PL2022-54
PL202200054

esi engineering

November 23, 2022

Mr. Tanner Brandt
Christianson Companies
4609 33rd Avenue S., Suite 400
Fargo, ND 58104

Subject: Summary Report for
Carwash Noise Control
Tommy's Express Car Wash – Bloomington, Minnesota

Dear Mr. Brandt:

We understand you are in the process of developing a new Tommy's Express Car Wash in Bloomington, Minnesota. The proposed site is on West 98th Street with residential neighbors to the north and south, and commercial neighbors to the east and west (see Figure 1). Noise from the car wash must meet the City of Bloomington Code requirements at the nearest receivers. ESI Engineering was asked to measure noise levels at an existing Tommy's Express Car Wash and at the proposed project site, prepare calculations to evaluate car wash equipment noise levels, and if necessary, develop recommendations to meet the Code requirements. The following is a summary of our analysis.

Figure 1 – Aerial image with the Tommy's Express Car Wash project site highlighted.

Site Conditions

The proposed project site is a 1.08 acre commercial lot that is located on the north side of the West 98th Street and Pillsbury Avenue South intersection. As shown in Figure 2, the current architectural site plan has the car wash building located near the middle of the lot with the car wash entrance facing north and the exit facing south. Ten vacuums are shown at the head of parking stalls near the west side of the car wash building. A condensing unit is located near the carwash entrance. Figure 2 also shows the distances from the building and vacuums to the nearest receiver property lines.

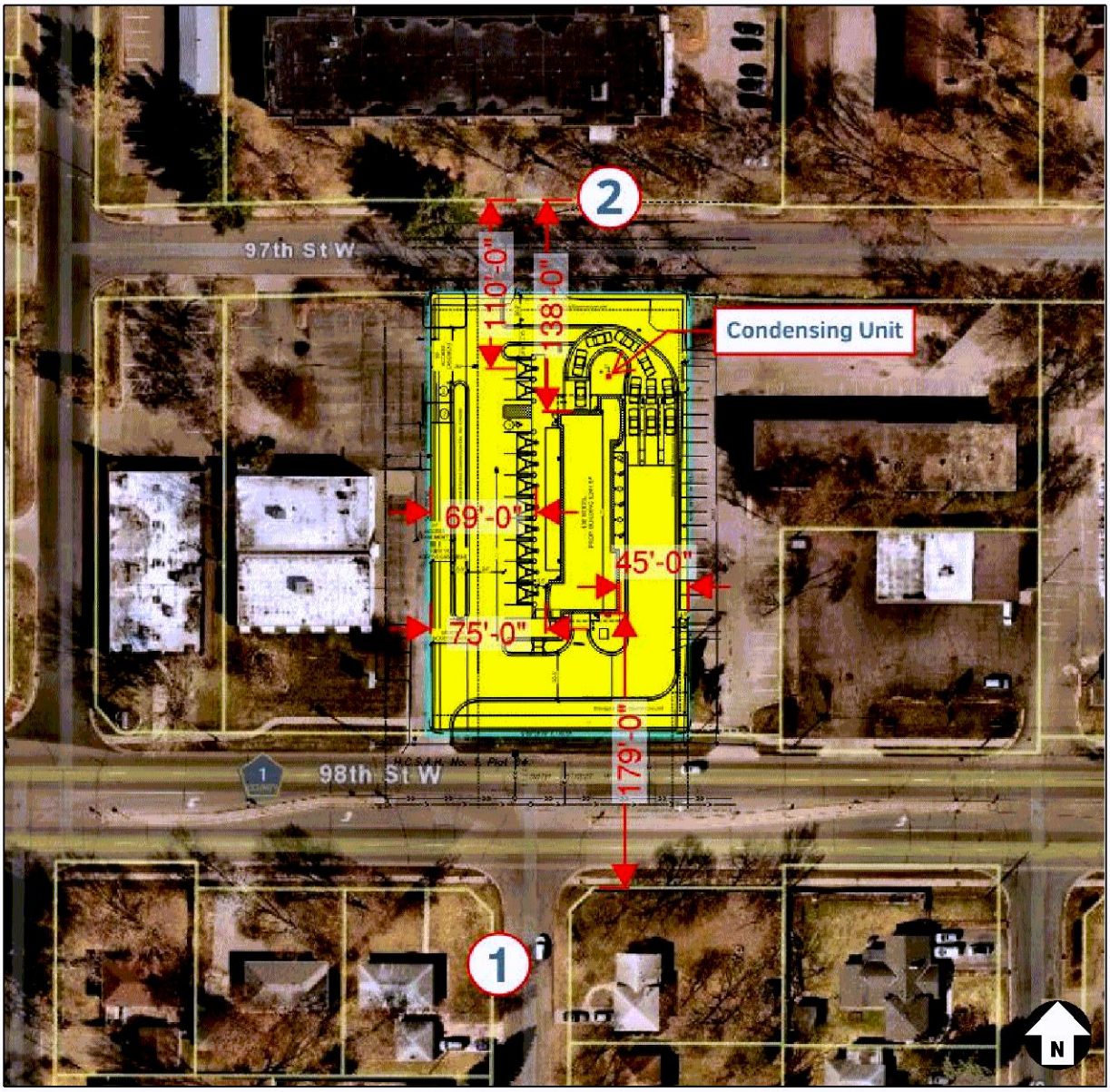

Figure 2 – Car wash site plan overlaid on an aerial image showing the distances to the nearest receiver property lines and the ambient noise measurement locations.

Noise Code Requirements

Minnesota Rule 7030: Noise Pollution, prepared by the Minnesota Pollution Control Agency (MPCA), has requirements for maximum allowable sound levels by receiving land use evaluated at the point of the nearest receiver. These requirements are also listed in the City of Bloomington Code – Chapter 10: Environmental Control – Article IV: Noise Code. Table 1 shows the L10[1] and L50[2] noise limits per noise area classification (NAC). NAC 1 is residential and recreational land use, NAC 2 is commercial, and NAC 3 is industrial. Daytime is defined as being from 7:00 AM to 10:00 PM, and nighttime is from 10:00 PM to 7:00 AM. The requirements are to be evaluated over 1 hour periods and apply to all sources of noise with few exceptions.

Table 1 – MPCA / City of Bloomington Maximum Noise Level Requirements

Noise Area Classification	Receiver Type	Daytime (7AM - 10PM)		Nighttime (10PM - 7AM)	
		L10	L50	L10	L50
1	Residential	65 dBA	60 dBA	55 dBA	50 dBA
2	Commercial	70 dBA	65 dBA	70 dBA	65 dBA
3	Industrial	80 dBA	75 dBA	80 dBA	75 dBA

The nearest receivers to the north and south of the project site are residential properties, and the nearest receivers to the east and west are commercial properties. We understand the car wash will only operate between the hours of 7:00 AM and 9:00 PM, which are entirely daytime hours. Also, because the car wash noise will occur more than 50% of any given hour, the noise levels must meet the L50 requirement that is more stringent that the L10 limit. Therefore, the project requirements are maximum L50 noise levels of 60 dBA[3] and 65 dBA at the nearest residential and commercial receivers, respectively.

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[1] L10 is the sound level that is exceeded 10% of the time during a measurement period.

[2] L50 is the sound level that is exceeded 50% of the time during a measurement period.

[3] As defined in ANSI S12:60, "*A-weighted sound level.* Sound pressure level measured with a conventional frequency weighting that roughly approximates how the human ear hears different frequency components of sounds at typical listening levels for speech. The A-weighting (see IEC 61672-1) attenuates the low-frequency (or low-pitch) content of a sound. A-weighted sound level is expressed in decibels, unit symbol dB[A]."

Ambient Noise Measurements

On Wednesday, February 9, 2022, and Monday, February 14, 2022, Mr. Ryan Skoug of ESI Engineering visited the project site to perform ambient noise measurements. A one hour measurement was made between 8:00 PM and 9:00 PM during each visit. The 8:00 PM hour was chosen because it is one of the hours when the car wash will be operational and ambient noise levels will be relatively quiet. Location 1, shown in Figure 2 above, was the monitoring position on the 9th, and the measurement was made at Location 2 on the 14th. Data sheets showing the measurement results are provided in Attachment A. The measured L50 noise levels were 56 dBA and 43 dBA at locations 1 and 2, respectively, which are less than the 60 dBA Code limit for residential receivers during daytime hours. The dominant noise sources were vehicular traffic on streets and highways. The results are provided for reference only because the Code requirements do not include the contribution of the ambient noise at the site.

Existing Car Wash Measurements

On Tuesday, February 8, 2022, Mr. Ryan Skoug of ESI Engineering visited an existing Tommy's Express Car Wash in Mounds View, Minnesota to make observations and perform noise measurements. Sound measurement data sheets are provided in Attachment B. The following is a summary of the visit findings:

1. There were multiple Tommy Car Wash Systems vacuums at the site (see Figure 3). No mufflers were installed on top of the vacuums. The measured L50 sound pressure level at a distance of 10' from one running vacuum was 72 dBA.

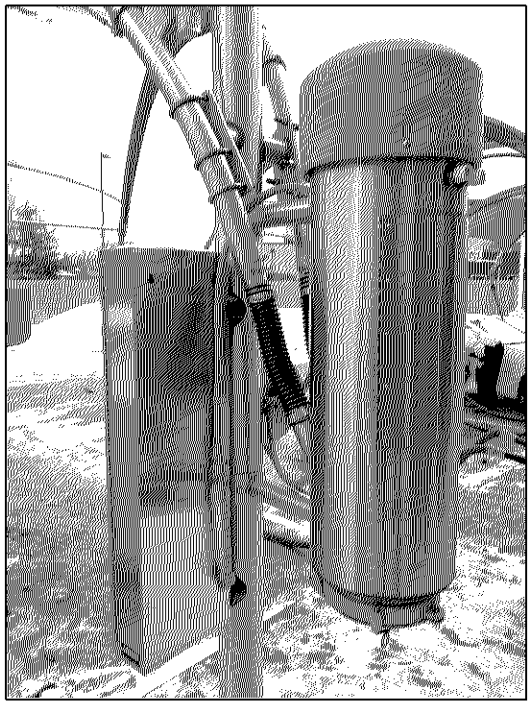

Figure 3 – Photo of a vacuum at the Tommy's Express Car Wash.

2. The dominate noise source near the car wash exit (see Figure 4) was the drier system, which had eighteen blowers (shown in Figure 5). The measured L50 sound pressure level at a distance of 58' from the exit, with a zero degree offset from the exit centerline, was 83 dBA. When a measurement was made 54' from the exit with a 45 degree offset from the exit centerline, the measured L50 was 79 dBA.

