POLYSONICS
Acoustics & Technology Consulting

April 17, 2026

Grimm & Parker
11720 Beltsville Drive, Suite 600
Calverton, MD 20705
Attn: Kerry Porter-Hill

Project: Pickleball Noise Propagation for Woodward High School
Location: Montgomery County, MD
Report: #6340 – Update #1

Dear Ms. Porter-Hill,

Polysonics has made in situ measurements, developed a model for the radiated sound of a pickleball game and evaluated various pickleball game play scenarios for the Woodward High School site in Montgomery County, MD.

Our analysis also included a thorough literature review to ensure that we were utilizing the latest collective knowledge pertaining to the challenges of Pickleball acoustics.

Polysonics recommends that administrative controls be implemented and, if challenges persist, that a barrier along the fencing around the tennis courts be installed to mitigate the sound radiated from the Pickleball games to the nearby residences.

Please let us know if you have any further questions.

Sincerely,
Polysonics

Rob Miller
Principal, Acoustics

Morteza Karimi
Acoustical Consultant

Stephen P. Rittmueller
Chief Scientist, Acoustics

Abbie Granahan
Acoustical Consultant

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NOISE PROPAGATION MODEL: PICKLEBALL AT WOODWARD HS MONTGOMERY COUNTY, MD

REPORT #6340 – UPDATE #1

PREPARED FOR: GRIMM & PARKER

APRIL 17, 2026

EXECUTIVE SUMMARY

Polysonics was asked to perform an acoustical analysis of the impact of using tennis courts as Pickleball (PB) courts at Charles W. Woodward High School, 11211 Old Georgetown Rd, Rockville, MD 20852 (the site). Polysonics understands that there have been some complaints from nearby residences given the PB play that is currently happening at the site.

Polysonics has conducted extensive research into the subject of PB noise and has determined that there is no consensus on how to quantify PB noise nor what limits should apply to PB noise. With no objective toolkit to formally quantify PB noise, for this report Polysonics has implemented an evaluation paradigm of "expected and/or increased complaints" in the spirit of the "Noise Disturbance" section of the local municipal noise code.

Pickleball is known to be acoustically challenging for a number of reasons. Polysonics has developed an acoustic model of the site and has evaluated many different configurations in order to develop an understanding of the ramifications of allowing PB play on the tennis courts on the Woodward High School Campus. Polysonics concludes that it is expected to be possible to maintain PB play on the site by first implementing administrative controls.

The primary administrative control that Polysonics understands will be implemented is that no outside (non-student) PB play will be allowed on these tennis courts. This will eliminate the possibility of more experienced players playing PB on these courts; this analysis has shown that expert players produce significantly more sound than student players.

The secondary administrative control that will be implemented is to limit the number of PB games allowed per tennis court. Up to four PB games will fit on a tennis court and the school will be limiting this to two games per court.

If these administrative controls deemed insufficient, then an acoustic barrier can be added to the fencing around the PB courts. The barrier Polysonics evaluated is of the wrap type which affixes directly to the fencing already around the tennis courts. A reasonable example of this barrier is this:

> https://www.fencescreen.com/Sports-and-Events/Facilities/Pickleball-Privacy-Sound-Solutions/Pickleball-Courts-Acoustic-Wraps.aspx

OVERVIEW OF RESIDENTIAL NOISE CODE

The municipal code for Montgomery County, MD, can be found here:

> https://codelibrary.amlegal.com/codes/montgomerycounty/latest/montgomeryco_md/0-0-0-138850

The code itself is typical of many municipal noise codes with pathways to waivers for some situations and prohibition for others (e.g., leaf blowers). The code provides good details as to what constitutes "tonal" noise and what constitutes "impulsive" noise as both of these types of noise are known to be more annoying than steady state noise. The literature review indicates that PB noise is technically neither tonal nor impulsive, but that it is very close on both accounts. Polysonics is proceeding with the understanding that PB noise is neither tonal nor impulsive per the requirements of this AHJ.

Unfortunately, the municipal code does not prescribe a length of time over which a sound level measurement shall be made. Guidance provided by Montgomery County simply states:

> "Measurements are taken at the property line of the alleged violator as to determine the maximum A-weighted (dBA) sound level..."

This is important for PB noise because the hits are of short duration which means rather high levels of sound energy are packed into comparatively short periods of time which result in spikes of sound pressure. These spikes, if averaged over, say, 35 ms (0.035 sec), can have quite high levels, sometimes exceeding 90 dBA even for an average player; if averaged over one second, this spike gets "drowned out" by the background sound and the sound level as averaged over 1 second can be more than 20 dB lower than a sound level averaged over 35 ms. This averaging time is called a "time constant" and a one-second time constant for noise measurements related to municipal code is typical and almost always reasonable; however, a 1 second time constant is not suitable for quantifying PB noise and the noise code of this jurisdiction provides no guidance as to what time constant should be used, even for general situations.

Please see Table 1 for the maximum allowed sound levels at the property line. Polysonics has kept these levels in mind during this analysis, but Polysonics feels that the more applicable parts of the Noise Ordinance pertain to the concept of "Noise Disturbance":

From §31B-2:

> *Noise disturbance* means any noise that is:
> (1) unpleasant, annoying, offensive, loud, or obnoxious;
> (2) unusual for the time of day or location where it is produced or heard; or
> (3) detrimental to the health, comfort, or safety of any individual or to the reasonable enjoyment of property or the lawful conduct of business because of the loudness, duration, or character of the noise.

From §31B-5:

> (b) *Noise disturbance.* A person must not cause or permit noise that creates a noise disturbance.

Table 1: Maximum Noise Levels At Property Line, From §31B-5 of Noise Ordinance

Maximum Allowable Noise Levels (dBA) for Receiving Noise Areas		
	Daytime	***Nighttime***
Non-residential noise area	67	62
Residential noise area	65	55

OVERVIEW OF PICKLEBALL ACOUSTICS

Pickleball was created in 1965 on Bainbridge Island in Washington State and has recently experienced an explosion in popularity. One of the most significant issues associated with PB is that the hit between the paddle and the ball is quite loud. A number of preliminary acoustical investigations and analyses have been performed; however, there is no agreed definition for many important acoustic characteristics of the PB game. This even includes which acoustic metrics one might use to quantify PB sound. Polysonics has conducted an extensive review of the published literature on this topic which has informed this analysis.

Relative to tennis, PB is significantly louder. One estimate of the radiated sound power for a PB hit puts it at 10 dB higher than the radiated sound power for a tennis hit. Sound power is generally abbreviated as "L_W" and is quantified in dB re 1 pW. Another estimate of the radiated sound pressure of a PB game has it 20 dB louder than tennis, which is perceived to be about 4x as loud. Sound Pressure is generally abbreviated "L_{EQ}" and is quantified in dB re 20 μPa. Deeper analysis has shown that the nature of the sound of the PB hit is almost – but not quite in a formal sense – tonal in nature at roughly 1200 Hz which is about where human hearing is most sensitive. This frequency is known to trigger a visceral response in humans, perhaps not coincidentally because it is very close to the average frequency of crying babies. In addition to being loud and random during gameplay, the PB sound could actually be inducing subconscious stress similar to being around a crying baby. Noise complaints about PB abound, including many where once open and busy PB sites have been completely shuttered.

Another intriguing aspect of PB acoustics is that the hit itself seems to have a large directional component to it: the sound seen along the axis perpendicular to the paddle face has been measured as much as 20 dB higher than the sound seen along the axis parallel to the paddle face. In practice, this means that the orientation of a PB court can impact the amplitude of the radiated sound. Understandably, hits during active gameplay are not always perfectly aligned with the court; using data measured for this project, Polysonics has observed that an 8 dB off-axis directivity factor for actual PB gameplay is consistent with the measured data.

Fundamental research into the PB hit itself (in a controlled environment) indicates that the peak sound power from a single hit by an experienced player is roughly 102.5 dB. Less experienced players are not capable of producing sufficient paddle/ball velocity to produce these sound power levels. Using data taken for this project, Polysonics estimates that caliber of players that were playing PB when measurements were made – presumed to be either beginning or average players – produce PB hits with peak sound power on the order of 88.5 dB.

Municipal noise ordinances and the acoustics community in general have not yet "solved" many of the issues surrounding PB noise, from applicable measurement techniques to meaningful noise limits using such techniques. With no objective toolkit to formally quantify PB noise, for this report Polysonics has implemented an analysis paradigm of "expected and/or increased complaints" in the spirit of the "Noise Disturbance" section of the municipal code. Polysonics understands that there have been complaints from neighbors regarding the PB play that is currently happening at the site.

THE PROJECT SITE AND THE MEASURED DATA

An overview of the site including measurement and analysis points is shown in Figure 3 in the appendix below. The measurement points (M1-M5) were chosen to capture the PB noise from the tennis courts as effectively as possible and the analysis points (H1-H9) were chosen to represent the likely outdoor recreation areas of nearby residences (i.e., back yards or porches). Please see Figure 4 for pictures of the sound level meters made during the measurements, Figure 5 for a view of the tennis courts from Old Georgetown Road and Figure 6 for a view of Cedarwood Drive which is immediately adjacent to the site, just south of the tennis courts.

Measurements were coordinated such that active PB play was to be taking place during the measurements and the measurements lasted roughly 10 minutes at each of the indicated measurement points. Sound level meters cannot differentiate between different sound sources on their own. Unfortunately, the measurement at location M1 included school busses active nearby during the measurement, which masks the PB noise; the measurement at location M2 captured only 5 minutes of PB play and was also impacted by a UPS truck during the second half of the measurement. Therefore, the data from the M1 and M2 measurement locations were not used in this analysis and are not presented in this report.

Please see Figures 7 - 12 for plots of the measured data for measurement locations M3, M4 and M5. With data logged at 100 ms intervals and the running $L_{EQ(1\text{-}SEC)}$ also shown on the L_{EQ} vs. time graphs, one can observe the impact that a longer time constant has on sound level: high peaks are "smoothed out" into the general trend of the measured sound.

DEVELOPING THE PICKLEBALL MODEL

The first challenge of a PB acoustic analysis is selecting which metric to use to evaluate the sound from a PB game. The literature review Polysonics performed yielded several candidates; however, there is no consensus among acoustics professionals about which metric to use. After several rounds of iterative analyses Polysonics has determined that the statistical sound level "L1%" is the most reasonable metric to use for this analysis. "L1%", also abbreviated L1, is a "Statistical Noise Level" and is simply the level for a given dataset that is exceeded by 1% of the data points within that given dataset.

> *Technical aside: the L1 metric is not often used in environmental acoustical analyses. The L10 level, or the sound level exceeded by 10% of the measured data, gets far more use when evaluating environmental data such as this. We have utilized the L1 metric here because of the relatively low sound level seen for PB hits by the caliber of players being observed and we wanted to ensure that we were evaluating sound levels from PB and not from other sources. Our analysis has determined that the L1 metric is more suitable for this specific analysis than the L10 metric, especially in the context of a "noise disturbance" as opposed to a hard sound level limit at the property line.*

An acoustic model is considered to be calibrated if it is within 3 dB of the measured data. Polysonics started with settings suggested in the literature for sound power and directivity and iterated until our configuration came within 3 dB of the measured data. The model of the PB hit that best matched our measured data had a sound power level of 88.5 dB and an off-axis (90°) directivity setting of 8 dB (using a standard cosine gradient).

In addition to the PB sound sources, Polysonics decided to include a sound source for the traffic on Old Georgetown Road in its model. This was done for 2 reasons: the modeled results at the M5 location – the meter closest to the road – needed the addition of the traffic noise to match the measured results (because the measured PB noise was rather low in amplitude at this location) as well as to provide a reference for the soundscape surrounding the courts without the PB noise.

Technical aside: since the modeled traffic source simulates steady-state sound levels and the PB hit sound source is based on the L1, statistical metric representing peak sound levels which are transient, summing these different level types together is technically not proper in a strict quantitative sense. This "mixing of metrics" is perfectly valid in a subjective sense, especially with no formal quantitative metrics available for this situation. With an appropriate baseline, this analysis helps to inform us how readily PB sound will be heard over the ambient traffic noise. Discussed more below, the baseline for this evaluation is "Configuration 0" with traffic noise but no PB noise.

Please see Table 2 for the results of this calibration; if a model is within 3 dB of the measured data, it is considered to be calibrated.

Table 2: Calibration of SoundPLAN Pickleball Model.

Meter	Active Courts	PB Hit Sound Power (dB re 1pW)	PB Hit Directivity Setting (Delta 0° to 90°, dB)	Measured L1 Sound Level (dBA)	Modeled Sound Level (dBA)	Delta (dB)
M3	BCE	88.5	8	63.1	65.9	-2.8
M4	BC	88.5	8	61.6	63.6	-2.0
M5	BC	88.5	8	64.0	61.7	2.3

Polysonics did not make measurements capable of calibrating a Traffic Noise Model for this project. The traffic settings used in this model came from the MDDOT database and are seen in Table 3 in the appendix, below. In Polysonics' experience, the traffic count data from the MDDOT has been very consistent in its close agreement with measured data on a large number of projects over the previous several years. Polysonics considers using this MDDOT data without a formal calibration to be very low risk.

USING THE PICKLEBALL MODEL

Polysonics has evaluated multiple configurations in order to develop an understanding of the ramifications of having PB courts on the Woodward High School Campus.

Please see Table 4 in the appendix for a description of the various configurations that Polysonics has evaluated. Please see Table 5 for the modeled sound levels for the various nearby residences (no mitigation). To remind, locations H1-H4 are on the opposite side of Old Georgetown Road while locations H5-H9 are in the neighborhood circa Cedarwood Drive, immediately adjacent to the site. The colors applied to the table are for visual comparison only.

