



ACOUSTICS GROUP, INC.
Consultants in Acoustics, Noise & Vibration

December 15, 2020

Rich Riffle
Terravita Country Club
34034 North 69th Way
Scottsdale, AZ 85266

Subject: Pickleball Noise Analysis for Terravita Country Club in Scottsdale, AZ.

Dear Mr. Riffle

Terravita Country Club retained Acoustic Group Inc. (AGI) to update the 2014 and 2015 noise studies that were conducted to evaluate the noise generated by Pickleball play at the club. AGI has over 33 years of directly related past project experience, past work with Terravita Country Club and numerous other pickleball court projects where pickleball was added after the initial community development and noise level reduction was successfully obtained.

This study will predict the Pickleball noise level near houses that are adjacent to the tennis court area. The noise level from Pickleball play will be evaluated based on several noise control measures including 1) locating the Pickleball courts at a new location further away from the homes 2) evaluation of noise control material around the court at an appropriate height to reduce propagation 3) use of new pickleball equipment (rackets) specifically designed to reduce noise and 4) orientation of the direction of the courts to minimize noise. The results of this study provides a comparison of the actual measured sound levels when play was measured on several different courts in 2014, to the predicted value of the sound levels at the same locations with each of the four (4) noise reduction measures outlined above.

December 15, 2020

For Terravita Country Club Use Only



NOISE AND THE A-WEIGHTED SOUND LEVEL

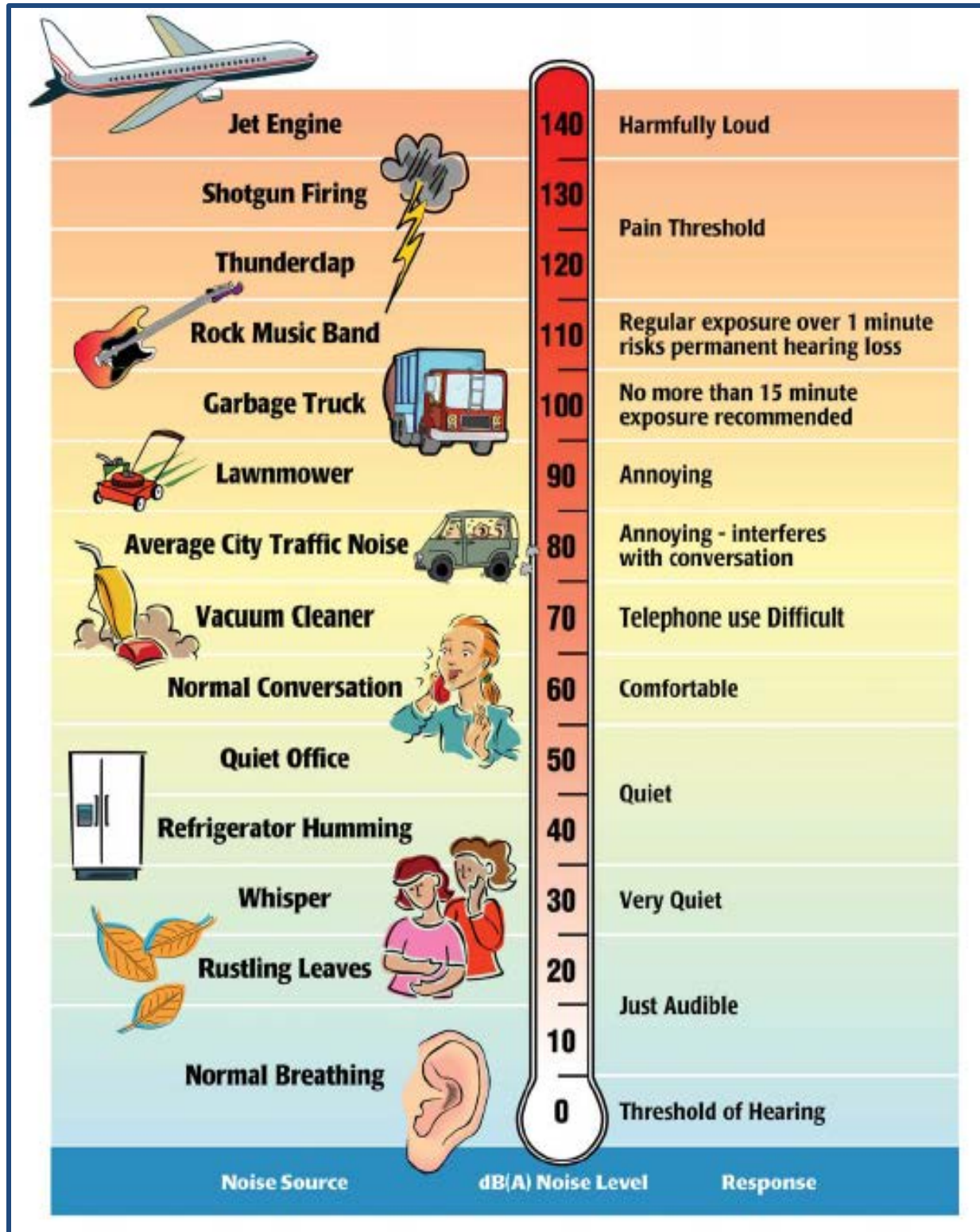
Noise is most often defined as unwanted sound. Although sound can be easily measured, the perceptibility is subjective and the physical response to sound complicates the analysis of its impact on people. People judge the relative magnitude of sound sensation in subjective terms such as “noisiness” or “loudness.” Sound pressure magnitude is measured and quantified using a logarithmic ratio of pressures, the scale of which gives the level of sound in decibels (dB).