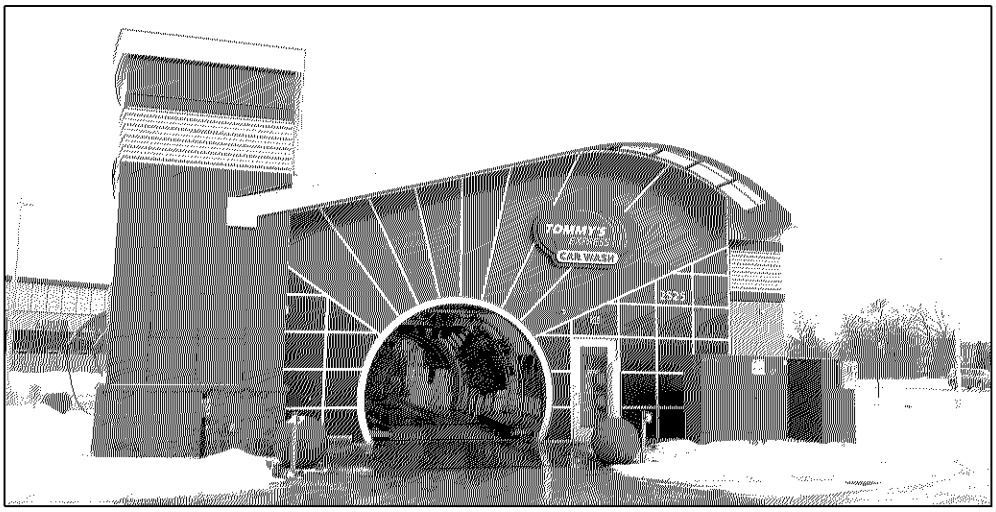

Figure 4 – Photo of the Tommy's Express Car Wash exit with drier system beyond.

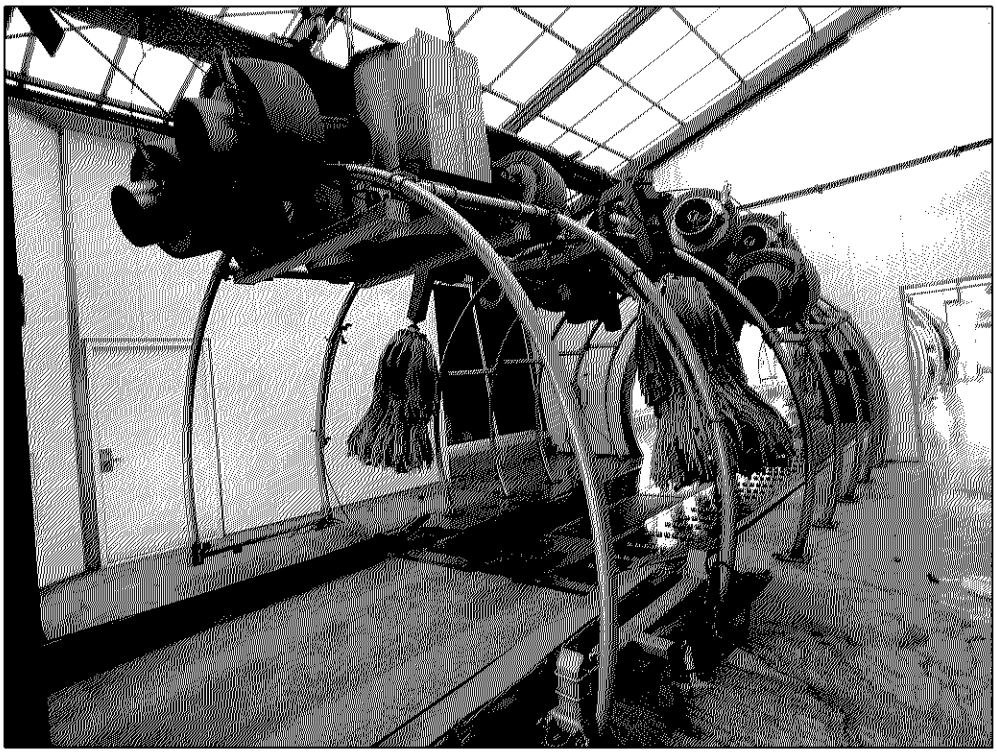

Figure 5 – Photo of the Tommy's Express Car Wash drier system.

3. The dominate noise sources near the car wash entrance were the automated audio system (see Figure 6) and the drier system at the other end of the car wash. The measured L50 sound pressure level at a distance of 48' from the entrance, with a zero degree offset from the entrance centerline, was 71 dBA.

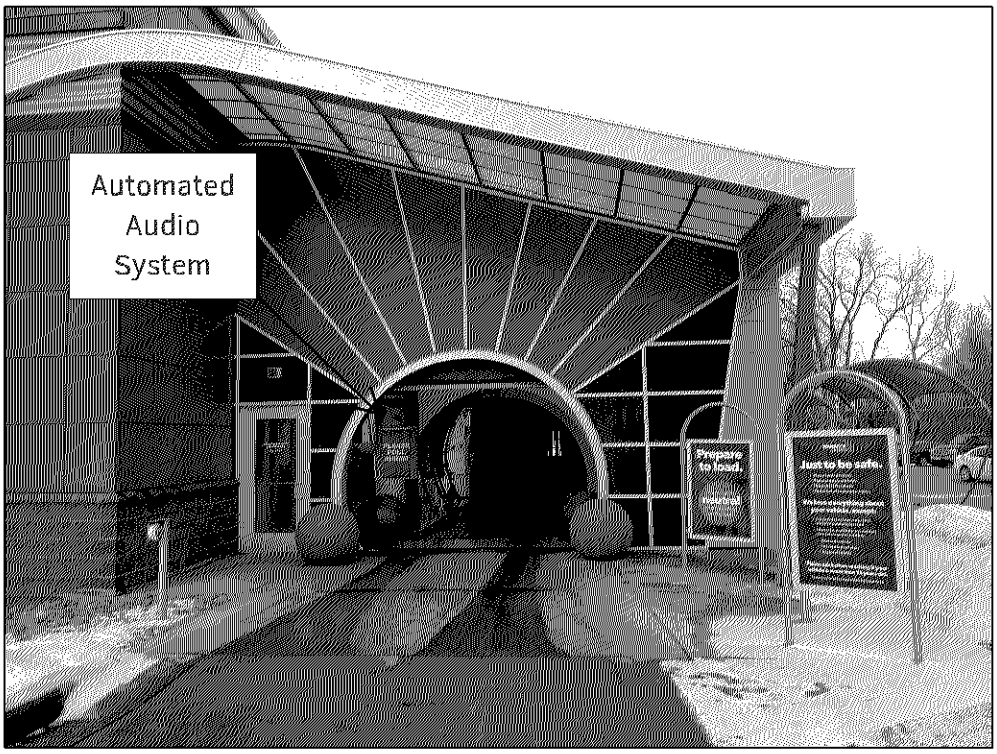

Figure 6 – Photo of the Tommy's Car Wash entrance.

4. The car wash building had louvers with dampers on each side (see Figure 7). The dampers could be opened and closed to control the release of heat and steam from inside the building, which also allows sound to leak out. The dominate noise source radiating from the dampers was the drier system. The measured L50 level at a distance of 8.5' from one open damper (shown in Figure 8) was 75 dBA.

Figure 7 – Photo of the Tommy's Express Car Wash with sidewall louvers circled.

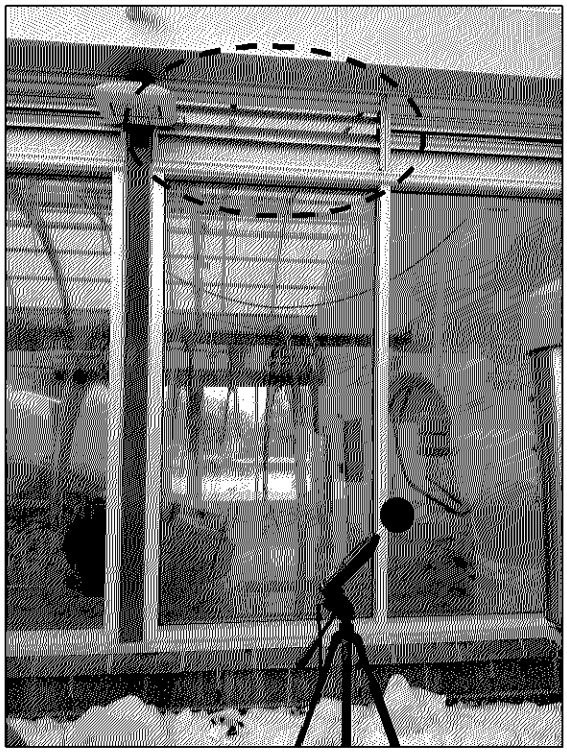

Figure 8 – Photo of the Tommy's Express Car Wash with an open damper circled.

Noise Analysis

Calculations were prepared to determine the car wash noise levels at the nearest residential and commercial receiver locations to the Bloomington project site. The measured Tommy's Express Car Wash L50 sound pressure level results were used as source data for the analysis. The results were converted into L50 sound power levels to determine the noise from each source independent of distance. We also included sound power data for a condensing unit that was based on data provided by the manufacturer (see Attachment C). Table 2 shows the sound power levels used for each noise source.

Table 2 – Source Sound Power Levels

Source	Sound Power Levels (dBA) Per Frequency (Hz)								Overall Sound Power Level (dBA)
	63	125	250	500	1k	2k	4k	8k	
One Vacuum	54	56	66	75	81	86	84	80	90
Exit Opening	78	91	101	110	112	108	102	93	115
Entrance Opening	70	80	89	96	99	97	90	85	103
Open Side Louver	59	71	81	85	88	83	76	67	91
Condensing Unit	-	54	63	69	69	67	61	56	74

A noise contour plot was prepared to help evaluate the car wash noise levels at the proposed project site. The calculations included the car wash building, all other nearby buildings, and a source for each of the car wash noise producers. Sources were the exit opening, entrance opening, eleven east facing sidewall louvers, twelve west facing sidewall louvers, ten vacuums near the west side of the car wash building, and one condensing unit.

The existing car wash measurement results also showed that drier system noise at the exit and entrance was directional. At a 45 degree offset from the centerline, the sound power was about 5 dBA quieter. This "tunnel effect" of the sound dispersion from the exit and entrance was included in the noise calculations.

The calculation results for these basis-of-design conditions are summarized in the noise contour plot shown in Figure 9. The noise level results at the nearest residential and commercial receivers exceeded the daytime requirements of 60 dBA. The highest exceedance was the noise level at the nearest residential receiver south of the car wash exit. The calculated level at this position was 74 dBA, which exceeds the requirement by 14 decibels.

