



Pickleball Sound Assessment Report with Findings:

Marco Island Racquet Center

Marco Island, Florida

by

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I. Executive Summary

PSM Consulting was retained to assess the sound impacts associated with the proposed expansion of the pickleball facilities at the Marco Island Racquet Center. The existing facility includes nine pickleball courts, eight along the northeastern boundary and one on the northwestern side. The proposed expansion would add eight new courts to the south of the eastern group, demolish the existing racquet building and the single western court, and convert that area to parking, bringing the total to 16 active courts.

Acoustical modeling was performed using NoiseTools software integrated with Google Earth Pro satellite imagery. Sixteen sound source points were modeled across the expanded court layout, and predicted sound pressure levels were evaluated at five representative residential receptors surrounding the facility. The Marco Island Noise Ordinance sets a daytime limit of 68 dBA at residential receivers. Based on PSM Consulting's experience and national guidelines, a design target of 50–55 dBA (LAFmax) is applied, as levels at or below this range are associated with negligible community noise complaints.

Three sound mitigation configurations were evaluated against the current baseline (existing courts with a 10-foot reflective barrier on the east only):

Option A: 10-foot-high sound-absorbing barriers along the east, west, and south of the existing courts (no center barriers).

Option B: 10-foot-high sound-absorbing barriers along the east, west, and south of the existing courts, plus a 10-foot-high clear sound-reflecting barriers between courts.

Option C: Full 8-court expansion with 12-foot-high sound-absorbing barriers along the east, west, and south, plus 10-foot-high clear sound-reflecting barriers between courts.

All three options are predicted to produce sound levels below the 68 dBA ordinance limit at all neighboring properties. Options B and C, which include center barriers, produce significantly lower sound levels than Option A alone, particularly at residences to the south. Option C yields the greatest overall predicted sound reduction of all configurations evaluated. A solid wall on the south side was also considered as an alternative to center barriers; modeling showed it would need to reach 18 feet to achieve equivalent reduction, a height deemed impractical, and this option was dismissed.

Option C is recommended as the preferred approach. It provides the greatest predicted sound reduction compared to the current baseline and represents a modular extension of the mitigation system designed for the existing courts. Clear acoustic panels, such as the Hushtec-USA® ClearPlay 360™ or tempered glass panels such as Pickleglass™ by Pickletile™, are recommended for the center barriers to preserve sightlines from the pro shop and address security considerations. All barrier installations must be engineered by a Florida licensed Professional Engineer to meet structural and wind load requirements.

II. Overview of the Site

The City of Marco Island Racquet Center currently includes a total of nine pickleball courts—eight located along the northeastern boundary of the property and one situated on the northwestern side. A 10-foot fence lines the eastern side of the pickleball courts and is fitted with a sound-reflecting barrier (Acoustiblok®). The proposed project includes expanding the eastern group of courts southward by adding 8 new pickleball courts, demolishing the existing racquet building and the single pickleball court to the west, and replacing them with additional parking.



Figure 1: Photos of site existing condition and proposed expansion

The site is surrounded by diverse neighborhoods.

- **North:** San Marco Road, Marco Island Fire-Rescue Department, Marco Island Police Department
- **East & South:** San Marco Villas Condominiums
- **West:** Residential properties on South Heathwood Drive



Figure 2: Marco Island Fire-Rescue Department (north)



Figure 3: Backyard of 10 – 20 Marco Villa Drive residences facing the pickleball courts (east)



Figure 4: Backyard of 90 – 104 Marco Villa Drive residences facing the pickleball courts (south)



Figure 5: Backyard of residences on South Heathwood Drive (west)

III. A Description of Pickleball Sound Characteristics

The Sounds of Pickleball

Pickleball is a game played with paddles, a ball, and a net on a court that is approximately one half the size of a tennis court. The paddles are made of wood, plastic, or composite materials, and the ball is made of plastic. The sound generated by pickleball is louder than the sound generated by tennis play, and it has a higher pitch. Homeowners in proximity to pickleball courts hear a louder sound than that from tennis. At elevated sound level, pickleball sounds are sometimes considered as noise and may become bothersome.

Properties of Pickleball Sound

Sound is generated when an object vibrates and excites the air molecules with which it is in contact. These vibrating air molecules create sound waves that radiate outward from the source of the sound at a speed of about 1,100 feet per second. As sound moves away from the source, it decreases in amplitude at a rate of 6 dB for each doubling of distance. The sound level or loudness is measured in decibels (dB). The louder the sound, the higher the dB level that is measured, and the more likely the sound will be an annoyance. The tonal quality is the combination of low frequency and high frequency components of the sound. Frequency is measured in cycles per second or Hertz (Hz). Most sounds include a combination of low frequency booming tones and high frequency shrill or sharp tones. Sound also varies with time. A steady state noise is continuous with little or no change in level or frequency content. Impulse noises have short duration and may or may not be repetitive and recurring.

Tennis vs. Pickleball

In general, tennis is one half as loud as pickleball with a lower tone at impact and fewer impacts per minute of play. One half as loud means 10 dB lower sound level. The lower pitch of a tennis hit comes from the hollow tennis ball with a felt surface, the strings, which have less surface area than a hard flat surface and which stretch during impact and act more like a trampoline, as opposed to a hard surface which is more like a drum head.

Human Hearing and Annoyance

The human ear is sensitive to a sound's level, its frequency content, and its duration. The higher the sound level, the greater the annoyance becomes. Each 10 dB increase in sound level is perceived as a doubling in the sound level, which is a 100% increase. Each 6 dB increase is perceived as a 50% increase, and each 3 dB increase is perceived as a 23% increase. The human ear is more sensitive to high frequency sounds than to low frequency sounds. It is also sensitive to the duration of a noise.

Typical Sound Levels

Normal human hearing has a very large range of capability, usually expressed in decibels above a selected sound pressure level designated as zero dB. Human hearing has a lower sensitivity to low pitch sounds and readings of meters and sound software are usually adjusted to account for this by using the A scale.



