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Noise Measurements of US-41 Transverse Rumble Strips

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16. Abstract

This report focuses on collecting and analyzing external and internal noise levels generated by the modified transverse rumble strips on US-41 that were reconstructed in October 2022. The goal is to enable a comparison with noise levels generated by the previous rumble strips that were constructed in the same location in 2019. This work is organized in three tasks: (1) observe and document the construction of the 2022 transverse rumble strips, (2) collect US-41 traffic flow data as well as external and internal noise levels generated by the 2022 transverse rumble strips, and (3) compare the collected external noise levels generated by the 2022 US-41 rumble strips to those generated by the 2019 US-41 rumble strips that were collected and reported in the related 2021 study. The comparison results demonstrate that the time-equivalent continuous sound pressure level (Leq) generated by the 2022 US-41 transverse rumble strips at the AASHTO T 390-recommended measurement distances of 25 and 50 feet were lower than those reported in the 2021 study.

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EXECUTIVE SUMMARY

This report focused on collecting and analyzing external and internal noise levels generated by the modified transverse rumble strips on US-41 that were reconstructed in October 2022. The goal was to enable a comparison with those noise levels collected and reported in the 2021 study. Key findings of this analysis and comparison included the following items:

- The 2022 in-vehicle internal noise increase caused by the newly constructed US-41 transverse rumble strips ranged from 11.3 to 15.1 dBA, which complies with the Federal Highway Administration-recommended range of 3 to 15 dBA.

- Total traffic volumes on US-41 during the morning and afternoon external noise data collection periods in 2022 were 7.8% and 1.4% lower than those of 2021, respectively.

- All descriptors of the 2022 external noise levels generated by continuous traffic flow on US-41 transverse rumble strips (Leq, L10, L50, and L90) were consistently lower than those collected and reported in the 2021 study at both AASHTO T 390-specified testing locations of 25 and 50 ft.

- The 2022 time-equivalent continuous sound pressure level (Leq) at the AASHTO T 390 primary sound meter location of 50 ft was lower than that reported in the 2021 study by 5.6 and 7.4 dBA during the morning and afternoon external noise data collection periods, respectively.

- External noise measurements at US-41 are more scientific and reliable than those collected at McCraren Road in assessing the impact of the 2022 changes in US-41 transverse rumble strips because the McCraren Road noise measurements were collected 950 ft from US-41 and were influenced by other noise sources such as traffic on McCraren Road and nearby O'Hare airplanes.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION 1

BACKGROUND 1

OBJECTIVE 1

CHAPTER 2: CONSTRUCTION OF MODIFIED RUMBLE STRIPS ON US-41 2

CHAPTER 3: TRAFFIC AND NOISE DATA COLLECTION 5

TRAFFIC DATA COLLECTION 5

NOISE DATA COLLECTION PROCEDURE (AASHTO T 390) 6

Noise Measurement Equipment 6

Equipment Setup 6

EXTERNAL NOISE MEASUREMENTS 9

US-41 9

McCraren Road 12

INTERNAL NOISE MEASUREMENTS 14

CHAPTER 4: COMPARISONS OF 2022 AND 2021 RESULTS 15

TRAFFIC DATA 15

EXTERNAL NOISE MEASUREMENTS 16

US-41 16

McCraren Road 17

CHAPTER 5: CONCLUSION 19

REFERENCES 20

APPENDIX A: 2022 IDOT DESIGN OF US-41 TRANSVERSE RUMBLE STRIPS 21

APPENDIX B: COLLECTED NOISE DATA ON MCCRAREN ROAD IN 2022 22

APPENDIX C: COMPARISON OF MCCRAREN NOISE DATA IN 2022 AND 2021 27

LIST OF FIGURES

Figure 1. Photo. Location of rumble strips. 2
Figure 2. Photo. Construction of 2022 rumble strips. 3
Figure 3. Illustration. Design of 2022 rumble strips. 3
Figure 4. Illustration. Measurements of 2022 transverse rumble strips dimensions. 4
Figure 5. Graph. Hourly traffic data on November 1, 2022. 5
Figure 6. Photo. Noise measurement equipment. 6
Figure 7. Illustration. Equipment setup for external noise level measurement on US-41. 7
Figure 8. Photo. Laser speed gun. 7
Figure 9. Photo. Equipment setup for external noise level measurement on McCraren Road. 8
Figure 10. Photo. Equipment setup for internal noise level measurement on US-41. 9
Figure 11. Graph. US-41 external noise data from 11:50 to 12:00 on November 1 at 25 ft location. 10
Figure 12. Graph. US-41 external noise data from 12:40 to 13:00 on November 1 at 25 ft location. 10
Figure 13. Graph. US-41 external noise data from 11:50 to 12:00 on November 1 at 50 ft location. 11
Figure 14. Graph. US-41 external noise data from 12:40 to 13:00 on November 1 at 50 ft location. 11
Figure 15. Graph. Sound level descriptors during first interval on November 1 for 25 and 50 ft locations. 12
Figure 16. Graph. Sound level descriptors during second interval on November 1 for 25 and 50 ft locations. 12
Figure 17. Graph. External noise level at McCraren Road from 17:15 to 18:00 on November 1, 2022. 13
Figure 18. Graph. Collected external noise data on McCraren Road from 17:35:39 to 17:39:49. 14
Figure 19. Graph. Comparison of total hourly traffic data on November 18, 2021, and November 1, 2022. 15
Figure 20. Graph. Collected external noise data on McCraren Road from 18:04:08 to 18:09:48. 18
Figure 21. Illustration. 2022 IDOT engineering drawings of US-41 transverse rumble strips. 21
Figure 22. Graph. External noise levels at McCraren Road from 18:00 to 19:00 on November 1, 2022. 22
Figure 23. Graph. External noise levels at McCraren Road from 19:00 to 20:00 on November 1, 2022. 22
Figure 24. Graph. External noise levels at McCraren Road from 20:00 to 21:00 on November 1, 2022. 23

Figure 25. Graph. External noise levels at McCraren Road from 21:00 to 22:00 on November 1, 2022. 23
Figure 26. Graph. External noise levels at McCraren Road from 22:00 to 23:00 on November 1, 2022. 24
Figure 27. Graph. External noise levels at McCraren Road from 23:00 on November 1 to 00:00 on November 2, 2022. 24
Figure 28. Graph. External noise levels at McCraren Road from 00:00 to 00:30 on November 2, 2022. 25
Figure 29. Graph. External noise levels at McCraren Road from 11:50 to 12:00 on November 2, 2022. 25
Figure 30. Graph. External noise levels at McCraren Road from 12:00 to 13:00 on November 2, 2022. 26
Figure 31. Graph. External noise levels at McCraren Road from 13:00 to 14:00 on November 2, 2022. 26
Figure 32. Graph. External noise data on McCraren Road from 18:18:26 to 18:35:38. 27
Figure 33. Graph. External noise data on McCraren Road from 18:38:32 to 18:53:27. 27
Figure 34. Graph. External noise data on McCraren Road from 18:55:12 to 19:17:04. 28
Figure 35. Graph. External noise data on McCraren Road from 19:53:51 to 20:11:06. 28

LIST OF TABLES

Table 1. Transverse Rumble Strips Specifications 4
Table 2. Internal Noise Data inside Passenger Vehicle Driving over US-41 14
Table 3. Traffic Data Comparison during First Data Collection Period from 11:50 to 12:00 16
Table 4.Traffic Data Comparison during Second Data Collection Period from 12:40 to 13:00..... 16
Table 5. Collected External Noise Data at US-41..... 17

CHAPTER 1: INTRODUCTION

BACKGROUND

Transverse rumble strips are placed in the travel lane perpendicular to the direction of travel to alert drivers of a need to slow down or stop due to roadway changes that may not be anticipated by inattentive drivers. Typical locations for these rumble strips are on approaches to intersections, toll plazas, horizontal curves, and work zones (Federal Highway Administration, 2022). A report published by the National Cooperative Highway Research Program (NCHRP, 2009) stated that rumble strips should generate additional noise of 3 to 15 dBA above the ambient in-vehicle sound level to alert inattentive, distracted, drowsy, or fatigued drivers. Centerline rumble strips were reported to be effective in reducing crashes on rural and urban two-lane roads by up to 45% and 64%, respectively (NCHRP, 2016). Despite these safety benefits, unexpected external noise generated when a vehicle hits a rumble strip can be disruptive to those in the surrounding area (Bedsole et al., 2017).

The Illinois Department of Transportation (IDOT) reported the need for transverse rumble strips on US-41 to ensure traffic safety and to alert motorists to slow down or stop as they approach Park Avenue, which is the first traffic signal northbound vehicles encounter after coming off the Interstate 94 Expressway (Sadin, 2021). These northbound US-41 transverse rumble strips were first installed in the mid-1990s and were redone as part of a resurfacing project in 2019 (Sadin, 2021). After reconstruction of the 2019 rumble strips, residents in Highland Park, Illinois, expressed concerns of noise in their neighborhood generated by vehicles passing over transverse rumble strips on US-41 northbound, south of the intersection with West Park Avenue. To address noise complaints from Highland Park residents, IDOT reconstructed the US-41 transverse rumble strips in October 2022 to reduce their external noise levels.

OBJECTIVE

The objective of this report is to collect and analyze external and internal noise levels generated by the modified transverse rumble strips on US-41 that were reconstructed in October 2022. The goal is to enable a comparison with the noise levels generated by the original rumble strips that were constructed in the same location in 2019. This work is organized in three tasks: (1) observe and document the construction of the 2022 transverse rumble strips to collect relevant data on their construction process and actual as-built dimensions; (2) collect US-41 traffic flow data as well as external and internal noise levels generated by the 2022 transverse rumble strips following the AASHTO T 390 testing procedure for the continuous-flow traffic time-integrated method; and (3) compare the collected external and internal noise levels generated by the 2022 US-41 rumble strips to those generated by the 2019 US-41 rumble strips that were previously collected in 2021. The following three chapters provide a concise description of these tasks.

CHAPTER 2: CONSTRUCTION OF MODIFIED RUMBLE STRIPS ON US-41

This chapter provides an overview of the construction of the 2022 transverse rumble strips on US-41, including their construction method and the measurements of their actual as-built dimensions. The modified rumble strips are located on US-41 near the intersection with Park Avenue in Highland Park, Illinois, as presented in Figure 1. The rumble strips are located approximately 950 ft from the houses on McCraren Road, and there are a number of facilities that are located between them, including southbound lanes of US-41, an electric utility company building and yard, an electric substation, train tracks, and trees, as presented in Figure 1. The milling of these transverse rumble strips was performed from 20:00 to midnight on October 24, 2022, using a milling machine with a rotary cutting head that creates grooves into the pavement, as presented in Figure 2. In order to reduce their external noise level, the 2022 transverse rumble strips were designed to have a shorter panel length of 15 ft with a shallower depth of 3/16 in. compared to the 2019 rumble strips that were designed to have a panel length of 25 ft with a depth of 1/4 in., as presented in Figure 3. As presented in Table 1 and Figure 4, there were minor differences between the design and as-built dimensions that were caused by equipment and construction operations. For example, the designed panel length was 15 ft while the as-built panel length varied from 14'8" to 15'3". The design of the 2022 transverse rumble strips is presented in an engineering drawing, as demonstrated in Figure 21 in Appendix A.

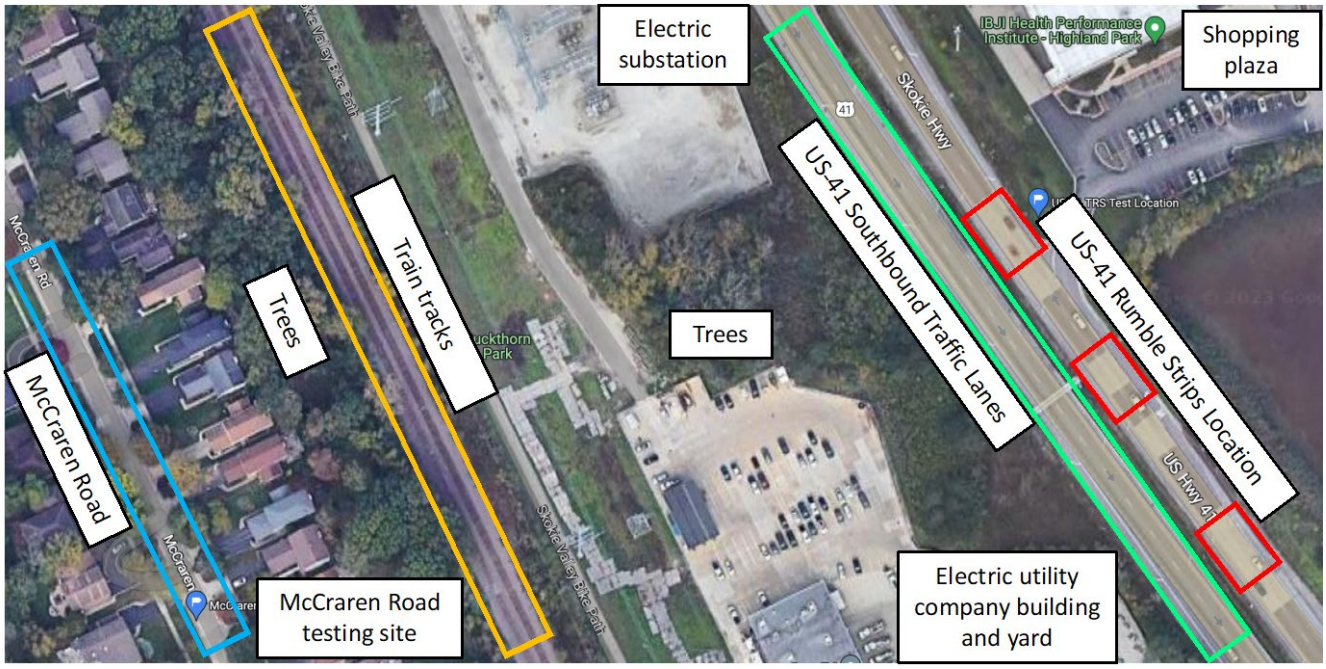

Figure 1. Photo. Location of rumble strips.