Table 5: Modeled Results at Analysis Points for Various Configurations (No Barrier)

Receiver Name	Config. 0 Sound Level (dB)	Config. 1 Sound Level (dB)	Config. 2 Sound Level (dB)	Config. 3 Sound Level (dB)	Config. 4 Sound Level (dB)	Config. 5 Sound Level (dB)	Config. 6 Sound Level (dB)	Config. 7 Sound Level (dB)	Config. 10 Sound Level (dB)	Config. 11 Sound Level (dB)	Config. 12 Sound Level (dB)
H1	62.2	62.4	62.4	62.6	63.0	62.9	62.3	65.3	65.1	62.5	64.0
H2	61.9	62.2	62.2	62.7	63.4	63.4	62.0	66.9	66.7	62.4	65.0
H3	61.4	61.7	61.7	62.3	63.1	63.1	61.4	66.8	66.7	61.8	64.9
H4	60.7	61.0	61.0	61.5	62.2	62.2	60.8	65.6	65.5	61.1	63.8
H5	44.9	60.1	59.8	61.3	64.5	63.3	58.5	71.4	70.3	65.3	68.2
H6	50.7	59.3	58.8	61.0	63.8	61.6	60.2	70.6	68.3	66.8	67.6
H7	47	61.2	60.2	61.7	64.4	58.7	63.1	71.3	65.4	70.0	68.5
H8	45.1	62.7	61.4	63.3	66.3	61.5	64.6	73.3	68.4	71.5	70.2
H9	45.3	60.2	58.1	62.8	65.9	64.1	61.3	72.9	71.1	68.2	69.7

EVALUATION OF MODEL: OBSERVED CONDITIONS

Polysonics has incorporated 3 of the 5 measurements that were made while active PB play was ongoing into this analysis: one while active play was taking place on courts B, C and E and two while active play was taking place on courts B and C; these are modeled as configurations 1 and 2. These configurations put a single game on the courts as indicated and utilize the PB hit sound power setting for "beginner" players: 88.5 dB. Please see Figures 13 and 14 for site noise contour plots for these two configurations.

For configurations 1 and 2, locations H1-H4 experience virtually no increase in sound level when the simulated PB sound sources are included with the simulated traffic sound source. Listeners at locations H1-H4 will not hear PB noise over the traffic noise, except perhaps when there are long lulls in the traffic.

> *Technical Aside: It is important to understand that the simulated sound power settings for the PB hit assume a continuous sound source and not a transient sound as the PB hit actually is; therefore, these simulations assume that each hit on each court happens simultaneously which will almost never happen. One can understand the given sound levels (except for configuration 0) to be the* ***absolute loudest*** *the peak sound level observed can ever be due to PB and traffic, i.e., a true worst-case scenario.*

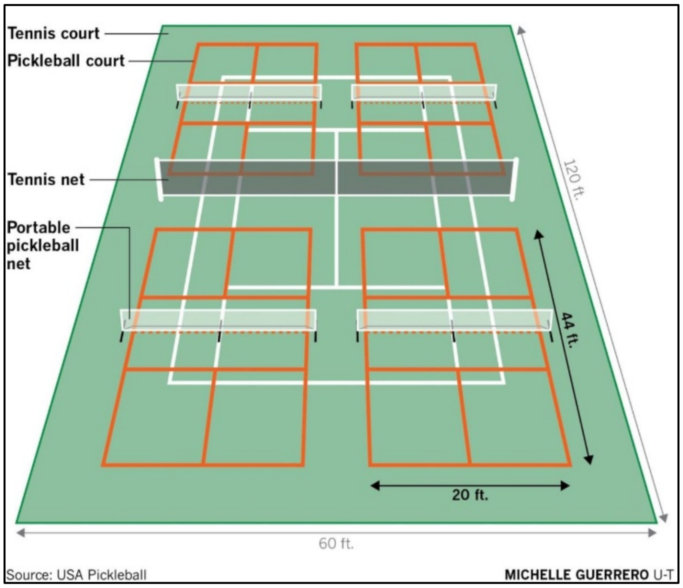
For configurations 1 and 2, locations H5-H9 will be able to hear the PB games over the ambient traffic noise with the simulated PB hits seen to be 10-15 dB above the ambient sound level. Still, the highest modeled sound level for these configurations, the 62.7 dB at H8 for configuration 1, is not very high. To put things in perspective, normal human conversation exists at about 65 dB. At locations H5-H9, a listener would be able to hear the "beginner" PB hits but they will be at the same or lower sound level as normal human conversation. Polysonics understands that complaints for these two configurations have already happened. This is most likely because of the random nature of the hits in a PB game coupled with the potentially "stressful" nature of the frequency content of the PB hit, even at these relatively low sound levels.

The modeled sound levels would not trigger any formal noise code violations under any reasonable time constant and complaints were still received. *This* is the inherent acoustic challenge with PB noise: complaints start at sound levels far lower than most other sources of noise. While eliminating all complaints is the ultimate goal of any acoustic remediation that may be recommended, Polysonics is using the few complaints received for these "beginner" use cases as a baseline for evaluating other configurations.

EVALUATION OF MODEL: OTHER CONDITIONS, MORE COURTS & GAMES PER COURT

One reason why PB has recently become popular is that four PB courts can fit within a single tennis court, increasing resource usage efficiency. Please see Figure 1 showing the relative size of these courts and a common configuration of 4 PB courts on one tennis court. Polysonics understands that there will be no more than 2 PB courts per tennis court on this site, with one on each side of the tennis net in the same orientation as shown.

Figure 1: Tennis and Pickleball Court Sizes



At the time when Polysonics made the PB measurements at Woodward HS, single active PB games were observed on two and three of the five available courts. To evaluate more simultaneous games, Polysonics created configurations 3 and 4 with a single PB game on each of the five courts and two PB games per court, respectively. The skill level for these simulations was kept at beginner. Please see Figures 15 and 16 for the noise contour plots for these two configurations.

Not surprisingly, having a higher number of simultaneous PB games causes an increase in the sound levels at the various measurement points, as Table 5 shows. For positions H1-H4, the level increases as compared to configuration 0 are still less than 2 dB. Subjectively, this is not significant and we would expect no increase in complaints from locations H1-H4 if all 5 courts were active with beginner games, with either one or two PB games per tennis court.

Comparing configuration 3 to configuration 2, we see an increase of ~2 dB for locations H5-H8 with the modeled levels still coming in below 65 dB; the 4.7 dB increase for H9 is caused by the fact that this is the first simulation with a game on Court D which is closest to H9. A change in sound level of 2 dB is not significant so we expect that the level of complaints for configuration 3 to be the same as for configuration 2.

Comparing configuration 4 to configuration 2, however, we see an increase of ~5 dB for locations H5-H8 with the modeled levels coming in at or a bit above 65 dB. Subjectively, with all 5 courts active with 2 beginner games, the PB games will be more clearly heard at positions H5-H9. The peak sound levels modeled for configuration 4 will still be at roughly the same level as a normal conversation but there will be more hits heard because there will be more active games taking place simultaneously.

For positions H5-H9, at the locations along Cedarwood Drive, with an increase in sound level of ~2 dB, having a single beginner game active on all five courts would not be expected to increase complaints. With configuration 4 increasing this to 2 games per court, however, the sound levels at positions H5-H9 increase by ~5 dB as compared to configuration 2. Polysonics would expect configuration 3 to have no increase in complaints while we would expect a small increase in complaints for configuration 4.

EVALUATION OF MODEL: OTHER CONDITIONS, DIRECTIONAL CONSIDERATIONS

The literature review indicated that the sound radiated from a PB hit is much more directional than the sound radiated from a tennis hit. Some studies indicated that the hit itself has a 20 dB difference between on- and off-axis directions; obviously, not all hits in a PB game are perfectly aligned with the court so this 20 dB difference will be reduced in practice. Polysonics has iteratively determined that a difference between on-axis sound and off axis sound of 8 dB is consistent with the data measured for this project. There is no consensus among the acoustics community as to the proper value for this directivity but this 8 dB delta is supported by this project's measured data and is reasonable based on other documented investigations. Please see Figure 2 for a representation of this directivity characteristic as modeled.

Figure 2: Pickleball Game Sound Directivity

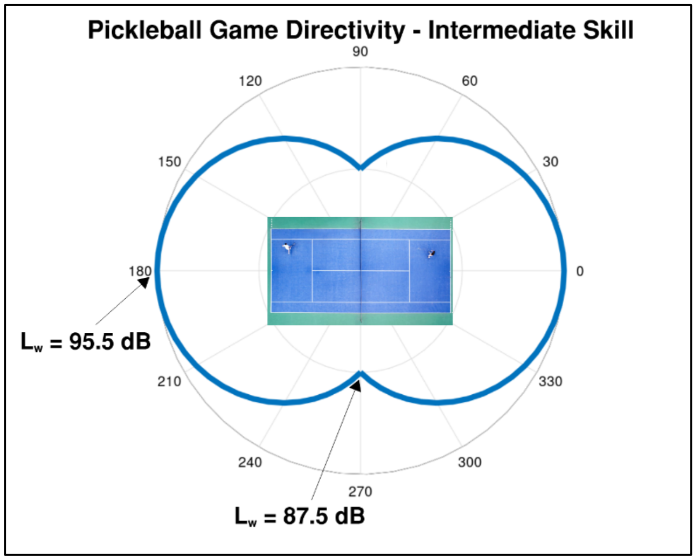


Figure 2 shows the directivity pattern used for a nominal PB game indicating that the sound radiated along the long axis of the court (baseline to baseline) is 8 dB louder than the sound radiated along the axis of the net (side to side). The scale factor used as a function of angle was a standard cosine. The sound power (L_W) settings for the intermediate skill level are shown.

Please see Figure 17 for the noise contours with 2 beginner games per court on courts where the loud axis points to Old Georgetown Road, configuration 5; please see Figure 18 for the noise contours with 2 beginner games per court where the loud axis points to Cedarwood Drive, configuration 6.

Table 5 shows that, for measurement points H1-H4 across the street, there is still very little change in sound level when comparing either configuration 5 or configuration 6 to the baseline configuration 0. This adds further support to the earlier conclusion that at beginner sound power levels the PB games will be difficult to hear on the other side of Old Georgetown Road over the ambient traffic noise.

These two configurations were investigated in the hope that we could take advantage of the directivity inherent to PB by directing most of the sound in a direction where less sensitive neighbors existed, i.e., we hoped that configuration 5 would be better for locations H5-H9 than configuration 6. This has indeed turned out to be true, but to such a small degree as to be insignificant. Any advantage gained by configuration 5 at point H7 is almost completely offset by the results seen at points H5 and H9.

While perhaps unexpected, this directivity characteristic for PB is real and could be used to inform potential administrative controls on PB court use; however, it is not the "miracle cure" it was hoped it could have been, at least not for this site.

EVALUATION OF MODEL: INTERMEDIATE SKILL WITH 2 GAMES PER COURT

Configurations 1 – 6 were configured using what we've been calling "beginner" PB players. In practice, this means we used the sound power setting we determined to match the measured data or 88.5 dB. The literature review showed that a reasonable estimate of the sound power of the PB hit is 102.5 dB. We consider this the sound power level of "expert" players. For our definition of "intermediate" players, we split the difference and set the sound power level at 95.5 dB.

Per discussions with the client, since PB is not to be played by the general public on these courts, expert players are not expected to utilize these courts; therefore, the highest skill level included in this report is "intermediate". The 8 dB directivity factor has been maintained for the intermediate skill level. Polysonics understands that Configuration 7 represents the loudest configuration expected to exist during PB play at the site: 2 PB games per tennis court with the highest skill level allowed to utilize the courts.

Configuration 7 has two active PB games per court and sets the skill level for all games to "intermediate". Please see Figure 19 for the noise contour plot for configuration 7. This is the first time that we have seen any significant increase in the sound levels observed at locations H1-H4 with levels ~5 dB above the baseline configuration 0. These peak levels are still in the range of normal conversation so are not "loud"; however, given that these levels are several dB above ambient, we can expect that these locations on the other side of Old Georgetown Road would be able to hear the PB games clearly under configuration 7 potentially causing complaints to increase from these locations.

The modeled levels at locations H5-H9 for configuration 7, however, have gone over 70 dB. To put things in perspective, 70 dB is about the sound level of a standard vacuum cleaner as heard by its operator. At these levels, the sound from repetitive hits from the multiple PB games will start to interfere with normal speech and we can be quite confident that an increase in complaints as compared to the baseline active PB conditions of configurations 1 and 2 would happen.

EVALUATION OF MODEL: INVESTIGATING ADMINISTRATIVE CONTROLS

With the goal of investigating potential long-term solutions in lieu of installing a barrier, Polysonics investigated additional administrative controls on PB games that the school could implement. Polysonics investigated three configurations that we feel represent reasonable administrative limits on the use of the tennis courts for PB games. Over time, Polysonics thinks it safe to assume that the student PB players on this site will achieve "intermediate" but not "expert" status and we further think it reasonable to consider a policy to limit the number of active PB games per tennis court.

Configuration 10 has two PB games per court on Courts A, B and D while configuration 11 has two PB games per court on Courts C and E. Configuration 12 has one PB game per court on all 5 Courts. The skill level for all of these simulated games was maintained as "intermediate". Please see Figures 20 - 22 for the noise contours for these configurations.

For locations H5-H9, configurations 10 and 11 are seen to behave similarly to configurations 5 and 6: the hoped for directional advantage exists but only to a small degree. The levels seen are ~8 dB higher than for the baseline PB configurations 1 and 2 so we would expect more complaints than currently received from these locations for these conditions.

For locations H1-H4, configuration 11 results in levels only a few tenths of a dB above traffic levels so no additional complaints would be expected. For configuration 10, the levels, while still not loud, do exceed traffic by 3-5 dB so we would expect more complaints from these locations in this configuration.

Configuration 12, with a single intermediate PB game on each of the five courts, was hoped to result in sound levels that would not increase complaints. Unfortunately, with levels at locations H1-H4 ~3dB above the ambient and levels at locations H5-H9 ~8 dB above the levels seen for configurations 1 and 2, we expect that this configuration would increase complaints as compared to the baseline active PB of configurations 1 and 2.

