the difference between these two measurements were used to determine whether the noise generated from the test vehicle striking the rumble strips was perceptible at various distances from the rumble strip under test conditions. Figures 3 and 4 are graphical representations of the average noise level increase during the rumble strip runs as compared to the base runs for each location and at each offset from the outside of the rumble strip for the minivan and dump truck, respectively.

Table 3: Summary of External Rumble Strip Noise Impacts

Noise Meter Offset from Outside of Rumble Strip	Base Run		Rumble Strip Run		Average Noise Level Increase (dBA)	Range of Average Noise Level Increases (dBA)
	Average Noise Level (dBA)	Noise Level Range (dBA)	Average Noise Level (dBA)	Noise Level Range (dBA)		
Minivan						
50 feet	64.1	60.2 - 66.6	76.5	73.3 - 78.0	12.4	10.8 – 15.0
250 feet	56.8	52.9 - 63.6	60.1	56.4 - 62.3	3.3	2.5 – 3.9
500 feet[1]	50.4	49.4 - 51.4	51.3	50.3 - 51.8	0.9	0.9
Dump Truck						
50 feet	72.8	71.4 - 74.9	78.2	75.4 - 79.9	5.4	4.3 – 6.0
250 feet	59.9	56.8 - 63.4	62.6	58.7 - 65.2	2.7	1.8 – 3.3
500 feet[1]	53.1	53.1	53.4	53.4 - 53.5	0.4	0.4

[1] The noise meter located 500 feet from the outside of the rumble strip lost power at Locations 1 and 2; therefore, the number of runs used in the average noise measurement for this meter was significantly less than the other meters.

Figure 3 – Average Noise Level Increase by Location (Minivan)

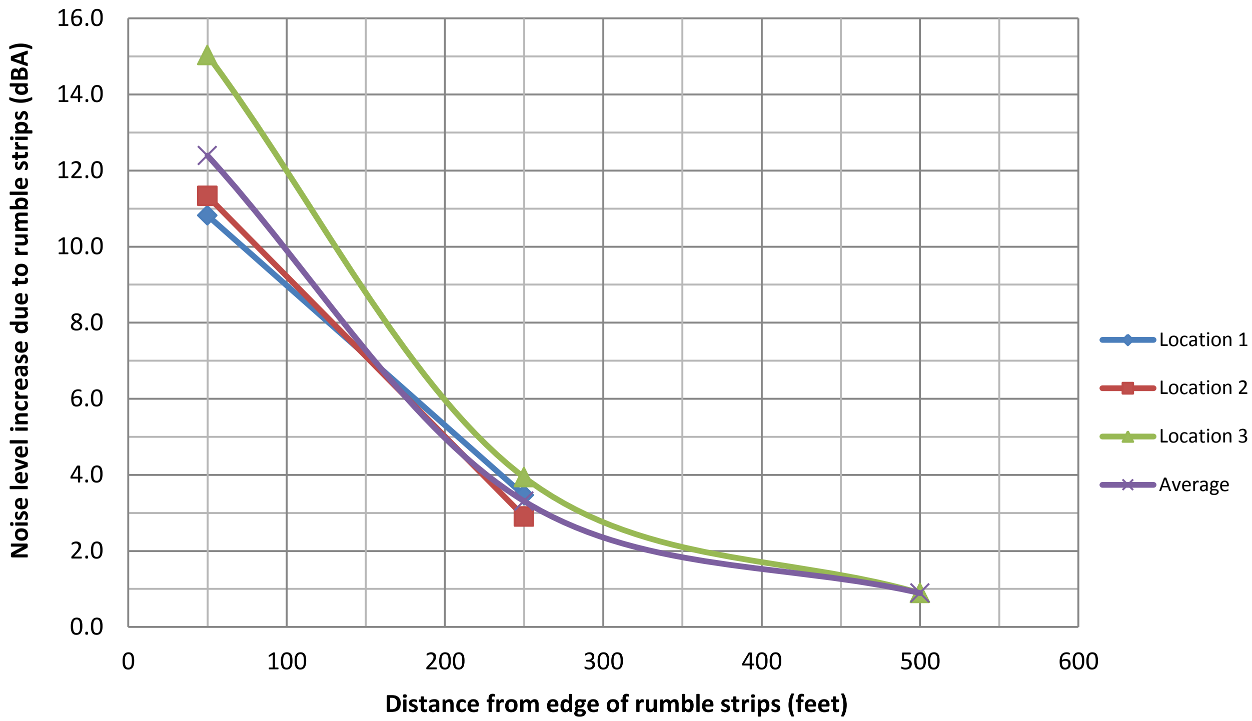
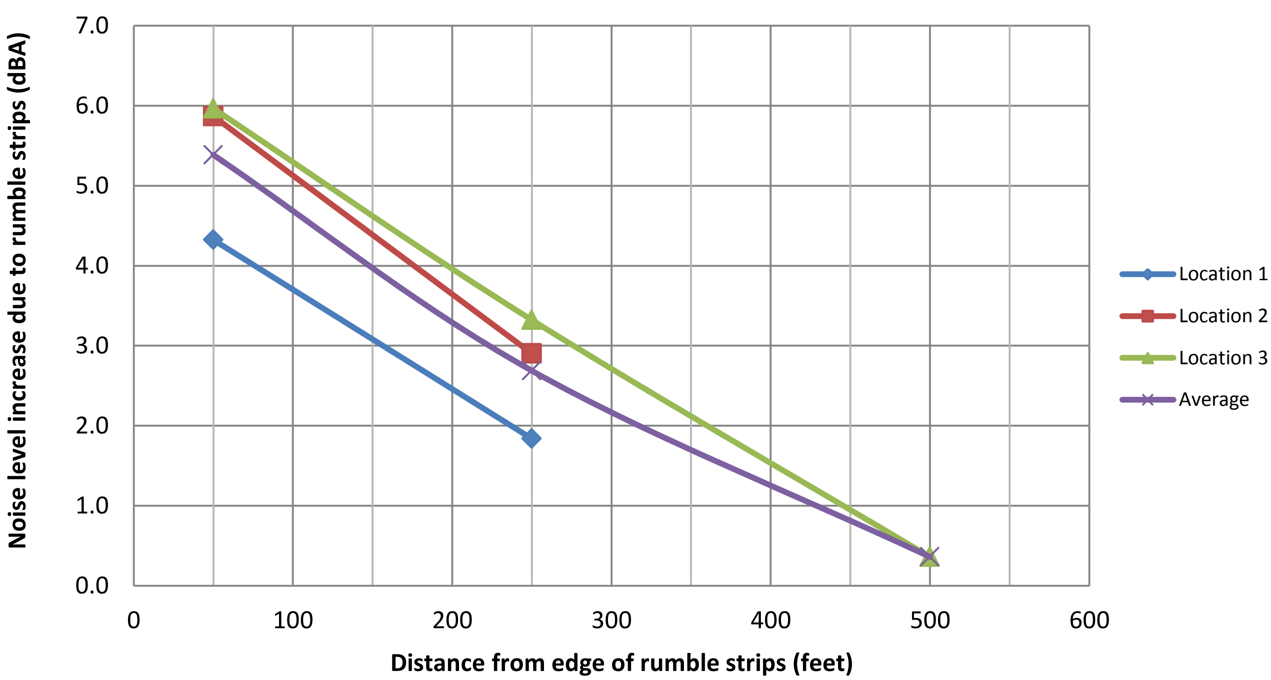