Figure 2. Photo. Construction of 2022 rumble strips.

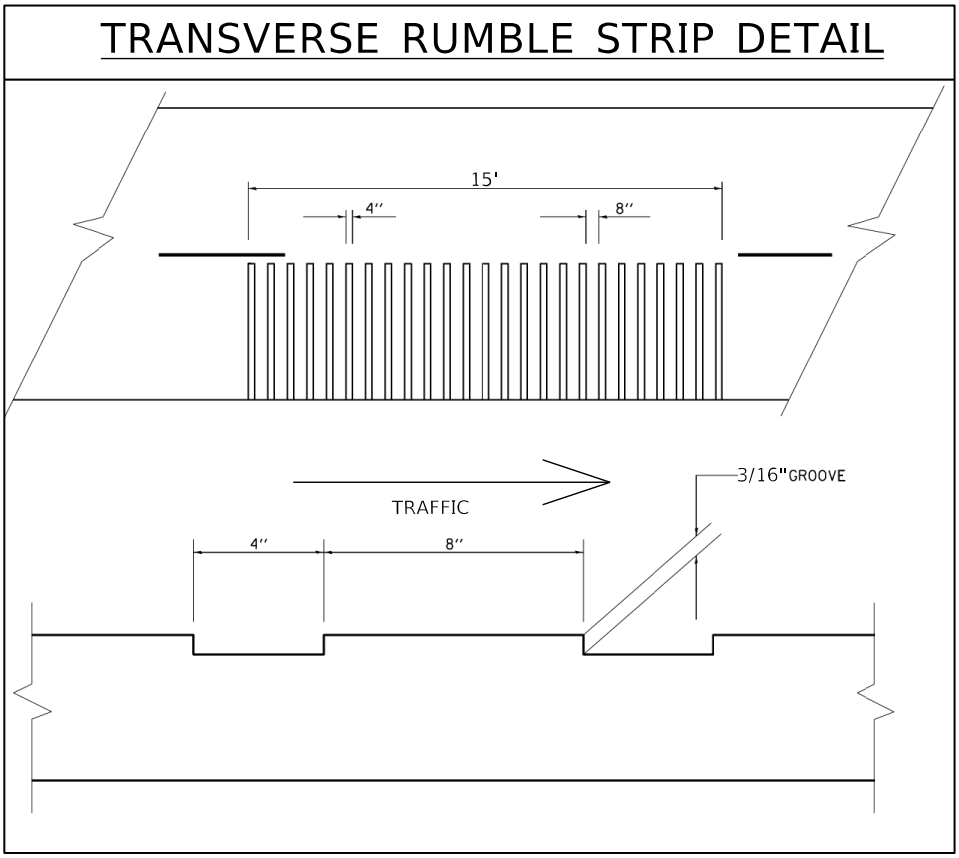

Figure 3. Illustration. Design of 2022 rumble strips.

Table 1. Transverse Rumble Strips Specifications

Specifications	As designed 2019	As designed 2022	As built 2022
Offset	–	–	4″–6″ from center line 8″–9″ from edge line
Length	–	–	10′8″–10′10″
Width	4″	4″	4″
Depth	1/4″	3/16″	3/16″–5/16″
Spacing (Gap)	12″ (8″)	12″ (8″)	11.5″–12″ (7.5″–8″)
Panel size	25′	15′	14′8″–15′3″
Number of strips per panel	25	–	16
Number of panels per lane	3	3	3

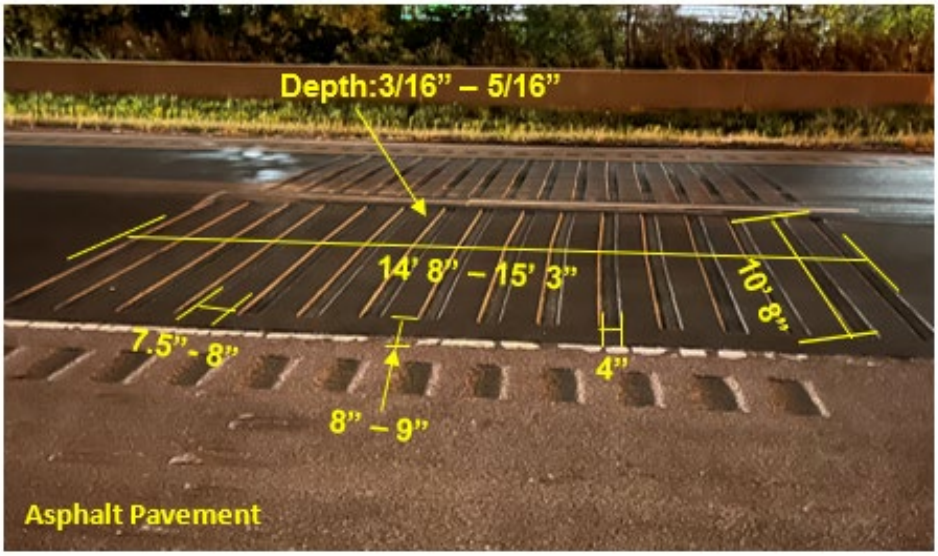

Figure 4. Illustration. Measurements of 2022 transverse rumble strips dimensions.

CHAPTER 3: TRAFFIC AND NOISE DATA COLLECTION

This chapter highlights the data collection of (1) 24-hour traffic flow on US-41 on the day of the external noise measurements, (2) external noise generated by the continuous traffic flow over the 2022 transverse rumble strips, and (3) internal noise generated inside a passenger vehicle while driving over the newly constructed rumble strips. To enable a comparison with the noise data previously collected and analyzed in the 2021 study for the 2019 rumble strips, the external noise measurements in this chapter were collected at two sites. Noise measurements at the first site, US-41, were collected using two microphones that were placed 25 and 50 ft away from the center of the 2022 transverse rumble strips following the AASHTO T 390 testing procedure for the continuous-flow traffic time-integrated method. Noise measurements at the second site, McCraren Road, were collected following the same procedure used in the 2021 study. Similarly, the internal noise data were collected inside a passenger vehicle while driving over the 2022 rumble strips at different speeds that range from 30 to 50 mph.

TRAFFIC DATA COLLECTION

IDOT installed a traffic counter on US-41 north of the rumble strips for vehicle count and classification. Vehicle counts were made available for every 15-minute period from 00:00 on November 1 to 00:00 on November 2, 2022. Traffic was classified as passenger cars (four tire), medium trucks (SU), and heavy trucks (MU). The 24-hour collected traffic flow data are summarized in Figure 5.

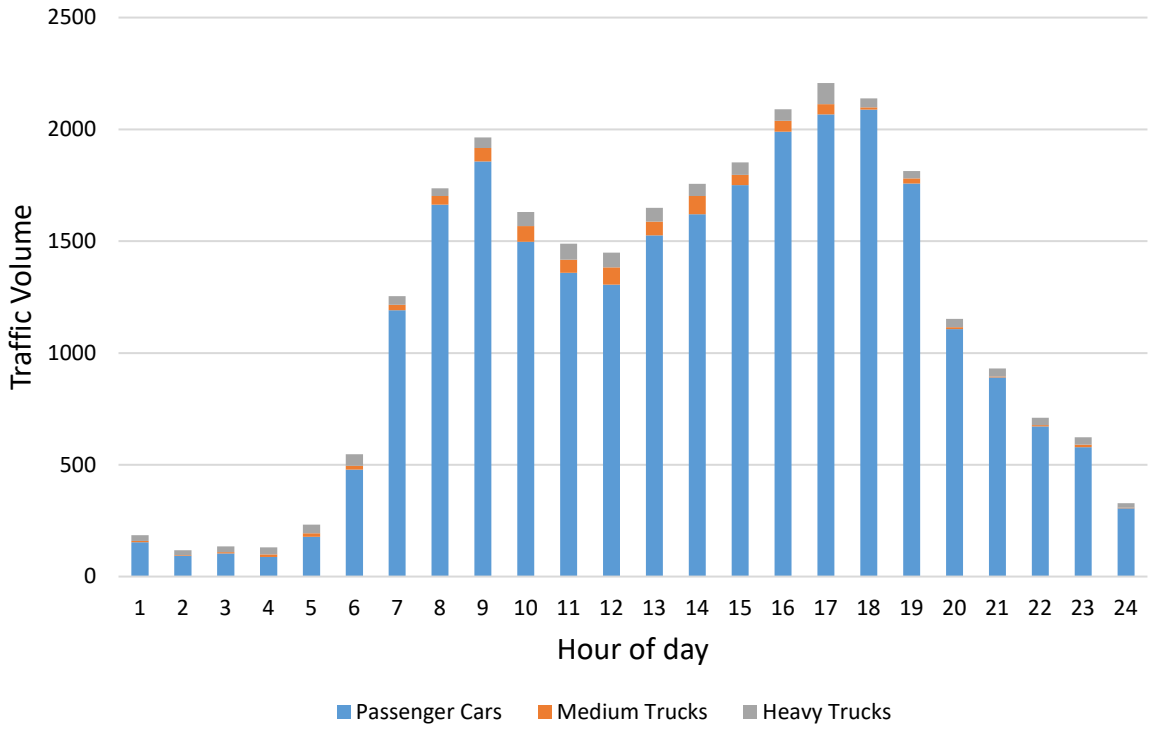

Figure 5. Graph. Hourly traffic data on November 1, 2022.

NOISE DATA COLLECTION PROCEDURE (AASHTO T 390)

The external noise measurements were conducted using the AASHTO Testing Procedure 390-20 for "Determining the Influence of Road Surfaces on Traffic Noise Using the Continuous-Flow Traffic Time-Integrated Method" (AASHTO, 2020). The following subsections provide a concise description of the noise measurement equipment and their setup.

Noise Measurement Equipment

The external and internal noise level generated from the newly constructed transverse rumble strips at US-41 and McCraren Road were measured using (a) two class I PCE-430 sound level meters, (b) a sound calibrator, (c) three tripods, (d) a weather station, and (e) a laser speed gun (Figure 6).

(a) Sound meter

(b) Sound calibrator

(c) Tripods

(d) Weather station

(e) Laser speed gun

Figure 6. Photo. Noise measurement equipment.

Equipment Setup

The following three subsections provide a brief description of the equipment setup for collecting (1) external noise data at US-41, (2) external noise data at McCraren Road, and (3) internal noise data inside a passenger vehicle while driving over the newly constructed rumble strips.

External Noise Measurements at US-41

The noise measurement equipment was set up to collect external noise data at US-41 based on the recommendations of the AASHTO T 390 testing procedure. Accordingly, the two sound meters for measuring external noise were placed on the right-of-way of US-41 northbound (NB) adjacent to the third and last panel of rumble strips before the intersection with West Park Avenue. The first sound meter was installed 5 ft above the pavement level on a tripod that was placed 25 ft from the center of the easternmost lane (measured perpendicular to the lane) and its coordinates were 42°11′11″N, 87°49′24″W, as presented in Figure 7. The second sound meter was installed 12 ft above the pavement level on a second tripod that was placed 50 ft from the center of the easternmost lane (see Figure 7), and its coordinates were 42°11′11″N, 87°49′23″W. All setup heights and distances were verified on site using a measuring tape. A laser speed gun was used to measure the speed of incoming vehicles as they approach the last panel of rumble strips, as presented in Figure 8.

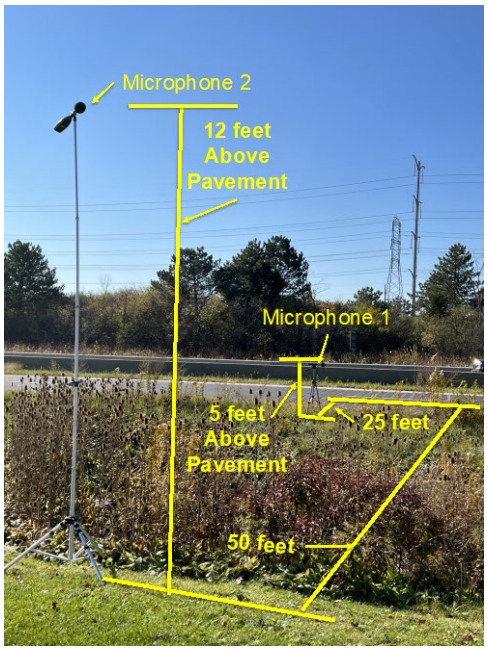

Figure 7. Illustration. Equipment setup for external noise level measurement on US-41.

Figure 8. Photo. Laser speed gun.

External Noise Measurements at McCraren Road

The noise measurement equipment was set up to collect external noise data at McCraren Road following the same procedure used in the 2021 completed study to enable a comparison with its results. Accordingly, the sound meters for measuring external noise at McCraren Road were placed 5 ft above the pavement level at the curb on the western side of the 1800 block of McCraren Road to analyze the noise levels experienced by pedestrians at that location, as presented in Figure 9.

Figure 9. Photo. Equipment setup for external noise level measurement on McCraren Road.

Internal Noise Measurements

The noise measurement equipment was set up to collect internal noise data inside a passenger vehicle while driving on US-41 transverse rumble strips at various speeds following the same procedure used in the 2021 completed study (Chehab, 2022) to enable a comparison with its results. Accordingly, the internal noise level measurements were collected using a PCE-430 sound meter that was fixed firmly to the passenger seat, as presented in Figure 10. The data were collected while all windows were closed, and the radio, flashers, signals, air conditioner, heating, and other sources of internal noise were shut off. Note that the testing vehicle for internal noise measurements in this study was a hybrid sedan, which typically generates lower in-vehicle ambient noise levels compared to the SUV test vehicle used in the 2021 study (Chehab, 2022).