BRIEF DISCUSSION OF ACOUSTIC BARRIERS

Acoustic barriers utilize two primary mechanisms to attenuate sound: distance (spherical spreading) and physical barriers (transmission loss).

Considering attenuation by distance, the sound energy of a given source is finite, moving away from that source distributes that finite energy over larger and larger areas (i.e., the surface of a sphere with increasing radius), the physical consequence of this is quieter sound. Mathematically, this works out to be a 6 dB reduction in sound pressure level for each doubling of distance from a sound source. If the sound level 10’ from a sound source is 60 dB, the sound level 20’ from the source will be 54 dB and the level 40’ from the source will be 48 dB.

Considering sound attenuation by transmission loss, such as what happens with actual walls, either interior or exterior, sound energy in the air induces vibrations in the wall that get re-radiated on the other side of the wall with some loss of energy based on the nature of the wall. This is true whether the wall is a true deck to deck partition as inside a house or an outdoor barrier with finite height and air above.

The practice of constructing outdoor sound barriers brings both of these mechanisms together. To have any impact, a sound barrier must be sufficiently “beefy” – have a solid structure that can provide ~25 dB of attenuation (not difficult to achieve) – and must break the line of sight between source and receiver. Once these two things happen, sound attenuation as a function of distance comes into play with the top of the barrier effectively re-radiating the sound from one side to the other. The taller an outdoor sound barrier is, the greater the effective distance between source and receiver and the barrier is more effective. In practice, the highest level of sound attenuation outdoor acoustic barriers achieve is ~10 dB, though certain aspects of a specific site can conspire to reduce this. This is discussed further below, but as an example, the maximum attenuation in PB noise expected by a barrier on this site is 7.2 dB (Configuration 14, Location H8) with the average attenuation seen for all configurations and sites H5-H9 being 5.0 dB.

EVALUATION OF MODEL: ADDING A NOISE BARRIER

Polysonics has modeled a barrier within SoundPLAN. This modeled barrier was placed directly on the terrain and set to 12' high. Because we are evaluating locations that are not on the site, the terrain used in our model was obtained from Google Earth. Polysonics envisions a barrier similar to this being implemented:

https://25.fencescreen.com/Sports-and-Events/Facilities/Pickleball-Privacy-Sound-Solutions/Pickleball-Courts-Acoustic-Wraps.aspx

Polysonics set the height of the barrier to 12' to account for the ~2' stone wall at the base of the chain-link fence around the tennis courts. Please see Figures 23 and 24 for graphical representations of this barrier. Polysonics understands that this modeled barrier does not perfectly represent the fences currently surrounding the tennis courts; however, we are confident that the modeled performance of this barrier will be sufficiently close to the actual performance that would be achieved by implementing an acoustic wrap type of product to allow us to make accurate conclusions. Polysonics understands that a barrier of the type suggested has been priced out at ~$120k for this site.

Please see Table 6 and Figures 25-34 for the modeled results with this 12' barrier. With the tabular data taken at the same locations as previously discussed without the barrier, the basis of evaluation for this barrier will primarily be a comparison of the results for the 12' barrier shown in Table 6 with the results for no barrier shown in Table 5, as summarized in Table 7.

Table 6: Modeled Results at Analysis Points for Various Configurations (12' Barrier)

Receiver Name	Config. 0 Sound Level (dB)	Config. 13 Sound Level (dB)	Config. 14 Sound Level (dB)	Config. 15 Sound Level (dB)	Config. 16 Sound Level (dB)	Config. 17 Sound Level (dB)	Config. 18 Sound Level (dB)	Config. 19 Sound Level (dB)	Config. 22 Sound Level (dB)	Config. 23 Sound Level (dB)	Config. 24 Sound Level (dB)
H1	62.2	62.5	62.5	62.7	63.0	62.9	62.3	65.3	65.0	62.7	64.4
H2	61.9	62.2	62.2	62.3	62.8	62.7	62.0	65.4	65.0	62.6	64.0
H3	61.4	61.5	61.5	61.7	61.9	61.8	61.5	63.3	63.2	61.6	62.6
H4	60.7	60.7	60.7	60.8	61.0	61.0	60.7	62.4	62.3	60.8	61.6
H5	44.9	54.6	54.3	55.6	58.6	56.5	54.9	65.5	63.3	61.5	62.3
H6	50.7	56.3	55.7	56.9	58.9	56.7	56.4	65.4	62.7	62.3	63.0
H7	47	57.3	56.3	57.8	60.3	54.4	59.3	67.1	60.6	66.1	64.4
H8	45.1	56.3	54.2	57.0	60.3	54.9	58.9	67.2	61.6	65.8	63.9
H9	45.3	56.5	54.4	58.1	61.1	58.3	58.0	68.0	65.2	64.9	65.0

Table 7: Barrier Effectiveness: SPL Delta Between Configurations With Barrier and Without Barrier

Receiver Name	Delta Config. 13 to Config. 1 (dB)	Delta Config. 14 to Config. 2 (dB)	Delta Config. 15 to Config. 3 (dB)	Delta Config. 16 to Config. 4 (dB)	Delta Config. 17 to Config. 5 (dB)	Delta Config. 18 to Config. 6 (dB)	Delta Config. 19 to Config. 7 (dB)	Delta Config. 22 to Config. 10 (dB)	Delta Config. 23 to Config. 11 (dB)	Delta Config. 24 to Config. 12 (dB)
H1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	-0.2	-0.4
H2	0.0	0.0	0.4	0.6	0.7	0.0	1.5	1.7	-0.2	1.0
H3	0.2	0.2	0.6	1.2	1.3	-0.1	3.5	3.5	0.2	2.3
H4	0.3	0.3	0.7	1.2	1.2	0.1	3.2	3.2	0.3	2.2
H5	5.5	5.5	5.7	5.9	6.8	3.6	5.9	7.0	3.8	5.9
H6	3.0	3.1	4.1	4.9	4.9	3.8	5.2	5.6	4.5	4.6
H7	3.9	3.9	3.9	4.1	4.3	3.8	4.2	4.8	3.9	4.1
H8	6.4	7.2	6.3	6.0	6.6	5.7	6.1	6.8	5.7	6.3
H9	3.7	3.7	4.7	4.8	5.8	3.3	4.9	5.9	3.3	4.7

Not surprisingly, the barrier was not seen to be all that effective at mitigating sound at locations H1-H4; it was never really intended to improve things across the street. For configurations 19 and 22 the barrier provides up to ~3 dB of attenuation but otherwise the improvements are negligible and are below the human ability to discern a difference.

Jumping straight to the loudest evaluated configurations, 7 and 19, we see that the barrier is predicted to provide ~5 dB of attenuation across locations H5-H9 but that these levels will still be ~6 dB above the baseline PB levels seen at these locations for configurations 1 and 2. Therefore, even with a barrier, an increase in complaints relative to the PB baseline for configuration 19 would be expected.

A primary reason a barrier is not as effective on this site as one would have hoped is the terrain. Figures 25 and 26 show that the land immediately adjacent to the tennis courts is actually a number of feet above the tennis courts. Figures 4 and 5 show this to a lesser extent. The acoustical consequences of this terrain can be seen in Figure 30: immediately adjacent to the fence we see sound levels in the range of 55 – 60 dB and away from the fence we see a rather wide swath of levels in the range of 60 – 65 dB. This counterintuitive result is caused by the higher elevation of the terrain to the south of the tennis courts.

EVALUATION OF MODEL: ADMINISTRATIVE CONTROLS

The loudest configuration possible on the site occurs with 2 PB games per court with PB hits at the intermediate sound power level of 95.5 dB; these settings were evaluated without a barrier as configuration 7 and with a barrier as configuration 19. Configurations 10, 11 and 12 (without the barrier) and configurations 22, 23 and 24 (with the barrier) evaluate administrative controls: reducing the number of active courts and/or reducing the number of games per court.

As described above, limiting the PB play to tennis courts with a certain orientation can reduce the levels seen at some adjacent sites, though not all; on balance, there is no demonstrable difference between configurations 10 and 11 or between configurations 22 and 23. This further supports the earlier stated conclusion that controlling the orientation of the tennis courts used for PB does not provide an overall improvement.

Configurations 12 and 24 investigate reducing the number of intermediate games on each court to 1, with all courts active. These levels, while reduced when compared to configurations 7 and 19, are still a bit higher than the baseline and would be expected to receive more complaints than are currently received.

CONCLUSIONS: ADMINISTRATIVE CONTROLS WITH POSSIBLE BARRIER

Pickleball is very challenging acoustically for several reasons which are intrinsic to the game itself. This site is especially challenging given the terrain immediately adjacent to the tennis courts that are also being used as PB courts. Prohibiting PB play on these tennis courts is the only way to be 100% sure that no complaints from nearby residences will be received. Fortunately, this analysis has shown that a combination of administrative controls and adding a barrier if problems persist should maintain a workable environment for both the school and its neighbors.

As this analysis progressed, it became clear that expert PB players would acoustically overwhelm this site. Polysonics has been informed by the school that no outside PB play will be allowed on these courts and that the only PB play these courts will see will be students during gym class and students when competing in tournaments against other schools. This final report was therefore limited to documenting only beginner and intermediate skill levels.

The loudest PB configurations modeled were configurations 7 and 19 with 2 intermediate games per court. Based on the PB games as observed and an expectation that most of the student players are of beginner skill level, it is expected that a more common PB condition for this site will be configuration 4 with 2 beginner games per court. While the PB games will be audible at the levels seen for configuration 4, they will be in the range of normal conversation and will not be loud. Furthermore, these levels will exist only during the course of the school day or immediately after the school day if a tournament is played.

If the current student use of these tennis courts for PB continues to be problematic, Polysonics recommends these additional administrative controls:

- Pickleball play can be restricted to Courts B, D, and E.
- Pickleball play can be limited to 1 game per tennis court on Courts B and D.

If these additional administrative controls are not effective, then an acoustic wrap can be added to the fencing.

APPENDIX

Figure 3: Site Layout Showing Meter Locations (M1-M5) and Analysis Points (H1-H9)

