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November 20, 2017

Mr. Ben Levinson,
Law Offices of Benjamin R. Levinson
46 N. Second Street, Suite A
Campbell, California 95008
VIA E-Mail: **ben@benlevinsonlaw.com**

SUBJECT: **Bascom Andoil Car Wash at 3702 S. Bascom Ave., San Jose, CA**
Independent Environmental Noise Assessment

Dear Mr. Levinson:
This report presents the results of Illingworth & Rodkin, Inc's (I&R) environmental noise assessment of the proposed carwash addition at the existing Andoil service station located at 3702 South Bascom Avenue in San Jose, CA performed at the request of the residential neighbors of the site. This study considers the equipment and noise mitigations analyzed in a previous assessment of noise from the carwash commissioned by the applicant[1], the findings of an ambient noise monitoring survey conducted by I&R at the residential property line shared with the Andoil site, the results of computer noise modeling of the levels produced by the proposed carwash operations at adjacent noise sensitive residential uses, and the guidelines established by the City of San Jose's General Plan Noise Element and Zoning Code. Persons not familiar with environmental noise analysis are referred to Appendix A for additional discussion.

REGULATORY BACKGROUND

City of San José General Plan. The Environmental Leadership Chapter in the Envision San José 2040 General Plan sets forth policies with the goal of minimizing the impact of noise on people through noise reduction and suppression techniques, and through appropriate land use policies in the City of San José. The following policies are applicable to the proposed project:

EC-1.2 Minimize the noise impacts of new development on land uses sensitive to increased noise levels by limiting noise generation and by requiring use of noise attenuation measures such as acoustical enclosures and sound barriers, where feasible. The City considers significant noise impacts to occur if a project would:

- Cause the DNL at noise sensitive receptors to increase by five dBA DNL or more where the noise levels would remain "Normally Acceptable;" or
- Cause the DNL at noise sensitive receptors to increase by three dBA DNL or more where noise levels would equal or exceed the "Normally Acceptable" level.

EC-1.3 Mitigate noise generation of new nonresidential land uses to 55 dBA DNL at the property line when located adjacent to existing or planned noise-sensitive residential and public/quasi-public land uses.

[1] Mei Wu Acoustics (MWA) Noise Analysis (12/20/16) & Peer Review Response (10/23/17)

EC-1.6 Regulate the effects of operational noise from existing and new industrial and commercial development on adjacent uses through noise standards in the City's Municipal Code.

City of San José Municipal Code. The City's Municipal Code contains a Zoning Ordinance that limits noise levels at adjacent properties. The noise performance standards in Chapter 20.40.600 of this code states that sound pressure levels generated by any use or combination of uses at a Commercial use adjacent to a property used or zoned for residential purposes shall not exceed a maximum level of 55 dBA at the shared property line, except upon issuance and in compliance with a Conditional Use Permit.

EXISTING NOISE ENVIRONMENT

The project site is located at the southeast corner of the intersection South Bascom Avenue and Woodard Road. Two story multi-family residences share a property line with the project site to the west and a retail use (Bascom Liquor & food) shares the project site to the south. Additional multifamily residential uses are located to the north across Woodard Road and to the east across South Bascom Avenue. Farnham Elementary School is located northwest of the site, beyond the Woodard Road/Starview Drive intersection. The closest noise sensitive receptors to the proposed car wash are the two story multi-family residences on the western property line.

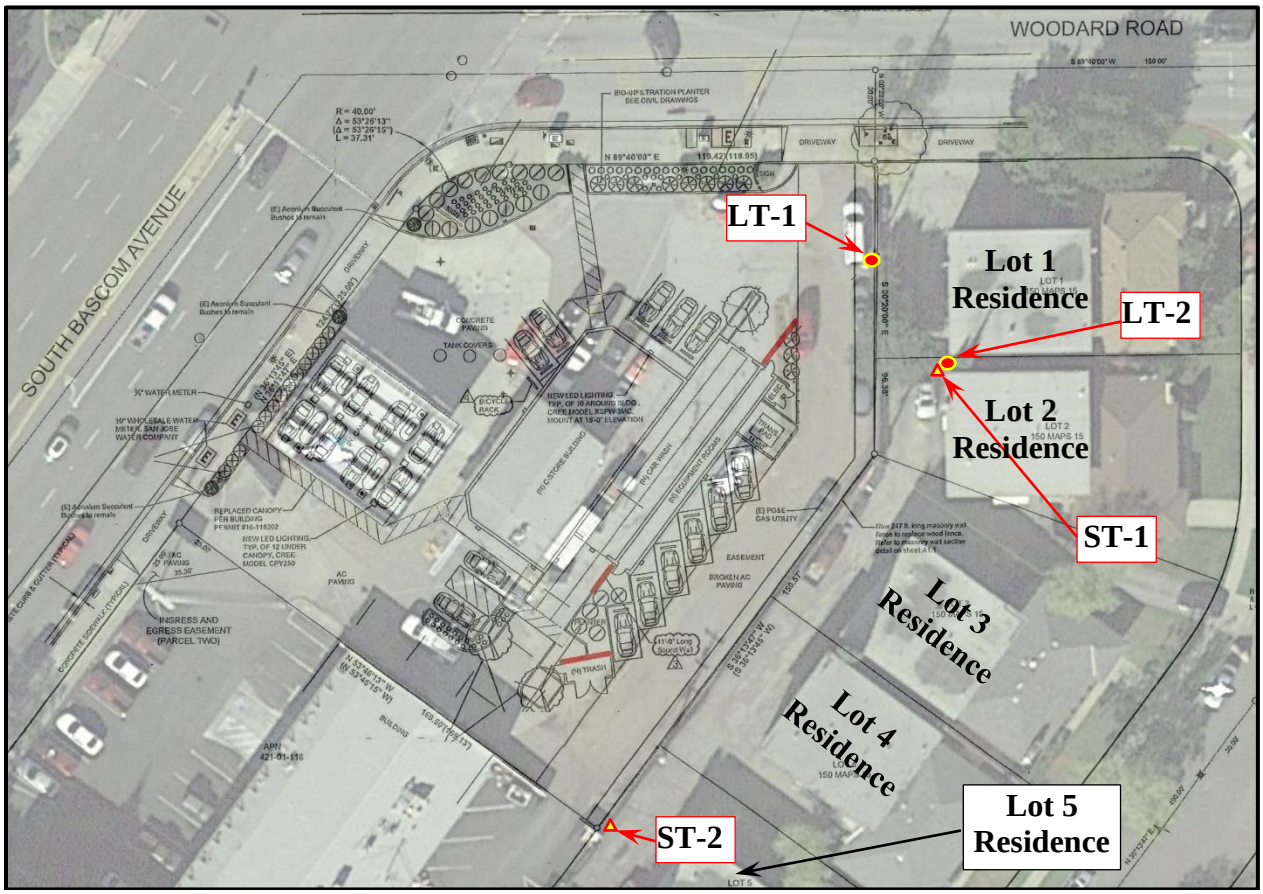


Figure 1: Project Site, Vicinity and Noise Measurement Locations.