Figure 10. Photo. Equipment setup for internal noise level measurement on US-41.

EXTERNAL NOISE MEASUREMENTS

This section highlights the collection procedure of external noise data at US-41 and McCraren Road.

US-41

The external noise data at US-41 were collected during two intervals on November 1, 2022—from 11:50 to 12:00 and from 12:40 to 13:00—to enable a comparison with the reported results in the 2021 study (Chehab, 2022). There was no precipitation on the day of measurement or on prior days. The relevant weather data on the day of the experiment were collected on site using a weather station (see Figure 6-d) that was located approximately 6 ft above pavement level. The collected weather data include (a) wind speed, which varied from 1.4 to 4.5 mph SSW and which complies with the AASHTO T 390 testing procedure that requires wind speed to be less than 11 mph during the measurements, and (b) temperature, which varied from 68° to 70°F.

The external noise data were collected using two PCE-430 microphones that were positioned at heights of 5 ft and 12 ft above pavement level at distances of 25 and 50 ft from the center of the right lane, as stated earlier. At the 25 ft location during the first interval, the collected noise levels ranged from 58.8 to 95.9 dBA and its time-equivalent continuous sound pressure level (Leq) was 81.5 dBA, as presented in Figure 11. At the 25 ft location during the second interval, the collected noise levels ranged from 55.8 to 94.5 dBA and its Leq was 81.7 dBA, as presented in Figure 12. At the 50 ft location during the first interval, the collected noise levels ranged from 56.3 to 87.9 dBA and its Leq was 76.44 dBA, as presented in Figure 13. At the 50 ft location during the second interval, the collected noise levels ranged from 58 to 87.7 dBA and its Leq was 76.6 dBA, as presented in Figure 14.

For the first measurement interval from 11:50 to 12:00 on November 1, 2022, Figure 15 compares all sound descriptors of the collected data (L10, L50, L90, and Leq) at 25 and 50 ft from the center of the right lane. Similarly, Figure 16 compares all sound descriptors of the collected data during the second measurement interval from 12:40 to 13:00 on November 1, 2022. As expected, all descriptors of the collected data at the 25 ft location are larger than those at 50 ft. For example, the Leq at the 25 ft location is approximately 5 dBA greater than the one at 50 ft.

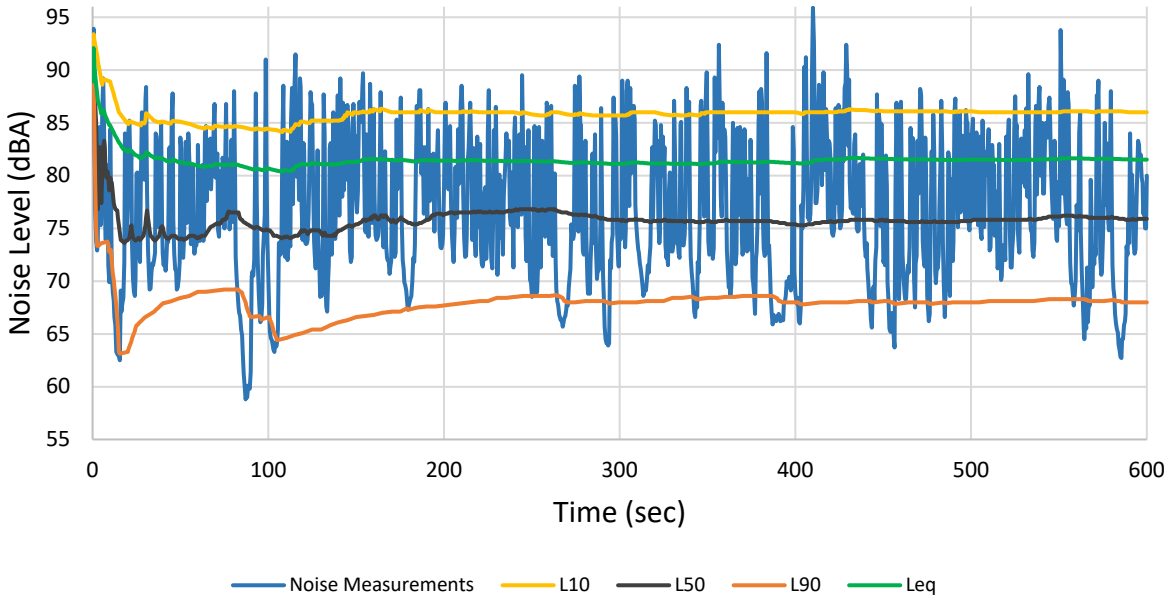

Figure 11. Graph. US-41 external noise data from 11:50 to 12:00 on November 1 at 25 ft location.

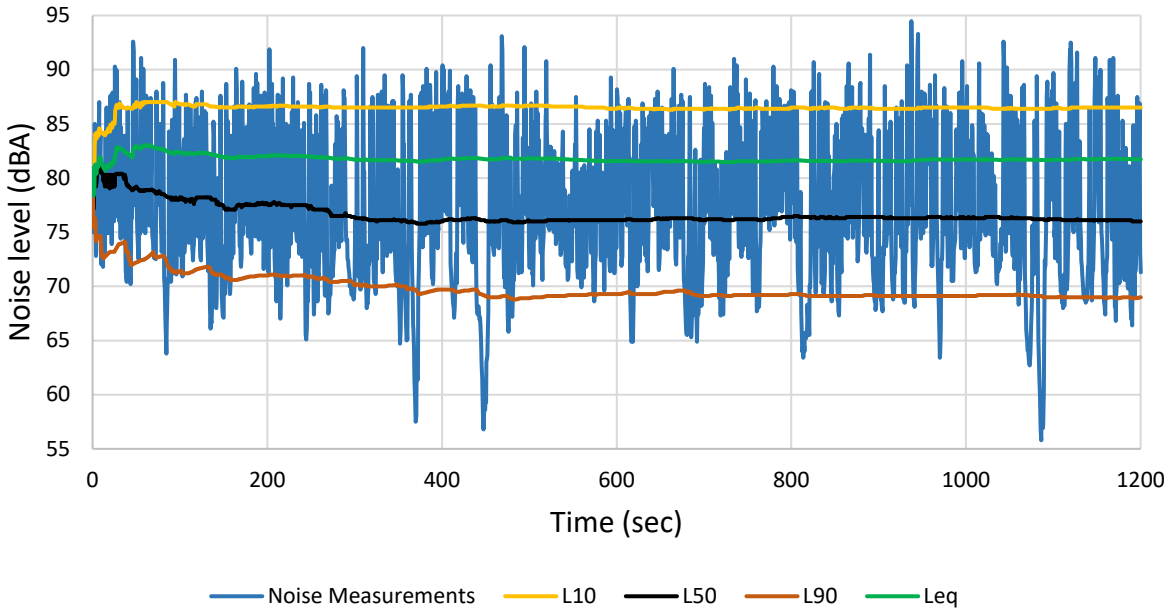

Figure 12. Graph. US-41 external noise data from 12:40 to 13:00 on November 1 at 25 ft location.

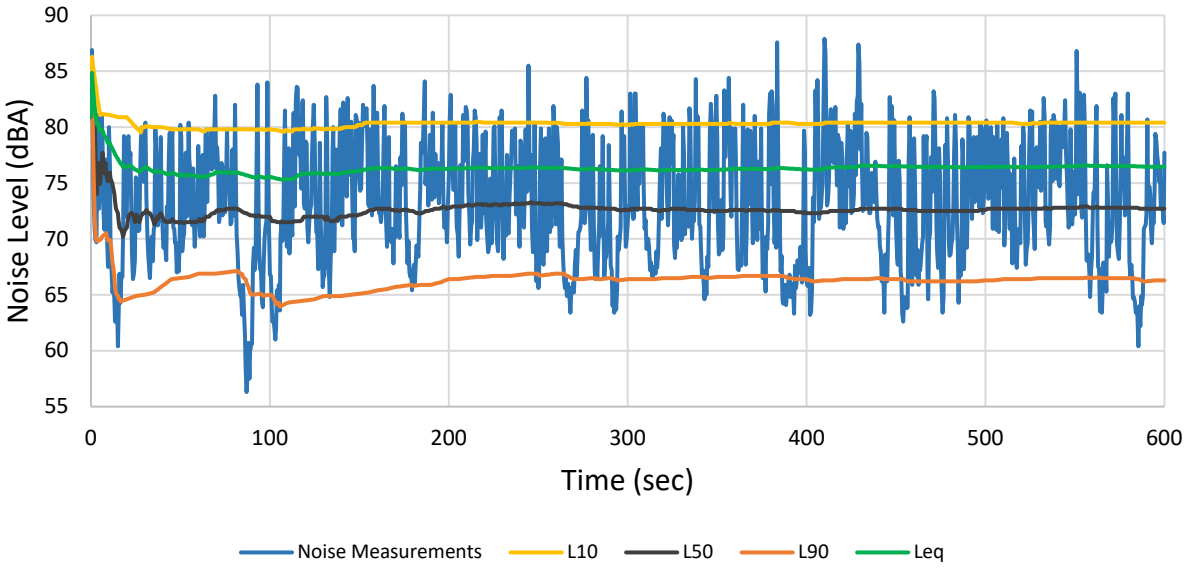

Figure 13. Graph. US-41 external noise data from 11:50 to 12:00 on November 1 at 50 ft location.

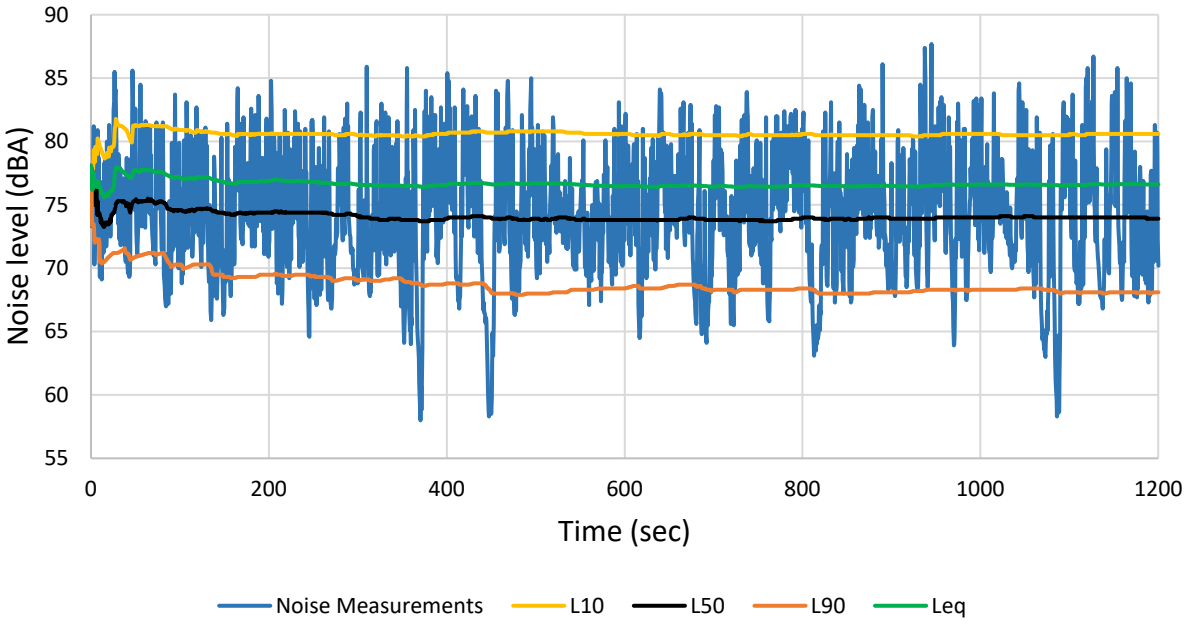

Figure 14. Graph. US-41 external noise data from 12:40 to 13:00 on November 1 at 50 ft location.

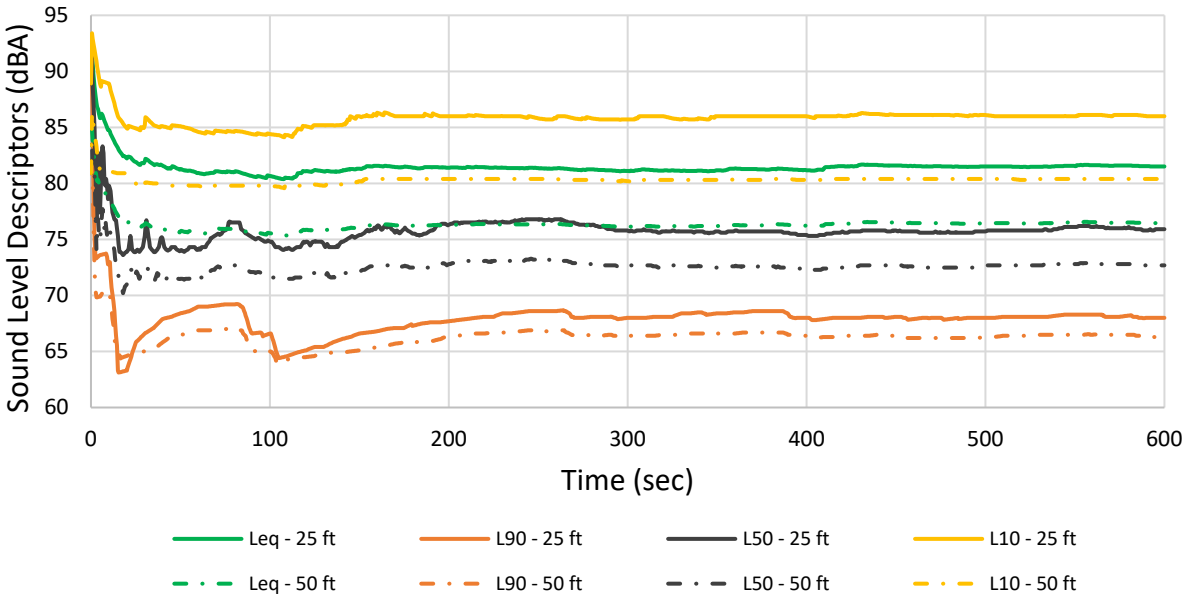

Figure 15. Graph. Sound level descriptors during first interval on November 1 for 25 and 50 ft locations.