Figure 4: Measurement Microphone Location Photographs

Figure 5: Tennis Courts as Seen From Old Georgetown Road

Figure 6: Cedarwood Drive, To The Immediate South of the Tennis Courts

Figure 7: Measured Data for Measurement Location M3

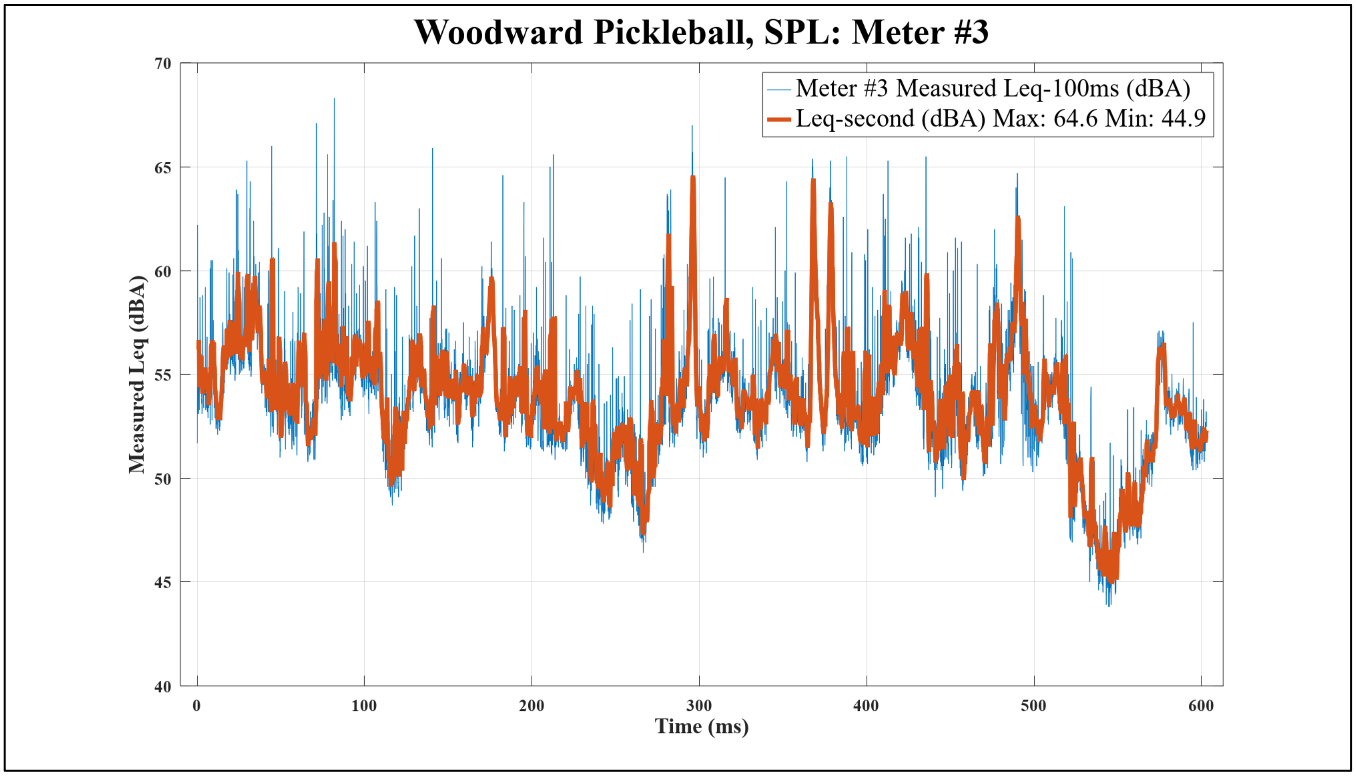


Figure 8: Histogram of Measured Data for Measurement Location M3

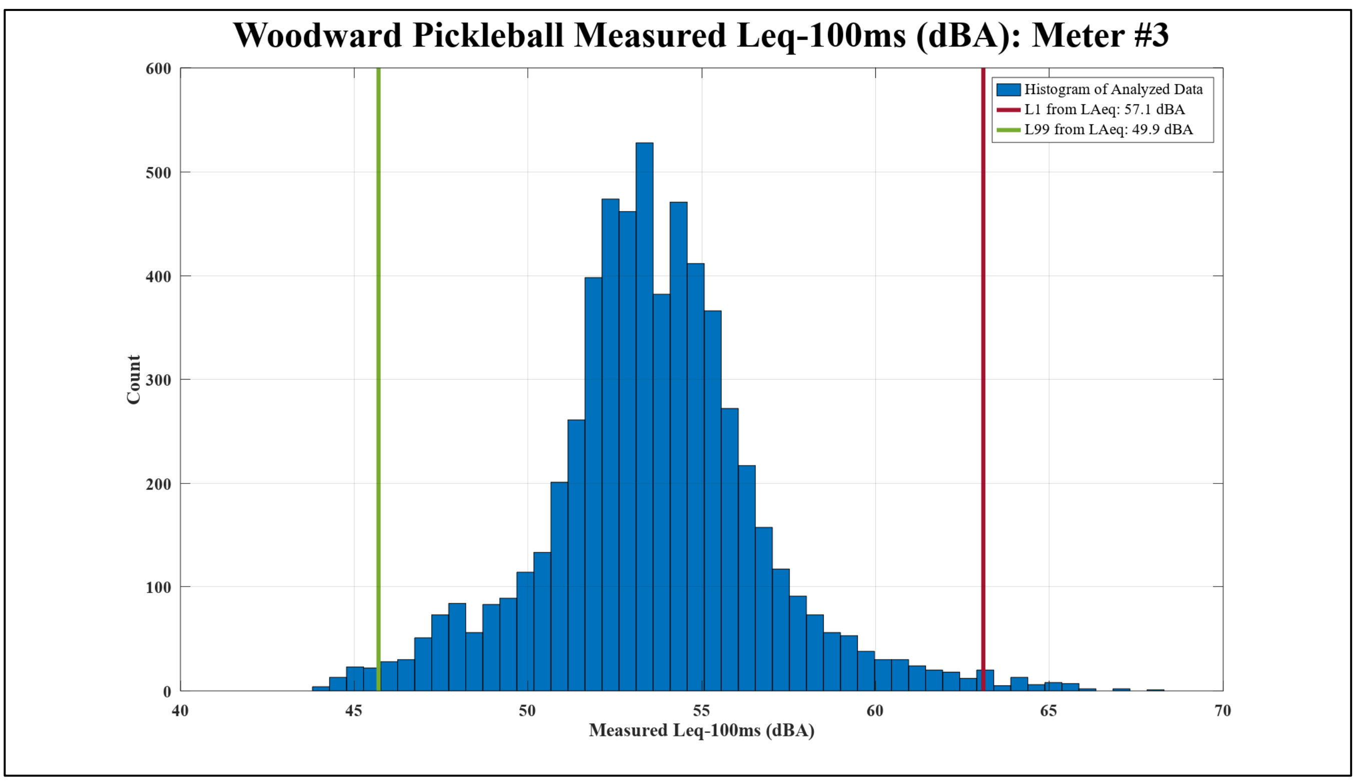


Figure 9: Measured Data for Measurement Location M4

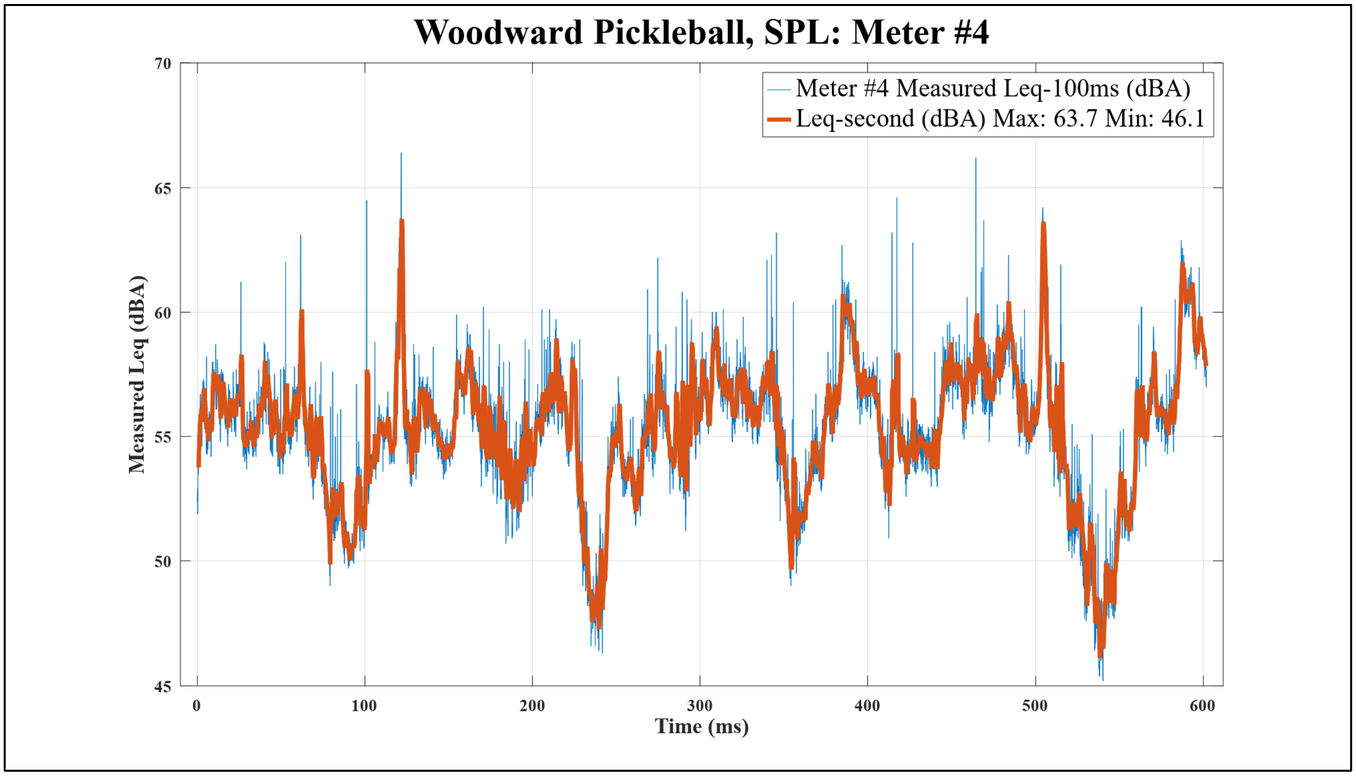


Figure 10: Histogram of Measured Data for Measurement Location M4

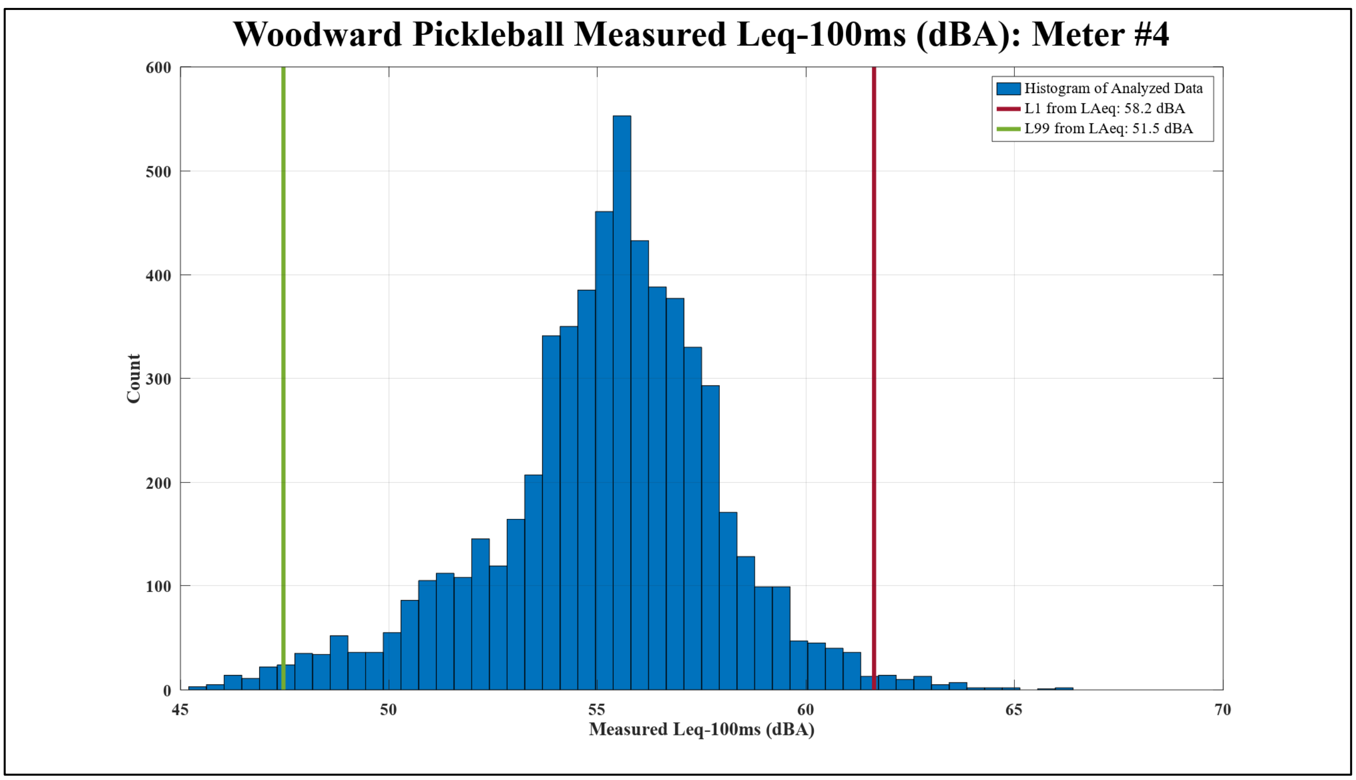


Figure 11: Measured Data for Measurement Location M5

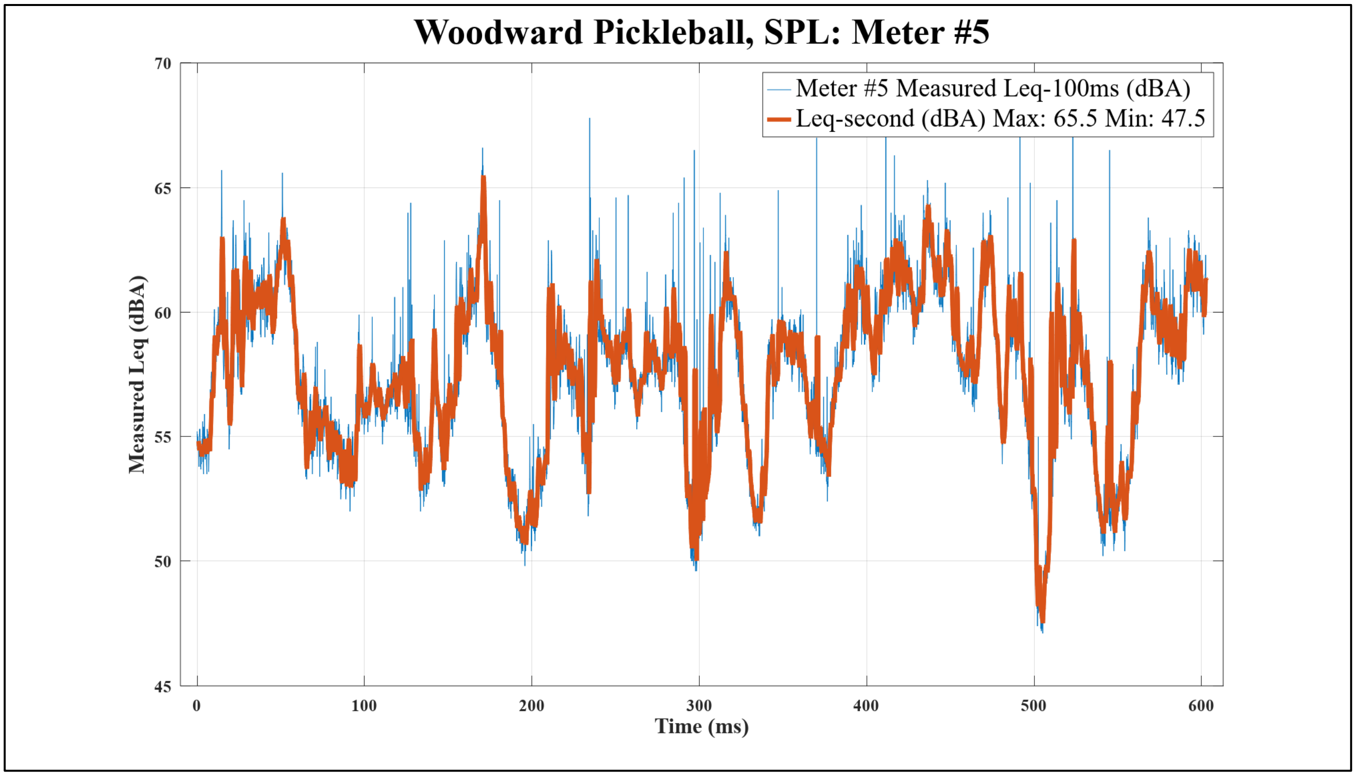


Figure 12: Histogram of Measured Data for Measurement Location M5

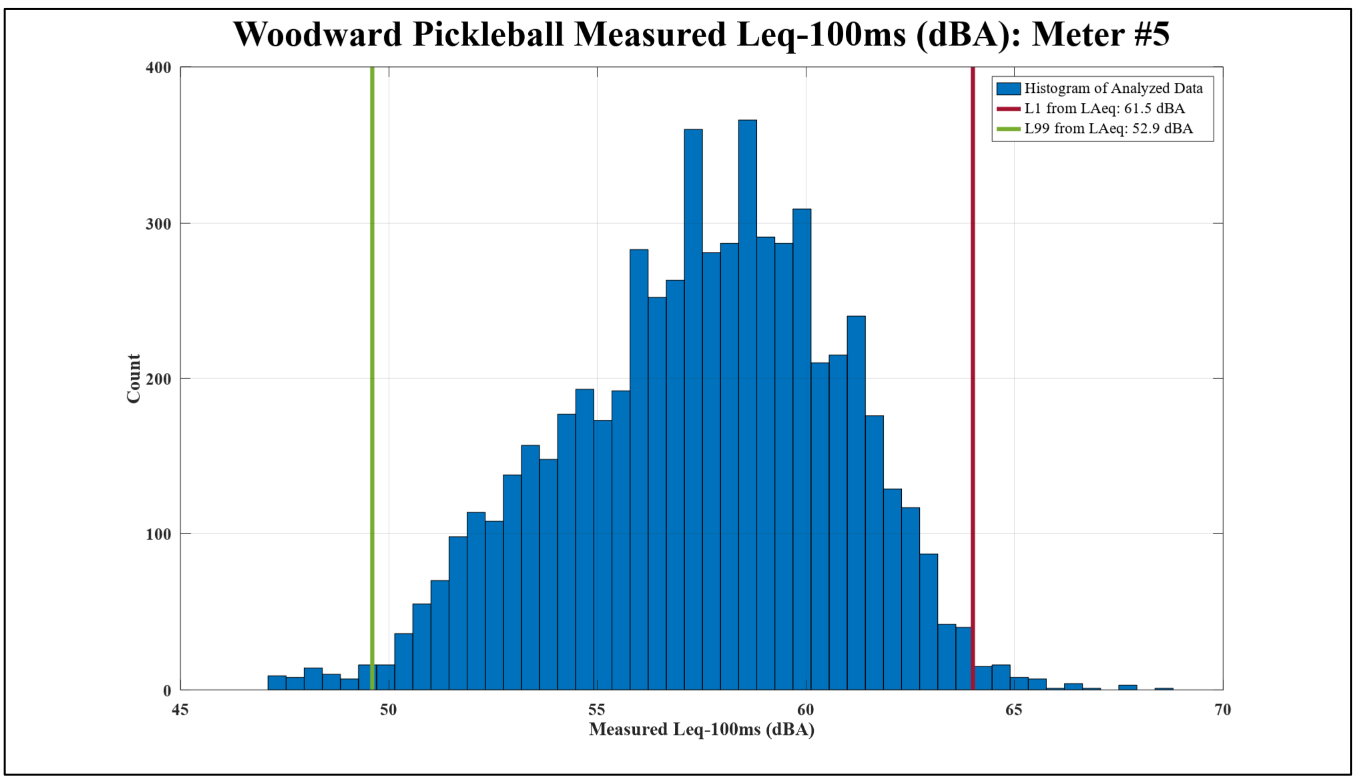


Table 3: Traffic Count Settings for Old Georgetown Road.

Old Georgetown Rd Near						Old Georgetown Rd Far					
		Veh/h (d)	% Veh (d)	Veh/h (n)	% Veh (n)			Veh/h (d)	% Veh (d)	Veh/h (n)	% Veh (n)
2026	Automobiles	1065	96.0	444	96.0	**2026**	Automobiles	771	96.0	321	96.0
	Medium Trucks	29	2.6	12	2.6		Medium Trucks	21	2.6	9	2.6
	Heavy Trucks	6	0.5	2	0.5		Heavy Trucks	4	0.5	2	0.5
	Bus	7	0.7	3	0.7		Bus	5	0.7	2	0.7
	Motor Cycles	3	0.2	1	0.2		Motor Cycles	2	0.2	1	0.2
	Hourly Total	1109	100	462	100		**Hourly Total**	803	100	335	100