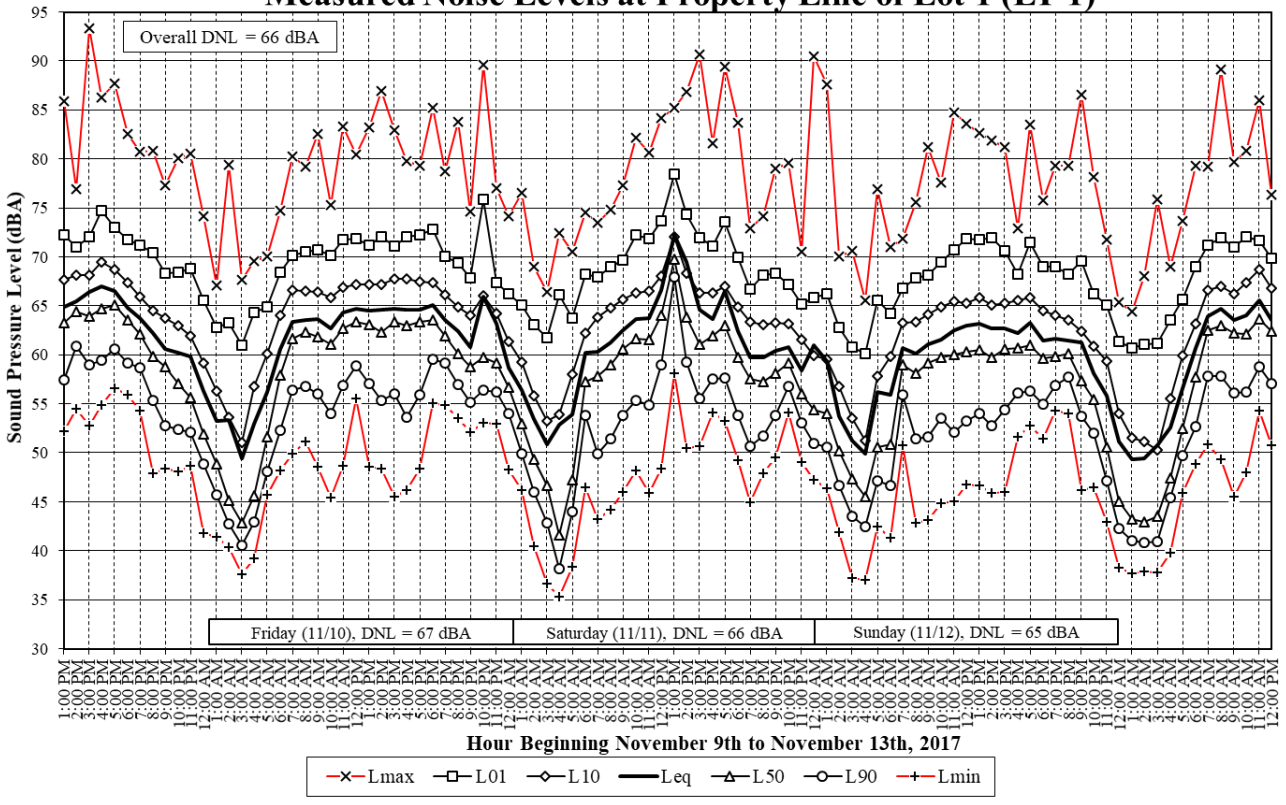
The noise environment in the vicinity of the site is dominated by local and distant traffic, with noise from the existing gas station operations, elementary school related activities, and mechanical noise

from the adjacent retail store also contributing to the noise environment. A noise monitoring survey was undertaken between Thursday, November 9th and Monday, November 13th, 2017 to quantify ambient weekday and weekend noise levels on the western property line and at the upper floor facades of the adjacent residences project. The noise monitoring survey included two long-term (LT) noise measurements and two short-term (ST) noise measurements. The measurement locations are shown in Figure 1, above.

All noise measurements were made with Larson Davis Model 820 Integrating Sound Level Meters set at "slow" response. The sound level meters were equipped with a G.R.A.S. Type 40AQ ½ - inch random incidence microphones fitted with windscreens. All instrumentation used meets the requirements of the American National Standards Institute (ANSI) SI.4-1983 for Type 1 use. The sound level meters were calibrated prior to the noise measurements using a Larson Davis Model CAL200 acoustical calibrator. The response of the system was checked after each measurement session and was always found to be within 0.2 dBA.

The first long term measurement (see LT-1 on Figure 1) was conducted on a utility pole above the western project property line shared with the residence on Lot 1 over a 96-hour weekday/weekend period between 1:00 p.m. on Thursday, November 9th and 1:00 p.m. on Monday, November 13th, 2017. Noise levels measured at this site were produced by existing gas station activities, vehicles parking on the gas station side of the property line, and traffic on S. Bascom Avenue. The hourly trend in noise levels at this location, including the energy equivalent noise level (L_{eq}), maximum (L_{max}), minimum (L_{min}), and the noise levels exceeded 1, 10, 50, and 90 percent of the time (indicated as L_{01}, L_{10}, L_{50}, and L_{90}) are shown on Chart 1.