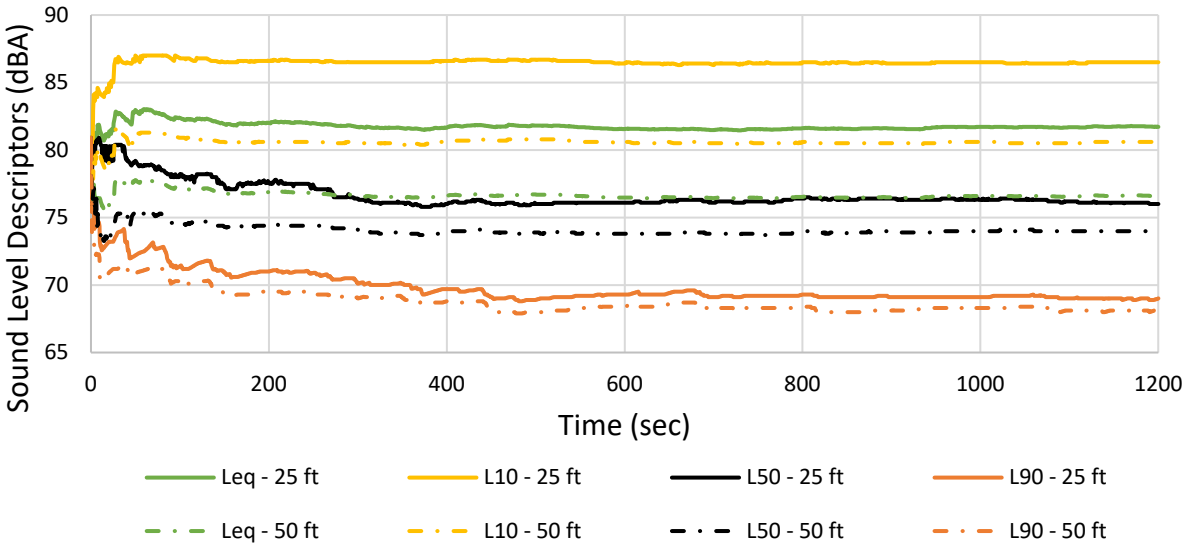

Figure 16. Graph. Sound level descriptors during second interval on November 1 for 25 and 50 ft locations.

McCraren Road

The external measurements at McCraren Road were conducted on November 1 and 2, 2022, at various intervals throughout the measurement period at 5 ft above the ground, as presented in Figure 9. There was no precipitation on the day of measurement or on prior days. The relevant weather data on the day of the experiment were collected on site using a weather station (see Figure

6-d) that was located approximately 6 ft above pavement level. The collected weather data include (1) wind speed, which varied from 1.5 to 4.5 mph SSW, and (2) temperature, which varied from 62°F at noon to 50°F at midnight.

External noise data were collected on McCraren Road during two daily periods: (1) evening of November 1, 2022, from 17:00 to 00:30 and (2) afternoon of November 2, 2022, from 12:00 to 14:00 to enable a comparison with the reported results in the 2021 study (Chehab, 2022). The external noise data were collected using two PCE-430 sound meters that were positioned 5 ft above the pavement level, as presented in Figure 9. A sample of the collected noise data at McCraren Road during the evening of November 1 from 17:15 to 18:00 is presented in Figure 17. The collected noise data for the remaining evening and afternoon periods of November 1 and 2 are summarized in Figures 22 through 31 in Appendix B. Note that the collected noise measurements at McCraren Road were influenced by multiple sources of background noise, including those generated by traffic on US-41, vehicles on McCraren Road, and airplane traffic, as presented in Figure 18. In the absence of passing vehicles on McCraren Road or airplanes, the background noise levels ranged from 41.6 to 50 dBA, as presented in Figure 17.

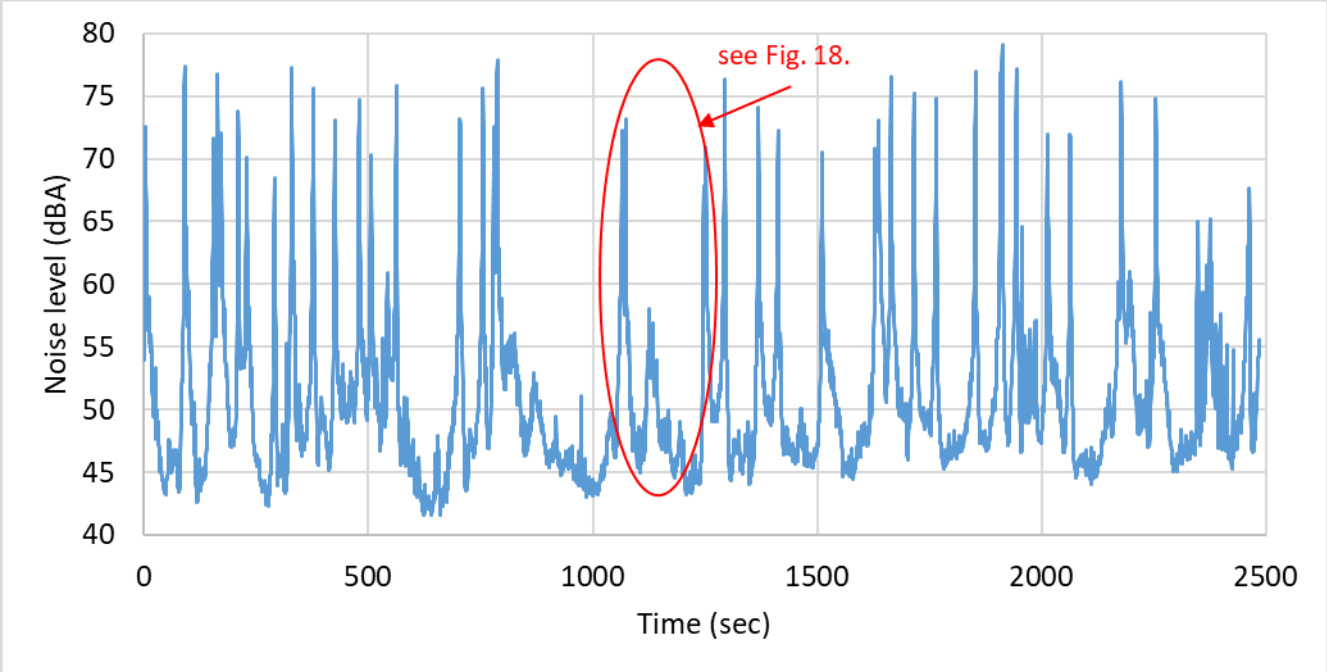

Figure 17. Graph. External noise level at McCraren Road from 17:15 to 18:00 on November 1, 2022.

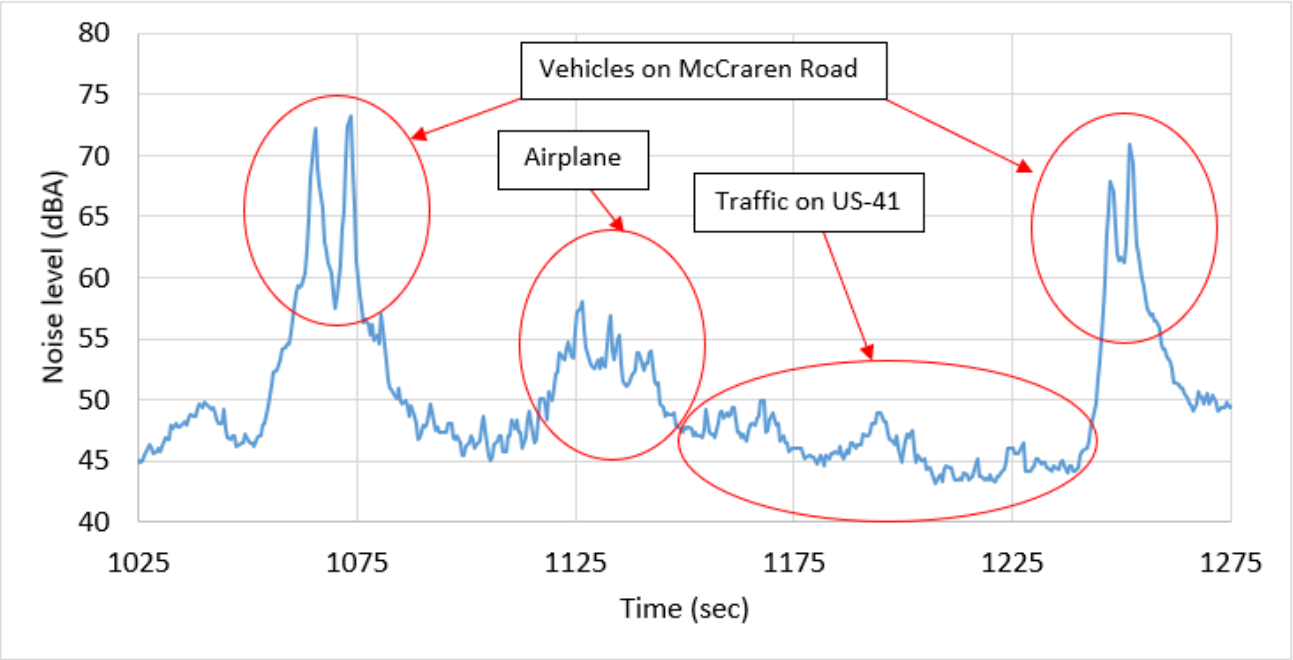

Figure 18. Graph. Collected external noise data on McCraren Road from 17:35:39 to 17:39:49.

INTERNAL NOISE MEASUREMENTS

Internal noise data were collected to evaluate the effectiveness of the US-41 transverse rumble strips in alerting inattentive drivers of the upcoming intersection traffic signal. The internal noise data were collected on November 2, 2022, while traveling over the transverse rumble strip panels at varying speeds of 35, 40, and 45 mph. Ambient or baseline sound level was identified as the average over the first 0.5 seconds before hitting the rumble strips (NCHRP, 2009). The baseline internal noise levels while traveling on the roadway at 35, 40, and 45 mph in cruise control were 61.1, 58.5, and 60.8 dBA, respectively, as presented in Table 2. The average noise level when the test vehicle passed over rumble strip at 35, 40, and 45 mph were 72.4, 73.6, and 75.6 dBA, respectively, as presented in Table 2. This resulted in an in-vehicle internal noise increase that ranged from 11.3 to 15.1 dBA for a hybrid sedan, which complies with the FHWA recommendation that rumble strips should generate additional noise of 3 to 15 dBA above the ambient in-vehicle sound level to alert inattentive drivers (NCHRP, 2009).

Table 2. Internal Noise Data inside Passenger Vehicle Driving over US-41

Speed (mph)	**Baseline** (dBA)	**Panel 1** (dBA)	**Panel 2** (dBA)	**Panel 3** (dBA)	**Average** (dBA)	**Average In-vehicle Increase** (dBA)
35	61.1	72.2	74.7	70.3	72.4	11.3
40	58.5	74.7	73.9	72.2	73.6	15.1
45	60.8	75.8	75.8	75.3	75.6	14.8

CHAPTER 4: COMPARISONS OF 2022 AND 2021 RESULTS

This chapter focuses on comparing the collected external noise levels generated by the 2022 US-41 rumble strips to those generated by the 2019 US-41 rumble strips that were previously collected and analyzed in 2021 (Chehab, 2022). This goal was achieved by comparing (a) traffic flow data on US-41 for a 24-hour period collected in November 2022 and 2021; (b) external noise levels generated by the 2022 and 2019 transverse rumble strips at 25 and 50 ft from the center of the rumble strips, as recommended by AASHTO T 390 standards; and (c) external noise levels recorded on McCraren Road in 2022 and 2021 over the evening and afternoon periods.

TRAFFIC DATA

As stated earlier, IDOT installed a traffic counter on US-41 north of the rumble strips for vehicle count and classification during 15-minute periods from 00:00 on November 1, 2022, to 00:00 on November 2, 2022. The 2022 traffic data were then compared to those collected on November 18, 2021, and reported in the 2021 study (Chehab, 2022), as presented in Figure 19. The 2022 collected traffic data were then used to calculate the traffic volumes during the two specific periods of external noise data collection at US-41: from 11:50 to 12:00 and from 12:40 to 13:00. These 2022 traffic volumes during the periods of external noise data collection were compared to those reported in the 2021 study (Chehab, 2022), as presented in Table 3 and Table 4. This comparison illustrates that the traffic volumes during the morning and afternoon external noise data collection periods in 2022 were 7.8% and 1.4% lower than those of 2021, respectively (see Table 3 and Table 4).