	ADT	20799					**ADT**	15061			
	Speed (mph)	40					**Speed (mph)**	40			

Table 4: Description of Various Analysis Configurations.

Analysis Config.	Active Courts	Games per Court	Skill Level	Barrier	Comments
0	None	0	N/A	N	Traffic Noise Only
1	BCE	1	Beginner	N	Calibrates M3
2	BC	1	Beginner	N	Calibrates M4 & M5
3	ABCDE	1	Beginner	N	Investigates More Active Games
4	ABCDE	2	Beginner	N	Investigates More Active Games
5	ABD	2	Beginner	N	Investigates Directivity
6	CE	2	Beginner	N	Investigates Directivity
7	ABCDE	2	Intermediate	N	Investigates More Skill
10	ABD	2	Intermediate	N	Investigates Adminstrative Control Option
11	CE	2	Intermediate	N	Investigates Adminstrative Control Option
12	ABCDE	1	Intermediate	N	Investigates Adminstrative Control Option
13	BCE	1	Beginner	12'	Observed Conditions (w/ Barrier)
14	BC	1	Beginner	12'	Observed Conditions (w/ Barrier)
15	ABCDE	1	Beginner	12'	Investigates More Active Games
16	ABCDE	2	Beginner	12'	Investigates More Active Games
17	ABD	2	Beginner	12'	Investigates Directivity
18	CE	2	Beginner	12'	Investigates Directivity
19	ABCDE	2	Intermediate	12'	Investigates More Skill
22	ABD	2	Intermediate	12'	Investigates Adminstrative Control Option
23	CE	2	Intermediate	12'	Investigates Adminstrative Control Option
24	ABCDE	1	Intermediate	12'	Investigates Adminstrative Control Option