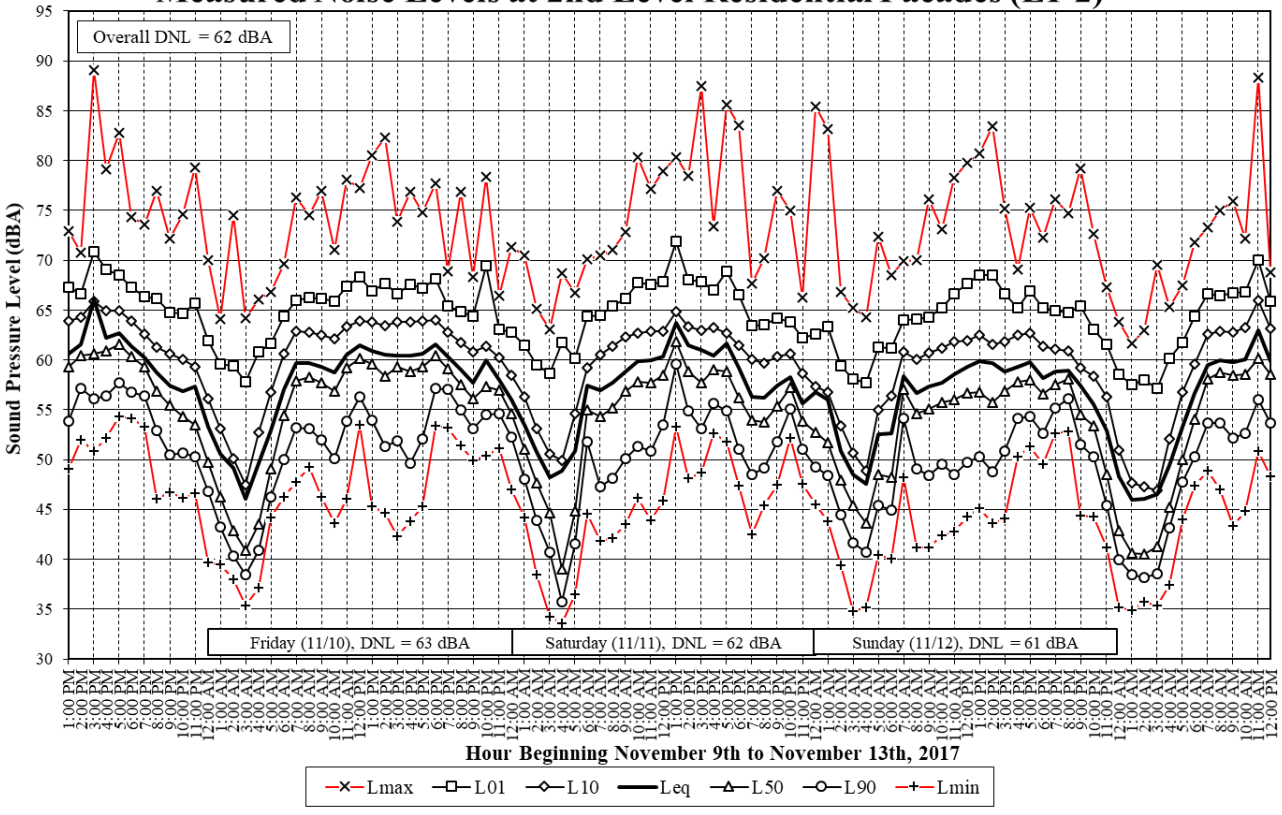
Chart 1:
Measured Noise Levels at Property Line of Lot 1 (LT-1)



A review of Chart 1 indicates that the average weekday noise levels on the property line of Lot 1 (LT-1) ranged from 61 to 67 dBA L_{eq} during the day, and 49 to 66 dBA L_{eq} at night, the average weekend noise levels ranged from 57 to 70 dBA L_{eq} during the day and 50 to 61 dBA L_{eq} at night. The calculated average day/night noise level (DNL) at the property line of Lot 1 ranged from 65 to 67 dBA, with an overall DNL of 66 dBA.

The second long-term measurement (see LT-2 on Figure 1) was conducted in a juniper tree situated between and at the setback of the facades of the residences on Lots 1 and 2. This measurement was made at approximately 16 feet above grade at the level of the upper floor windows of these homes. This measurement was also made over a 96-hour weekday/weekend period between 1:00 p.m. on Thursday, November 9th and 1:00 p.m. on Monday, November 13th, 2017. Noise levels measured at this site were also produced by existing gas station activities, vehicles parking on the gas station side of the property line, and traffic on S. Bascom Avenue. The hourly trend in noise levels at this location, including the energy equivalent noise level (L_{eq}), maximum (L_{max}), minimum (L_{min}), and the noise levels exceeded 1, 10, 50, and 90 percent of the time (indicated as L_{01}, L_{10}, L_{50}, and L_{90}) are shown on Chart 2.

Chart 2:
Measured Noise Levels at 2nd Level Residential Facades (LT-2)



A review of Chart 1 indicates that the average weekday noise levels between the upper facades of the Residences on Lots 1 and 2 (LT-2) ranged from 57 to 66 dBA L_{eq} during the day, and 46 to 60 dBA L_{eq} at night, the average weekend noise levels ranged from 56 to 64 dBA L_{eq} during the day and 48 to 58 dBA L_{eq} at night. The calculated average day/night noise level (DNL) at this location ranged from 61 to 63 dBA, with an overall DNL of 62 dBA.

Two short-term (10-minute duration) noise measurements were made simultaneously with the long-term measurements at heights of 5 feet above grade between 1:00 and 1:20 pm on Monday November 13th, 2017. Measurement ST-1 was conducted at the setback of the residences on Lots 1 and 2 immediately below long-term monitoring position LT-2, and measurement ST-2 was made near the southwest corner of the site on the property line shared with the residence on Lot 5. The measurement results and estimated L_{dn} levels are shown in Table 1, following.

Table 2: Summary of Short-Term Noise Measurement Data, dBA

Noise Measurement Location	L_{max}	L_{01}	L_{10}	L_{eq}	L_{50}	L_{90}	L_{min}	L_{dn}
ST-1: 5 feet above grade, at the setback of the residences on Lots 1 & 2 (1:00-1:10 pm)	65	64	60	57	56	50	46	**58**
ST-2: 5 feet above grade, at the property line shared with Lot 5 (1:10-1:20 pm)	62	60	58	55	54	52	51	**61**

Note: L_{dn} is approximated by correlation to the corresponding measurement period at the long-term sites.