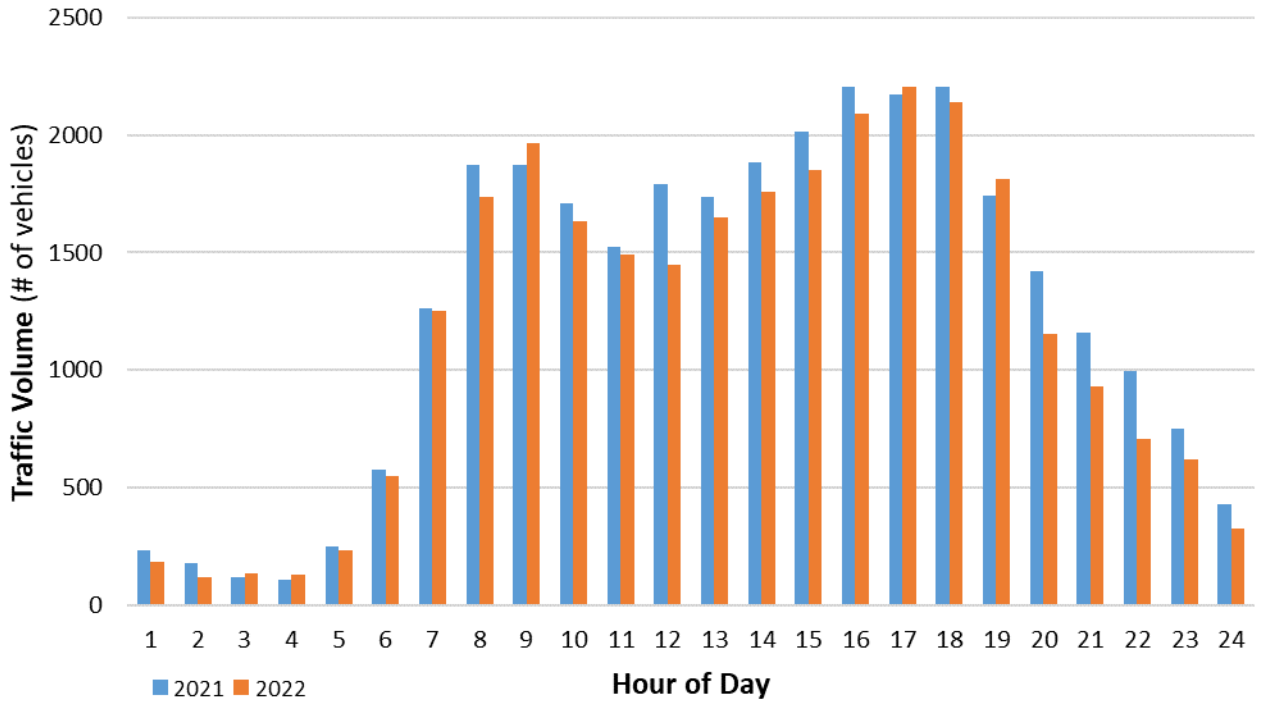

Figure 19. Graph. Comparison of total hourly traffic data on November 18, 2021, and November 1, 2022.

Table 3. Traffic Data Comparison during First Data Collection Period from 11:50 to 12:00

Traffic Data	Type	Period	Passenger	SU	MU	Total
Collected	2022	11:45–12:00	406	16	15	437
	2021	11:45–12:00	434	16	26	476
Calculated	2022	11:50–12:00	271	11	10	292
	2021	11:50–12:00	289	11	17	317
Difference from 2021 to 2022		11:50–12:00	−18	0	−7	−25 (−7.8%)

Table 4.Traffic Data Comparison during Second Data Collection Period from 12:40 to 13:00

Traffic Data	Type	Period	Passenger	SU	MU	Total
Collected	2022	12:30–12:45	378	14	8	400
	2021	12:30–12:45	391	13	16	420
Collected	2022	12:45–13:00	391	18	15	424
	2021	12:45–13:00	400	15	11	426
Calculated	2022	12:40–13:00	517	23	18	558
	2021	12:40–13:00	530	19	16	566
Difference from 2021 to 2022		12:40–13:00	−13	4	2	−8 (−1.4%)

EXTERNAL NOISE MEASUREMENTS

This section highlights the comparison between the 2022 and 2021 external noise data collected at US-41 and McCraren Road.

US-41

As stated earlier, the 2022 external noise generated by the US-41 transverse rumble strips were collected using AASHTO T 390 and the same measurement time and location as those reported in the 2021 study to enable a comparison with its reported results (Chehab, 2022). A comparison of the 2022 and 2021 external noise generated by US-41 transverse rumble strips is summarized in Table 5. The results of this comparison illustrate a consistent reduction in the time-equivalent continuous sound pressure level (Leq) generated by the continuous traffic flow on the US-41 transverse rumble strips from 2021 to 2022, as presented in Table 5. For the AASHTO T 390-specified primary sound meter location at 50 ft (AASHTO, 2020), this includes an Leq reduction of 5.6 dBA during the first period from 11:50 to 12:00 and 7.4 dBA during the second period from 12:40 to 13:00, as presented in Table 5.

Table 5. Collected External Noise Data at US-41

Distance	Sound level descriptor	Period: 11:50–12:00 2022	11:50–12:00 2021	11:50–12:00 Decrease from 2021 to 2022	Period: 12:40–13:00 2022	12:40–13:00 2021	12:40–13:00 Decrease from 2021 to 2022	Average 2022	Average 2021	Average Decrease from 2021 to 2022
50 ft	L_{eq}	76.4	82	5.6	76.6	84	7.4	76.5	83	6.5
	L_{90}	66.3	69	2.7	68.1	71	2.9	67.2	70	2.8
	L_{50}	72.7	80	7.3	73.9	77	3.1	73.3	78	4.7
	L_{10}	80.4	84	3.6	80.6	86	5.4	80.5	85	4.5
25 ft	L_{eq}	81.5	84	2.5	81.7	85	3.3	81.6	85	3.4
	L_{90}	68.0	70	2.0	69.0	72	3.0	68.5	71	2.5
	L_{50}	75.9	80	4.1	76.0	80	4.0	75.9	80	4.1
	L_{10}	86.0	89	3.0	86.5	89	2.5	86.2	89	2.8

McCraren Road

The 2022 external noise data at McCraren Road were collected using the same measurement time and location as those reported in the 2021 study to enable a comparison with its reported results (Chehab, 2022). A comparison of the 2022 and 2021 external noise data at McCraren is summarized in Figure 20 and Figures 32–35 in Appendix C. A sample comparison of the 2022 and 2021 external noise data at McCraren is presented in Figure 20. The remaining comparisons of McCraren Road noise data in 2022 and 2021 are summarized in Figures 32–35 in Appendix C. Note that the collected noise data at McCraren Road cannot be used to make scientific and reliable assessments of the impact of the 2022 changes in US-41 transverse rumble strips on the external noise levels at McCraren Road because these noise levels were collected 950 ft from US-41 and could be influenced by traffic on McCraren Road and adjacent streets, nearby railroad traffic located between US-41 and McCraren Road (see Figure 1), and airplanes departing or arriving at nearby O'Hare airport (see Figure 18). For example, the noise levels measured at McCraren Road from 17:35:39 to 17:39:49 on November 1, 2022, display peaks of noise levels that were caused by vehicles passing on McCraren Road, traffic on US-41, and airplanes approaching O'Hare airport based on the field observations of the research team, as presented in Figure 18. Accordingly, the more scientific and reliable dataset that can be used to evaluate the impact of the 2022 reconstruction of US-41 rumble strips is the external noise dataset that was collected at US-41 following the specifications of the AASHTO T 390 testing procedure.

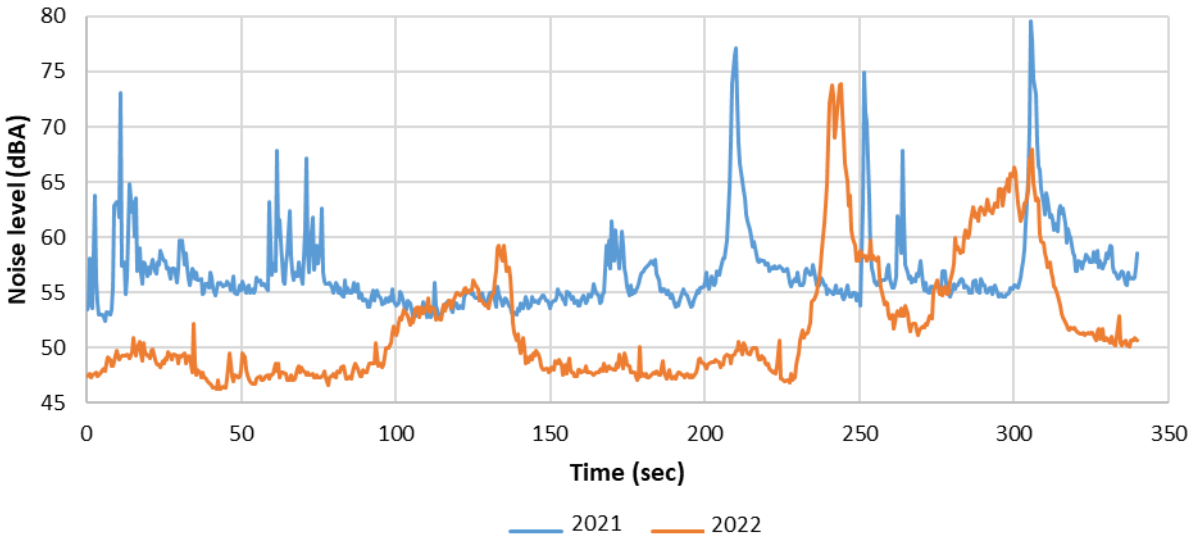

Figure 20. Graph. Collected external noise data on McCraren Road from 18:04:08 to 18:09:48.

CHAPTER 5: CONCLUSION

This report focused on collecting and analyzing external and internal noise levels generated by the modified transverse rumble strips on US-41 that were reconstructed in October 2022. The goal was to enable a comparison with noise levels generated by the original rumble strips that were constructed in the same location in 2019. This work was organized in three tasks: (1) observing and documenting the construction of the 2022 transverse rumble strips; (2) collecting US-41 traffic flow data as well as external and internal noise levels generated by the 2022 transverse rumble strips following the AASHTO T 390 testing procedure for the continuous-flow traffic time-integrated method; and (3) comparing the collected external noise levels generated by the 2022 US-41 rumble strips to those generated by the 2019 US-41 rumble strips that were previously collected in 2021.

Key findings of the conducted analysis and comparison of the 2022 and 2021 external noise levels generated by US-41 transverse rumble strips include the following five items. First, in-vehicle internal noise increase caused by the newly constructed US-41 transverse rumble strips ranged from 11.3 to 15.1 dBA, which complies with the FHWA-recommended range of 3 to 15 dBA. Second, traffic volumes on US-41 during the morning and afternoon external noise data collection periods in 2022 were 7.8% and 1.4% lower than those of 2021, respectively. Third, all descriptors of the 2022 external noise levels generated by continuous traffic flow on US-41 transverse rumble strips (Leq, L10, L50, and L90) were consistently less than those collected and reported in the 2021 study at both AASHTO T 390-specified testing locations of 25 and 50 ft. Fourth, the 2022 time-equivalent continuous sound pressure level (Leq) at the AASHTO T 390 primary sound meter location of 50 ft was less than that reported in the 2021 study by 5.6 and 7.4 dBA during the first and second measurement periods, respectively. Fifth, external noise measurements at US-41 are more scientific and reliable than those collected at McCraren Road in assessing the impact of the 2022 changes in US-41 transverse rumble strips because the McCraren Road noise measurements were collected 950 ft from US-41 and were influenced by other noise sources such as traffic on McCraren Road and nearby O'Hare airplanes.

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APPENDIX A: 2022 IDOT DESIGN OF US-41 TRANSVERSE RUMBLE STRIPS

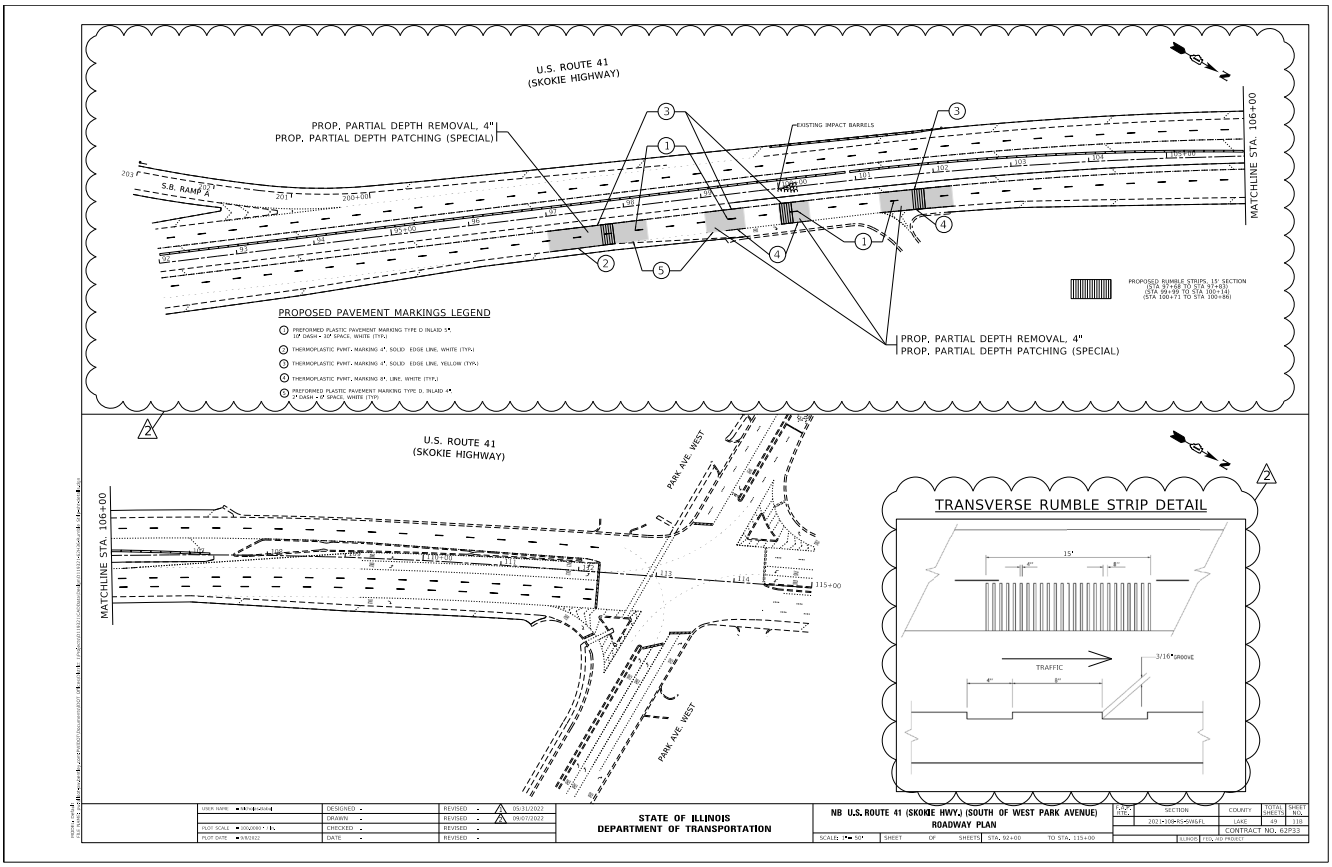

Figure 21. Illustration. 2022 IDOT engineering drawings of US-41 transverse rumble strips.