The human hearing system is not equally sensitive to sound at all frequencies. Therefore, to approximate this human, frequency-dependent response, the A-weighting filter system is used to adjust measured sound levels. The A-weighted sound level is expressed in “dBA” or “dB(A).” Figure 1 provides typical A-weighted sound levels measured for various sources, as well as people’s responses to these levels.

When sound is measured for distinct time intervals, the statistical distribution of the overall sound level can be obtained during that period. The energy-equivalent sound level (Leq) is the most common parameter associated with such measurements. The Leq metric is a single-number noise descriptor which represents the average sound level over a given period of time, where the actual sound level varies with time. Lmax, Lmin, and Lxx are also common noise descriptors. Lmax and Lmin are the maximum and minimum noise levels, respectively, and Lxx, known as a statistical sound level, is the time-varying noise level which would be exceeded xx percent of the time.

NOISE STANDARDS & GUIDELINES

The City of Scottsdale Municipal Code does not specifically adopt noise standards to regulate noise from recreational activity within parks. However, an appropriate noise level limit would be 50 – 55 dBA at outdoor living areas. The acceptance of any noise guideline would be subject to the approval of the HOA board and or the City of Scottsdale.



Source: Melville Branch and R. Beland, 1970. EPA/ONAC 550/9-74-004, March 1974.

Figure 1. Typical A-weighted Noise Levels



SUMMARY OF 2014 STUDY

AGI previously conducted a noise survey on February 17, 2014 to document the noise levels from Tennis and Pickleball activities at the Terravita Tennis and Pickleball Courts¹. Hourly noise measurements were conducted at the rear yard of 6847 E Amber Sun Drive (NM1). Hourly noise measurements were also conducted along the rear yard fence of 6863 E Amber Sun Drive (NM2). The measurement was conducted with a Larson Davis Model 831 Noise Analyzer and the instrument was operated in accordance with manufacturer's standards. Figure 2 shows the location of the noise measurement relative to the Tennis and Pickleball courts and the nearby residences.

The Leq measured during the survey ranged from 40.4 to 45.4 dBA at NM1. The sources of noise that contributed to the measurement data were tennis and pickleball play, basketball play, distant traffic, wildlife birds, aircraft, talking, and homeowner activity. At location NM2, the Leq ranged from 46.9 to 48.3 dBA. Noise from tennis and pickleball play, basketball play, distant traffic, wildlife birds, aircraft, talking, and homeowner activity also were measured at this location. Table 1 summarizes the noise measurement data. Table 2 summarizes the noise from individual noise events measured at each location.

Tennis Noise

Noise associated with Tennis play was measured at locations NM1 and NM2 during the survey. During the tennis play, all 6 courts were active with doubles play at each court. There were a total of 24 players on the courts during the survey. At location NM1, tennis ball impact noise ranged from 40 to 58 dBA. At location NM2, tennis ball impact noise ranged from 39 to 53 dBA. Players talking and shouting were also noticeable noise sources at each location. Talking generated noise levels ranging from 40 to 55 dBA at NM1 and 37 to 42 dBA at NM2. Shouting generated noise levels at approximately 65 dBA at NM1.

Pickleball Noise

Noise associated with Pickleball play was measured at locations NM1 and NM2 during the survey. During the pickleball play, Court 6 was active with doubles play at each pickleball court. There were a total of 8 players on the courts during the survey. At location NM1, pickleball impact noise ranged from 39 to 53 dBA. At location NM2, pickleball ball impact noise ranged from 47 to 65 dBA. Players talking were also a noticeable noise source at each location. Talking generated noise levels ranging from 35 to 57 dBA at NM1 and 45 to 52 dBA at NM2.

¹ AGI letter Report for the Terravita Country Club Tennis and Pickleball Courts in Scottsdale, AZ, dated February 21, 2014.

Basketball Noise

Noise associated with basketball play was measured at locations NM1 and NM2 during the survey. Basketball play was demonstrated by one player located at Court 6. At location NM1, basketball impact noise ranged from 35 to 54 dBA. At location NM2, basketball impact noise ranged from 39 to 65 dBA.

Other Noise

Other noise sources experienced at NM1 and NM2 included birds, homeowners, aircraft, golf carts, cars, and trucks. Overall, at both measurement locations the ambient noise was 35 dBA. Birds created sound levels of 45 to 53 dBA. Nearby homeowners created sound levels ranging from 38 to 62 dBA. Aircrafts passing generated a sound level ranging from 42 to 53 dBA. A golf cart passing has a sound level of 45 dBA. A car passing has a sound level ranging from 42 to 45 dBA. Trucks passing had a sound level of 58 dBA. Based on the results of the noise survey, the noise from the pickleball and tennis courts had a range of sound levels ranging from 35 to 65 dBA.