Figure 6: dB Values of Common Noise Sources, A-weighted

This chart illustrates that sounds in the range of 50 to 60 dBA are comparable to the loudness of normal conversation and 70 dBA to the sound levels usually present in a busy restaurant. A quiet library has a sound level of about 40 dBA.

Atmospheric conditions affect propagation (movement of sound waves)

The wind, temperature and humidity of air (the primary medium for pickleball sound), affect attenuation (reduction in sound level as it moves from the source), so changing conditions complicate prediction of sound level reduction, and impact the rate of attenuation. On calm, humid, warm days when the density of air molecules is greater, the losses are less, and sound propagates further/faster. In mornings or evenings, versus midday, the different conditions will result in different reception of sound at distance. These variable conditions are not fully captured by acoustical modeling; actual sound levels at any given time may therefore differ from the predicted values in this report.

IV. The Measurement of Pickleball Sound Levels

The human ear does not hear all sounds equally. It has more sensitivity in a mid-frequency range of 1000 to 4000 Hz and has diminished sensitivity at frequencies above and below this range. A frequency weighting can be applied to any sound measurement to match the hearing sensitivity of the human ear. This is called the A-weighting and is shown below. Decibel measurements with the A-weighting are listed as dBA.

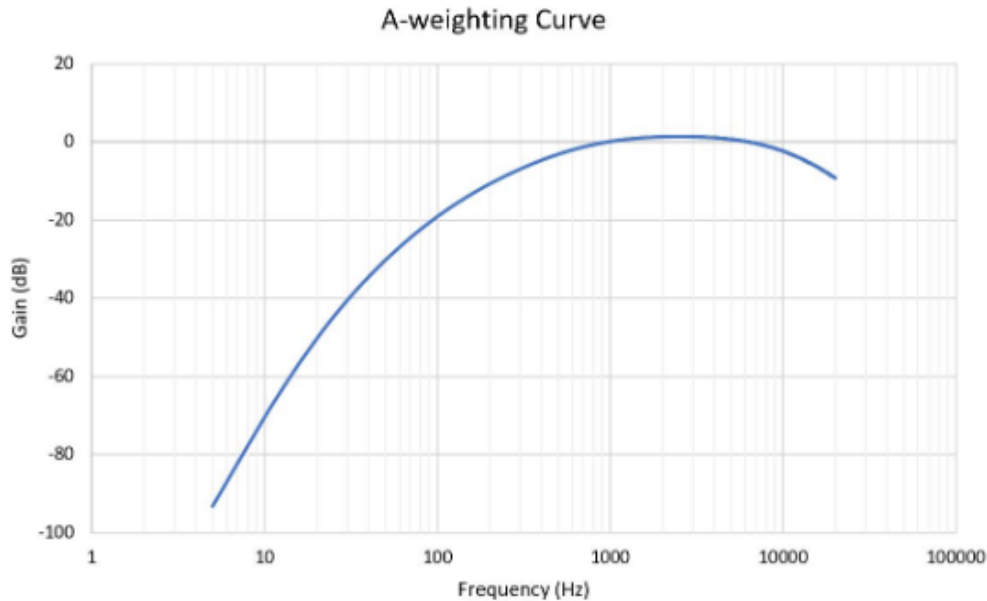


Figure 7: A-weighting curve

Because sound is not constant and varies with time, the sound level meter has several measurement settings to average these sound fluctuations over the measurement period. These settings report the sound level for the measurement period selected. The meter setting must be properly selected to capture the sound level based on the duration of the sound and the response time of the human ear.

What measurement setting is best for pickleball play? For short duration sounds like pickleball impacts, the fast response with an A weighting best corresponds to the averaging time and sensitivity of the human ear. A maximum hold setting can also be used. The maximum hold setting “listens” for the maximum sound level within the fast time averaging interval and continues to update the maximum level. In this manner, the maximum level of these rapid fluctuations can be captured over the averaging interval.

The fast meter setting will typically measure a higher sound level for a pickleball impact than a slow setting. The slow meter setting averages sound over a longer averaging period that includes intervals with no pickleball impacts. The slow setting is appropriate for continuous noise and for background noise but not for pickleball impacts. The slow setting understates the loudness of the short duration pickleball impact heard by the human ear. The peak setting of a sound level meter will measure an even higher level than a fast setting because of a shorter time interval. However,

peak settings neglect the duration of sound, which is critical to human annoyance. Also, the peak measurement does not have an A-weighting. Different time averaging intervals will therefore report different dB levels for the same sound event.

When the A-weighting setting on a sound level meter is selected, dB measurements are described as dBA. If the sound level (L) is measured with an A-weighting (A) and a fast (F) setting, it is described as LAF. When the maximum level is captured in the measurement interval, this is called LAFmax.

Unless otherwise noted, **pickleball sounds in this report will be described in units of LAF. LAFmax measures the maximum sound, regardless of the number of impacts. If the LAFmax sound pressure level can be reduced through sound mitigation low enough, then the number of impacts will not be meaningful.**