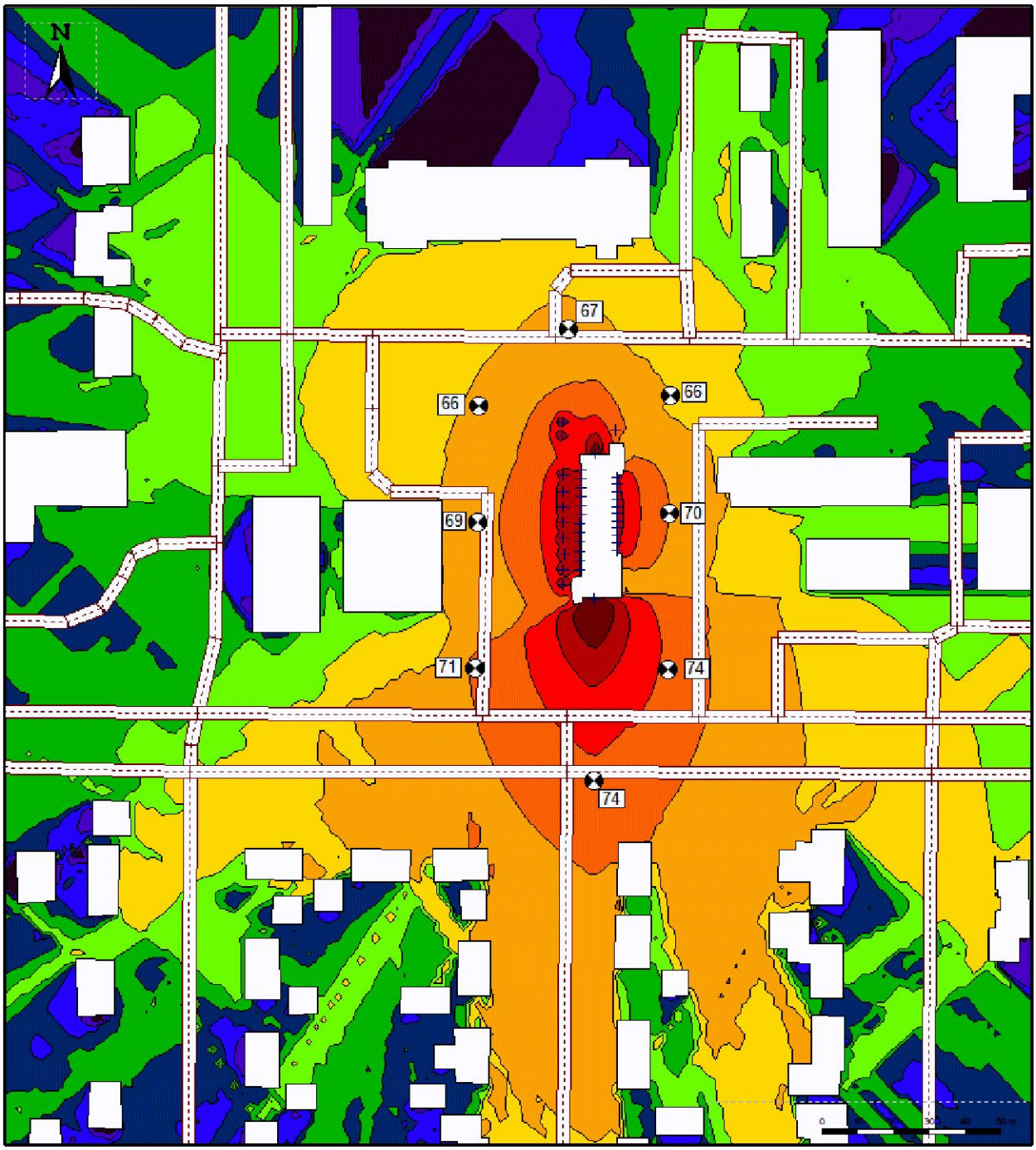

Figure 9 – Noise contour plot showing the basis-of-design Tommy's Express Car Wash equipment noise levels at the proposed Bloomington project site.

Recommendations

We recommend the following to reduce the car wash equipment noise levels:

1. Tommy Car Wash Systems has optional mufflers that can be provided with the vacuums. Based on a Tommy Car Wash Systems report (provided in Attachment D), installing a P-VAC-335 muffler (shown in Figure 10) on top of a vacuum reduces noise levels by 9 dBA and does not affect the vacuum suction. We recommend installing P-VAC-335 mufflers on all of the vacuums for the Bloomington project.

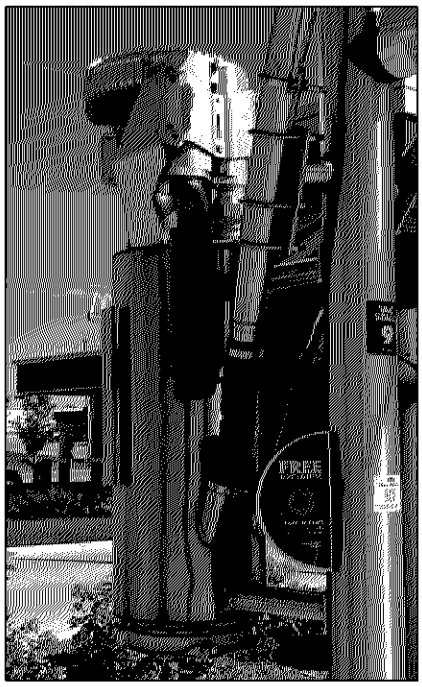

Figure 10 – Photo of a Tommy Car Wash Systems vacuum with a P-VAC-335 muffler.

2. The loudest car wash noise source is the drier system. We understand the individual Tommy Car Wash Systems blowers can be installed with variable frequency drives (VFDs) to control blower speeds between 0 Hz (0% speed) and 60 Hz (100% speed). Based on a Tommy Car Wash Systems report dated May 18, 2021 (provided in Attachment E), the car wash noise levels are reduced by 17 dBA when the blowers run at 30 Hz (50% speed). For the Bloomington car wash, we recommend running the blowers at around 30 Hz to achieve about 17 dBA of noise reduction.

The resultant noise contour plot with the vacuums having P-VAC-335 mufflers (9 dBA of reduction) and the blowers running at 30 Hz (17 dBA of reduction for the exit, entrance, and sidewall louver sources) is provided in Figure 11. With these recommendations, the results show a maximum noise level of 58 dBA at the loudest residential and commercial receiver positions, which meets the 60 dBA and 65 dBA daytime Code limits, respectively. No other modifications to the car wash equipment are necessary.

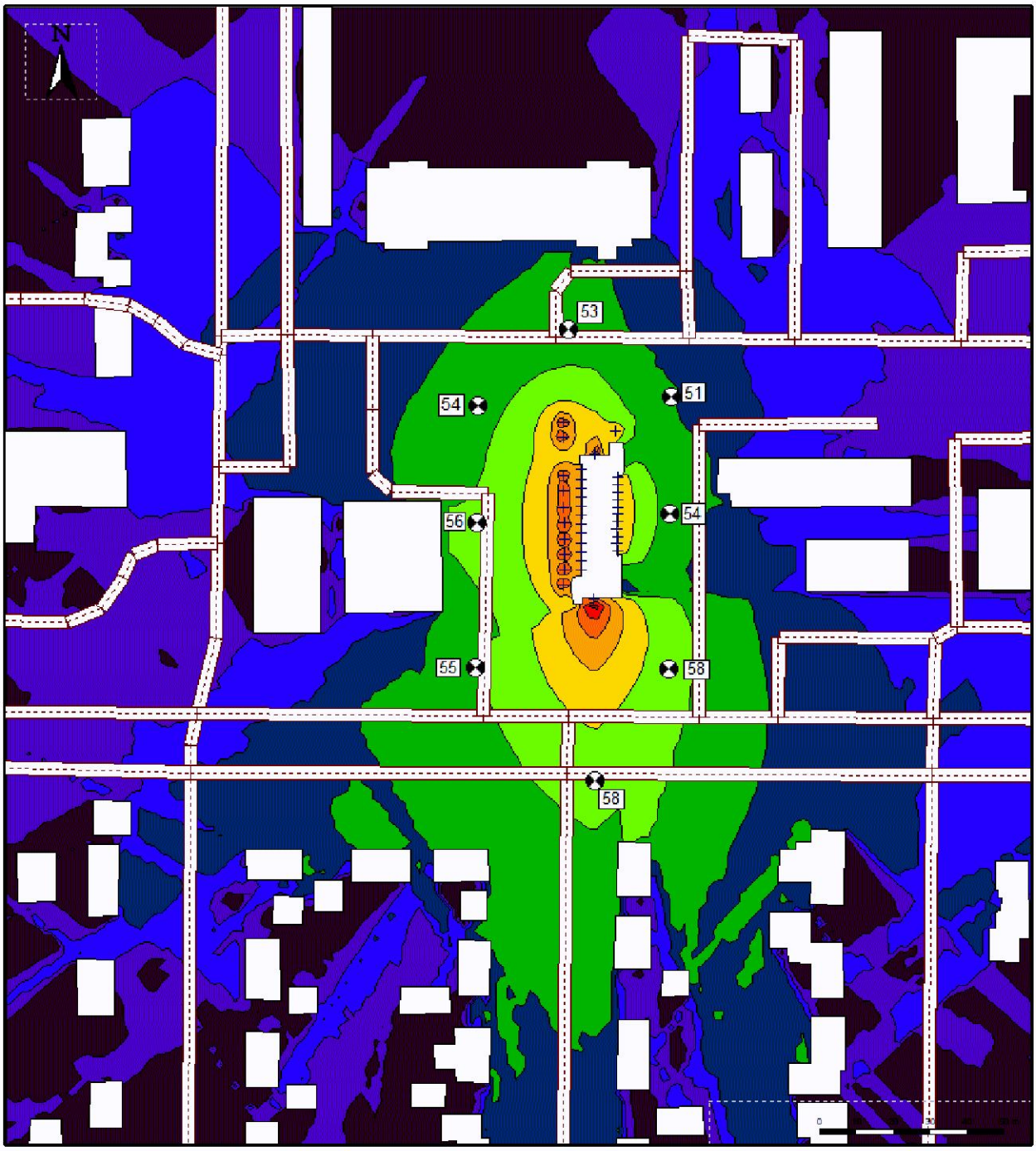

Figure 11 – Noise contour plot showing the Tommy's Express Car Wash equipment noise levels at the proposed Bloomington site with the recommended vacuum mufflers included and the blowers running at 30 Hz.

Conclusions

ESI Engineering was asked to evaluate equipment noise levels for a proposed Tommy's Express Car Wash in Bloomington, Minnesota. The Minnesota Rules and City of Bloomington Code require that noise at the nearest residential and commercial receivers not exceed 60 dBA and 65 dBA, respectively. Based on car wash equipment sound levels measured at a Tommy's Express Car Wash in Mounds View, Minnesota, the basis-of-design conditions produce calculated noise levels that exceed the Code requirements by as much as 14 dBA. To reduce equipment noise levels, we recommend installing mufflers on all vacuums (9 dBA reduction) and running the blowers at around 30 Hz (17 dBA reduction). With these recommendations, the car wash noise levels meet the Code requirements at all nearby residential and commercial receivers.