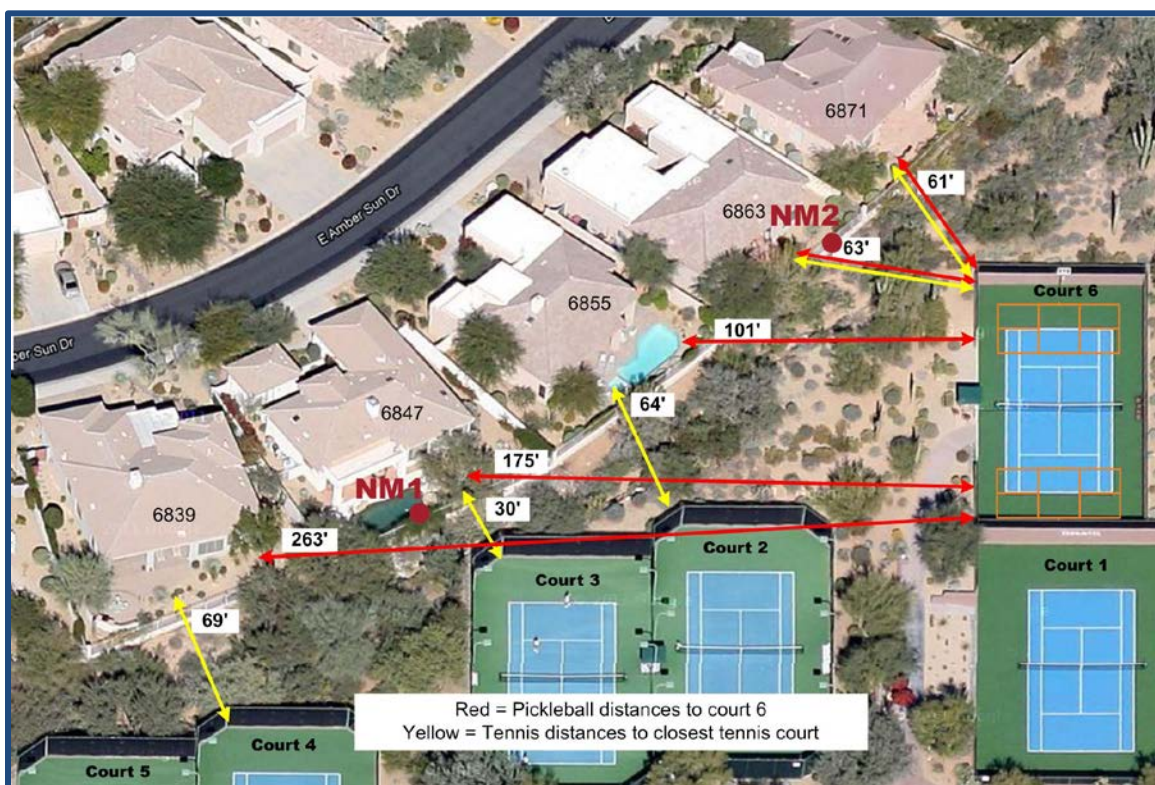


Figure 2. Location of the Noise Measurements



Table 1. Summary of the Statistical Noise Measurement Data

Description	Time	Leq, dBA	Lmax, dBA	Lmin, dBA
6847 E Amber Sun Drive (NM1)	11:00 AM - 12:00 PM	45.1	62.7	35.4
	2:00 PM - 3:00 PM	42.1	66.1	34.2
	3:00 PM - 3:10 PM	40.4	50.2	33.6
6863 E Amber Sun Drive (NM2)	12:00 PM - 1:00 PM	46.9	64.3	33.8
	1:00 PM - 1:05 PM	48.3	59.5	38.9
	1:00 PM - 2:00 PM	48.3	65.7	34.2

Table 2. Summary of Individual Noise Events by Location

Sources	Event Sound Level by Location and Time				
	Location NM1	Location NM2	Location NM2	Location NM1	Location NM1
	11 AM - 12 PM	12 PM - 1 PM	1 PM - 2 PM	2 PM - 3 PM	3 PM - 4 PM
Ambient	35	35	35	35	35
Birds	-	-	-	43-53	-
Homeowner	-	-	-	38-62	-
Basketball	-	39-45	45-65	-	35-54
Pickleball Ball Impact	-	-	47-65	39-53	-
Pickleball Players Talking	-	-	45-52	35-57	-
Tennis Ball Impact	42-58	39-53	-	40-50	-
Tennis Net/Fence Strike	46-50	42	-	-	-
Tennis Players Shouting	65	-	-	-	-
Tennis Players Talking	40-55	37-42	-	-	-
Aircraft	-	45	43-53	42-48	-
Car	-	42-45	-	-	-
Cart	-	-	45	-	-
Truck	-	-	58	-	-



SUMMARY OF 2015 STUDY

The noise from the proposed Pickleball activity at Court #5 was previously analyzed in AGI's 2015 noise study². Table 3 summarizes the results of the previous noise analysis. The noise associated with pickleball activity at Court #5 are within the 50 to 55 dBA guideline for residential noise impact assessment at R1 and R4 – R6. The noise at R2 and R2 are above the guideline. However, based on the noise measurement data, the background noise at the residences is relatively low at around 35 dBA, and pickleball noise levels would be audible and clearly discernible to the nearest homeowners on E Amber Sun Drive.