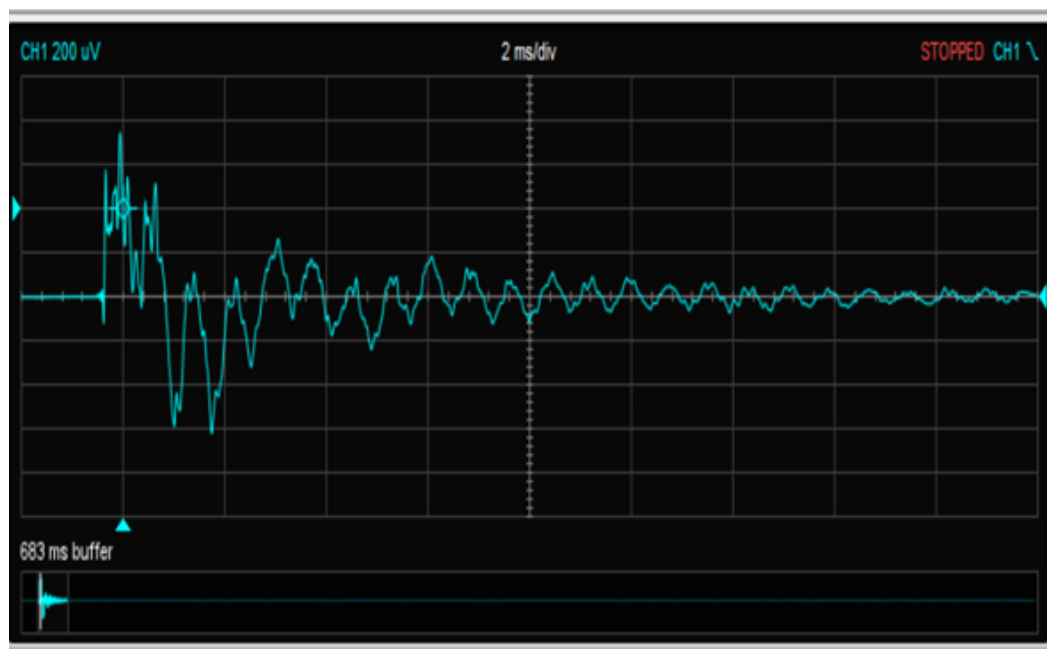


Figure 8: Time history of a single paddle and ball impact

The graphic shows a typical time history of a single paddle and ball impact, which has a usual time duration of about 10 to 20 milliseconds (ms). There is an impact, followed by lower amplitude sound pressure during most of the duration.

In a game of pickleball, a rally will involve several impacts spaced by intervals of less than a second to more than 2 seconds until the rally is over. A game involves several rallies until a team wins. The result is that pickleball impacts will occur randomly during the duration of a game. In addition to the hits being spaced randomly, not all impacts are of the same loudness. Soft paddle strikes will be barely audible and forceful paddle strikes will be much louder. Serves, returns, soft “dinks” at the net, bouncing balls, volleys hit without bounces are interspersed. Players of different skill levels, ages, genders and athletic abilities may be on the same court, so consecutive hits are usually quite different.

When pickleball play involves 2 or more courts, the sound from 2 or more games only marginally increases the maximum sound pressure level from hits. This is because each pickleball impact is a discrete event. The number of impacts per hour may increase from pickleball play on multiple courts, but the LAFmax sound levels do not increase. Note that because of the very short duration, it is extremely uncommon that two hits occur simultaneously, and the sound becomes additive.

The goal of noise mitigation is to reduce the loudest impacts to a low enough level so that the loudest impact and all lower impacts will not be bothersome.

V. Marco Island Noise Ordinance

(Ord. No. 24-15, § 2(Exh. A), 9-9-2024)

Sec. 18-104. General noise prohibitions.

(a) *Prohibition of excessive noise from a property. It is unlawful for any person, including the property owner(s), to permit, cause, allow, create, emit, or sustain excessive noise from a property, including the air space above the property. Noise disturbances are irreversible and irreparable violations of this article.*

(b) *Prima facie evidence. For the purposes of this subsection, the following shall constitute prima facie evidence that noise (whether recurrent, intermittent, or continuous) is excessive:*

(1) *Between the hours of 10:00 p.m. and 7:00 a.m., the sound is plainly audible a minimum of 50 feet from the property line of the source of the sound or within a fully enclosed structure or residence on any receiving property; or*

(2) *Sound pressure levels by receiving land use;*

| <i>Receiving Land Use Category</i> | <i>Time</i> | <i>Sound Pressure Level Limit (dBA)</i> |
|--|----------------------------|---|
| <i>Residential zone, public space, or institutional zone</i> | <i>7:00 a.m.—9:00 p.m.</i> | <i>68</i> |
| | <i>9:00 p.m.—7:00 a.m.</i> | <i>60</i> |
| <i>Commercial zone</i> | <i>7:00 a.m.—9:00 p.m.</i> | <i>72</i> |
| | <i>9:00 p.m.—7:00 a.m.</i> | <i>65</i> |

Comments on Marco Island Noise Ordinance

Our interpretation of the acoustical aspects of the noise ordinance is as follows:

Applicable Regulatory Sound Levels

- According to Sec. 18-104, the permissible sound levels at residential zone receivers are 68 dBA during daytime and 60 dBA during nighttime.
 - *Daytime* is defined as the period between 7:00 a.m. and 9:00 p.m.

Sound emitted from sport venues are not specifically addressed in the noise ordinance. Separate sound level limits for impact sound, the basic characteristic of pickleball sound, have not been provided.

Ambient Noise Considerations – San Marco Road, Marco Island Fire & Rescue, Marco Island Police department

San Marco Road is a moderately traveled municipal roadway with a posted speed limit of 30 to 35 mph. The expected A-weighted sound levels (dBA), as a function of distance from the roadway and traffic volume, are summarized below:

| Distance from Road | Light Traffic | Moderate Traffic | Heavy Traffic |
|--------------------|---------------|------------------|---------------|
| At curb (10–15 ft) | 60–65 dBA | 65–70 dBA | 70–75 dBA |
| 50 ft away | 55–60 dBA | 60–65 dBA | 65–70 dBA |
| 100 ft away | 50–55 dBA | 55–60 dBA | 60–65 dBA |

Residential properties located south of the project site are situated more than 500 feet from San Marco Road. Field measurements indicate ambient noise levels of approximately 45 dBA at that distance.

Target Sound Level Range for Evaluation

Community annoyance from pickleball noise can occur even when measured sound levels comply with existing municipal noise ordinances. Based on PSM Consulting’s extensive experience addressing and mitigating pickleball sound issues, and consistent with our interpretation of ANSI standards, a target design range of 50 – 55 dBA is recommended for evaluating maximum sound pressure levels and developing effective noise mitigation strategies. Depending on atmospheric conditions, the sound of pickleball play may still be audible occasionally; however, empirical evidence and field studies indicate that when sound levels remain at or below 50 dBA, noise complaints from individuals with normal sensitivities are negligible.

VI. Pickleball Sound Mitigation Methods

While an effective **sound barrier** near pickleball courts can reduce the pickleball sound levels, this requires the sound barrier to block the line-of-sight path. Vegetation is not typically a good sound barrier, but can reduce some sound, depending on the height and density.