Figure 13: Site Noise Contour Plot for Configuration 1

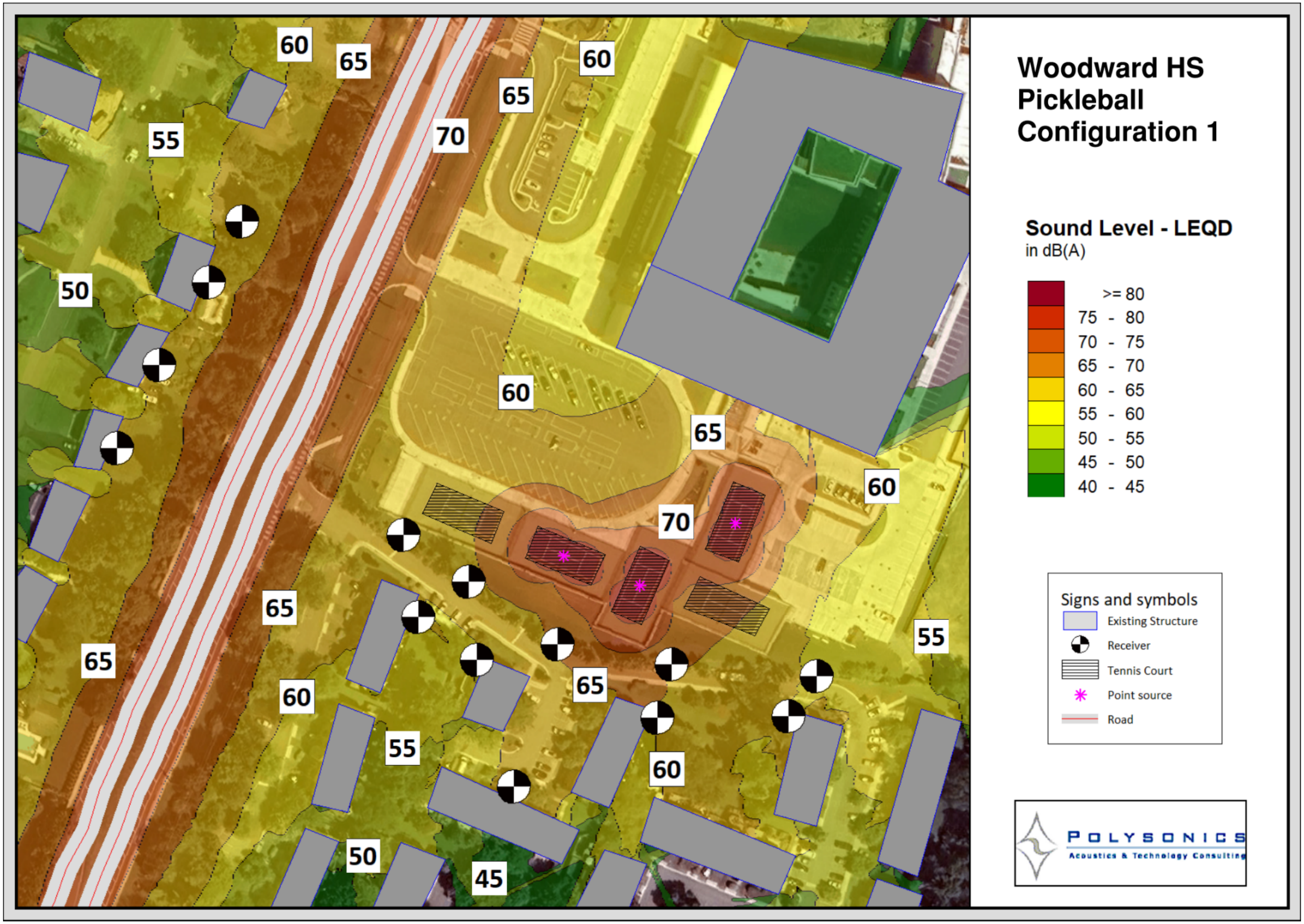


Figure 14: Site Noise Contour Plot for Configuration 2

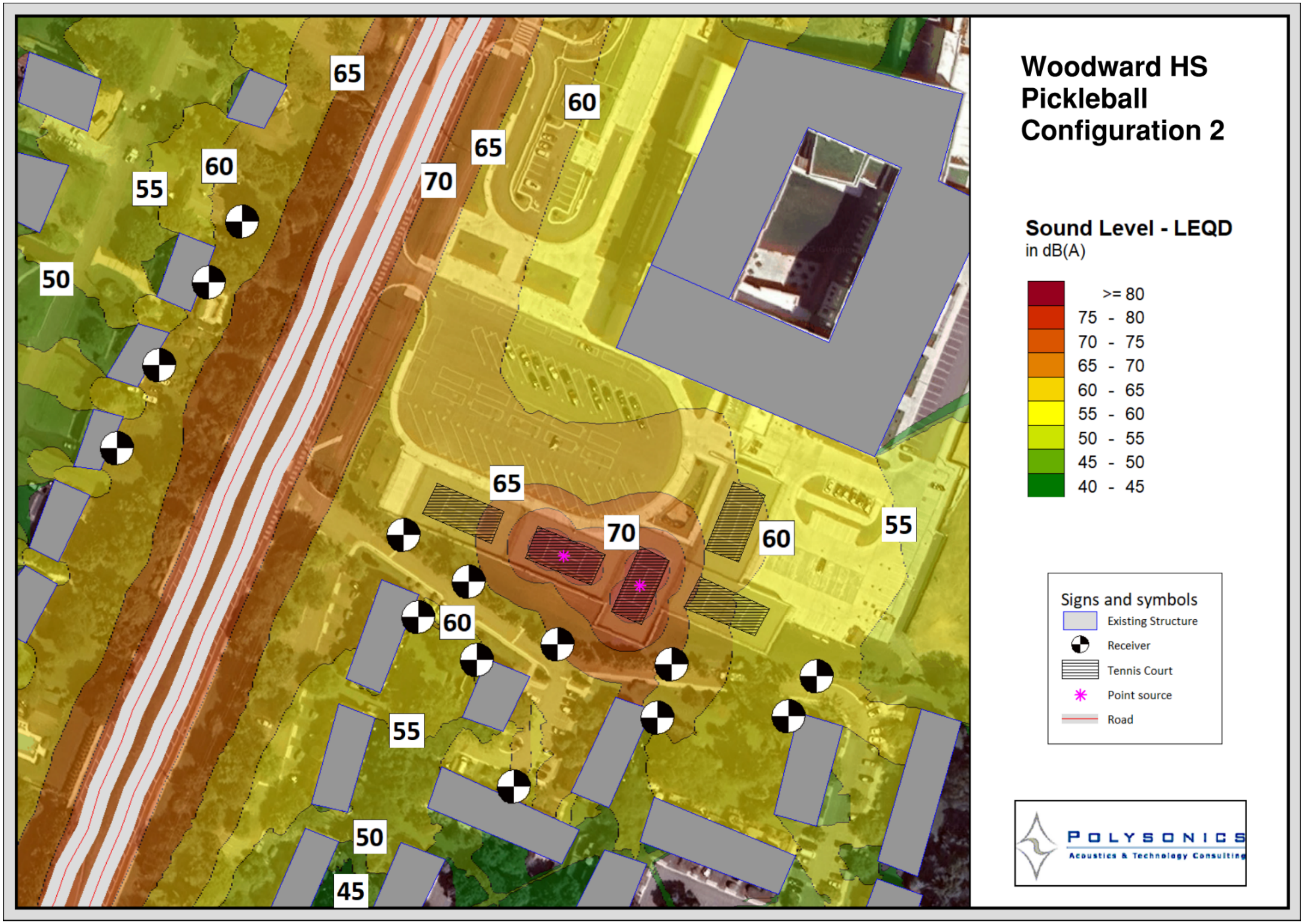


Figure 15: Site Noise Contour Plot for Configuration 3

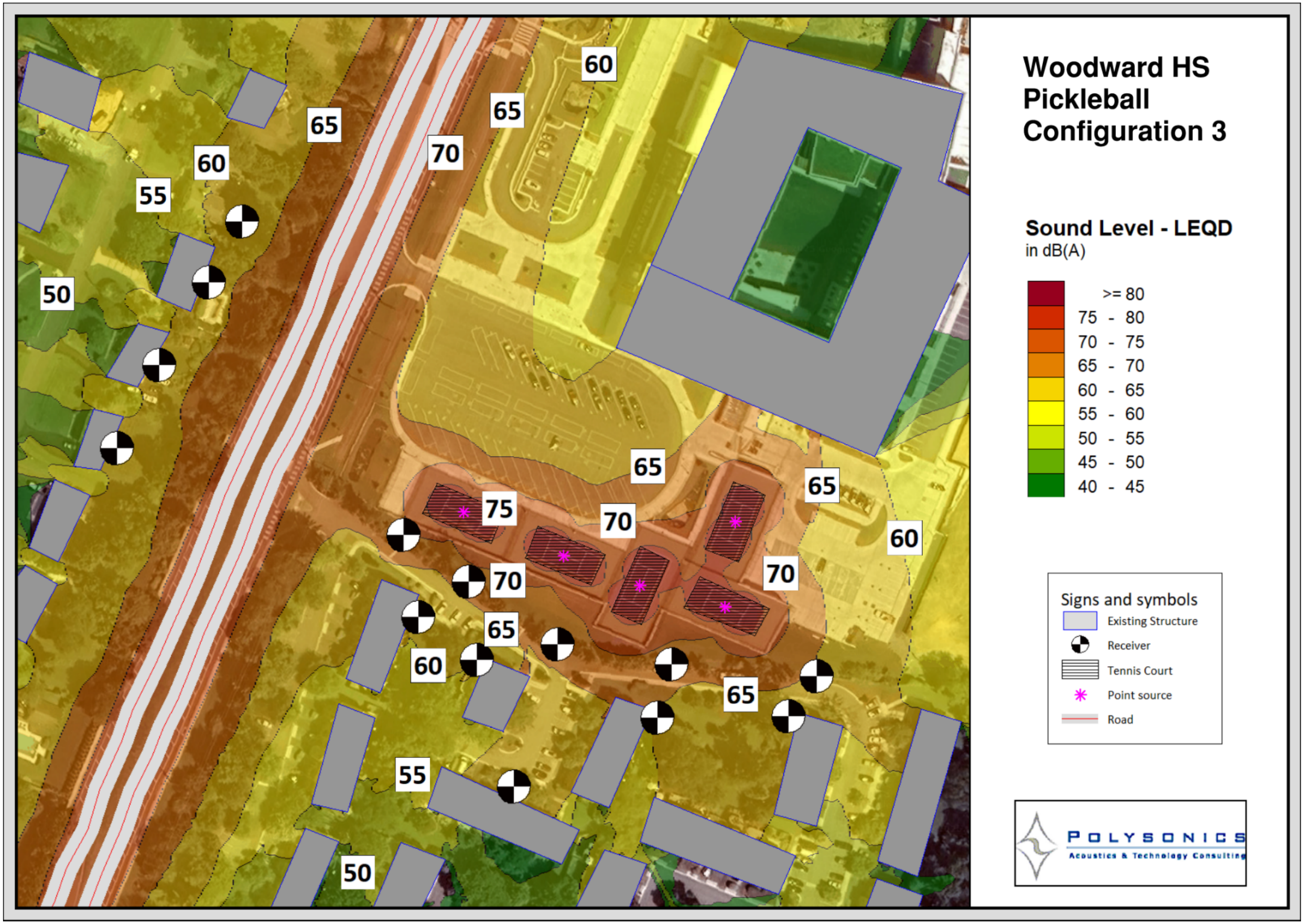


Figure 16: Site Noise Contour Plot for Configuration 4

Figure 17: Site Noise Contour Plot for Configuration 5

Figure 18: Site Noise Contour Plot for Configuration 6

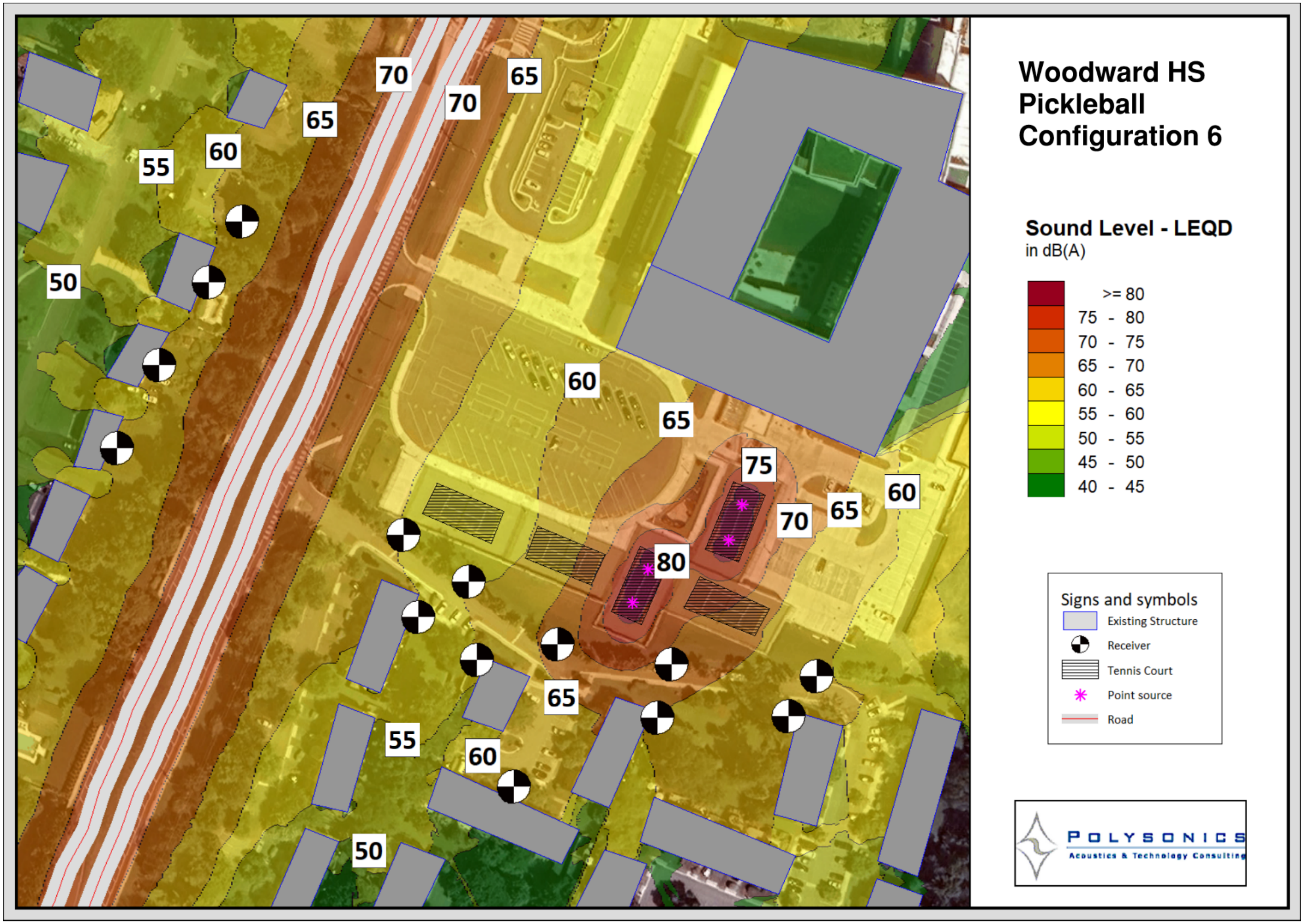