Table 3. Pickleball Noise Analysis for Court #5

Noise Sensitive Receivers	Pickleball Noise Level from Court #5 with No Noise Control, dBA
R1	51.7
R2	59.2
R3	58.9
R4	53.7
R5	49.5
R6	46.6

Note: Pickleball noise analysis based on 2 pickleball courts with a total of 8 players.

NEW PICKLEBALL LOCATION NOISE ANALYSIS

For the 2015 Court #5 study and the new pickleball location analysis, the methodology used to analyze and predict operations noise involved the use of the CadnaA computer noise model. CadnaA can simulate the physical environment by factoring in x, y, and z geometrics of a particular site to simulate the buildings, obstacles, and typography. The model uses industry recognized algorithms (ISO 9613) to perform acoustical analyses. The noise generated by future pickleball courts were calculated by inputting acoustical sources at the project site. AGI's measurement data from the pickleball noise measurements were used for the modeling inputs. The CadnaA Noise Model was also used to evaluate noise control options. This model has been validated by over 15 years and millions of successful test cases around the world.

AGI has analyzed the noise from the proposed Pickleball activity at the new proposed location shown in Figure 3. With no noise barriers, the future pickleball courts would produce noise levels ranging from 41.4 to 46.0 dBA at the nearest noise sensitive receptors. Table 4 summarizes the predicted pickleball noise levels at the nearest noise sensitive receptors.

² AGI Report - Summary of Pickleball Noise Analysis at Court #5 for Terravita Country Club in Scottsdale, AZ, dated June 23, 2015

Based on the noise measurement data from tennis and pickleball play, the noise associated with these activities are below the 50 to 55 dBA guideline for residential noise impact assessment. However, the background noise at the residences is relatively low at around 35 dBA, and pickleball noise levels would still be clearly discernible to the nearest homeowners on E Amber Sun Drive.

Table 4. Noise Analysis for New Pickleball Locations, dBA

Noise Sensitive Receivers	Pickleball Noise Level with No Noise Control, dBA
R1	41.4
R2	45.6
R3	46.0
R4	45.8
R5	43.9
R6	41.5

Note: Pickleball noise analysis based on 2 pickleball courts with a total of 8 players.

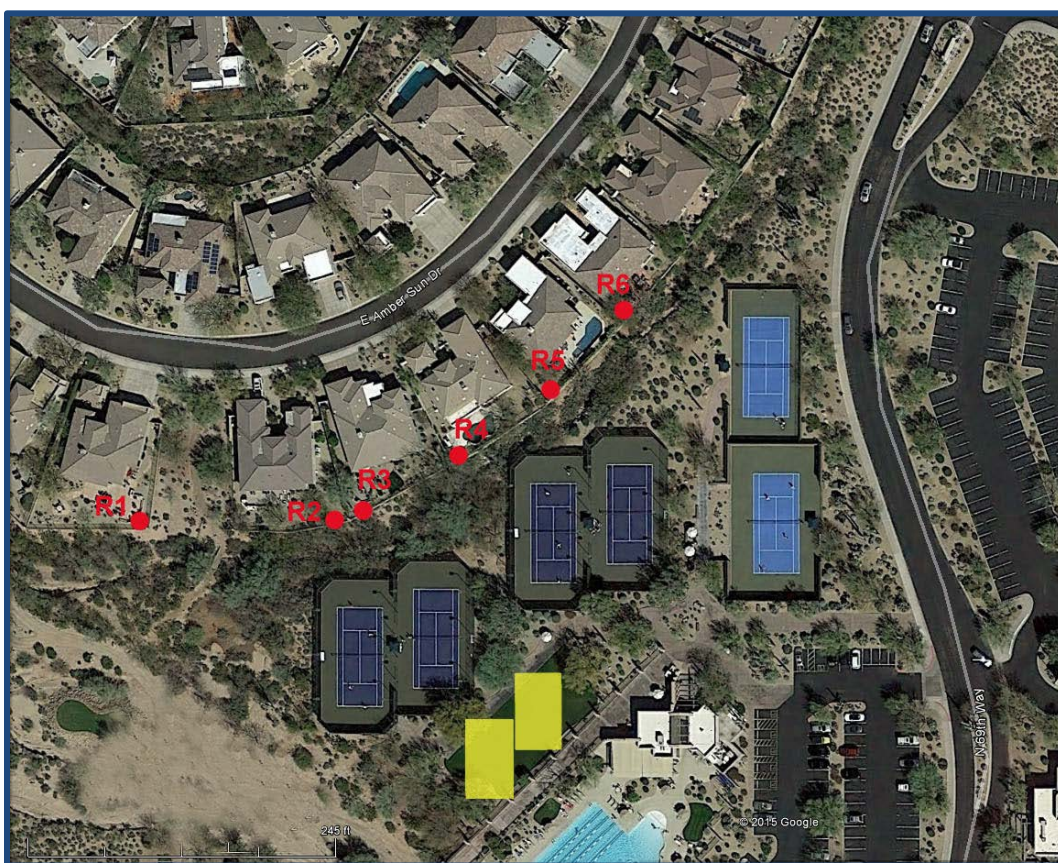


Figure 3. Proposed Pickleball Court Location



Compared to locating the pickleball courts on Court #5, the new pickleball court location further from the residences will result in a significantly noticeable reduction of noise levels ranging from 5.1 to 13.6 dB. Refer to Table 5 for a comparison of the pickleball noise levels from Court #5 and the new proposed pickleball location.