PROJECT DESCRIPTION

Based on a review of the planning submittal drawing set 03 for the Bascom Andoil Replacement and Car Wash Addition dated 2-17-17[2], the project proposes to construct a new automated car wash on the southwest side of a new store/office structure. The carwash building will be 17 feet wide by 80 feet long with 10-foot wide by 10-foot tall entrance and exit openings. Cars will enter the wash from the southwest and exit the wash to the northeast, towards Woodard Road.

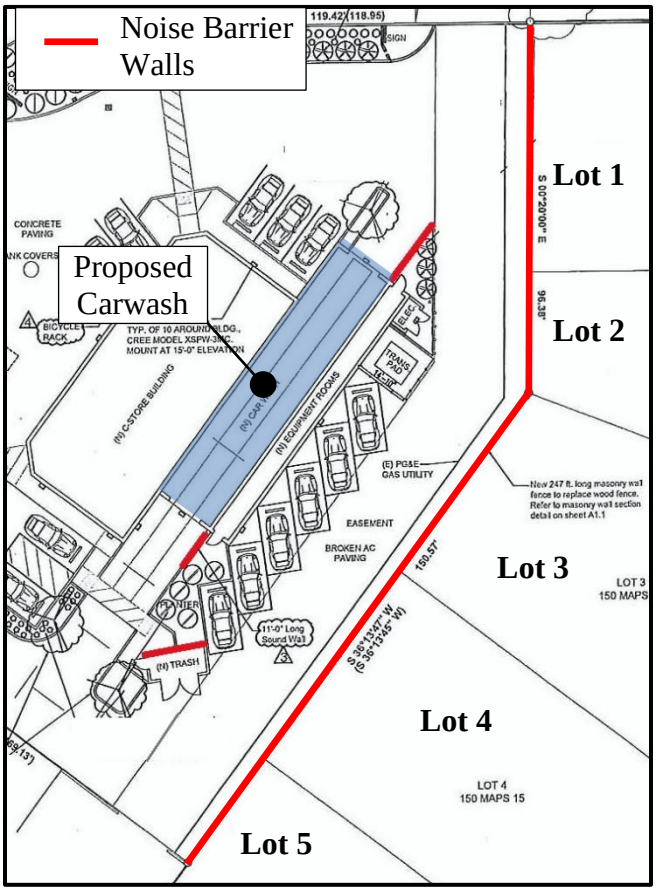


Figure 2: Carwash and Noise Barrier Layout

The project drawings along with the prior Noise Assessment indicate that the project will include the construction of an 18-foot long, 10-foot high noise barrier at the carwash exit, an 8-foot tall 16'-6" long masonry trash enclosure wall and an 11-foot long, 10-foot high noise barrier at the carwash entrance to reduce carwash noise emissions. Project drawings also show that the existing residential property line fence will be replaced with a 247-foot long 6-foot high masonry wall. Though this wall was not analyzed in the prior noise assessment, it may also be effective in reducing car wash noise at the adjacent residential uses. Figure 2 shows the carwash layout and noise barrier/masonry wall arrangements relative to surrounding properties.

As situated on the site the entrance opening will be as close as 50 feet from the property line shared with residential Lot 4 and the exit opening will be as close as 40 feet from the property line shared with residential Lot 1, as identified in Figures 1 and 2.

[2] Part of the Appeals document set for the 10-24-17 City Council Meeting

CAR WASH OPERATIONAL NOISE LEVELS

Automated car wash equipment and facilities include several noise sources associated with their operation. These include water pump and spray noise during the wash cycle inside the carwash building and the blower/dryers used during the drying process after the washing cycle is complete. The blower/dryers would be located at the exit of the carwash. Since the pumps are located in the building interior and the water spray noise occurs in the wash tunnel, the main noise source of an automated car wash system is produced by the blower/dryers. Therefore, this analysis examines car wash generated noise through an evaluation of sound levels generated by the dominant noise, the blower/dryer system.

The project description does not identify the manufacturer, make, or model of carwash equipment to be installed, however the applicants noise study considered the use of a Ryko 3-Fan SlimLine Dryer and Soft Gloss XS Car Wash system. The applicant's noise study used the Ryko carwash system as one that would be representative of the noise produced by the system that will ultimately be installed. I&R has conducted numerous studies of automated car wash installations and based on this work, we find the noise levels produced by the Ryko 3-Fan SlimLine Dryer system, producing a level of 84.2 dBA at 20 feet from the exit end of the tunnel, to fall in the mid-noise levels range of those which we have analyzed for other carwash installations. Based on this consideration, and to conduct a more complete analysis of the possible noise levels from the car wash at the adjacent residential uses, our analysis also considers a range of noise levels which may be produced by the unspecified automated car wash system. For this analysis we have reviewed our past projects and selected representative quieter and louder dryer systems evaluated our prior car wash noise analysis'. These systems are:

1. An AeroDry Systems, LLC, dryer system which produces a level of 79.4 dBA at 20 feet from the exit end of the tunnel, and
2. A Mark VII AquaDri F-40 Free Standing Dryer system which produces a level of 87.1 dBA at 20 feet from the exit end of the tunnel.

Maximum Car wash Noise Levels at Adjacent Residential uses

The sound pressure level data for these three car wash systems was used to calculate sound power levels (L_w)[3] for the dryer. These calculated sound power levels, along with the geometry of the proposed carwash, site buildings and noise barriers on the site were used as inputs to SoundPLAN, a 3-dimensional noise modeling software, to determine the maximum (L_{max}) noise levels due to carwash operations at the first and second level facades of the homes on Lots 1 through 5, which share a common property line with the project site[4]. These noise modeling results are presented in Table 2. Noise levels that are predicted to exceed the 55 dBA L_{max} threshold are bolded and highlighted in grey. Receiver locations are shown in Figure 3.

[3] The Sound Power Level represents the total sound energy produced by the source under the specified operating conditions. Sound Power Levels cannot be measured directly; instead they are computed from reference sound pressure level measurements, such as those reported by the manufacturer.

[4] Based on accepted distance attenuation factors and modeling results the noise levels at the actual property line would be 2 to 3 dBA higher, but considering that the shared property line is generally used for parking and other non-noise sensitive uses potential noise impacts were evaluated at the facades of the homes themselves.