Effective sound barriers are made of heavy, dense materials. That includes earth, concrete walls, thick vegetation such as tall thick hedges and mass-loaded vinyl. Barriers can be sound reflecting or absorbing; several companies manufacture hanging sound barrier materials of both types. Examples include the frequently used mass-loaded vinyl reflective sheets called Acoustifence™, supplied by Acoustiblok™, transparent glass supplied by Pickletile™, or PVC supplied by Hustec, and/or absorptive quilted fiberglass layers attached to mass-loaded vinyl sheets, like those offered by Insul-Quilt™ and eNoise Control.

Changing the **court orientation** 90 degrees can achieve some reduction in noise levels for sound coming from the direction parallel to the net. This is because a slightly lower sound pressure level is generated to the side of a paddle than from the front or the back of the paddle. The sound

level to the side of a paddle is 3 to 6 dB less than from the front of the paddle, but this is not a constant, due to the movement of players on the court.

Sound masking is the introduction of a second sound that will override or interfere with the bothersome sound. Common outdoor masking sounds include the sound from a fountain, waterfall, or ocean waves. Masking sound can also be artificially created with speakers to simulate any ambient sound. These masking sounds literally “swallow up” a lower-level offensive sound, but the offending sound is now replaced by a higher-level masking sound.

At private pickleball courts, the required use of **quieter paddles** can mitigate sound levels significantly (5-10 dB less); however, at public courts it is difficult to police restricted use policies.

Pickleball balls have different characteristics, with some being quieter than others. The differences in USA Pickleball Approved models are 1-4 dBA.

By agreeing to **limit play** to designated hours and days, noise complaints can be effectively managed and minimized.

VII. Fundamentals of Predicted Sound Levels

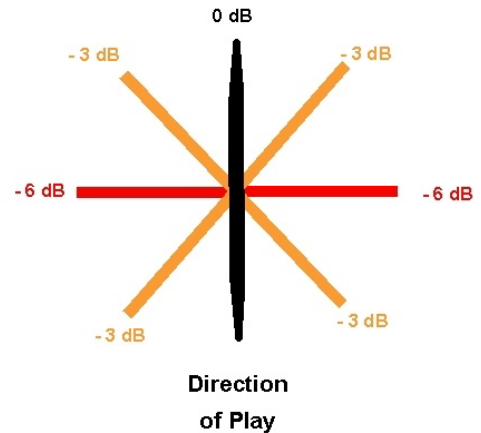
Combining NoiseTools software and Google Earth Pro satellite images, sound maps can be created showing the likely SPL (sound pressure level) at surrounding residential locations.

In the diagrams that follow, software has been used to estimate sound levels. Computer modeling requires a simplification of real-world conditions into basic components. For each simplification, there will be a degree of error added to the model. Modeling is only ever an estimate, and real-world measurements may differ.

In this report, attention has been given to the directional characteristics of propagation of sound from pickleball play. Actual measurements show that the sound propagating away from courts at angles is less than along the direction of play.

In general, the offset reduction in sound levels is:

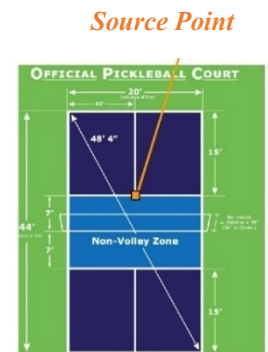
| | |
|---|----------------|
| $\pm 20^\circ$ angle from the axis of play | - 0 dBA offset |
| $20^\circ - 45^\circ$ angle from the axis of play | - 3 dBA offset |
| $45^\circ - 90^\circ$ angle from the axis of play | - 6 dBA offset |



The “source point” of pickleball sound (the loudest hit point) is typically referenced as the intersection of the service center line and non-volley zone (NVZ) line, 5 feet (1.5 m) above the court level.

Multiple source points (S1, S2, S3, etc.) are modeled to assess acceptable noise levels at the receivers.

The layout of the pickleball courts has been added to a satellite view in acoustical modeling software NoiseTools.net dB Maps. The red rectangles are approximately the size of the pickleball courts and within the rectangles are red crosses. These crosses are the selected sound source points 5 feet above the court surface. When one appears red (+), it is “off,” when black (+), it is “on.”