Table 5. Comparison of Pickleball Noise Levels from Court #5 and New Pickleball Location

Noise Sensitive Receivers	Pickleball Noise Level from Court #5 with No Noise Control, dBA	Pickleball Noise Level from New Location with No Noise Control, dBA	Delta, dB
R1	51.7	41.4	-10.3
R2	59.2	45.6	-13.6
R3	58.9	46.0	-12.9
R4	53.7	45.8	-7.9
R5	49.5	43.9	-5.6
R6	46.6	41.5	-5.1

Note: Pickleball noise analysis based on 2 pickleball courts with a total of 8 players.

Noise Control

The following measures were evaluated to minimize pickleball noise at the nearest homes from the proposed Pickleball Courts:

Noise Control Option 1

As the recommended option, a continuous solid noise barrier should be installed on the western and northern boundary of the pickleball courts as per Figure 4. Materials such as concrete block, plexiglass, or acoustical blanket (e.g. Acoustical Solutions Noise S.T.O.P Soundproof Blanket STC 33, NRC 0.75) should be used to provide the sound transmission needed. Figure 4 displays the recommended noise barrier location relative to the noise sensitive receivers. Table 6 summarizes the results of the noise barrier analysis.

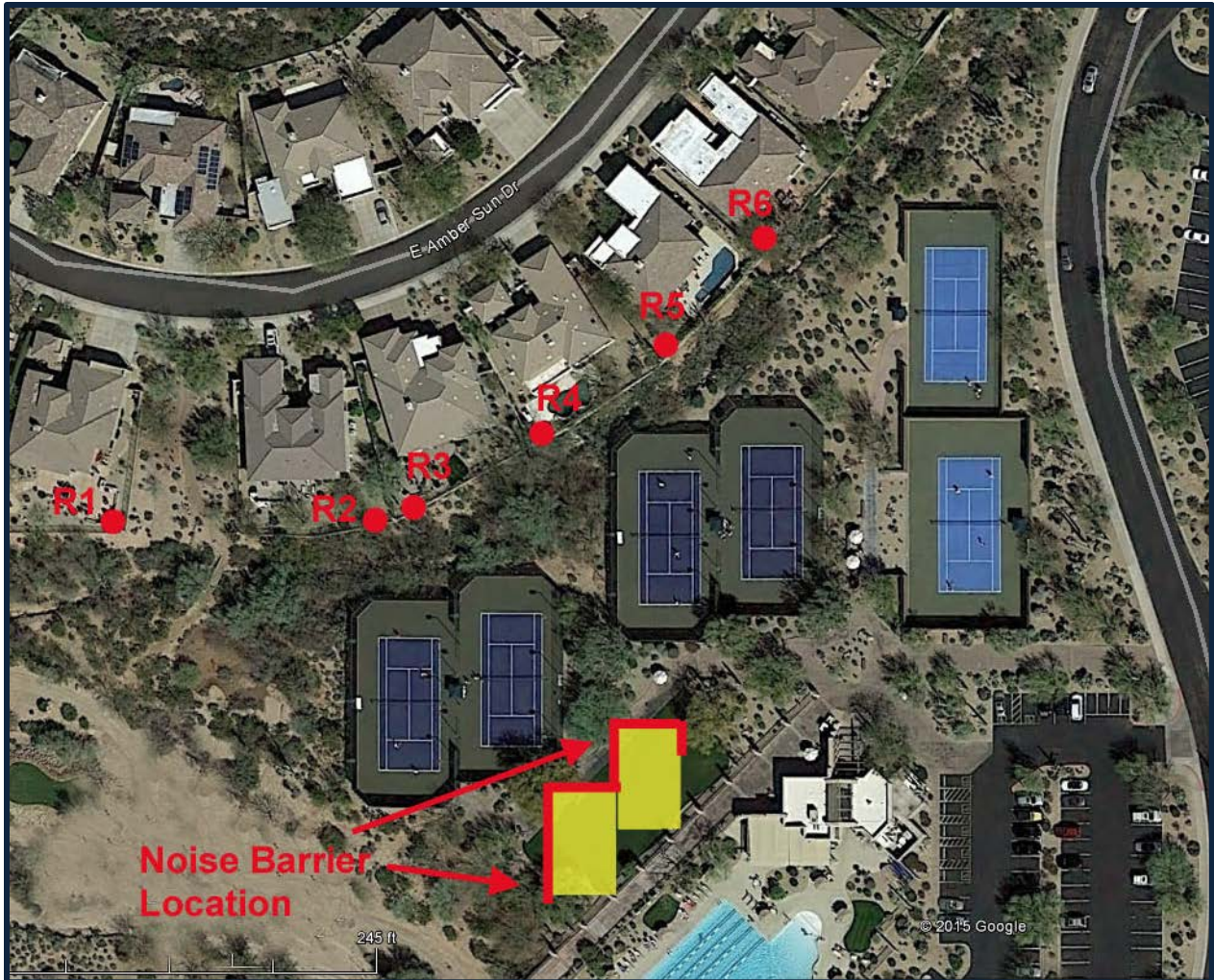


Figure 4. Recommended Noise Barrier Location

Table 6. Pickleball Noise Control Analysis – Solid Noise Barrier

Noise Sensitive Receivers	No Wall	Alternative Noise Barrier Heights, ft		
		10	12	14
R1	41.4	35.8	33.5	31.7
R2	45.6	39.6	37.3	35.5
R3	46.0	40.1	37.8	36.0
R4	45.8	40.1	37.9	36.1
R5	43.9	38.5	36.4	34.7
R6	41.5	37.3	36.0	35.0

Note: Pickleball noise analysis based on 2 pickleball courts with a total of 8 players.



Based on the results summarized in Table 6, a noise barrier of at least 12-feet in height is needed to provide a noticeable noise reduction at the nearby residences represented by Receptors 1 through 6. With a 12-foot high noise barrier, locating the new pickleball courts would result in noise levels of 