We appreciate the opportunity to serve the needs of Christianson Companies on this project and remain available to assist in the resolution of these and any other matters. Please let us know if you have any questions or need more information.

Sincerely,

Ryan L. Skoug, P.E. (OR), INCE Bd. Cert.
Consulting Engineer
ESI Engineering, Inc.

Anthony J. Baxter, P.E. (MN)
Principal
ESI Engineering, Inc.

Attachments

PL2022-54
PL202200054

Attachment A

Ambient Noise Measurement Data

Bloomington Car Wash Noise Control – November 23, 2022

PL2022-54
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Acoustic Test Results

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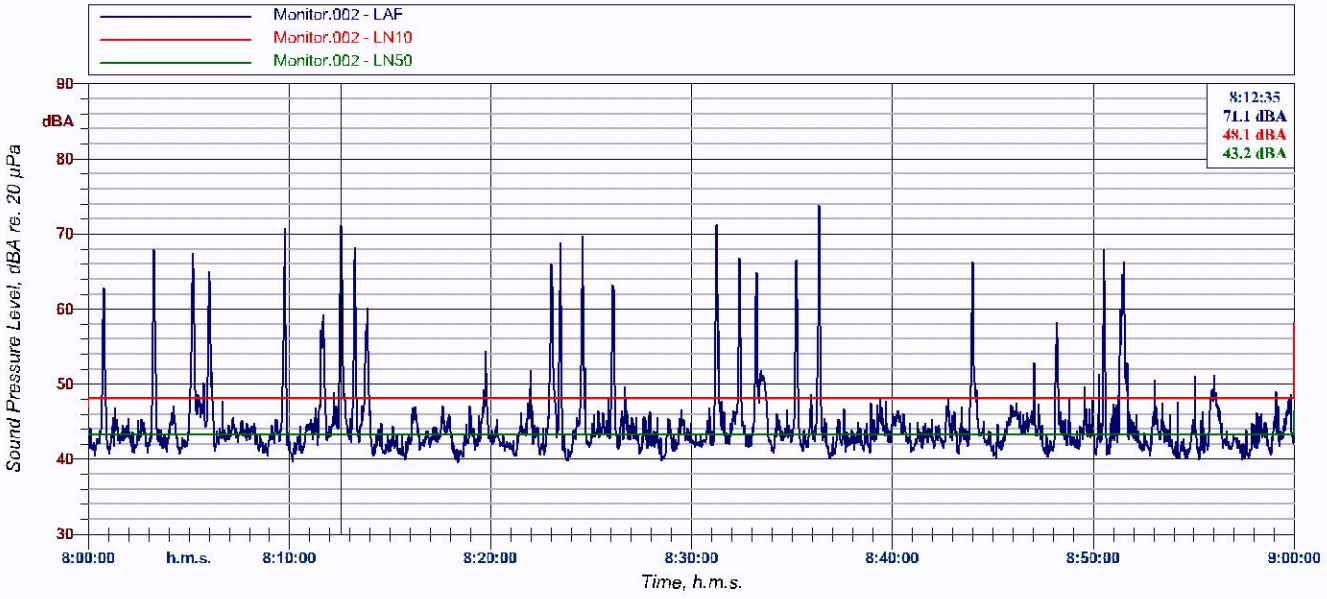
Project No:	P2816	**Analyzer:**	Larson Davis 831 s/n 4694
Project:	Christianson Co. - Tommy's Car Wash	**Preamplifier:**	Larson Davis PRM831 s/n 070949
Location:	Bloomington, MN	**Microphone:**	Larson Davis 377C20 s/n 320010
Engineer:	R.L. Skoug	**Calibrator:**	Larson Davic CAL200 s/n 18322
		Last Calibrated:	December 9, 2021

Location:	Location 2 (N Res. Property)	**Meteorology:**	Temperature: 12°F Wind Speed / Dir.: 3 MPH / N Humidity: 64%
Date:	2/14/2022		
Start Time:	7:54:59 PM	**Calibration Check:**	Calibration Frequency: 1 kHz Initial Calibration: 94.0 dB Final Calibration: 93.8 dB Last Cal. Check: 2/14/22 @ 9:04 PM
End Time:	9:02:50 PM		
Run Time:	4071.0 seconds		

Measurements: File N. 2: Ambient Noise from Traffic
On West 97th/98th Streets.
Monday, 8 PM to 9 PM



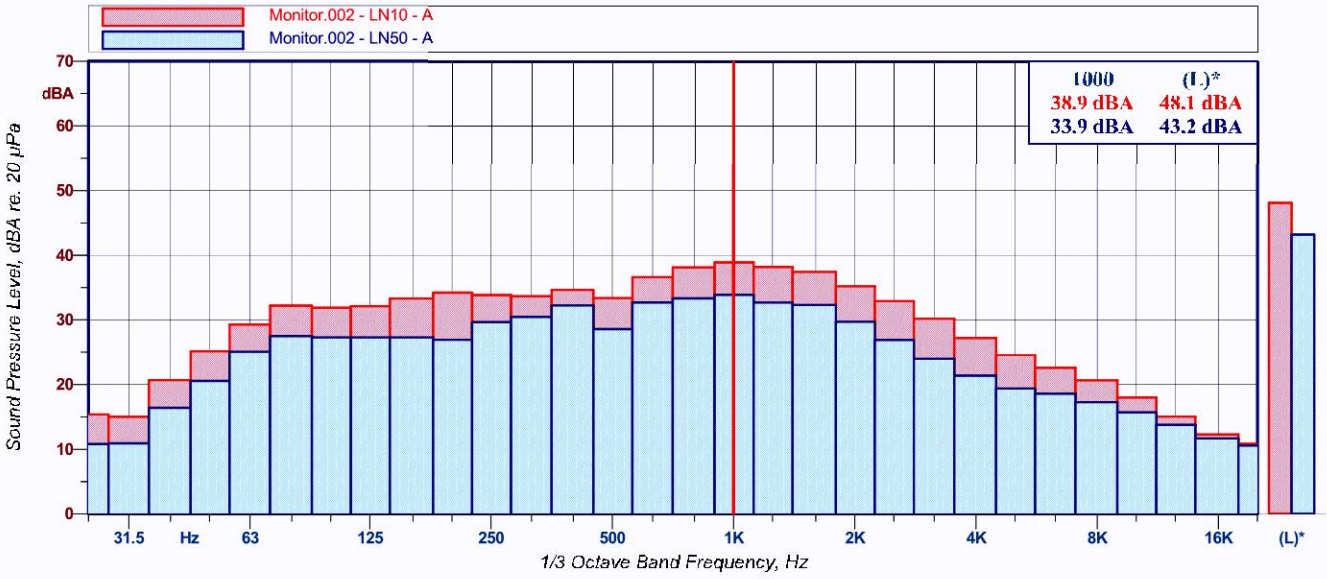


Figure A2

Attachment B

Existing Car Wash Noise Measurement Data

Bloomington Car Wash Noise Control – November 23, 2022

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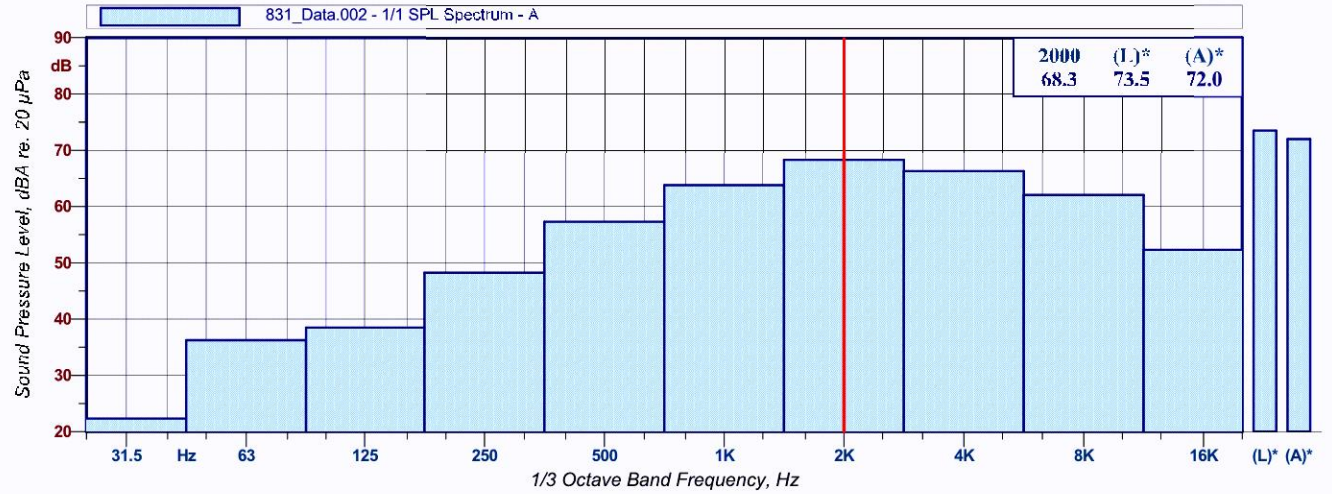
Project:	Christianson Co. - Tommy's Car Wash	**Preamplifier:**	Larson Davis PRM831 s/n 070949
Location:	Bloomington, MN	**Microphone:**	Larson Davis 377C20 s/n 320010
Engineer:	R.L. Skoug	**Calibrator:**	Larson Davic CAL200 s/n 18322
		Last Calibrated:	December 9, 2021

Location:	Tommy's Car Wash, Mounds View, MN	**Meteorology:**	Temperature: 26 °F Wind Speed / Dir.: 6 MPH / SW Humidity: 69%
Date:	2/8/2022		
Start Time:	10:06:49 AM		
End Time:	10:07:49 AM	**Calibration Check:**	Calibration Frequency: 1 kHz Initial Calibration: 94.0 dB Final Calibration: 93.8 dB Last Cal. Check: 2/8/22 @ 11:03 AM
Run Time:	60.5 seconds		
Measurements:	File N. 2: 10' from a Running Vaccuum.		