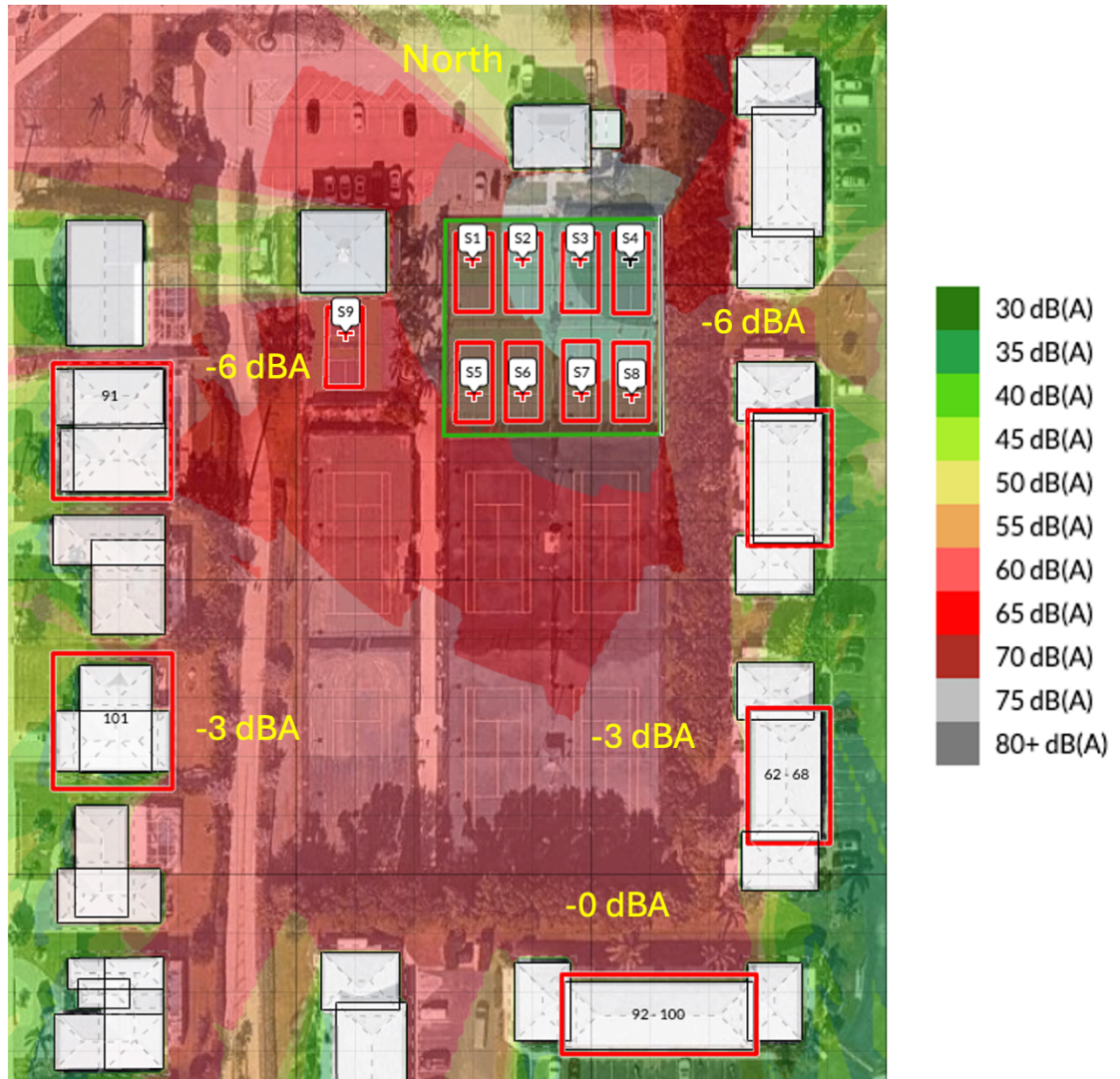


The impulse sound from a pickleball strike has been determined through measurements by PSM Consulting and others to be 108 dBA, with a correction factor for vegetation, 1200 Hz frequency, at the selected source point on the courts. In the following charts, when a sound source is activated, the white circles (receiver points) will display the modeled sound pressure level in dBA at each point. These are modeled estimates; actual measured values at these locations may differ.

VIII. Predicted Sound Levels

A. Current configuration

Sound Source = S4



-x dBA reflects the offset reduction applied for this area of the sound map

Figure 9: Noise Map, Current Configuration, S4

Summary

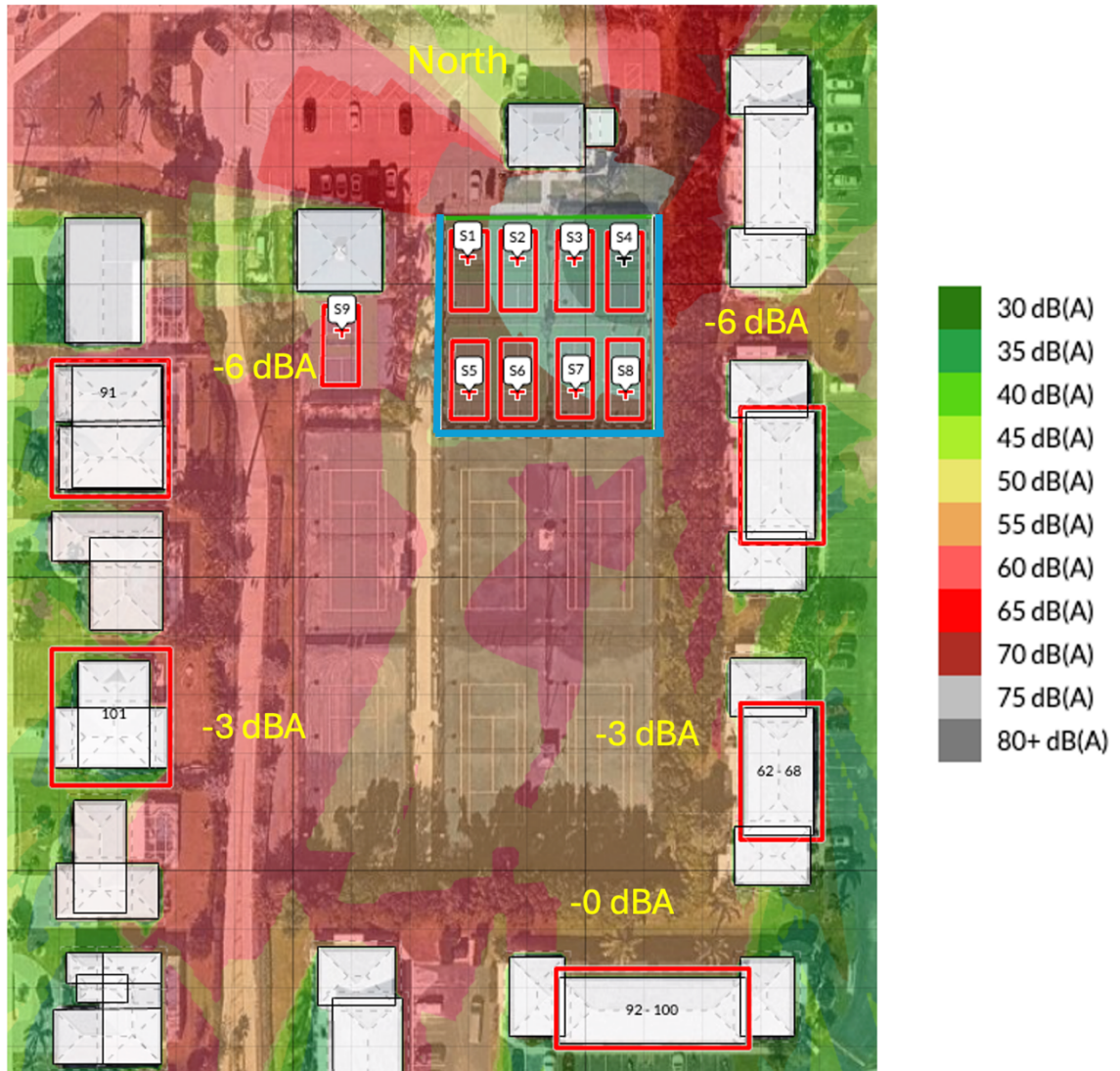
With only a 10-foot-high reflective barrier on the east, the predicted sound levels from S4 are:

- predicted sound levels are below the 68 dBA ordinance maximum at all properties
- above 60 dBA to the south receivers

B. Current configuration with 10-foot-high eNoise barriers on the east, south and west

Blue = 10-foot-high sound absorbing barriers on the east, south and west

Sound Source = S4



-x dBA reflects the offset reduction applied for this area of the sound map

Figure 10: Noise Map, 10-Foot-High Barriers to the East, West, South and between Courts

Summary

With 10-foot-high absorbing barriers to the east, west, south and reflecting barriers between courts, the predicted sound levels from S4 are:

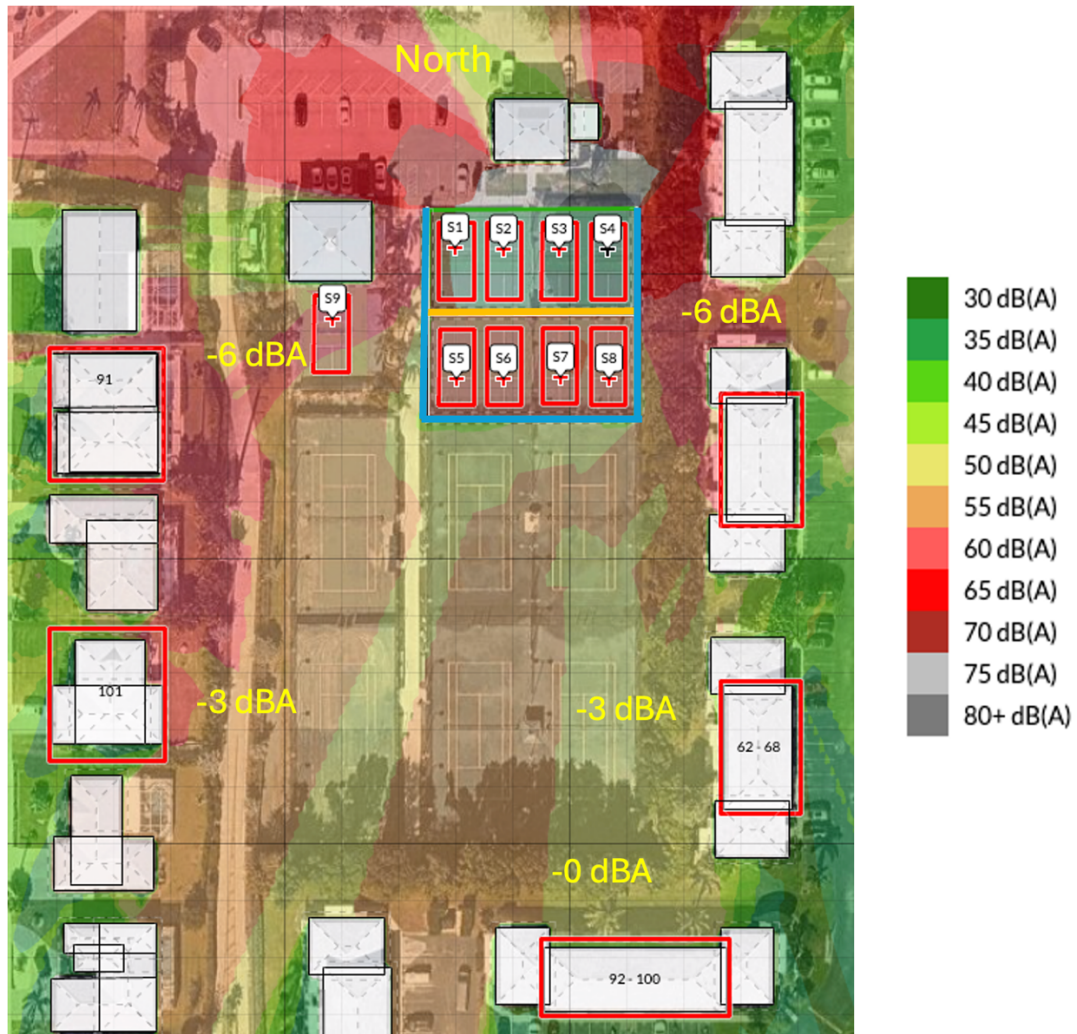
- predicted sound levels are below the 68 dBA ordinance maximum at all properties
- lower sound levels compared to current configuration

C. Expansion with 10-foot-high eNoise barriers to the east, west, south and clear barriers between courts

Blue = 10-foot-high sound absorbing barriers on the east, south and west

Orange = 10-foot-high clear sound reflecting barriers between courts

Sound Source = S4



-x dBA reflects the offset reduction applied for this area of the sound map

Figure 11: Noise Map, 10-Foot-High Barriers to the East, West, South and between Courts

Summary

With 10-foot-high absorbing barriers to the east, west, south and reflecting barriers between courts, the predicted sound levels from S4 are:

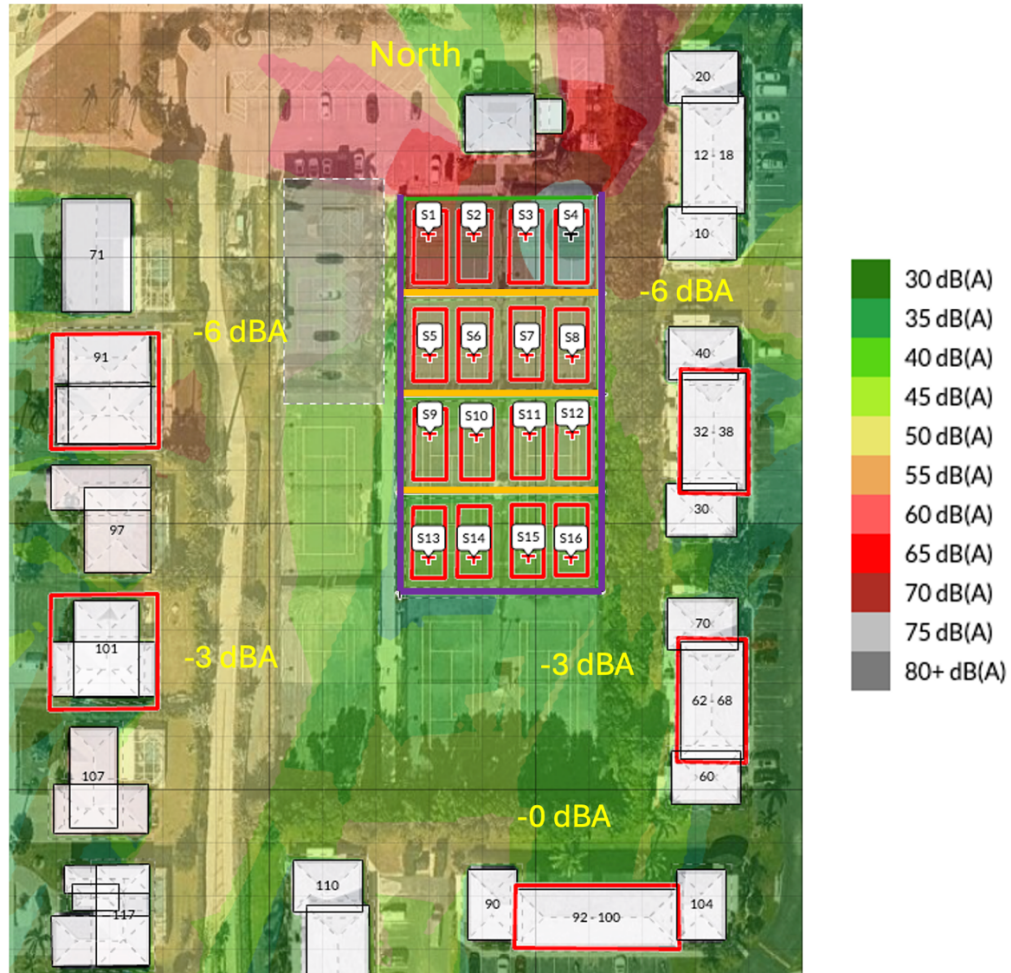
- predicted sound levels are below the 68 dBA ordinance maximum at all properties
- lower sound levels compared to current configuration

D. Expansion with 12-foot-high eNoise barriers to the east, west, south and clear 10-foot-high barriers between courts

Purple = 12-foot-high sound absorbing barriers

Orange = 10-foot-high sound reflecting barriers between courts

Sound Source = S4



-x dBA reflects the offset reduction applied for this area of the sound map

Figure 12: Noise Map, 12-Foot-High Barriers to the East, West, South and 10-Foot-High Barriers between Courts

Summary

With 12-foot-high barriers to the east, west and south and 10-foot-high barrier between courts, the predicted sound levels from S4 are:

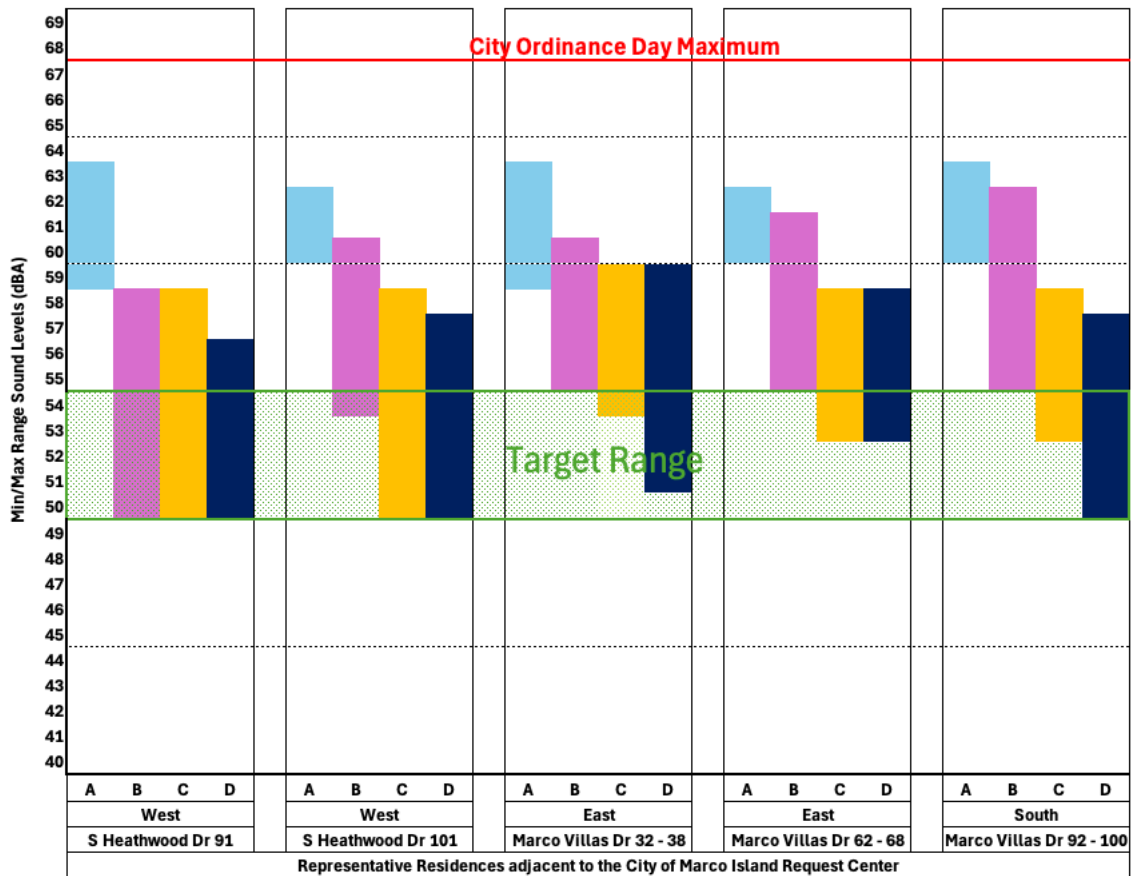
- predicted sound levels are below the 68 dBA ordinance maximum at all properties
- significantly lower sound levels compared to current configuration