33.5, 37.3, 37.8, 37.9, 36.4, and 36.0 dBA, at receptors R1 through R6, respectively. Compared to locating the pickleball courts on Court #5, the new pickleball courts with a 12-ft high solid noise barrier will result in noise levels ranging from 10.6 to 21.9 dB less than then noise levels from Court #5. Refer to Table 7 for a comparison of the pickleball noise levels from Court #5 and the new proposed pickleball location with the 12-foot high solid noise barrier.

With the solid 12-foot high barrier, the pickleball noise would be below the 50 to 55 dBA guidelines for residential noise impact assessment. Additionally, the pickleball noise levels would less than 3 dB higher than the ambient noise level at around 35 dBA. Because of the characteristics of the Pickleball impact noise, the sounds will be audible to the nearest residences.

Table 7. Comparison of Pickleball Noise Levels from Court #5 and New Pickleball Location with the 12-ft High Solid Noise Barrier

Noise Sensitive Receivers	Pickleball Noise Level from Court #5 with No Noise Control, dBA	Pickleball Noise Level from New Location with 12-ft High Solid Noise Barrier, dBA	Delta, dB
R1	51.7	33.5	-18.2
R2	59.2	37.3	-21.9
R3	58.9	37.8	-21.1
R4	53.7	37.9	-15.8
R5	49.5	36.4	-13.1
R6	46.6	36.0	-10.6

Note: Pickleball noise analysis based on 2 pickleball courts with a total of 8 players.

Noise Control Option 2

As an alternative to Option 1, install lightweight acoustical fencing (Acoustiblok or AcoustiFence) to the north, east, west, and south sides of the chain link fence surrounding the pickleball courts, as per Figure 5. The AcoustiFence (Figure 6), or acoustical equivalent should provide a minimum STC 28 rating or greater. The estimated barrier insertion loss values are consistent with AGI's field observations at similar pickleball facilities. Table 8 summarizes the pickleball noise levels with acoustical fencing surrounding the courts.