Table 3: Maximum Car Wash Noise Levels at the Facades of Adjacent Residences

	Lot 1 Residence		Lot 2 Residence		Lot 3 Residence		Lot 4 Residence		Lot 5 Residence	
Height above ground level	**16 ft.**	**5 ft.**	**16 ft.**	**5 ft.**	**16 ft.**	**5 ft.**	**16 ft.**	**5 ft.**	**16 ft.**	**5 ft.**
Previously Analyzed Ryko Slimline Carwash (84.2 dBA @ 20 feet)	**68**	**63**	**63**	**62**	54	52	**62**	**60**	**61**	**59**
Higher Limit Carwash Sound Level (87.1 dBA @ 20 feet)	**70**	**66**	**65**	**64**	**57**	55	**67**	**65**	**66**	**64**
Lower Limit Carwash Sound Level (79.4 dBA @ 20 feet)	**62**	**58**	**57**	**56**	50	48	**60**	**58**	**59**	**56**

A review of noise modeling results shows that the maximum noise levels due to the operation of the proposed carwash will exceed the City's zoning code limit of 55 dBA at the upper and lower level facades of the homes on Lots 1, 2, 4, and 5 for all analyzed car wash systems. The maximum noise levels at the home on Lot 3 will be at or below the City's maximum noise limit of 55 dBA at the lower level facades for all analyzed car wash systems, higher noise car wash systems would also exceed the City's maximum noise limit of 55 dBA at the upper level façade of this home[5].

Figure 3: Noise Modeling Locations

[5] As stated in Footnote 4, above, it should also be noted that car wash noise levels at the actual property line would be expected to be 2 to 3 dBA higher, but considering that the shared property line is generally used for parking and other non-noise sensitive uses potential noise impacts were evaluated at the facades of the homes themselves.

Day/Night Average Levels (DNL) due Only to Carwash Operations at Adjacent Residential uses

The maximum noise modeling results determined with the SoundPLAN model were also used to compute the average (L_{eq}) noise level for a carwash cycle, which were then used to calculate the DNL level resulting solely from carwash operation under various operational scenarios.

The results of the stopwatch measurements conducted by the applicant on 10/22/17 of an existing Belanger carwash system located at 4995 Mowry Ave in Fremont were used compute the L_{eq} noise level for a carwash cycle from the maximum dryer cycle noise levels. These stopwatch measurements showed that the drying cycle lasts approximately 80 seconds, whereas the entire wash cycle takes approximately 253 seconds[6]. These dryer times and total wash cycle times concur with general range of cycle times I&R has observed and considered in other carwash noise analysis'.

Considering dryer noise to be the dominant source of carwash noise, the average noise level over an entire carwash cycle can be calculated from the maximum dryer noise level, the duration of the dryer cycle, and the total duration of the carwash cycle[7]. Using the client measured total car wash cycle versus dryer cycle times, the average carwash L_{eq} was found to be 5 dBA lower than the maximum noise level produced by car wash operations.[8]

With continuous carwash operation over an hour, which would equate to about 14 cars being washed per hour, the average carwash L_{eq} would become the hourly L_{eq}. Such worst case continuous operation over the fourteen (14) daytime hour (7:00 a.m. to 9:00 p.m.) operations schedule (as assumed in the applicant commissioned noise study), would result in a DNL due solely to the car wash operation that is 7 dBA lower than the maximum noise level produced by car wash operations[9]. Considering this the DNL levels due solely to carwash operations at the first and second level facades of the homes on Lots 1 through 5 have been calculated and are presented in Table 3, below. Noise levels that are predicted to exceed the 55 dBA DNL General Plan limit for new nonresidential land uses to located adjacent to existing noise-sensitive residential are bolded and highlighted in grey.

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[6] Mei Wu Acoustics (MWA), Andoil Bascom Car Wash - Peer Review Response, 10/23/17

[7] Considering that the dryer noise is typically the dominant source of carwash noise, the average noise level over an entire carwash cycle, (Leq_{cw}) may be calculated using the maximum dryer noise level ($Lmax_d$), the duration of the dryer cycle (Td), and the total duration of the carwash cycle (Tcw) as follows:
$Leqcw = Lmaxd + 10 * \log(Td) - 10 * \log(Tcw)$

[8] It should be noted that other sources of noise which occur during the carwash cycle are not considered in this calculation. Though the addition of these other source would not typically change the resulting Leq level, the addition of any other car wash related noise to this calculation would not decrease, but rather increase the resulting level.

[9] This is calculated using the equation: DNLcw $= 10 * \log(\{14 * [[10]\text{^}(\text{Leqcw}/10)\ ]\}/24)$,
Where: DNLcw = average day/night noise levels due solely to carwash operation and
Leqcw = hourly L_{eq} noise level produced by car wash operations.

Table 4: DNL Levels due to solely to Car Wash operations at Adjacent Residential Facades

	Lot 1 Residence		Lot 2 Residence		Lot 3 Residence		Lot 4 Residence		Lot 5 Residence	
Height above ground level	**16 ft.**	**5 ft.**	**16 ft.**	**5 ft.**	**16 ft.**	**5 ft.**	**16 ft.**	**5 ft.**	**16 ft.**	**5 ft.**
Previously Analyzed Ryko Slimline Carwash (84.2 dBA @ 20 feet)	**61**	**56**	**56**	54	47	45	55	53	54	51
Higher Limit Carwash Sound Level (87.1 dBA @ 20 feet)	**63**	**58**	**58**	**56**	50	48	**60**	**58**	**59**	**56**
Lower Limit Carwash Sound Level (79.4 dBA @ 20 feet)	55	51	50	49	42	40	52	50	51	49