IX. Conclusions

To compare the three modeled configurations across multiple source points, results are presented side by side for five representative residential receptors surrounding the pickleball courts. The following residences were selected for comparison:

| Residence | Geographic Direction |
|------------------------|----------------------|
| 91 S Heathwood Dr | West |
| 101 S Heathwood Dr | West |
| 32-38 Marco Villas Dr | East |
| 62-68 Marco Villas Dr | East |
| 92-100 Marco Villas Dr | South |

The graph below illustrates the minimum and maximum predicted sound levels for each residence, accounting for all 16 modeled sound sources.



- A Current Configuration
- B Current Configuration with 10-foot-high eNoise barriers to the east, west and south
- C Current Configuration with 10-foot-high eNoise barriers to the east, west, south and clear barriers between courts
- D 16 court expansion - 12-foot-high eNoise barriers to the east, west, south and 10-foot-high clear barriers between courts

Figure 13: Option Comparison for 5 Representative Properties

Findings

Compared to the current configuration, installing 10-foot-high sound barriers to the east, west and south does not reduce the maximum sound levels for residences in the south. Installing higher barriers reduces the maximum sound levels but significantly increases the cost.

An effective low-cost alternative is to install 10-foot-high eNoise sound absorbing barriers to the east, west, south, and clear barriers in the center. This configuration significantly reduces sound levels for all surrounding residences while remaining cost competitive. Although the four southern courts would be fully enclosed, the use of clear panels (i.e. Hushtec-USA® -- ClearPlay 360™ or Pickleglass™ by Pickletile™) for the center barrier can preserve sightlines from the pro shop and mitigate security concerns that would otherwise arise from using standard sound barriers. Pickleglass™ is more expensive to install but is hurricane proof and maintenance free.

Compared to the current configuration, the expansion option with 12-foot-high eNoise sound barriers to the east, west, south and clear barriers in the center yield lower predicted sound levels at neighboring residences.

The predicted levels may or may not result in residential complaints, since human response to sound is not uniform. Annoyance associated with noise exposure is a subjective perception that varies among individuals. PSM Consulting recommends a target range of 50–55 dBA (LAFmax), based on our experience and national guidelines.

A solid wall on the south side, replacing the center barriers, was also evaluated. Modeling indicated that an 18-foot wall would be required to achieve sound level reductions equivalent to the center barrier option. Given the impracticality of a structure of that height, this option was dismissed.

The center barrier option offers an additional advantage: it can be viewed as a modular extension of the sound mitigation system already modelled for the existing eight courts.

eNoise selected for this site achieves the recommended Noise Reduction Coefficient (NRC) of at least 0.65 at 100 Hz. The barrier must be installed continuously from ground level to the full specified height, with no gaps at the base or at panel joints. The fence construction should be designed by a Florida licensed Professional Engineer to have adequate structural capacity for the weight of the barrier material and to withstand horizontal shear wind stresses.

X. Author's Credentials

Joerg Duebel

Joerg holds dual Master of Science degrees in Chemical Engineering from the University of Karlsruhe and Business Management from Purdue University. Post graduate studies include coursework at Cornell University. His broad career experience as a researcher and production engineer includes activities associated with environmental studies, water conservation, optimization of complex manufacturing processes and computer modeling. His research contributions have resulted in multiple scientific publications.

Joerg participates annually in the 2-day 180-mile Pelotonia bicycle ride for cancer research at the Ohio State University Comprehensive Cancer Center – The James. He is a pickleball Certified Referee and a PPR Certified Pickleball Instructor, living part time in Naples, Florida and Columbus, Ohio.

XI. Disclaimer

The sound levels presented in this report are either measured values or estimates of expected levels. Actual sound levels will vary over time and are dependent on players and equipment. Pickleball sound is inherently probabilistic, characterized by averages, statistical variation, and sound level distributions; it does not have a single fixed value.

This report makes no guarantee regarding the performance of the sound mitigation methods described. Perception of acceptable sound levels is subjective and cannot be determined by measurement alone. Background sound levels are also probabilistic and will vary by location, measurement method, and time.

The acoustical analysis herein is provided to inform barrier selection and placement. Final design and safety performance, including horizontal wind loads, vertical gravity (weight) loading, impact, security/sightlines, drainage, and operational safety, shall be determined and certified by a licensed Professional Engineer (P.E.). PSM Consulting LLC assumes no responsibility or liability for these design or safety determinations.

XII. Appendix A – Sound Mitigation Barrier Supplier

1. **Putterman Athletics LLC – NoiseGuard™**
800-621-0146,
Contact: Randy Fuddy
<https://www.puttermanathletics.com/>

2. **Acoustiblock® – AcoustiFence™**
813-980-1400
Contact: Charles O’Meara
<https://acoustiblok.com/acoustiblok-soundproofing-product-lines/acoustifence-noise-reducing-fences/>

3. **eNoise Control – Model UNC-XT-1**
317-774-1900
Contact: Dan Hester

4. **Hushtec-USA® -- ClearPlay 360™ Transparent Sound Panels**
774-282-1111
Contact: George Cancelmo (george@endotocorp.com)
<https://hushtecusa.com/clearplay>

5. **Pickletile -- PICKLEGLASS™**
847-630-8401
Contact: Scott Miller, CEO (scott@pickletile.com)
www.pickletile.com