Figure 19: Site Noise Contour Plot for Configuration 7

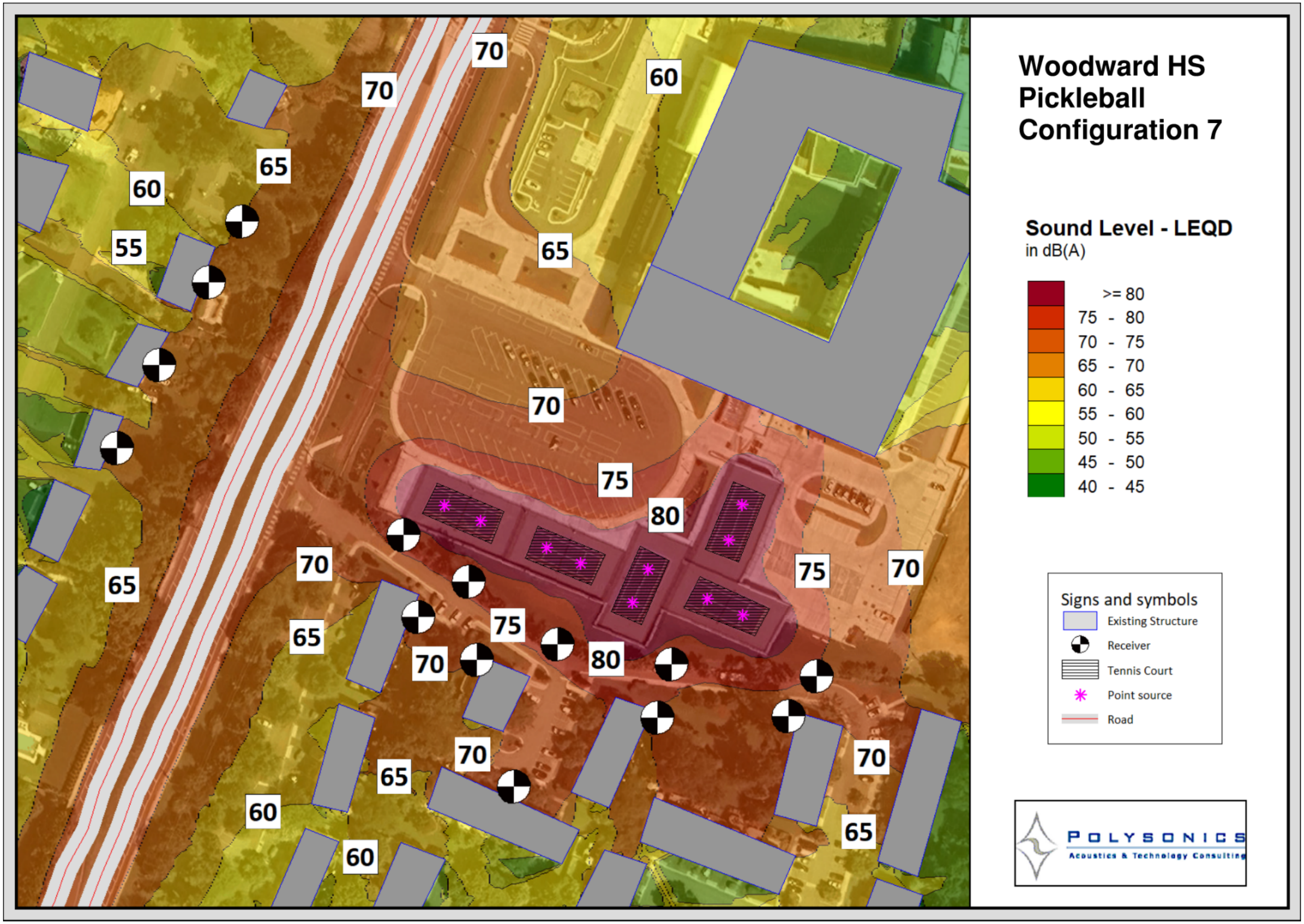


Figure 20: Site Noise Contour Plot for Configuration 10

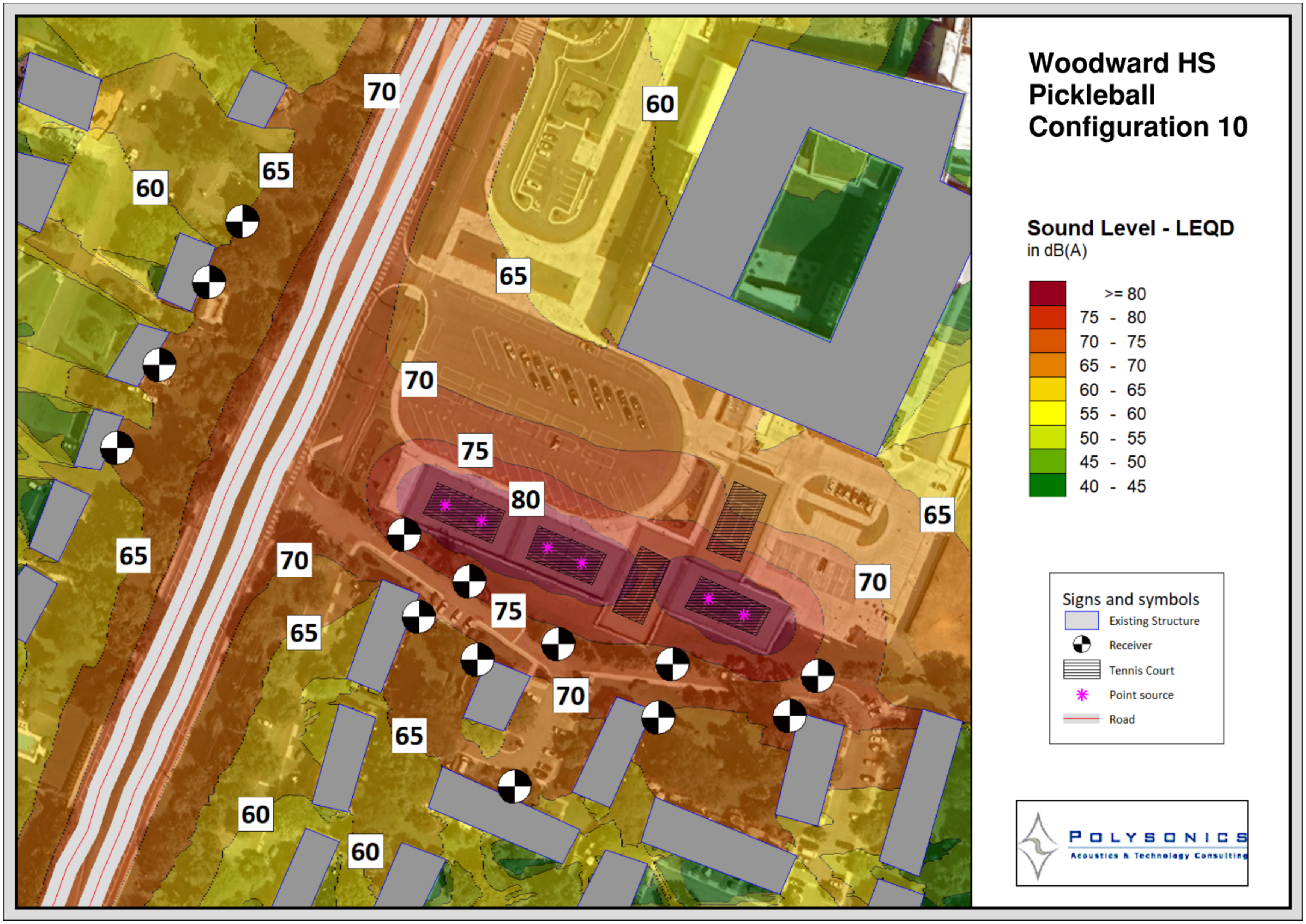


Figure 21: Site Noise Contour Plot for Configuration 11

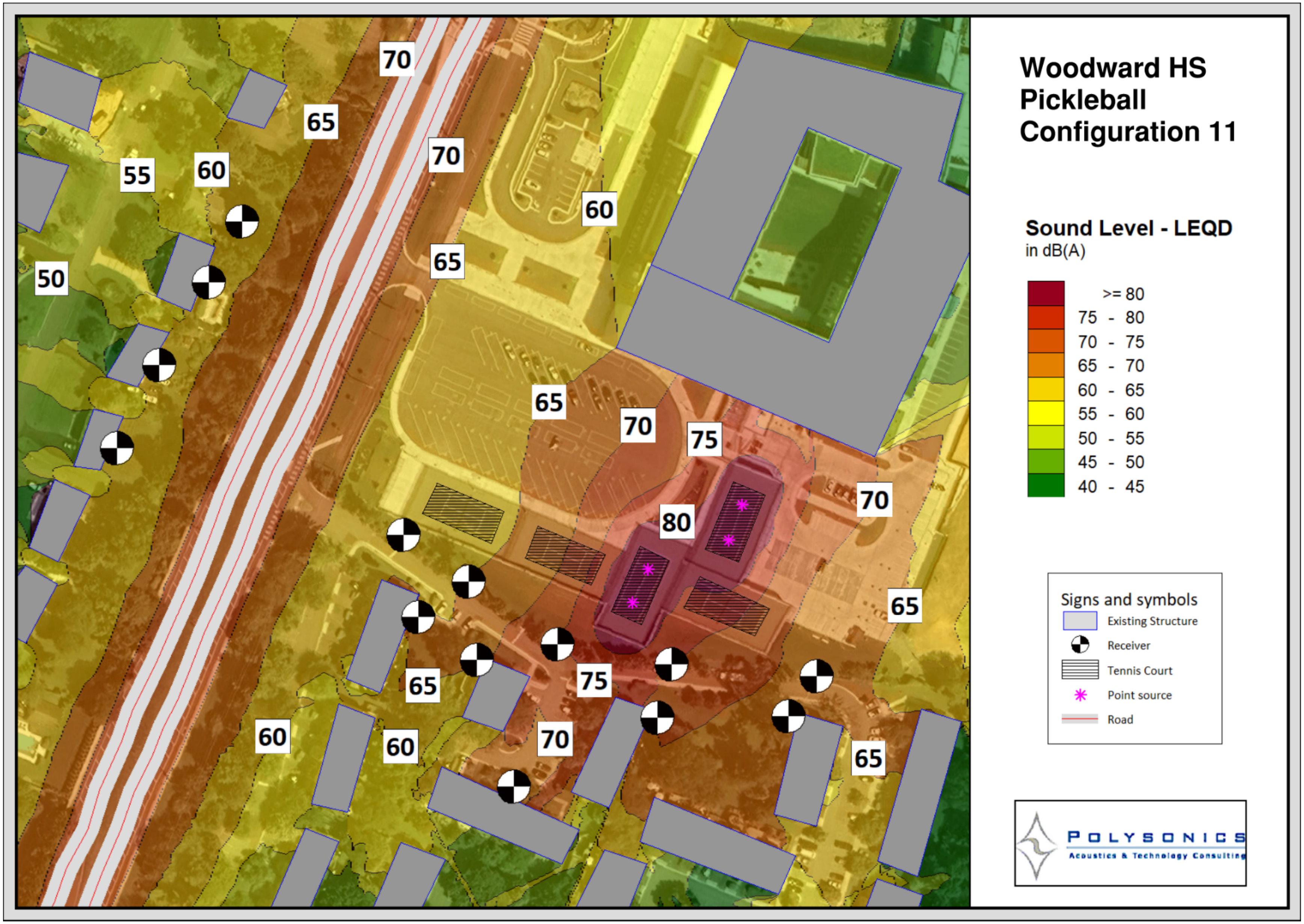


Figure 22: Site Noise Contour Plot for Configuration 12

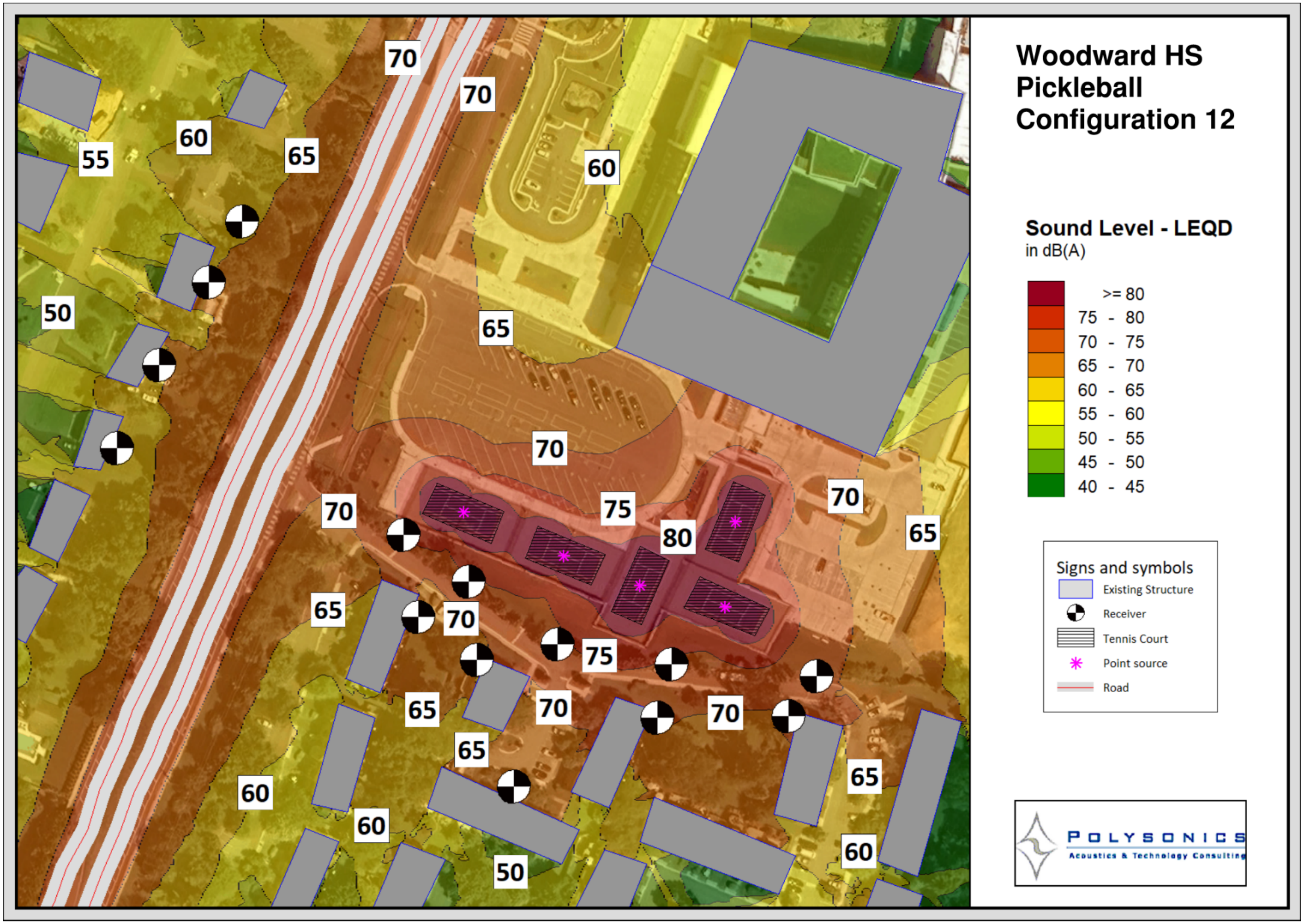


Figure 23: Modeled Acoustic Barrier, Looking East