L1.0: 72.7 dBA	**L50.0: 72.1 dBA**	**L95.0: 71.7 dBA**	**Leq: 72.1 dBA**
L10.0: 72.4 dBA	**L90.0: 72.1 dBA**	**LMin: 71.4 dBA**	**LMax: 72.9 dBA**

831_Data.002
1/1 SPL Spectrum - A

Hz	dBA	Hz	dBA	Hz	dBA	Hz	dBA	Hz	dBA
31.5	22.3 dBA	125	38.5 dBA	500	57.3 dBA	2000	68.3 dBA	8000	62.1 dBA
63	36.3 dBA	250	48.3 dBA	1000	63.8 dBA	4000	66.3 dBA	16000	52.3 dBA

Figure B1

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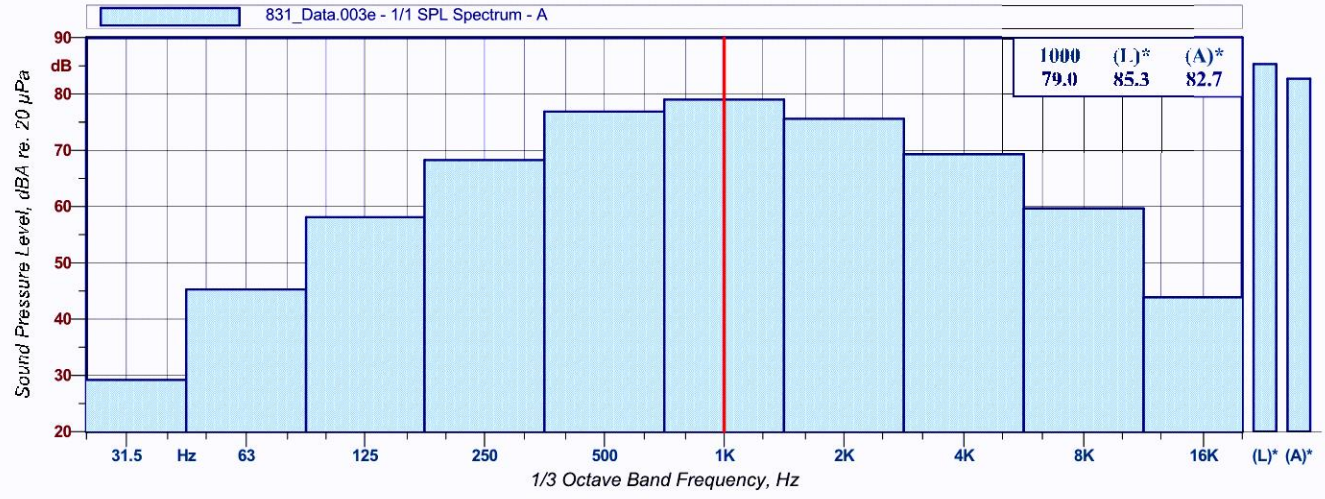
Location:	Bloomington, MN	**Microphone:**	Larson Davis 377C20 s/n 320010
Engineer:	R.L. Skoug	**Calibrator:**	Larson Davic CAL200 s/n 18322
		Last Calibrated:	December 9, 2021

Location:	Tommy's Car Wash, Mounds View, MN	**Meteorology:**	Temperature: 26 °F Wind Speed / Dir.: 6 MPH / SW Humidity: 69%
Date:	2/8/2022		
Start Time:	10:10:02 AM		
End Time:	10:13:12 AM	**Calibration Check:**	Calibration Frequency: 1 kHz Initial Calibration: 94.0 dB Final Calibration: 93.8 dB Last Cal. Check: 2/8/22 @ 11:03 AM
Run Time:	190.2 seconds		

Measurements: File N. 3: 57'-6" from the Exit.
Zero Degree Offset from Centerline.
Blowers On (Blowers Off Time Extracted).



L1.0: 85.1 dBA	**L50.0: 82.7 dBA**	**L95.0: 80.0 dBA**	**Leq: 82.7 dBA**
L10.0: 84.1 dBA	**L90.0: 80.7 dBA**	**LMin: 76.9 dBA**	**LMax: 85.7 dBA**

831_Data.003e
1/1 SPL Spectrum - A

Hz	dBA	Hz	dBA	Hz	dBA	Hz	dBA	Hz	dBA
31.5	29.2 dBA	125	58.1 dBA	500	76.9 dBA	2000	75.6 dBA	8000	59.7 dBA
63	45.3 dBA	250	68.3 dBA	1000	79.0 dBA	4000	69.3 dBA	16000	43.9 dBA

Figure B2

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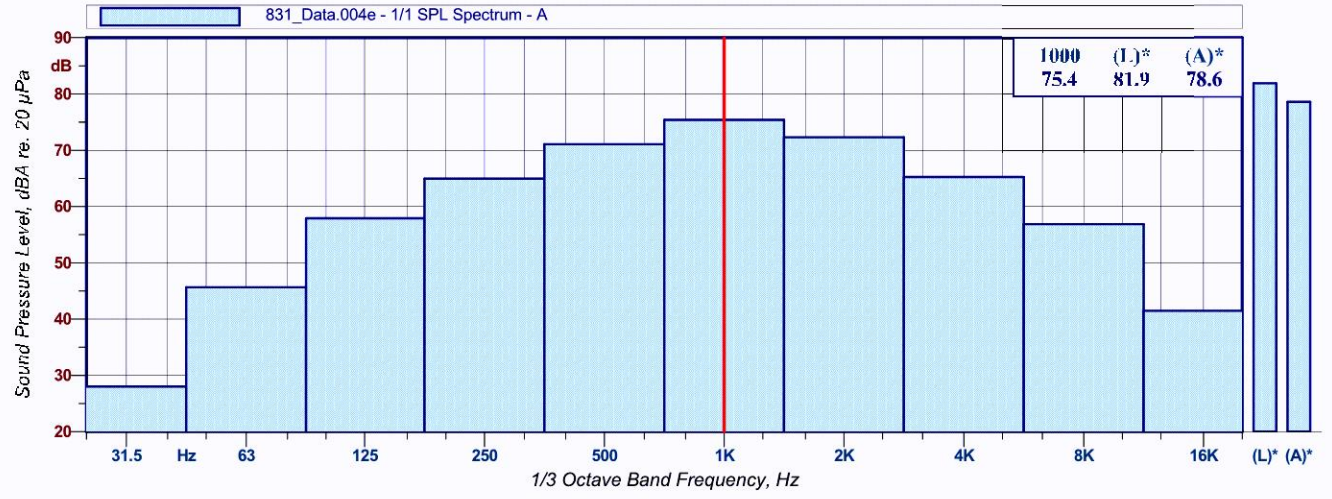
Project:	Christianson Co. - Tommy's Car Wash	**Preamplifier:**	Larson Davis PRM831 s/n 070949
Location:	Bloomington, MN	**Microphone:**	Larson Davis 377C20 s/n 320010
Engineer:	R.L. Skoug	**Calibrator:**	Larson Davic CAL200 s/n 18322
		Last Calibrated:	December 9, 2021

Location:	Tommy's Car Wash, Mounds View, MN	**Meteorology:**	Temperature: 26 °F Wind Speed / Dir.: 6 MPH / SW Humidity: 69%
Date:	2/8/2022		
Start Time:	10:23:00 AM		
End Time:	10:24:07 AM	**Calibration Check:**	Calibration Frequency: 1 kHz Initial Calibration: 94.0 dB Final Calibration: 93.8 dB Last Cal. Check: 2/8/22 @ 11:03 AM
Run Time:	67.4 seconds		

Measurements: File N. 4: 54' from the Exit.
45 Degree Offset from Centerline.
Blowers Drying 3 Cars (Blowers Off Time Extracted).



L1.0: 80.7 dBA	**L50.0: 78.6 dBA**	**L95.0: 76.7 dBA**	**Leq: 78.7 dBA**
L10.0: 80.0 dBA	**L90.0: 77.3 dBA**	**LMin: 66.4 dBA**	**LMax: 81.0 dBA**

831_Data.004e
1/1 SPL Spectrum - A

Hz	dBA	Hz	dBA	Hz	dBA	Hz	dBA	Hz	dBA
31.5	28.0 dBA	125	57.9 dBA	500	71.1 dBA	2000	72.3 dBA	8000	56.9 dBA
63	45.7 dBA	250	65.0 dBA	1000	75.4 dBA	4000	65.2 dBA	16000	41.5 dBA

Figure B3

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Acoustic Test Results

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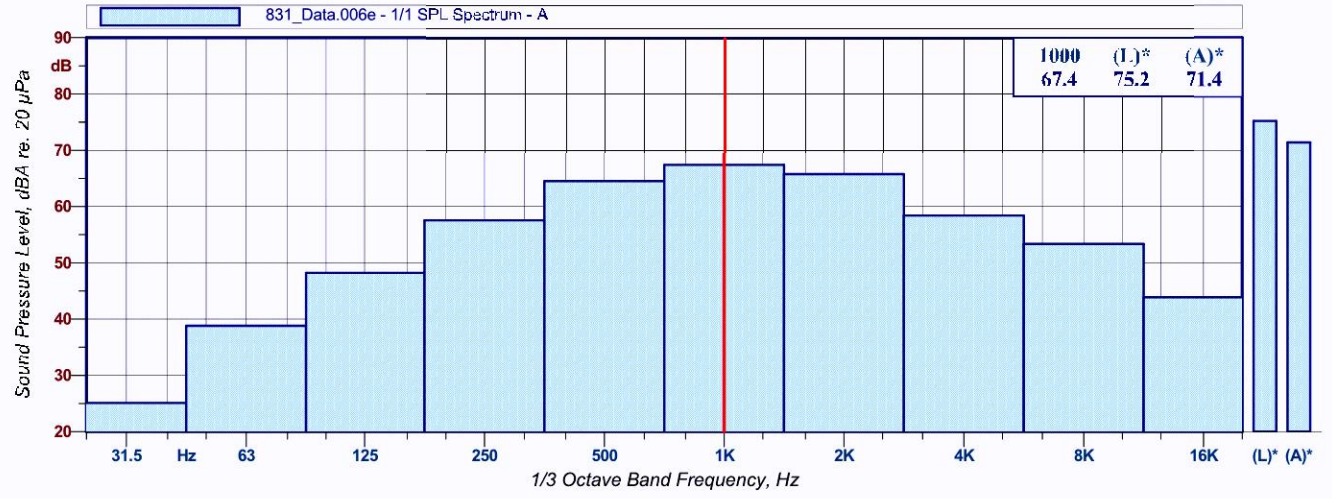
Project:	Christianson Co. - Tommy's Car Wash	**Preamplifier:**	Larson Davis PRM831 s/n 070949
Location:	Bloomington, MN	**Microphone:**	Larson Davis 377C20 s/n 320010
Engineer:	R.L. Skoug	**Calibrator:**	Larson Davic CAL200 s/n 18322
		Last Calibrated:	December 9, 2021

Location:	Tommy's Car Wash, Mounds View, MN	**Meteorology:**	Temperature: 26 °F Wind Speed / Dir.: 6 MPH / SW Humidity: 69%
Date:	2/8/2022		
Start Time:	10:35:04 AM		
End Time:	10:35:30 AM	**Calibration Check:**	Calibration Frequency: 1 kHz Initial Calibration: 94.0 dB Final Calibration: 93.8 dB Last Cal. Check: 2/8/22 @ 11:03 AM
Run Time:	26.6 seconds		

Measurements: File N. 6: 48'-4" from the Entrance Door. Doors Open.
Zero Degree Offset from Centerline.
Only Entry Automated Greeting and Blowers.