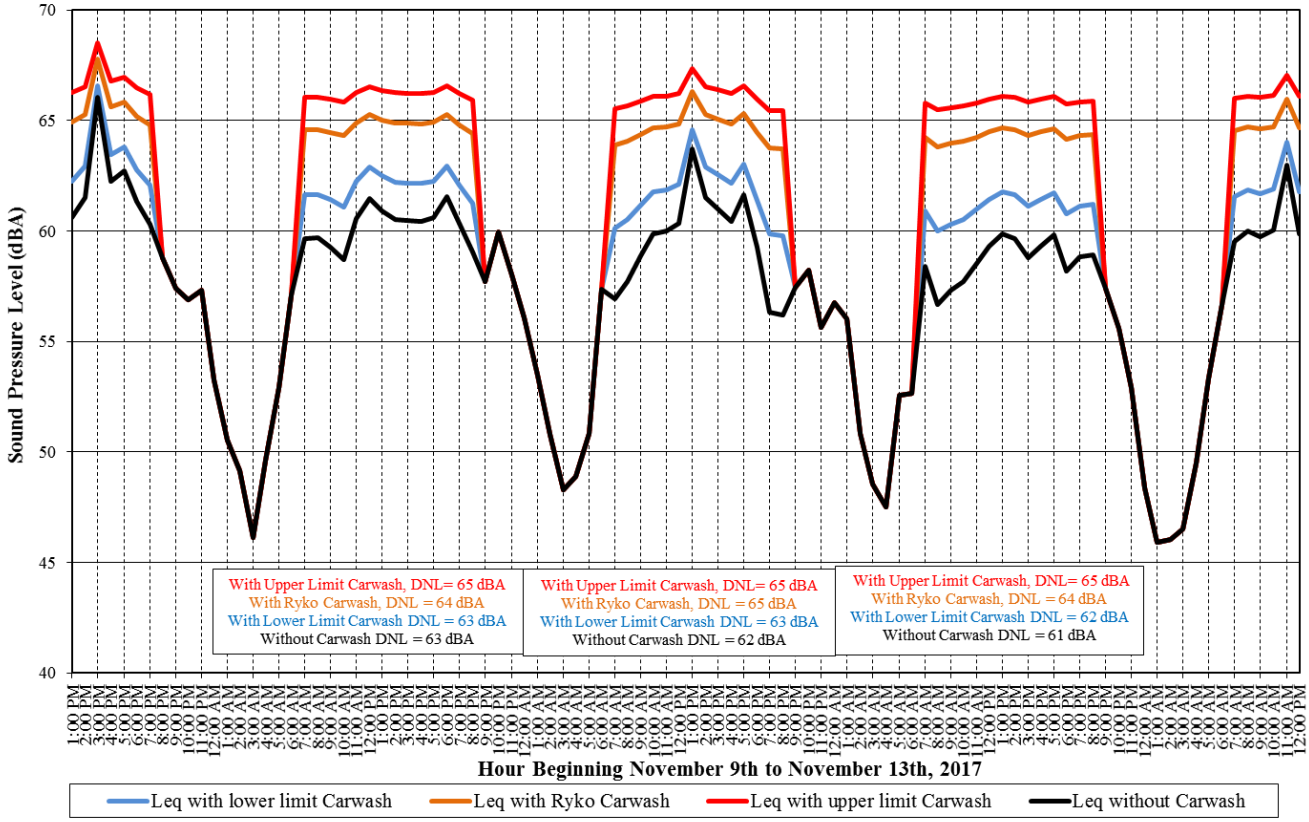
A review of noise modeling results shows that the DNL levels due solely to the operation of the previously analyzed (Ryko) and higher sound level carwash systems will exceed the City's General Plan EC-1.3 limit of 55 dBA DNL at the upper and lower level facades of the home on Lot 1. The Ryko system carwash noise would also exceed the General Plan EC-1.3 limit of 55 dBA DNL at the upper level of the residence on Lot 2, while the higher limit system carwash noise would exceed the General Plan EC-1.3 limit of 55 dBA DNL at the upper and lower level facades of the homes on Lots 1, 2, 4, and 5. The DNL levels due solely to the operation of the lower noise limit car wash system would not exceed the General Plan EC-1.3 limit of 55 dBA DNL at any residential façade.

Increase in existing DNL Levels due to Carwash Operations at Adjacent Residential uses

The maximum noise modeling results determined with the SoundPLAN model and the average (L_{eq}) noise level resulting carwash operations, as discussed above were also used to calculate the increase in the existing ambient DNL levels at the adjacent residential uses due to carwash operation. To undertake this analysis the hourly L_{eq} noise levels due to continuous carwash operations at modeled for the Lot 1 and 2 residential facades at the 16-foot height upper were logarithmically added[10] to the measured hourly noise levels between 7am and 9pm at measurement position LT-2. The graphical result of this analysis is shown in Charts 3a for the Residence on Lot 1 and Chart 3b for the residence on Lot 2.

[10] Sound levels which are expressed in decibels, are logarithmic quantities and so cannot be manipulated without being converted back to a linear scale.

Chart 3a: Average (Leq) Noise Levels
2nd Level Lot 1 Residential Facades with & without car wash noise