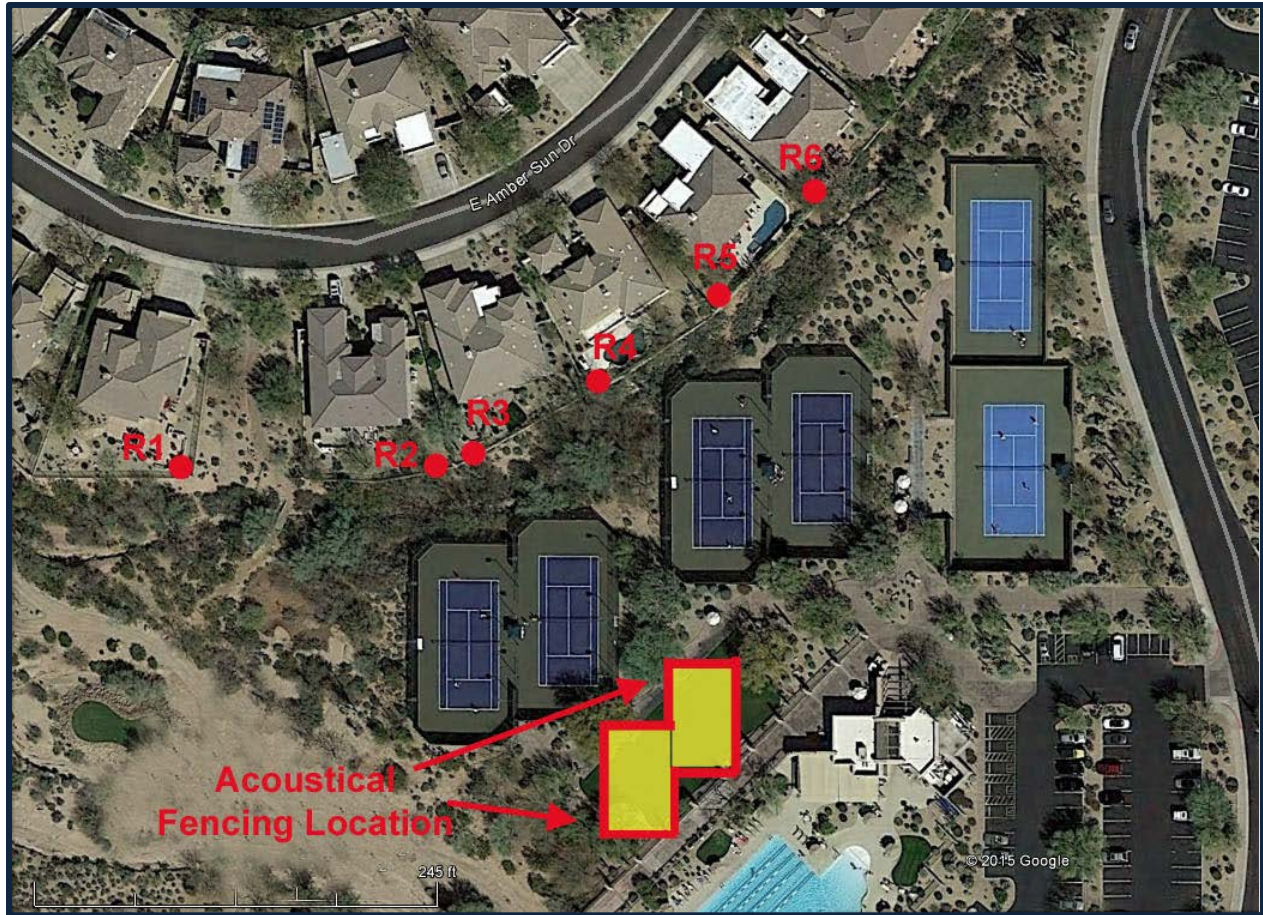


Figure 5. Recommended Acoustical Fencing Location Surrounding Pickleball Courts



Figure 6. AcoustiFence Surrounding Pickleball Courts

**Table 8. Pickleball Noise Control Analysis – Acoustical Fencing**

Noise Sensitive Receivers	No Wall	Alternative Acoustical Fencing Heights, ft		
		10	12	14
R1	41.4	37.2	36.8	36.6
R2	45.6	41.2	40.9	40.7
R3	46.0	41.7	41.3	41.2
R4	45.8	41.5	41.1	41.0
R5	43.9	39.5	39.1	38.9
R6	41.5	36.9	36.4	36.2

Note: Pickleball noise analysis based on 2 pickleball courts with a total of 8 players.

Based on the results summarized in Table 8, acoustical fencing of at least 12-feet in height is needed to provide a noticeable noise reduction at the nearby residences represented by Receptors 1 through 6. With a 12-foot high noise barrier, locating the new pickleball courts would result in noise levels of 36.8, 40.9, 41.3, 41.1, 39.1, and 36.4 dBA, at receptors R1 through R6, respectively. Compared to a solid noise barrier, acoustical fencing does not provide as significant amount of noise reduction.

Compared to locating the pickleball courts on Court #5, the new pickleball courts with a 12-ft high acoustic fencing will result in noise levels ranging from 10.2 to 18.3 dB less than then noise levels from Court #5. Refer to Table 7 for a comparison of the pickleball noise levels from Court #5 and the new proposed pickleball location with the 12-foot high acoustic fencing.

With the 12-foot high acoustic fencing, the pickleball noise would be below the 50 to 55 dBA guidelines for residential noise impact assessment. However, the pickleball noise levels would be approximately 6 dB higher than the ambient noise level at around 35 dBA and audible to the nearest residences.

Table 9. Comparison of Pickleball Noise Levels from Court #5 and New Pickleball Location with the 12-ft High Acoustic Fencing

Noise Sensitive Receivers	Pickleball Noise Level from Court #5 with No Noise Control, dBA	Pickleball Noise Level from New Location with 12-ft High Acoustic Fencing, dBA	Delta, dB
R1	51.7	36.8	-14.9
R2	59.2	40.9	-18.3
R3	58.9	41.3	-17.6
R4	53.7	41.1	-12.6
R5	49.5	39.1	-10.4
R6	46.6	36.4	-10.2

Note: Pickleball noise analysis based on 2 pickleball courts with a total of 8 players.



Noise Control Option 3

In addition to either Noise Control Option 1 or Noise Control Option 2, Terravita Country Club could enforce the requirement of the newer “Quietest” or “Quieter” Pickleball paddles. Table 10 lists the noise levels from pickleball paddles. Depending on the equipment type used, the noise level from pickleball noise could be reduced by 5.4 to 7.7 dB.