APPENDIX B: COLLECTED NOISE DATA ON MCCRAREN ROAD IN 2022

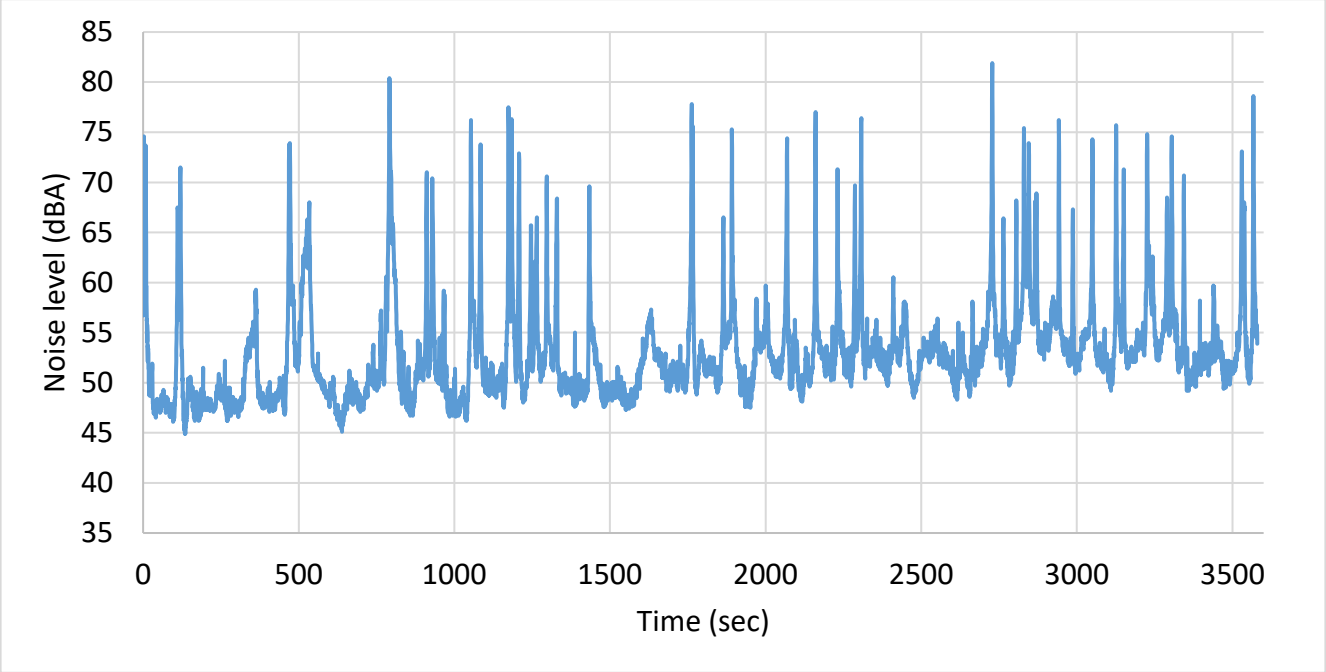

Figure 22. Graph. External noise levels at McCraren Road from 18:00 to 19:00 on November 1, 2022.

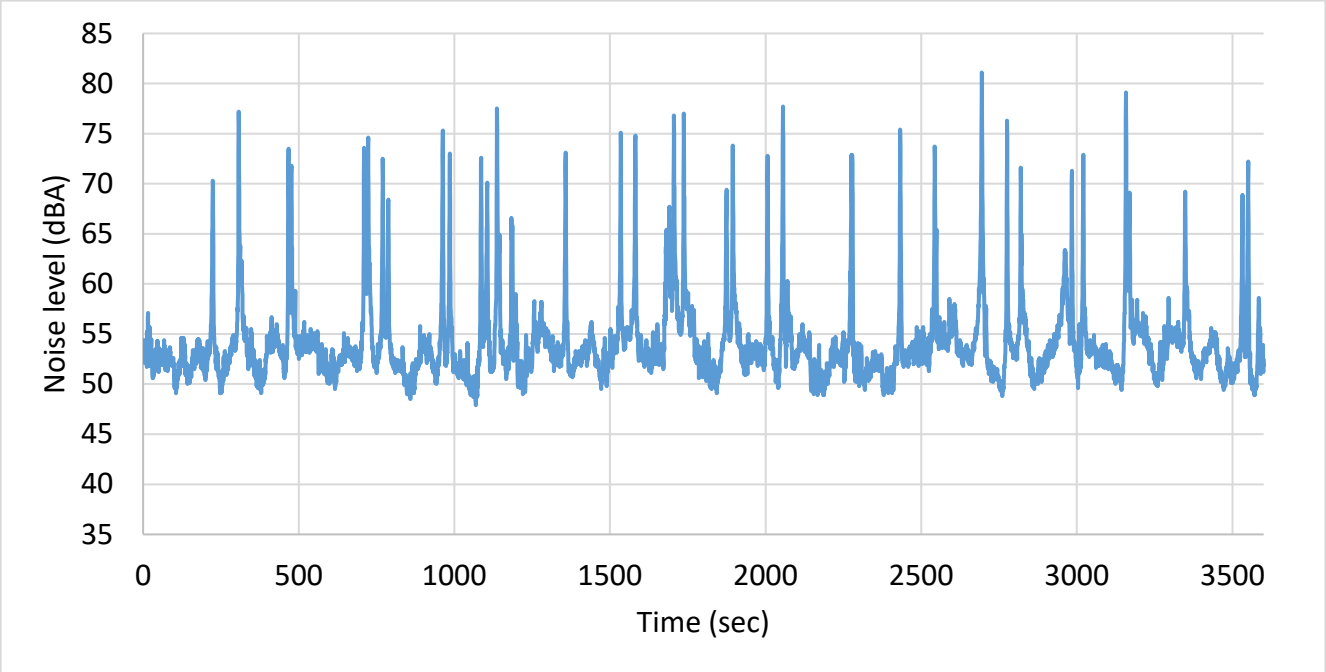

Figure 23. Graph. External noise levels at McCraren Road from 19:00 to 20:00 on November 1, 2022.

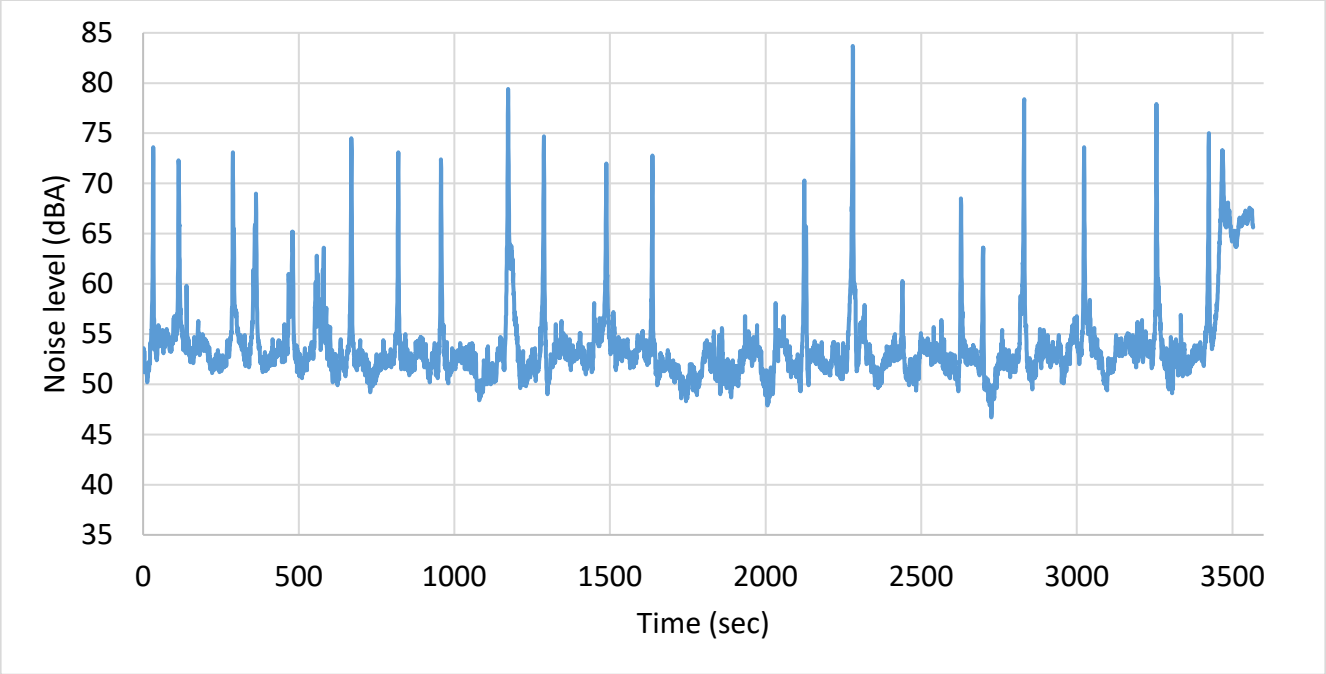

Figure 24. Graph. External noise levels at McCraren Road from 20:00 to 21:00 on November 1, 2022.

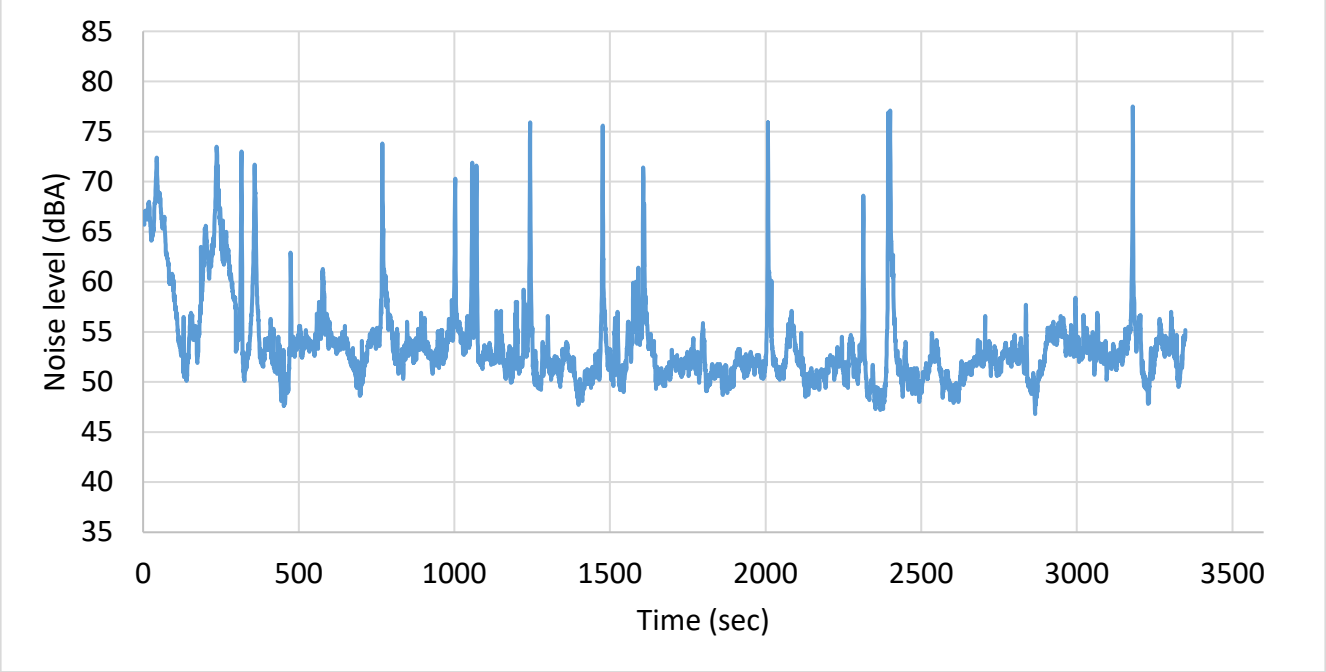

Figure 25. Graph. External noise levels at McCraren Road from 21:00 to 22:00 on November 1, 2022.