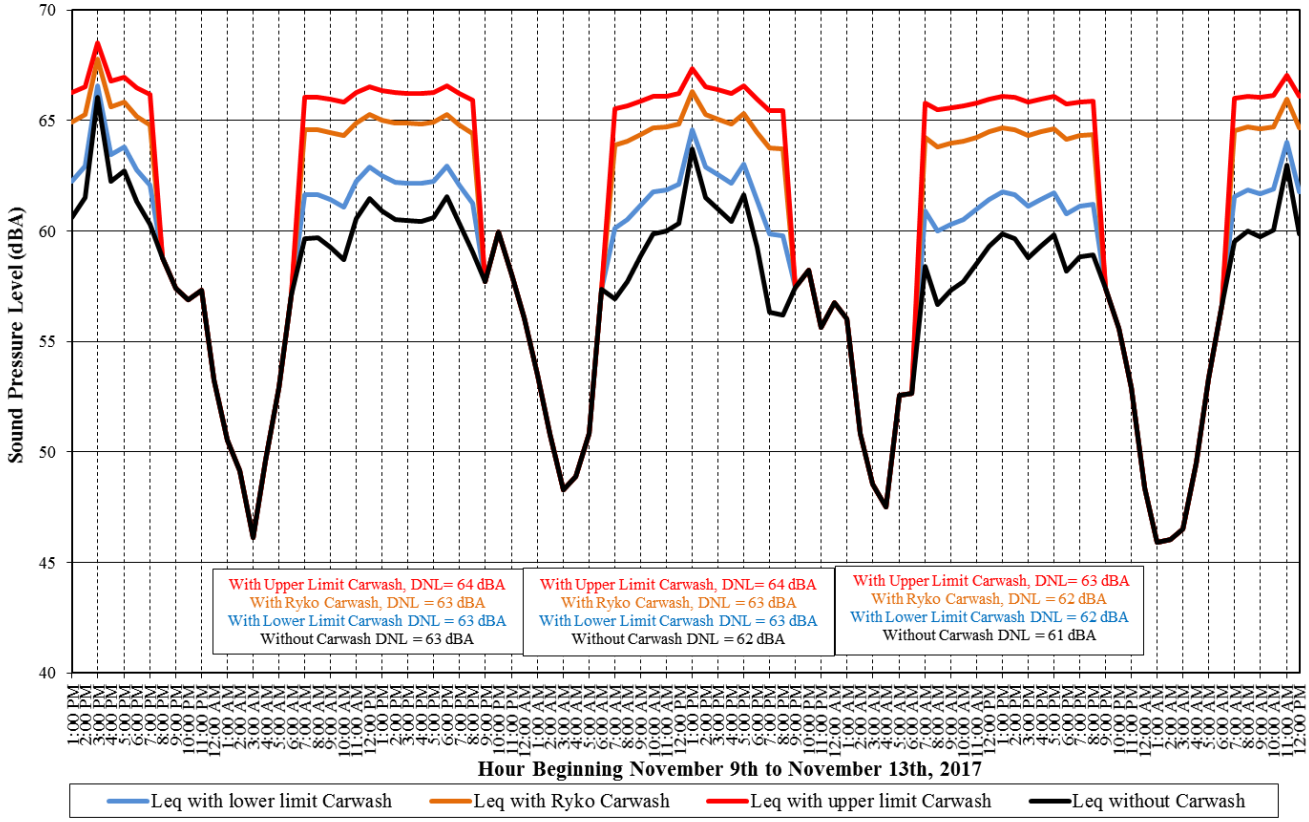


A review of Chart 3a shows that the average daytime noise levels at the upper floor facades of the residence on Lot 1 will increase due to carwash operations by between 2 to 9 dBA depending on the time of day and car wash system used. Due to these average noise level increases the DNL levels at this home will also increase, such that;

1. The lower noise level carwash system would increase the DNL measured on the Friday, Saturday and Sunday by 1 dBA,
2. The previously analyzed (Ryko) carwash system would increase the DNL measured on the Friday, Saturday and Sunday by 2, 2, and 3 dBA, respectively, and
3. The upper noise level carwash system would increase the DNL measured on the Friday, Saturday and Sunday by 3, 3, and 4 dBA, respectively.

These results indicate that the operation of either the previously analyzed Ryko carwash or the higher level carwash system analyzed would cause the DNL at the noise sensitive receptor on Lot 1 to increase by three dBA DNL or more in violation of General Plan policy EC-1.2.

Chart 3b: Average (Leq) Noise Levels
2nd Level Lot 2 Residential Facades with & without car wash noise



A review of Chart 3b shows that the average daytime noise levels at the upper floor facades of the residence on Lot 2 will increase due to carwash operations by between 1 to 5 dBA depending on the time of day and car wash system used. Due to these average noise level increases the DNL levels at this home will also increase, such that;

1. The lower noise level carwash system would not increase the DNL measured on the Friday, Saturday and Sunday,
2. The previously analyzed (Ryko) carwash system would increase the DNL measured on the Friday, Saturday and Sunday by 1 dBA each, and
3. The upper noise level carwash system would increase the DNL measured on the Friday, Saturday and Sunday by 1, 1, and 2 dBA, respectively.

Considering the results of the above analysis for the homes on Lots 1 and 2 in combination with a review of the Carwash only DNL levels presented in Table 4, we would expect that the increase in the existing DNL due to car wash operation will be less than 3 dBA at the residence on Lots 3, 4, and 5. However as noted above, the operation of either the previously analyzed Ryko carwash or the higher level carwash system analyzed would cause the DNL at the noise sensitive receptor on Lot 1 to increase by three dBA DNL or more in violation of General Plan policy EC-1.2.

SUMMARY OF FINDINGS

I&R's analysis of the proposed carwash addition to the existing Andoil service station located at 3702 South Bascom Avenue in San Jose, CA indicates that sound produced by the carwash operation will result noise levels which exceed the guidelines established by the City of San Jose's General Plan Noise Element and Zoning Code as follows:

1. The maximum noise levels due to the operation of an automated carwash system will exceed the City's zoning code limit of 55 dBA at the homes on four of the five adjacent residential lots by up to 15 dBA for the loudest carwash system analyzed, by up to 13 dBA for the previously analyzed (Ryko) carwash system, and by to up to 7 dBA for the quietest carwash system analyzed.
2. The Day/Night Average Levels (DNL) due to solely to carwash operations will exceed the City's General Plan Noise Element Policy limit EC-1.3 limit of 55 dBA DNL at the homes on four of the five adjacent residential lots by up to 8 dBA for the loudest carwash system analyzed and by up to 6 dBA for the previously analyzed (Ryko) carwash system.
3. The previously analyzed (Ryko) carwash system and loudest carwash system analyzed were both found to result in an increase in the DNL on weekend day by 3 dBA or more.

These exceedances of City noise guidelines and standards are considered significant and would be expected to result in a significant impact on the noise environment of the adjacent residential neighbors. Significant additional noise mitigation and/or a major project redesign will be is required to allow the project operations to comply with City Noise Standards.

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This concludes I&R's environmental noise assessment of the proposed carwash addition at the existing Andoil service station located at 3702 South Bascom Avenue in San Jose, CA. Please do not hesitate to call with any questions or concerns,

Sincerely,

[redacted]

Fred M. Svinth, INCE, Assoc., AIA
Senior Consultant, Principal
Illingworth & Rodkin, Inc.
Attachments: Appendix A.

APPENDIX A:

FUNDAMENTAL CONCEPTS OF ENVIRONMENTAL ACOUSTICS

Noise may be defined as unwanted sound. Noise is usually objectionable because it is disturbing or annoying. The objectionable nature of sound could be caused by its pitch or its loudness. Pitch is the height or depth of a tone or sound, depending on the relative rapidity (frequency) of the vibrations by which it is produced. Higher pitched signals sound louder to humans than sounds with a lower pitch. Loudness is intensity of sound waves combined with the reception characteristics of the ear. Intensity may be compared with the height of an ocean wave in that it is a measure of the amplitude of the sound wave.