Table 10. Ranking of the Tested Pickleball Paddles by Sound Level

Paddle	Pickleball Noise Level, Leq, dBA at 10-ft from edge of court	Description
ZZT	57.0	Quietest
Pickleball Now The Force	57.2	Quietest
Graphite Magnum	57.9	Quieter
Pickleball Now MetaLite	58.1	Quieter
Pro Lite Enforcer	58.9	Quieter
Paddle Tech	59.3	Quieter
Graphite	60.1	Moderately Quiet
Pro Lite Power	60.1	Moderately Quiet
Brian Jensen Designs	61.0	Moderately Quiet
Striker	61.3	Moderately Quiet
Blaster	61.4	Moderately Quiet
Pro Lite Aero D	61.4	Moderately Quiet
Prolite Magnum	62.8	Moderately Quiet
Pickleball Now Classic Lite	63.3	Loudest
Pickleball Now Force	64.0	Loudest
Whipper Snapper	64.7	Loudest

Noise Control Option 4

Depending on the orientation of the Pickleball Courts, the noise produced by the ball and paddle impact can exhibit a small amount of directivity. The noise experienced along the baseline of the Pickleball Courts can be approximately 2 dB higher than the noise along the sideline directions. To minimize the affect of directivity, the courts can be orientated such that the sidelines face the nearest residences and thus further reduce the noise in the direction of the nearest homes. This would involve an approximately 90-degree rotation of the courts.



SUMMARY OF NOISE CONTROL OPTIONS

Compared to locating the pickleball courts on Court #5, the new pickleball courts with a 12-ft high solid noise barrier will result in noise levels ranging from 10.6 to 21.9 dB less than then noise levels from Court #5. Compared to locating the pickleball courts on Court #5, the new pickleball courts with a 12-ft high acoustical fencing will result in noise levels ranging from 10.2 to 18.3 dB less than then noise levels from Court #5. Compared to a solid noise barrier, acoustical fencing does not provide as significant amount of noise reduction. Depending on the equipment type used, the noise level from using newer “Quietest” or “Quieter” pickleball paddles could be reduced 5.4 to 7.7 dB. Additionally, if the angle of the proposed courts was rotated 90 degrees, noise levels could be reduced an additional 2 dB. Table 11 summarizes the noise control options evaluated for the new pickleball location.

Table 11. Summary of Noise Control Options

Noise Control Option	Noise Reduction, dB	Description
(1) 12-ft High Solid Noise Barrier	10.6 to 21.9 ¹	Significantly Noticeable
(2) 12-ft High Acoustical Fencing	10.2 to 18.3 ¹	Clearly Noticeable
(3) Quiet Paddles	5.4 to 7.7	Noticeable
(4) Angle of Court Play	2	Not Noticeable

¹ Compared to Pickleball Play on Court #5 with No Noise Control

RECOMMENDATIONS

The following recommendations are identified to provide a substantial reduction of the pickleball noise at the nearest residences:

1. A 12-foot high noise barrier (barrier height is relative to the court elevation) should be constructed along the western and northern boundary of the pickleball courts as shown in Figure 4, to reduce the pickleball noise at Receptors 1 through 6. Materials such as concrete block, plexiglass, or acoustical blanket (e.g. Acoustical Solutions Noise S.T.O.P Soundproof Blanket STC 33, NRC 0.75) should be used to provide the sound transmission needed.
2. As an alternative, a 12-ft high acoustical fencing (acoustical fencing height is relative to the court elevation) can be constructed surrounding the proposed pickle court location as shown in Figure 5. Acoustiblok, AcoustiFence, or acoustical equivalent should provide a minimum STC 28 rating or greater.
3. Require pickleball players to use the newest “Quietest” or “Quieter” paddles. Require an inspection of the paddles and ball prior to begin of play.
4. Rotate the design of the Pickleball Courts by 90 degrees, so that the baselines are perpendicular to the residences to the North.
5. Consider limiting the days and hours of pickleball play to time periods that are less intrusive to nearby homeowners.



6. The engineering design of the noise barrier should be reviewed by a licensed engineer to ensure compliance with all applicable codes.

CONCLUSION

AGI has analyzed the pickleball noise from the new proposed pickleball courts and the potential noise reduction that could be achieved with a noise barrier along the western and northern edge of the courts or acoustical fencing surrounding the courts. The analysis has determined that a 12-foot high noise barrier would provide a significant and substantial noise reduction compared to the no noise barrier case. Alternatively, a 12-ft high acoustical fencing would provide a clearly noticeable noise reduction compared to the no noise barrier case. Requiring pickleball players to use quiet paddles and rotation of the court by 90 degrees would further reduce noise levels. Because the Terra Vita community is located in a quiet ambient environment, noise from the pickleball play will not be reduced to an inaudible level by constructing a noise barrier and additional noise control measures. However, the recommended noise control options could be collectively employed to provide a substantial reduction in the pickleball noise.

Please contact Mr. Robert Woo at 877-595-9988 if you have any questions regarding this summary.

Sincerely,

ACOUSTICS GROUP, INC.

A handwritten signature in black ink, appearing to read 'Robert Woo'.

Robert Woo
Principal Consultant

A handwritten signature in black ink, appearing to read 'Angelica Nguyen'.

Angelica Nguyen
Senior Consultant