L1.0: 76.9 dBA	**L50.0: 71.4 dBA**	**L95.0: 67.6 dBA**	**Leq: 71.9 dBA**
L10.0: 73.6 dBA	**L90.0: 68.3 dBA**	**LMin: 64.6 dBA**	**LMax: 80.8 dBA**

831_Data.006e
1/1 SPL Spectrum - A

Hz	dBA	Hz	dBA	Hz	dBA	Hz	dBA	Hz	dBA
31.5	25.1 dBA	125	48.2 dBA	500	64.5 dBA	2000	65.8 dBA	8000	53.4 dBA
63	38.8 dBA	250	57.6 dBA	1000	67.4 dBA	4000	58.4 dBA	16000	43.9 dBA

Figure B4

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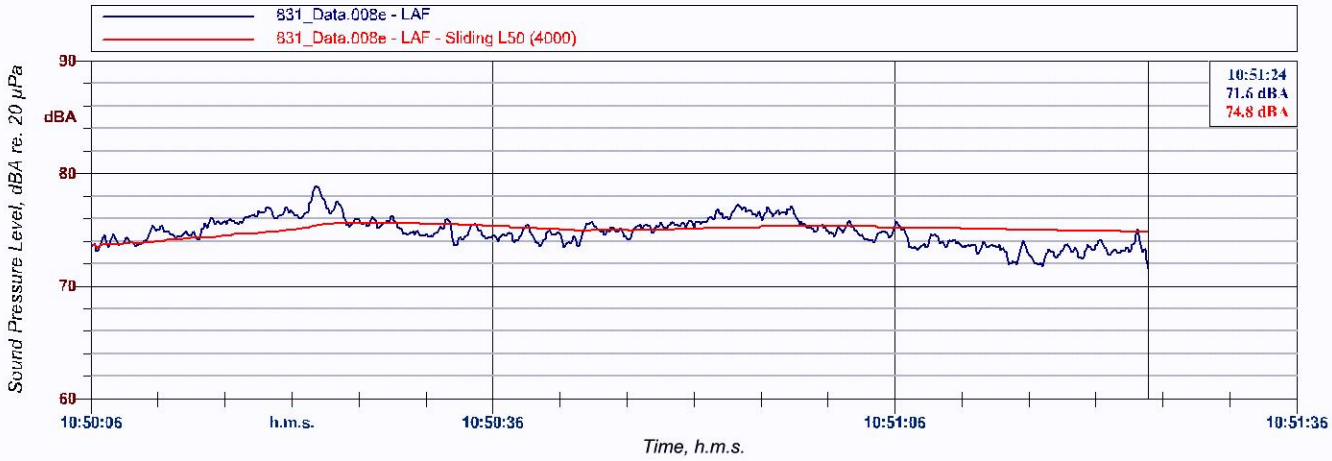
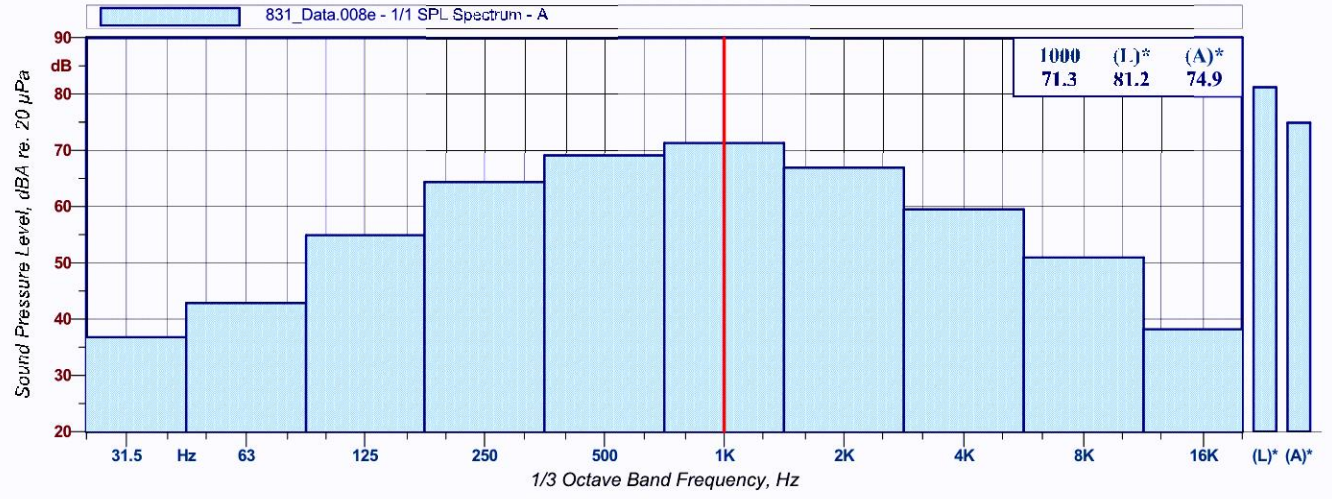
Engineer:	R.L. Skoug	**Calibrator:**	Larson Davic CAL200 s/n 18322
		Last Calibrated:	December 9, 2021

Location:	Tommy's Car Wash, Mounds View, MN	**Meteorology:**	Temperature: 26 °F Wind Speed / Dir.: 6 MPH / SW Humidity: 69%
Date:	2/8/2022		
Start Time:	10:50:06 AM		
End Time:	10:51:24 AM	**Calibration Check:**	Calibration Frequency: 1 kHz Initial Calibration: 94.0 dB Final Calibration: 93.8 dB Last Cal. Check: 2/8/22 @ 11:03 AM
Run Time:	78.9 seconds		

Measurements: File N. 8: 8'-6" from 1 Open Sidewall Louver.
Northeast Side of the Building.
Blowers On (Blowers Off Time Extracted).





L1.0: 77.8 dBA **L50.0: 74.9 dBA** **L95.0: 72.9 dBA** **Leq: 75.0 dBA**

L10.0: 76.5 dBA **L90.0: 73.3 dBA** **LMin: 71.6 dBA** **LMax: 78.9 dBA**

831_Data.008e
1/1 SPL Spectrum - A

Hz	dBA	Hz	dBA	Hz	dBA	Hz	dBA	Hz	dBA
31.5	36.8 dBA	125	54.9 dBA	500	69.1 dBA	2000	66.9 dBA	8000	51.0 dBA
63	42.9 dBA	250	64.4 dBA	1000	71.3 dBA	4000	59.5 dBA	16000	38.2 dBA

Figure B5

PL2022-54
PL202200054

Attachment C

Condensing Unit Sound Data Sheet

Bloomington Car Wash Noise Control – November 23, 2022

Accessories

Model No.		RA1418	RA1424	RA1430	RA1436	RA1442	RA1448	RA1460
Compressor crankcase heater*		44-17402-44	44-17402-44	44-17402-44	44-17402-44	44-17402-45	44-17402-45	44-17402-45
Low ambient control		RXAD-A08	RXAD-A08	RXAD-A08	RXAD-A08	RXAD-A08	RXAD-A08	RXAD-A08
Compressor sound cover		68-23427-26	68-23427-26	68-23427-26	68-23427-26	68-23427-25	68-23427-25	68-23427-25
Compressor hard start kit		SK-A1	SK-A1	SK-A1	SK-A1	SK-A1	SK-A1	SK-A1
Compressor time delay		RXMD-B01	RXMD-B01	RXMD-B01	RXMD-B01	RXMD-B01	RXMD-B01	RXMD-B01
Low pressure control		RXAC-A07	RXAC-A07	RXAC-A07	RXAC-A07	RXAC-A07	RXAC-A07	RXAC-A07
High pressure control		RXAB-A07	RXAB-A07	RXAB-A07	RXAB-A07	RXAB-A07	RXAB-A07	RXAB-A07
Liquid Line Solenoid (24 VAC, 50/60 Hz)	Solenoid Valve	200RD2T3TVLC	200RD2T3TVLC	200RD2T3TVLC	200RD2T3TVLC	200RD2T3TVLC	200RD3T3TVLC	200RD3T3TVLC
	Solenoid Coil	61-AMG24V	61-AMG24V	61-AMG24V	61-AMG24V	61-AMG24V	61-AMG24V	61-AMG24V
Liquid Line Solenoid (120/240 VAC, 50/60 Hz)	Solenoid Valve	200RD2T3TVLC	200RD2T3TVLC	200RD2T3TVLC	200RD2T3TVLC	200RD2T3TVLC	200RD3T3TVLC	200RD3T3TVLC
	Solenoid Coil	61-AMG120/240V	61-AMG120/240V	61-AMG120/240V	61-AMG120/240V	61-AMG120/240V	61-AMG120/240V	61-AMG120/240V
Achiever Top Cap w/Label		91-101123-21	91-101123-21	91-101123-21	91-101123-21	91-101123-21	91-101123-21	91-101123-21

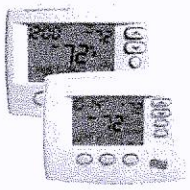
*Crankcase Heater recommended with Low Ambient Kit.

Weighted Sound Power Level (dBA)

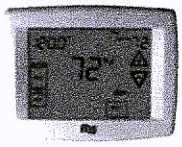
A-WEIGHTED SOUND POWER LEVEL (dBA)								
Unit Size - Voltage, Series	Standard Rating (dBA)	TYPICAL OCTAVE BAND SPECTRUM (dBA without tone adjustment)						
		125	250	500	1000	2000	4000	8000
RA1418A	76	51.4	59.6	65.2	65.9	64.3	58.5	53.7
RA1424A	75.2	49.4	60.4	64.3	64.2	63.4	58.9	53.8
RA1430A	74	48.8	57.5	63.5	64	61.9	56.1	51
RA1436A	76	52.2	61.3	65.4	65.3	62.4	57.3	53.1
RA1442A	75.6	54.9	61.5	65.3	66.3	62.8	59.5	53.2
RA1448A	75.8	52.3	59.1	66.7	65.7	62.4	59.3	55.9
RA1460A	75	53.4	59.1	65.9	66.9	62.8	58.7	54.3

NOTE: Tested in accordance with AHRI Standard 270-08 (not listed in AHRI)

Thermostats

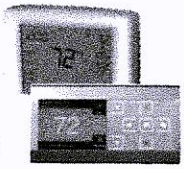


200-Series *
Programmable



300-Series *
Deluxe
Programmable

400-Series *
Special Applications/
Programmable



500-Series *
Communicating/
Programmable

Brand		Descripter (3 Characters)	Series (3 Characters)	System (2 Characters)	Type (2 Characters)
UHC	-	TST	213	UN	MS
UHC=Ruud		TST=Thermostat	200=Programmable 300=Deluxe Programmable 400=Special Applications/ Programmable 500=Communicating/ Programmable	GE=Gas/Electric UN=Universal (AC/HP/GE) MD=Modulating Furnace DF=Dual Fuel CM=Communicating	SS=Single-Stage MS=Multi-Stage

** Photos are representative. Actual models may vary.*

For detailed thermostat match-up information, see specification sheet form number T22-001.