In addition to the concepts of pitch and loudness, there are several noise measurement scales, which are used to describe noise in a particular location. A decibel (dB) is a unit of measurement, which indicates the relative amplitude of a sound. The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Sound levels in decibels are calculated on a logarithmic basis. An increase of 10 decibels represents a ten-fold increase in acoustic energy, while 20 decibels is 100 times more intense, 30 decibels is 1,000 times more intense, etc. There is a relationship between the subjective noisiness or loudness of a sound and its intensity. Each 10-decibel increase in sound level is perceived as approximately a doubling of loudness over a fairly-wide range of intensities. Technical terms are defined in Table 1. There are several methods of characterizing sound. The most common in California is the A-weighted sound level or dBA. This scale gives greater weight to the frequencies of sound to which the human ear is most sensitive. Representative outdoor and indoor noise levels in units of dBA are shown in Table 2.

Because sound levels can vary markedly over a short period of time, a method for describing either the average character of the sound or the statistical behavior of the variations must be utilized. Most commonly, environmental sounds are described in terms of an average level that has the same acoustical energy as the summation of all the time-varying events. This energy-equivalent sound/noise descriptor is called L_{eq}. The most common averaging period is hourly, but L_{eq} can describe any series of noise events of arbitrary duration.

The scientific instrument used to measure noise is the sound level meter. Sound level meters can accurately measure environmental noise levels to within about plus or minus 1 dBA. Various computer models are used to predict environmental noise levels from sources, such as roadways and airports. The accuracy of the predicted models depends upon the distance the receptor is from the noise source. Close to the noise source, the models are accurate to within about plus or minus 1 to 2 dBA.

Since the sensitivity to noise increases during the evening and at night -- because excessive noise interferes with the ability to sleep -- 24-hour descriptors have been developed that incorporate artificial noise penalties added to quiet-time noise events. The Day/Night Average Sound Level, L_{dn}, is a measure of the cumulative noise exposure in a community, with a 10 dB penalty added to nighttime (10:00 pm - 7:00 am) noise levels. The Community Noise Equivalent Level, CNEL, is a measure of the cumulative noise exposure in a community, with a 5 dB penalty added to evening (7:00 pm - 10:00 pm) and a 10 dB addition to nocturnal (10:00 pm - 7:00 am) noise levels.

Effects of Noise

Sleep and Speech Interference: The thresholds for speech interference indoors are about 45 dBA if the noise is steady and above 55 dBA if the noise is fluctuating. Outdoors the thresholds are about 15 dBA higher. Steady noise of sufficient intensity; above 35 dBA, and fluctuating noise levels above about 45 dBA have been shown to affect sleep. Interior residential standards for multi-family dwellings are set by the State of California at 45 dBA L_{dn}. Typically, the highest steady traffic noise level during the

daytime is about equal to the L_{dn} and nighttime levels are 10 dBA lower. The standard is designed for sleep and speech protection and most jurisdictions apply the same criterion for all residential uses.

TABLE 1: Definitions of Acoustical Terms Used in this Report

Term	Definitions
Decibel, dB	A unit describing, the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for air is 20.
Sound Pressure Level	Sound pressure is the sound force per unit area, usually expressed in micro Pascals (or 20 micro Newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 square meter. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressures exerted by the sound to a reference sound pressure (e.g., 20 micro Pascals). Sound pressure level is the quantity that is directly measured by a sound level meter.
Frequency, Hz	The number of complete pressure fluctuations per second above and below atmospheric pressure. Normal human hearing is between 20 Hz and 20,000 Hz. Infrasonic sound are below 20 Hz and Ultrasonic sounds are above 20,000 Hz.
A-Weighted Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise.
Equivalent Noise Level, L_{eq}	The average A-weighted noise level during the measurement period.
L_{max}, L_{min}	The maximum and minimum A-weighted noise level during the measurement period.
L_{01}, L_{10}, L_{50}, L_{90}	The A-weighted noise levels that are exceeded 1%, 10%, 50%, and 90% of the time during the measurement period.
Day/Night Noise Level, L_{dn} or DNL	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 pm and 7:00 am.
Community Noise Equivalent Level, CNEL	The average A-weighted noise level during a 24-hour day, obtained after addition of 5 decibels in the evening from 7:00 pm to 10:00 pm and after addition of 10 decibels to sound levels measured in the night between 10:00 pm and 7:00 am.
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
Intrusive	That noise which intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, and time of occurrence and tonal or informational content as well as the prevailing ambient noise level.

Typical structural attenuation is 12-17 dBA with open windows. With closed windows in good condition, the noise attenuation factor is around 20 dBA for an older structure and 25 dBA for a newer dwelling. Sleep and speech interference is therefore possible when exterior noise levels are about 57-62 dBA L_{dn} with open windows and 65-70 dBA L_{dn} if the windows are closed. Levels of 55-60 dBA are common along collector streets and secondary arterials, while 65-70 dBA is a typical value for a primary/major arterial. Levels of 75-80 dBA are normal noise levels at the first row of development outside a freeway right-of-way. In order to achieve an acceptable interior noise environment, bedrooms facing secondary roadways need to be able to have their windows closed, those facing major roadways and freeways typically need windows with special glass.

TABLE 2: Typical Noise Levels in the Environment

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
	110 dBA	Rock band
Jet fly-over at 1,000 feet		
	100 dBA	
Gas lawn mower at 3 feet		
	90 dBA	
Diesel truck at 50 feet at 50 mph		Food blender at 3 feet
	80 dBA	Garbage disposal at 3 feet
Noisy urban area, daytime		
Gas lawn mower, 100 feet	70 dBA	Vacuum cleaner at 10 feet
Commercial area		Normal speech at 3 feet
Heavy traffic at 300 feet	60 dBA	
		Large business office
Quiet urban daytime	50 dBA	Dishwasher in next room
Quiet urban nighttime	40 dBA	Theater, large conference room
Quiet suburban nighttime		
	30 dBA	Library
Quiet rural nighttime		Bedroom at night, concert hall
	20 dBA	
		Broadcast/recording studio
	10 dBA	
	0 dBA	

Source: Technical Noise Supplement (TeNS), Caltrans, November 2009.