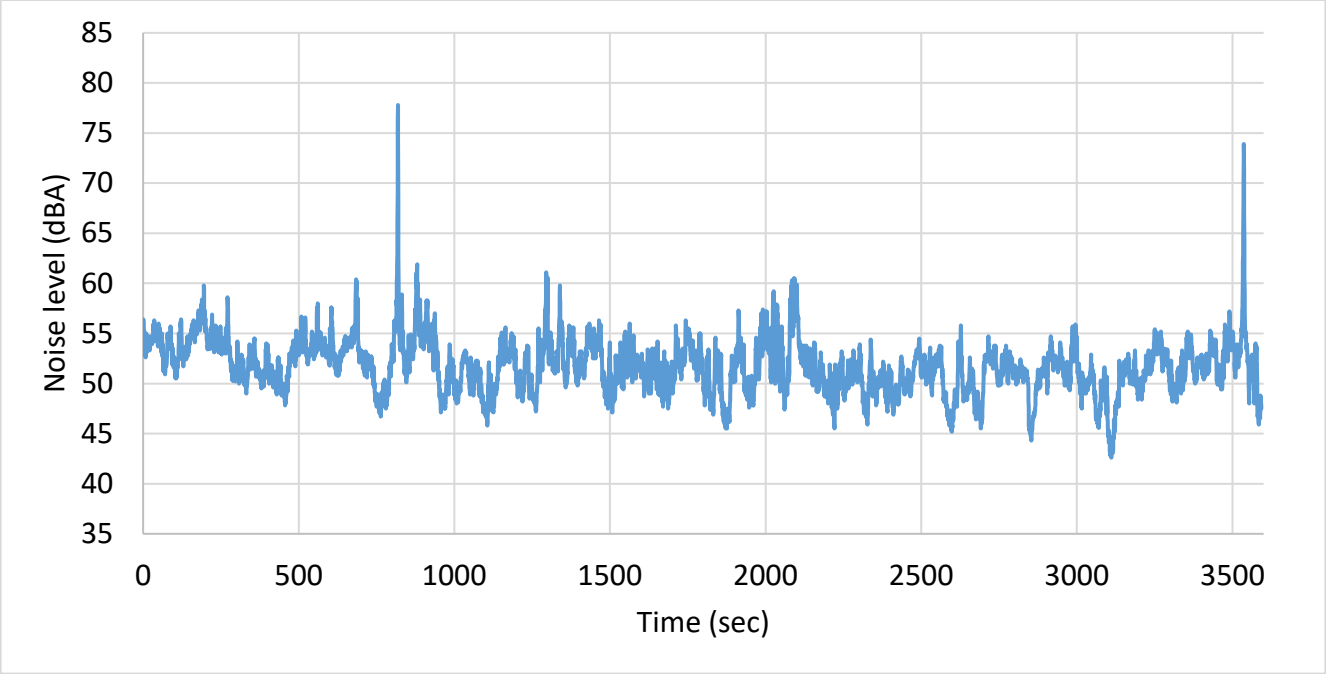

Figure 26. Graph. External noise levels at McCraren Road from 22:00 to 23:00 on November 1, 2022.

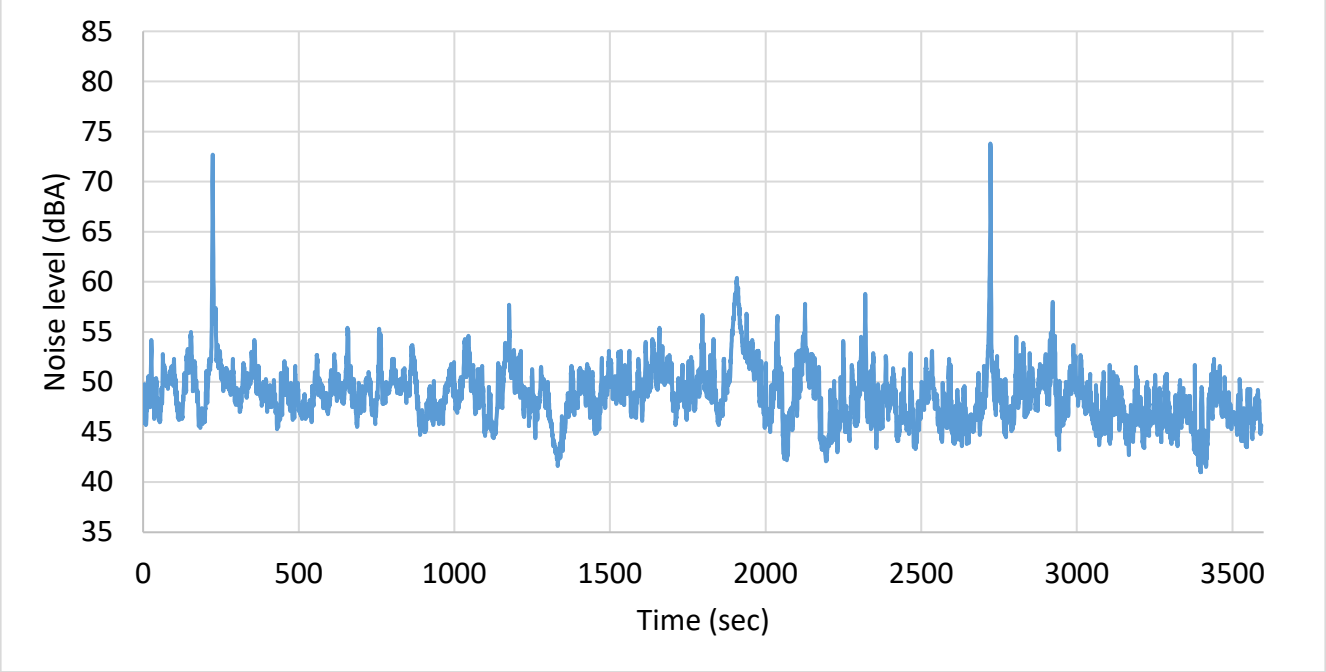

Figure 27. Graph. External noise levels at McCraren Road from 23:00 on November 1 to 00:00 on November 2, 2022.

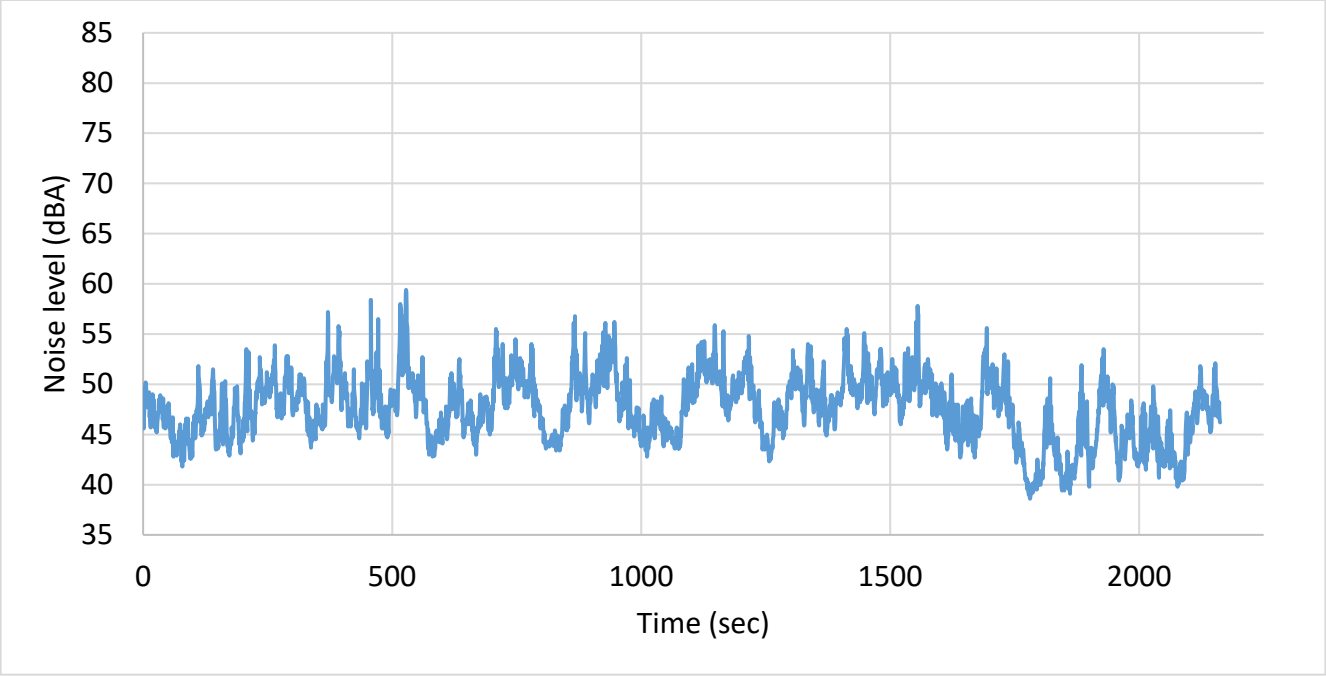

Figure 28. Graph. External noise levels at McCraren Road from 00:00 to 00:30 on November 2, 2022.

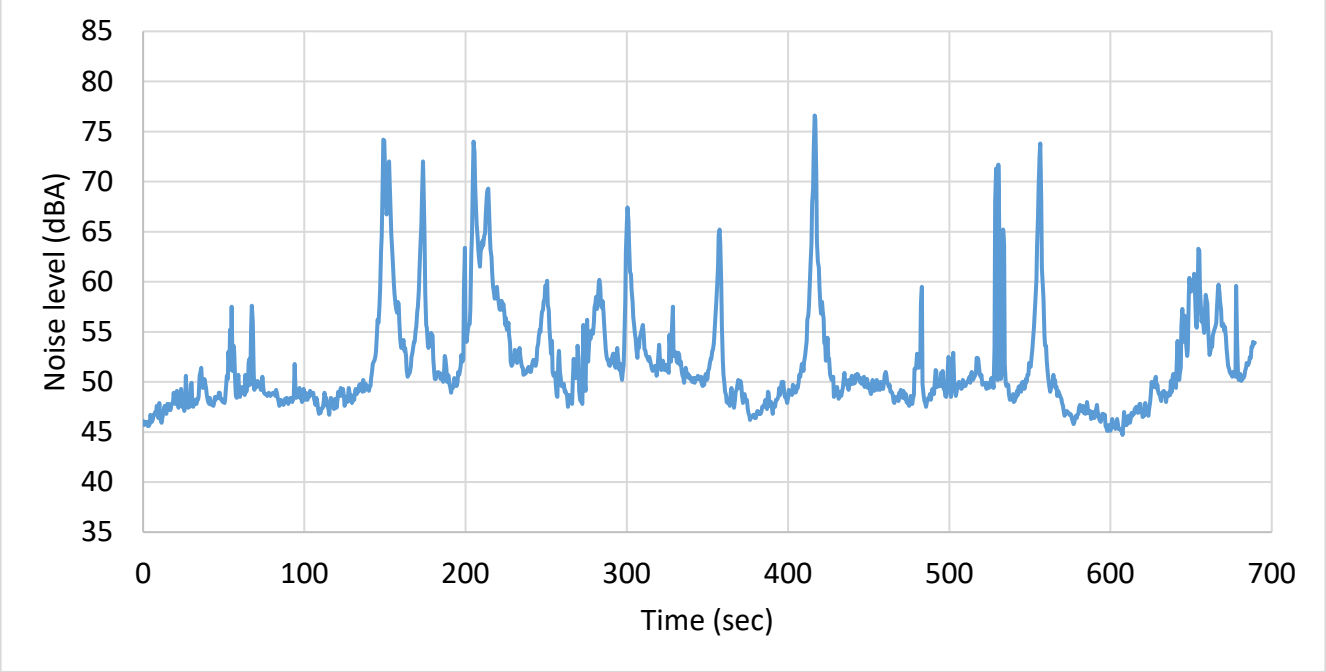

Figure 29. Graph. External noise levels at McCraren Road from 11:50 to 12:00 on November 2, 2022.

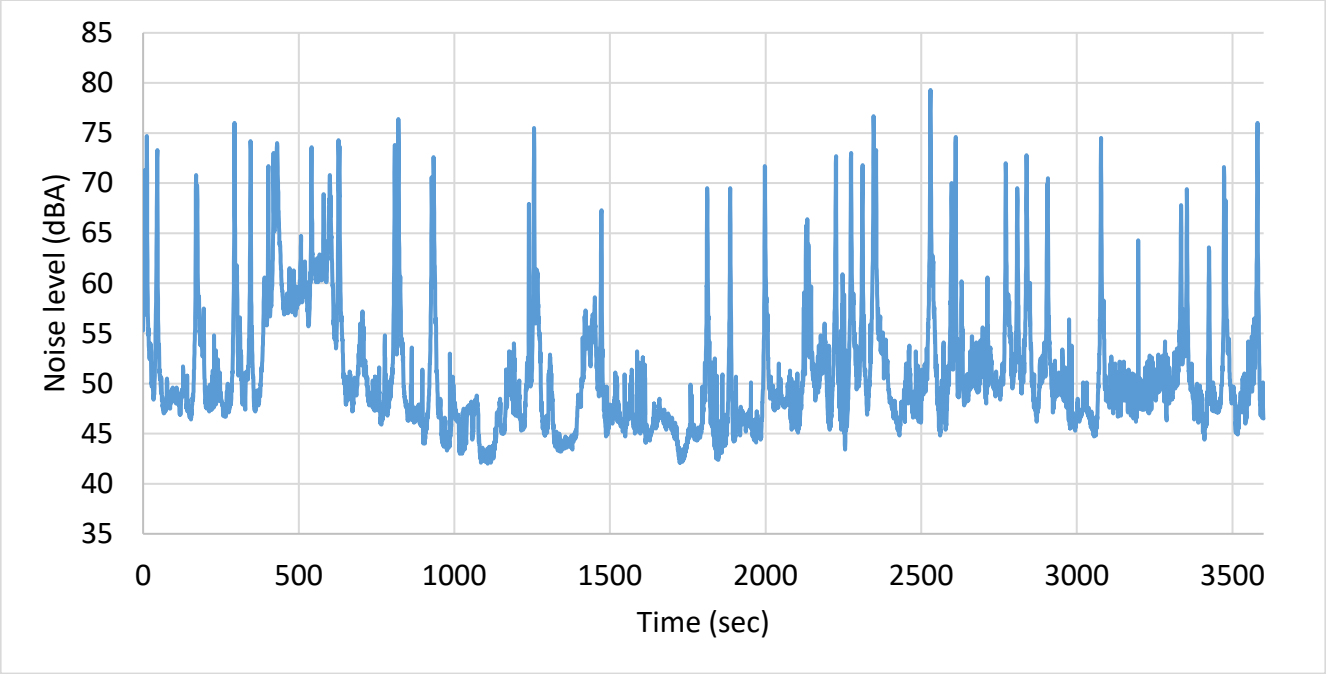

Figure 30. Graph. External noise levels at McCraren Road from 12:00 to 13:00 on November 2, 2022.