Attachment D

Tommy Car Wash Systems – Vacuum Muffler Noise Report

Bloomington Car Wash Noise Control – November 23, 2022

Tommy Car Wash Systems | 581 Ottawa Ave. | Holland, MI 49423 | tommycarwash.com

TCWS Muffler Report

Introduction: Vacuum mufflers were tested at TX Hudsonville for 2 weeks' time. The goal of this test, was to test three types of mufflers on site to attempt to reduce the noise output of the vacuums without loss of performance.

Methodology: Performance of the mufflers were tested with 4 criteria

1. Noise reduction (dB)
2. Additional Maintenance necessary / clogging (Yes or No)
3. Suction loss (kPa and % loss)
4. Aesthetics (Great, Good, Fair, Poor)

Results: Test results based on Methodology

1. BASELINE RESULTS (No mufflers attached)
    a. Noise
        i. Ambient (no vacs running): 65.7 dB (See figure 1.1)
        ii. Running Vac with no muffler: 88.1 dB (See Figure 1.2
    b. Additional Maintenance necessary / clogging: NO
    c. Suction: 50 kPa/ 0%
    d. Aesthetics: Great

FIGURE 1.1

FIGURE 1.2

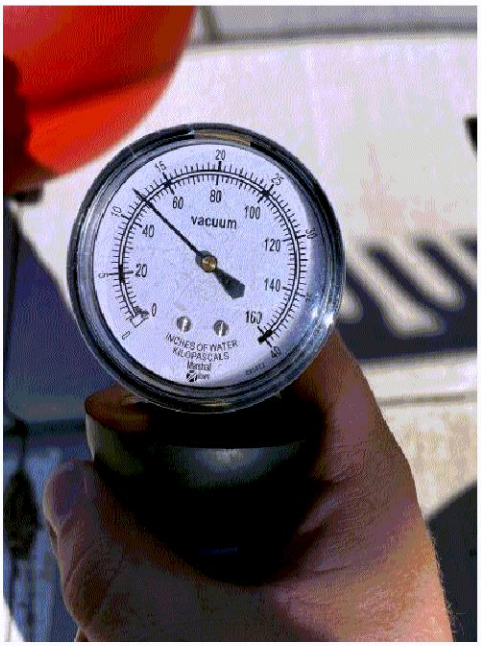


FIGURE 1.3

2. P-VAC-334 RESULTS

a. Noise reduction (dB):
    i. Reading: 77.6 dB (See Figure 2.1)
    ii. Reduction: 10.5 dB
b. Additional Maintenance necessary / clogging
    i. Yes: Minor (additional maintenance and clogging)
        1. Reverse pulse vacs to help with this
        2. Wash Mufflers to help with this
c. Suction loss (KPa and %)
    i. Reading: 40kPa (see Figure 2.2)
    ii. Loss: 10kPa – 20% loss in suction
d. Aesthetics
    i. Good (See Figure 2.3)

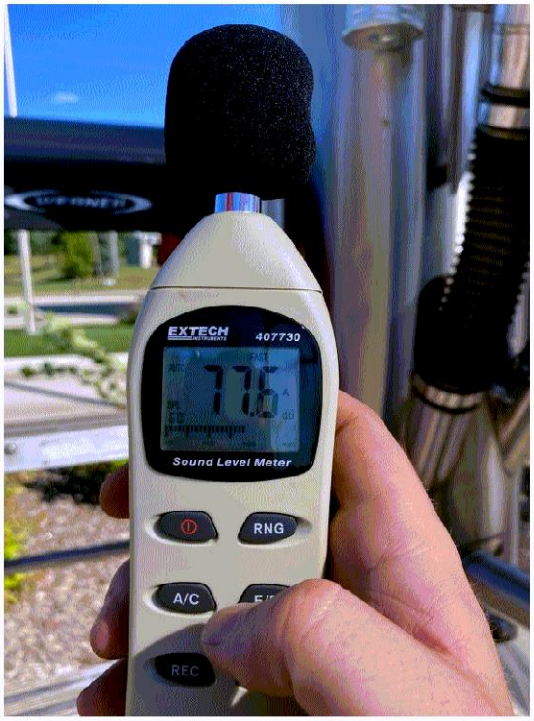


Figure 2.1

Figure 2.2

Figure 2.3: P-VAC-334

1. P-VAC-335 RESULTS

a. Noise reduction (dB):
    i. Reading: 79.1 dB (See Figure 3.1)
    ii. Reduction: 9 dB
b. Additional Maintenance necessary / clogging
    1. Yes: Minimal (additional maintenance, no clogging)
        a. Eventually replace filter of muffler.
c. Suction loss (KPa and %)
    i. Reading: 50kPa (see Figure 3.2)
    ii. Loss: 0kPa – 0% loss in suction
d. Aesthetics
    i. Fair (See Figure 3.3)

FIGURE 3.1

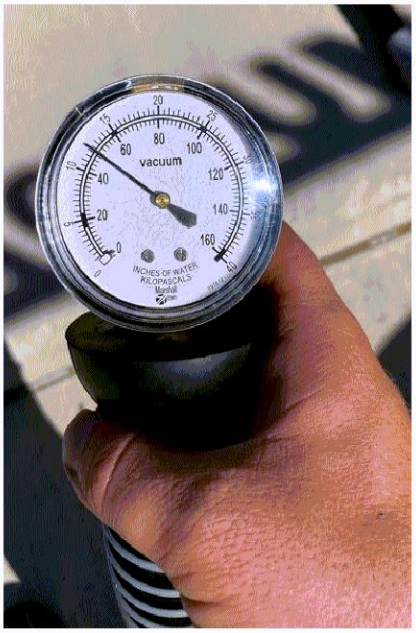


FIGURE 3.2

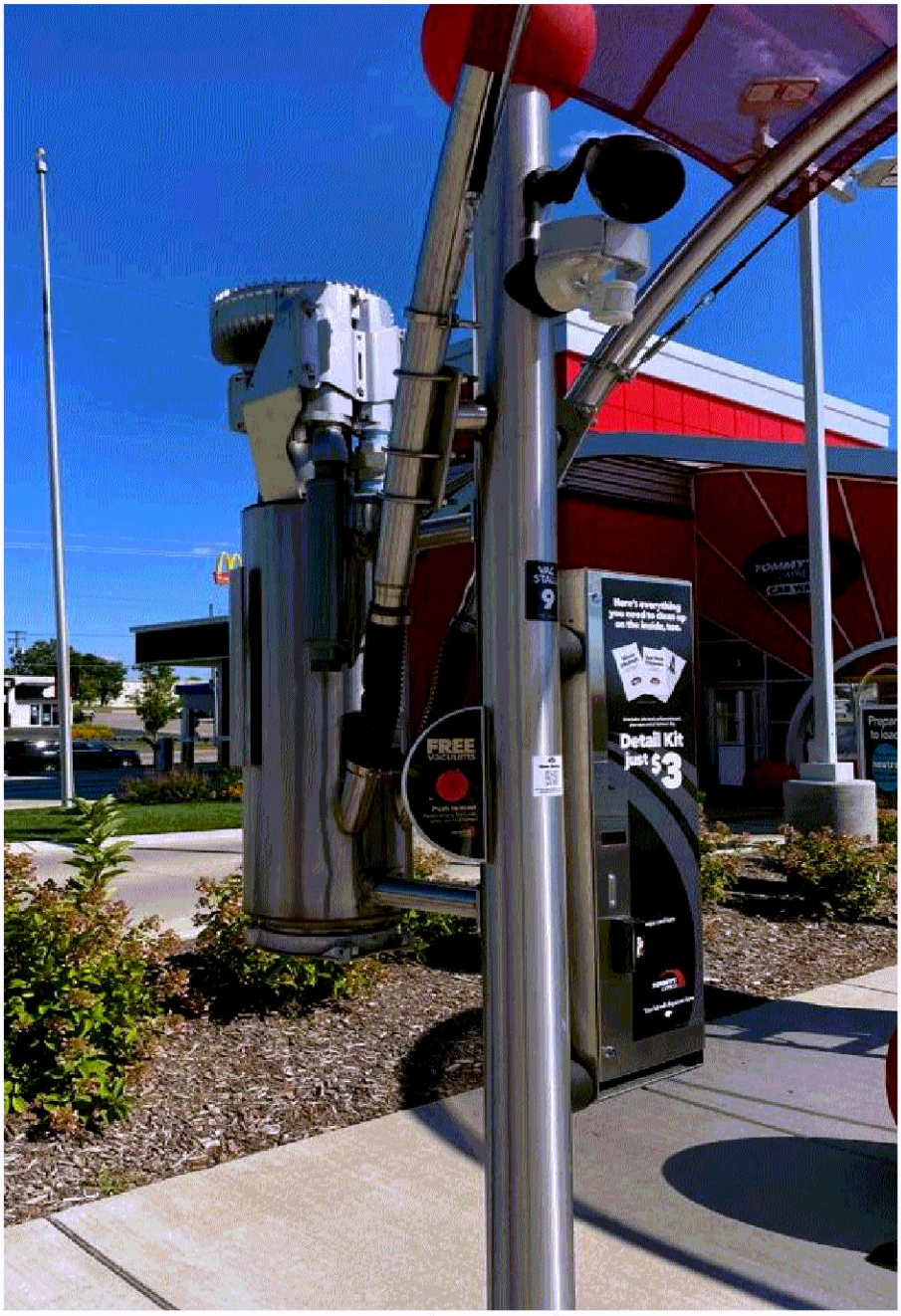


FIGURE 3.3 (P-VAC-335)

Attachment E

Tommy Car Wash Systems – Blower VFD Noise Report

Bloomington Car Wash Noise Control – November 23, 2022

PL2022-54
PL202200054

Tommy Car Wash Systems | 581 Ottawa Ave. | Holland, MI 49423 | tommycarwash.com.com

Sound Level Testing – Hudsonville 5/18/21

Introduction

Measurements of sound levels were collected on site to record noise levels generated by the standard 18 blower motor configuration at the wash exit. Measurements were taken between 10:00pm and 12:00am on May 18th at the Hudsonville Location.

Instrumentation & Procedure

Measurements were recorded using an Extech Instruments Model 407730 Sound Level Meter. This meter is calibrated and meets the standards of the National Institute of Standards and Technology and conforms with ISO 10012 and ANSI Z540-1-1994. Sound levels were recorded both at ground level as well as at a height of 5 feet off the surface. Measurements were recorded as an average of a 5 second period at each point. Samples were recorded with minimum possible ambient noise pollution when applicable and with the standard blower motor configuration. Procedure was repeated with blower motor frequency adjusted in 10Hz increments from 60Hz to 10Hz.