Figure 4 – Average Noise Level Increase by Location (Dump Truck)



As mentioned previously, noise level changes between 2 and 3 dBA are barely perceptible, while a change of 5 dBA is readily noticeable by most people. As shown, the increase in average noise levels due to the test vehicle driving across the rumble strip was greater for the minivan (12.4 dBA at 50 feet) than for the dump truck (5.4 dBA at 50 feet). However, the noise increases due to the test vehicles driving across the rumble strip were readily noticeable (i.e., > 5 dBA increase) at 50 feet for both vehicles. The dump truck generates more noise on smooth pavement than the minivan; therefore, the contribution of the dump truck itself to the cumulative noise level is relatively large, making the contribution from the tires striking the rumble strips less noticeable. This affect was much more pronounced at 50 feet than at distances farther from the rumble strips.

At 250 feet, the average increase in noise levels due to striking the rumble strip was 3.3 dBA for the minivan and 2.7 dBA for the dump truck; both average noise level increases are barely perceptible. At 500 feet, the average increase in noise levels (0.9 dBA for the minivan and 0.4 dBA for the dump truck) due to striking the rumble strip are not typically perceptible by most people. At 1,000 feet, the base run and rumble strip run noise measurements were indistinguishable. Additionally, it should be noted that the average noise level of the dump truck during the base runs is approximately equal to the average noise level of a minivan during the rumble strip runs at distances of 250 feet. The average noise level of the dump truck during the base runs is greater than the average noise level of a minivan during the rumble strip runs at distances of 500 feet.

CONCLUSION

According to DelDOT's Noise Policy, predicted exterior noise levels at a residential location must approach or equal 67 dBA or experience a substantial increase (i.e., 12 dBA or more) to be considered a noise impact. The results of the SR 24 Rumble Strip Noise Study indicate that neither of these conditions are met at distances of 250, 500, or 1,000 feet from the rumble strip; however, a minivan driving across the rumble strip does generate noise impacts (i.e., > 66 dBA and > 12 dBA increase) at a residence located 50 feet from the outside of the rumble strip. It should be noted that the average noise levels during both the base and rumble strip runs when the dump truck was driven along the roadway exceed 66 dBA at 50 feet from the edge of the rumble strip. The average noise level increases in this study area due to vehicles (minivan or DelDOT dump truck) striking the rumble strips were approximately 3 dBA at 250 feet from the outside of the rumble strip and less than one dBA at 500 feet from the outside of the rumble strip (noise level changes between 2 and 3 dBA are barely perceptible). Interpolation between these two values indicates that average noise level increases due to a vehicle (minivan or dump truck) driving across the rumble strips would not exceed 2 dBA at 350 feet and the average noise level increases due to a vehicle (minivan or dump truck) driving across the rumble strips would not exceed 3 dBA at 275 feet.

Therefore, the noise generated by vehicles driving across rumble strips will not typically be perceptible from distances 275 feet to 350 feet or greater from adjacent residences. Noise impacts should be given special consideration when installing rumble strips adjacent to residences within these distances from the outside of the proposed rumble strip. Additionally, engineering judgment should be used when installing rumble strips in areas that differ from the conditions of this study.

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Delaware Department of Transportation