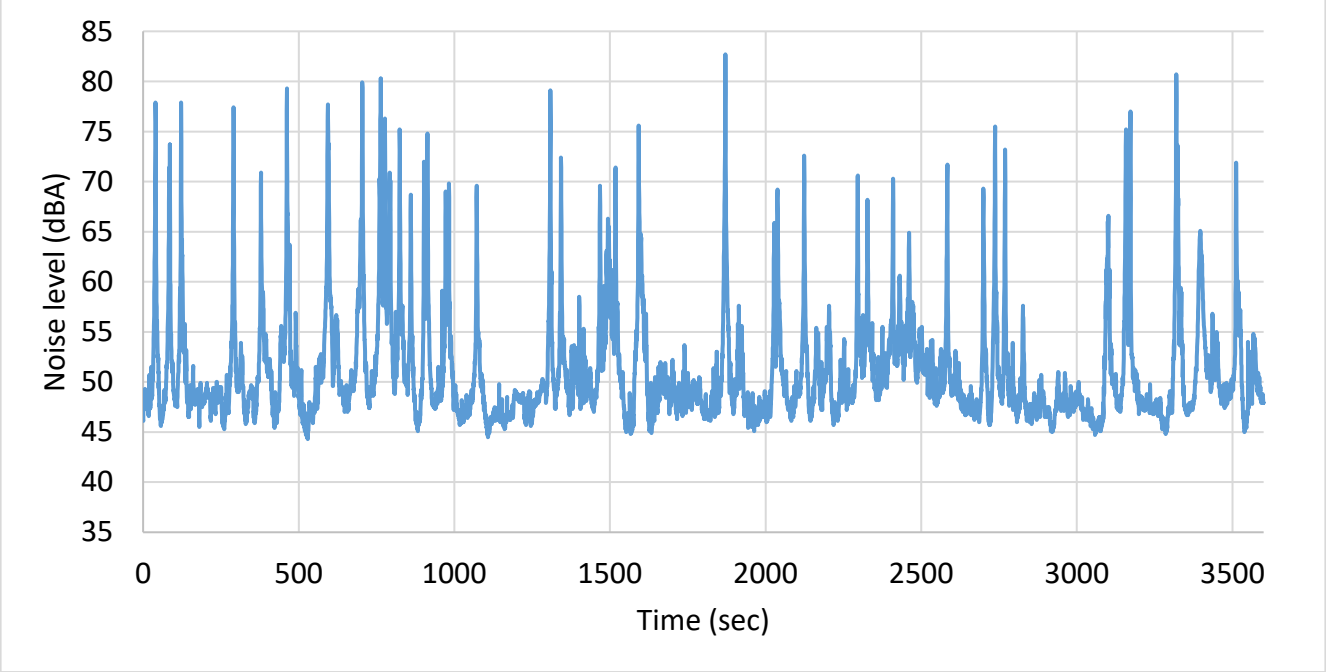

Figure 31. Graph. External noise levels at McCraren Road from 13:00 to 14:00 on November 2, 2022.

APPENDIX C: COMPARISON OF MCCRAREN NOISE DATA IN 2022 AND 2021

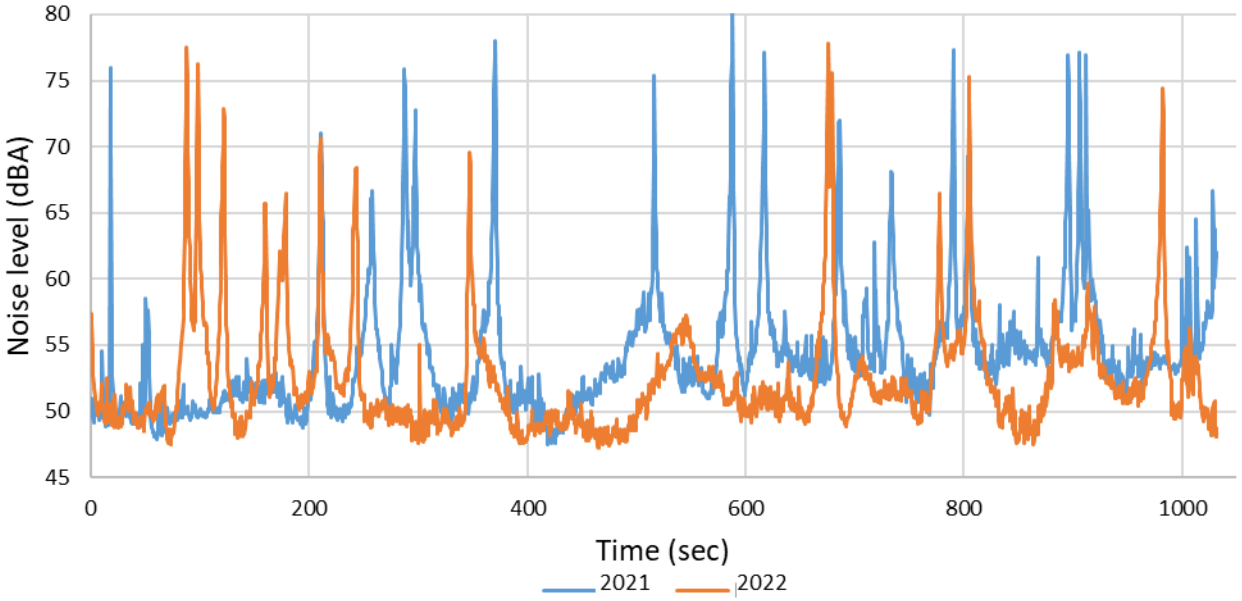

Figure 32. Graph. External noise data on McCraren Road from 18:18:26 to 18:35:38.

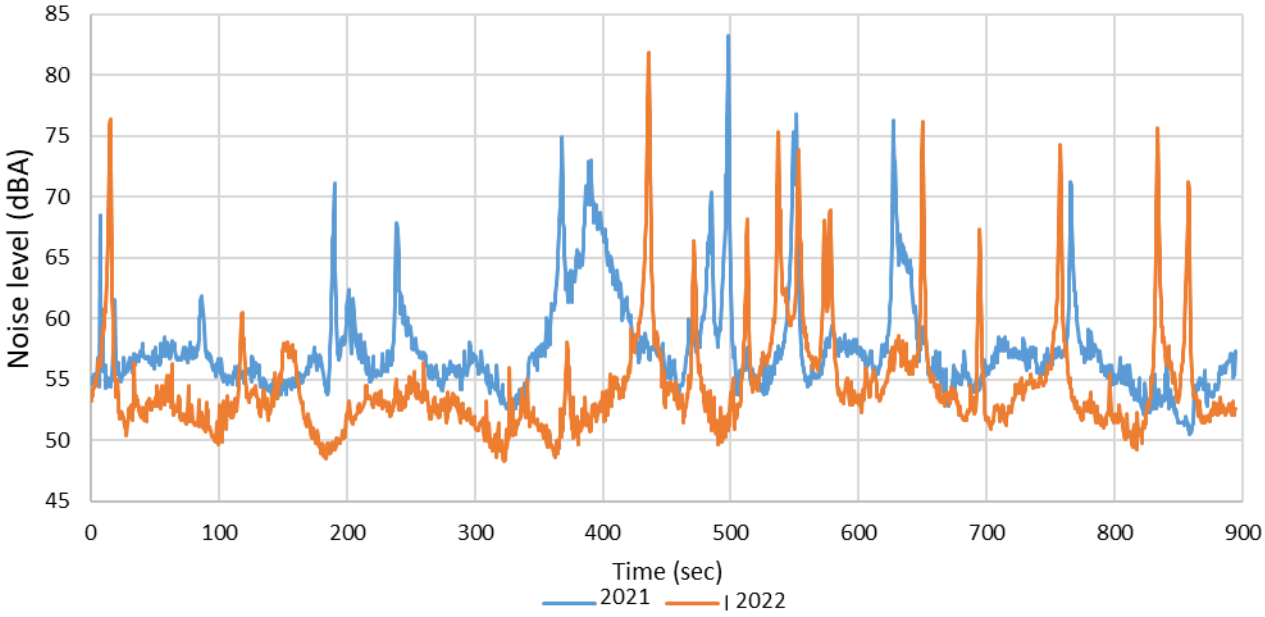

Figure 33. Graph. External noise data on McCraren Road from 18:38:32 to 18:53:27.

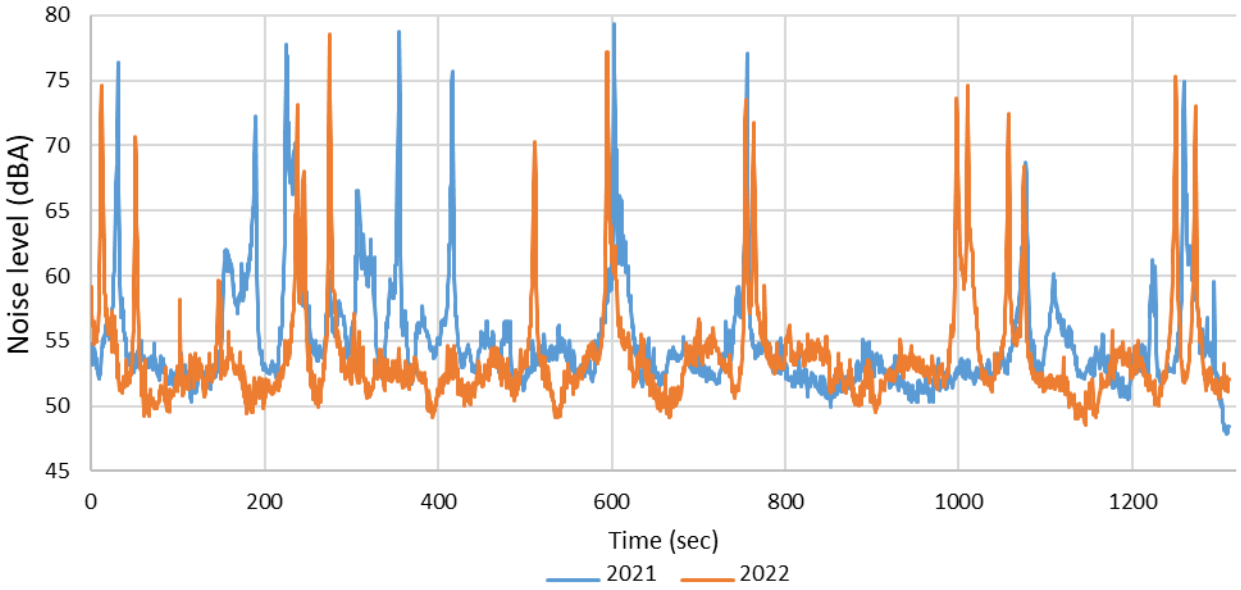

Figure 34. Graph. External noise data on McCraren Road from 18:55:12 to 19:17:04.

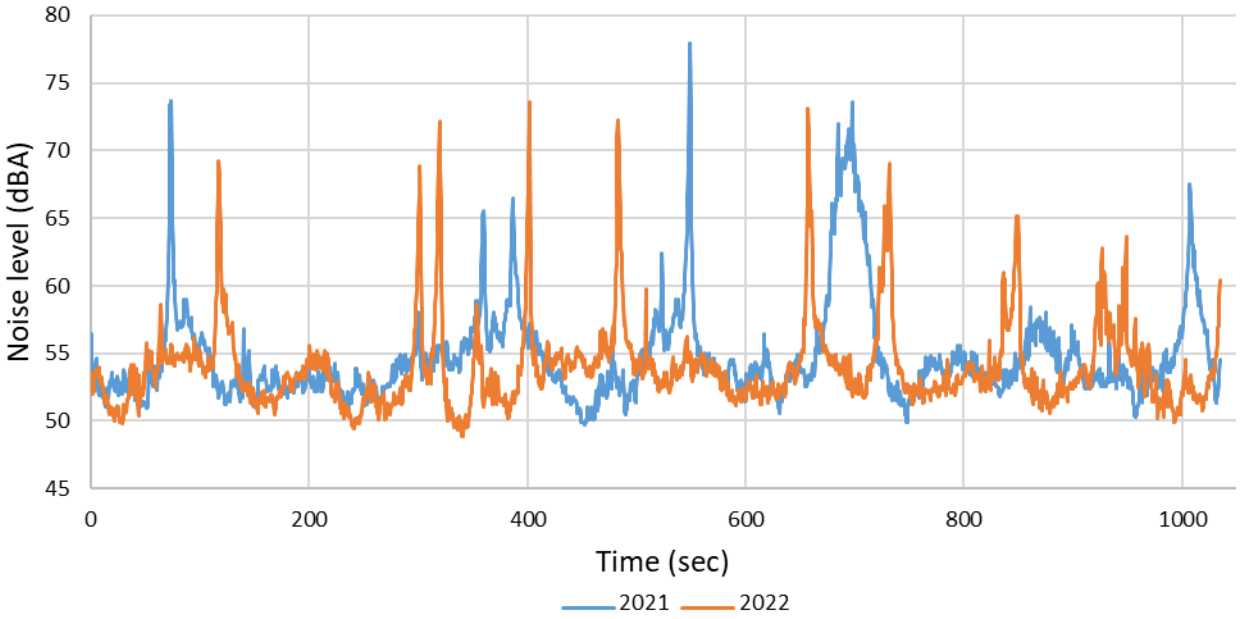

Figure 35. Graph. External noise data on McCraren Road from 19:53:51 to 20:11:06.


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