Atmospheric & Ambient Conditions

Atmospheric data is taken from the weather station at Gerald R. Ford International Airport and is shown in Table 1. Ambient sound levels were recorded at the maximum distance from the tunnel exit with all wash functions turned off. Ambient sound levels ranged from a minimum of 50dB to a maximum of 60dB. It should be noted that while efforts were made to prevent contamination of data from ambient conditions, some noise pollution from the environment was unavoidable.

Table 1: Environmental Conditions During Test Period

Time & Date	Average Temp (F)	Avg. Relative Humidity	Wind Direction	Avg. Wind Speed (MPH)	Precipitation (in)	Ambient Sound Level (dB)
10:00pm-12:00am May 18th, 2021	67	64.5%	E	4.6mph	0	50-60dB

Results

Recorded data for each position at ground level is shown below in Table 2. This data is displayed in Figure 1. Recorded data for each position at 5ft height is shown below in Table 3. This data is displayed in Figure 2.

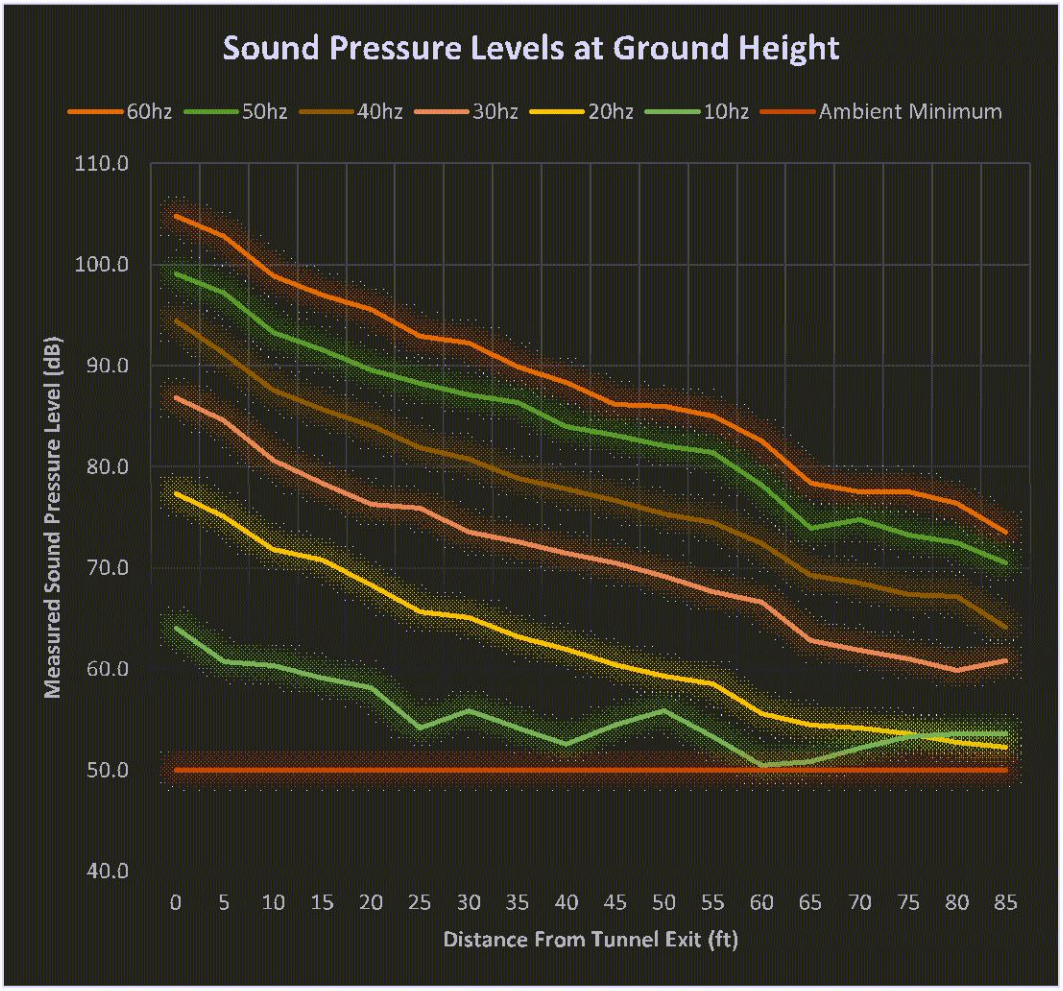


Figure 1: Measured Sound Pressure Levels at Ground Height

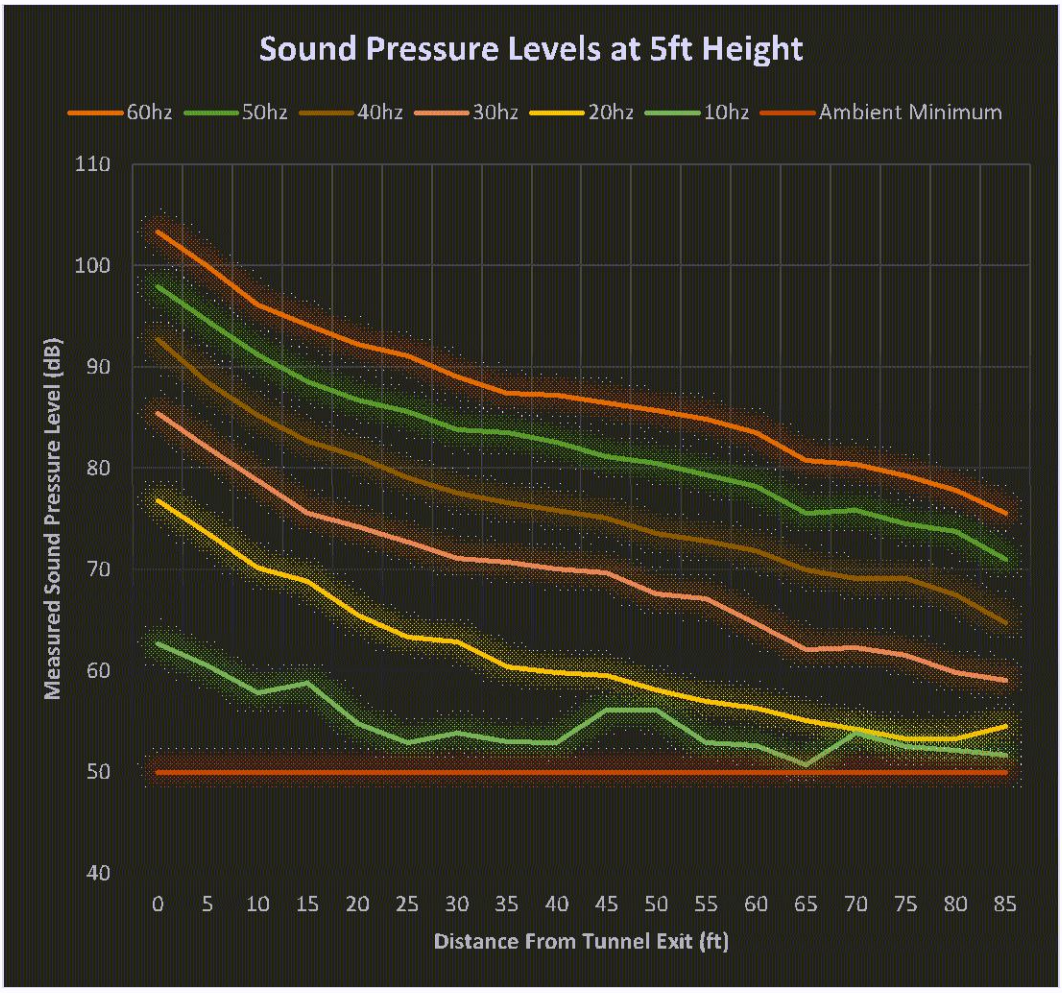


Figure 2: Measured Sound Pressure Levels at 5ft Height

Table 2: Measured Sound Levels at Ground Height						
Distance (ft)	**60hz**	**50hz**	**40hz**	**30hz**	**20hz**	**10hz**
0	104.8	99.1	94.5	86.9	77.4	64.1
5	102.8	97.2	91.2	84.6	75.1	60.7
10	98.9	93.3	87.6	80.7	71.9	60.4
15	97.0	91.6	85.7	78.4	70.8	59.1
20	95.6	89.6	84.1	76.3	68.3	58.2
25	92.9	88.3	81.9	75.9	65.7	54.2
30	92.3	87.1	80.8	73.6	65.1	55.9
35	89.9	86.4	78.9	72.6	63.2	54.2
40	88.4	84.0	77.8	71.5	62.0	52.6
45	86.2	83.2	76.7	70.5	60.5	54.5
50	86.0	82.1	75.4	69.2	59.3	55.9
55	85.1	81.4	74.5	67.7	58.6	53.3
60	82.6	78.2	72.4	66.6	55.6	50.5
65	78.4	73.9	69.3	62.8	54.5	50.9
70	77.6	74.8	68.5	61.9	54.2	52.2
75	77.6	73.3	67.4	61.0	53.6	53.3
80	76.4	72.5	67.2	59.9	52.8	53.6
85	73.6	70.5	64.2	60.8	52.3	53.6

Table 3: Measured Sound Levels at 5ft Height						
Distance (ft)	**60hz**	**50hz**	**40hz**	**30hz**	**20hz**	**10hz**
0	103.4	98	92.7	85.4	76.8	62.7
5	99.9	94.5	88.5	82	73.6	60.5
10	96.1	91.2	85.2	78.8	70.2	57.8
15	94.2	88.6	82.7	75.6	68.8	58.8
20	92.3	86.8	81.2	74.2	65.5	54.8
25	91.1	85.6	79.1	72.7	63.3	52.9
30	89	83.8	77.6	71.1	62.9	53.9
35	87.4	83.5	76.6	70.7	60.4	53
40	87.2	82.6	75.9	70.1	59.8	52.9
45	86.5	81.2	75.1	69.7	59.5	56.1
50	85.7	80.5	73.6	67.6	58.1	56.1
55	84.9	79.4	72.8	67.1	57	52.9
60	83.5	78.2	71.9	64.7	56.3	52.6
65	80.8	75.6	70	62.1	55.1	50.7
70	80.4	75.9	69.1	62.3	54.2	53.9
75	79.3	74.5	69.1	61.5	53.3	52.5
80	77.8	73.8	67.5	59.8	53.3	52.1
85	75.6	71	64.8	59.1	54.5	51.7

Conclusions

By varying the frequency of the blower motor, it was possible to achieve sound pressure levels which did not exceed the ambient conditions at the maximum recorded distance. It was not possible to record the true sound level at these positions due to ambient sound conditions.