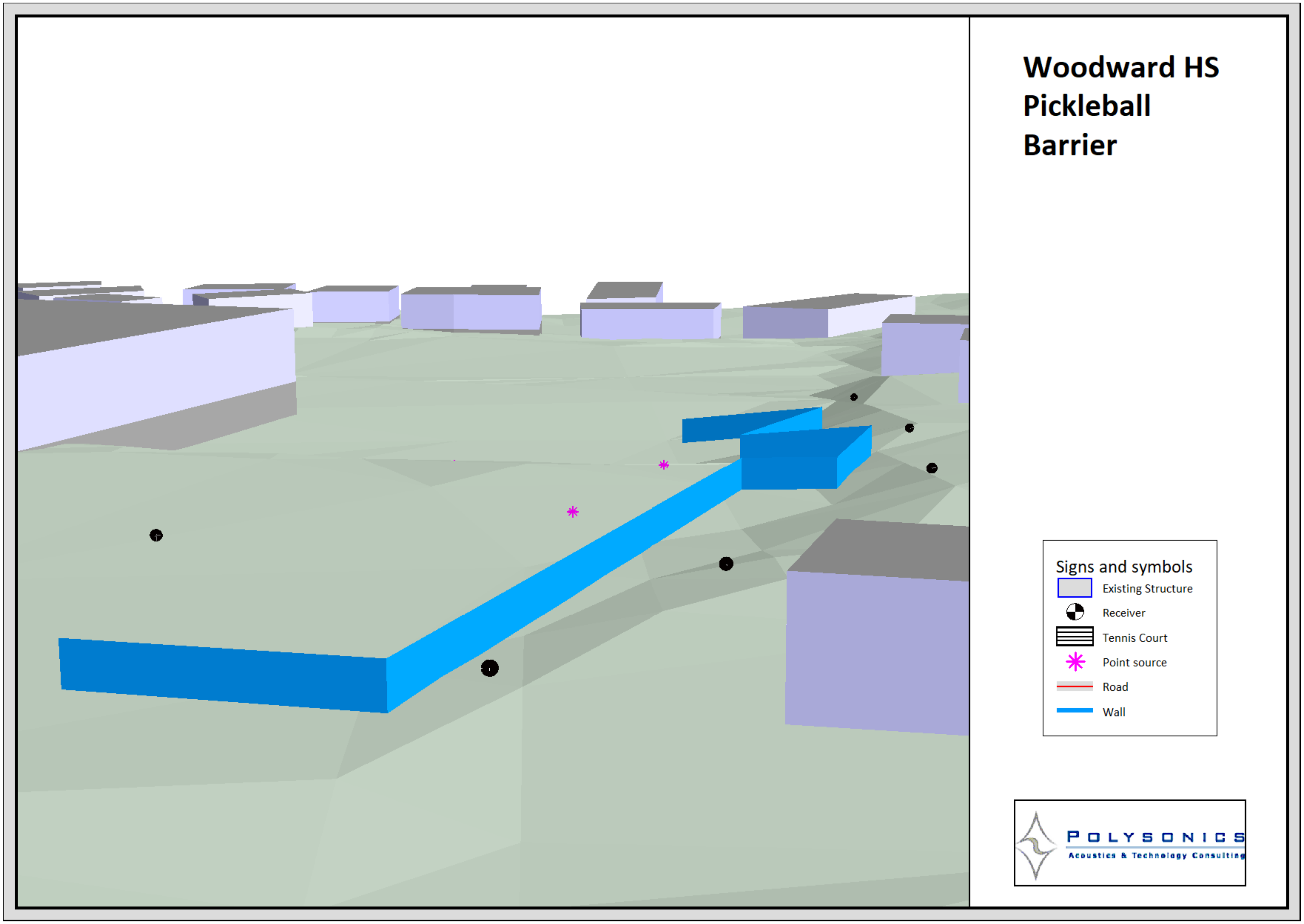


Figure 24: Modeled Acoustic Barrier, Looking West

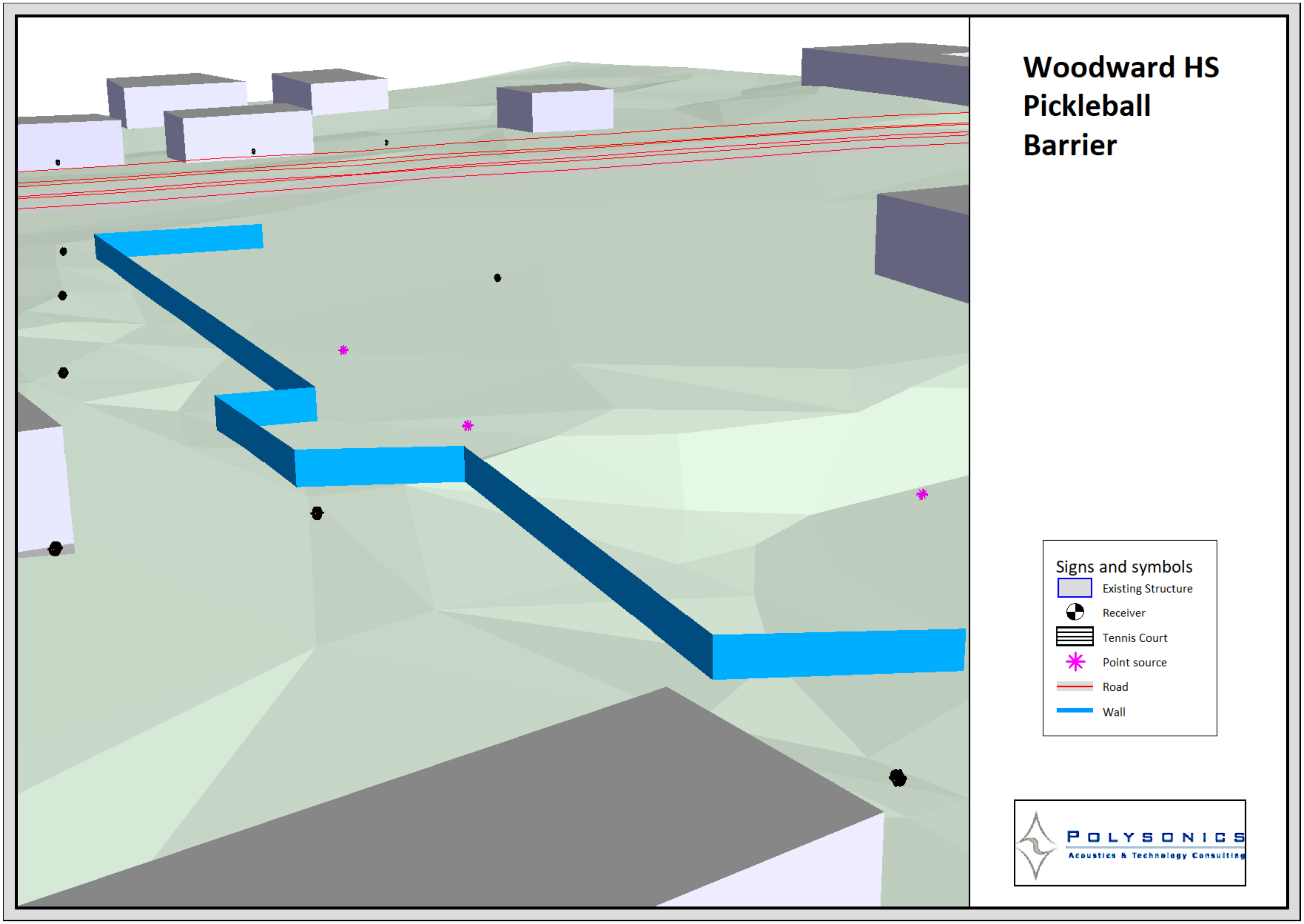


Figure 25: Site Noise Contour Plot for Configuration 13

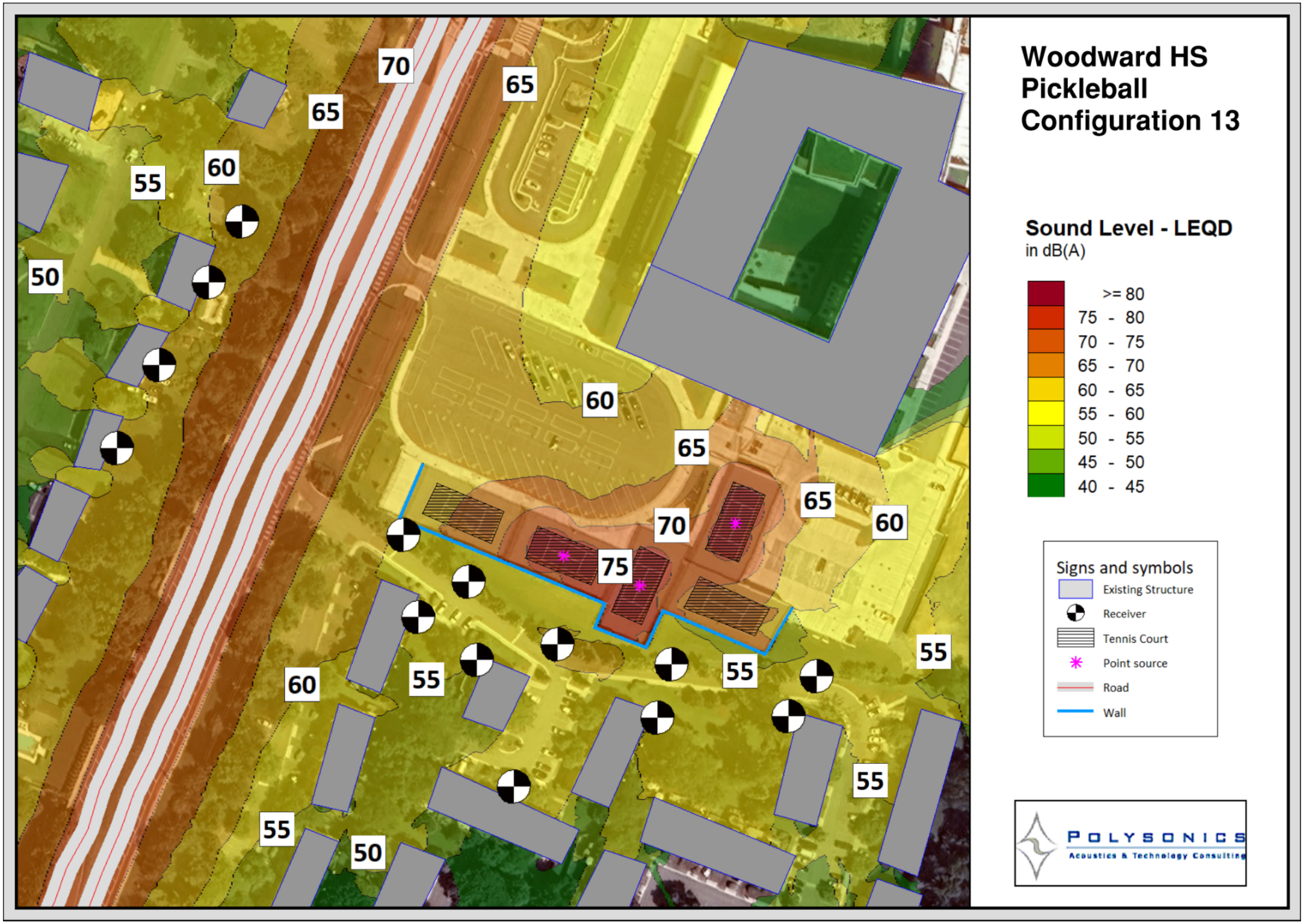


Figure 26: Site Noise Contour Plot for Configuration 14

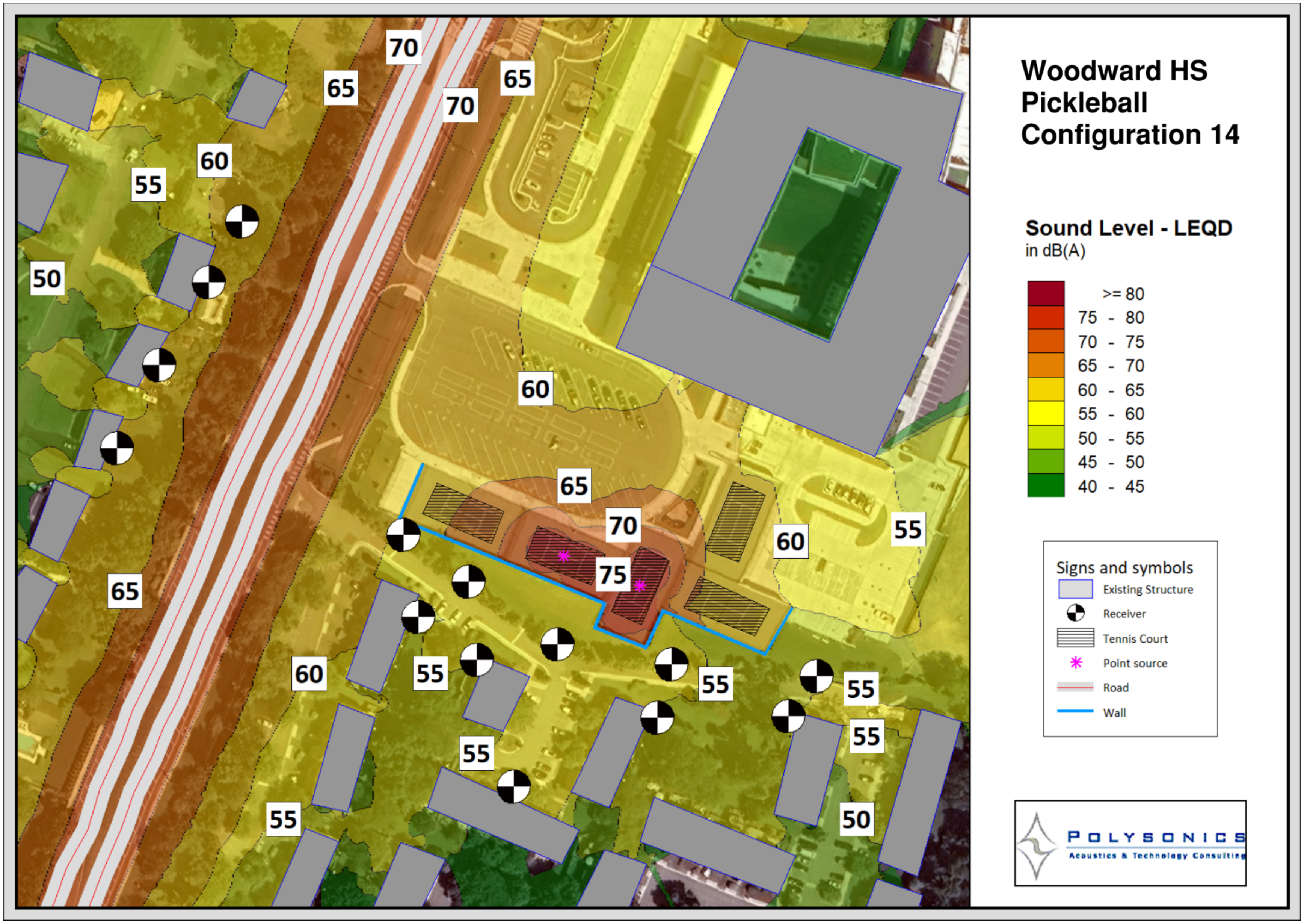
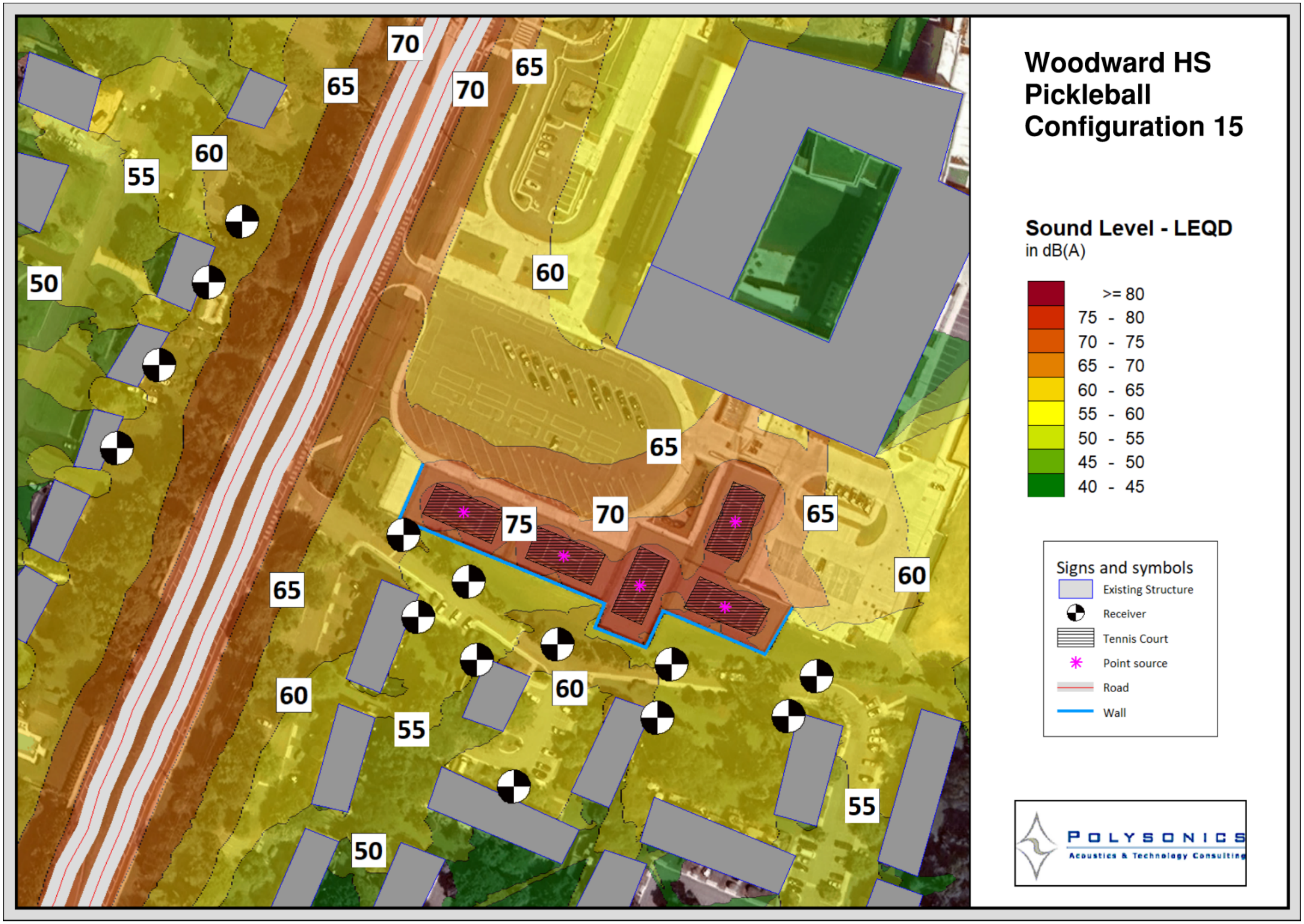


Figure 27: Site Noise Contour Plot for Configuration 15



<u>**Figure 28: Site Noise Contour Plot for Configuration 16**</u>

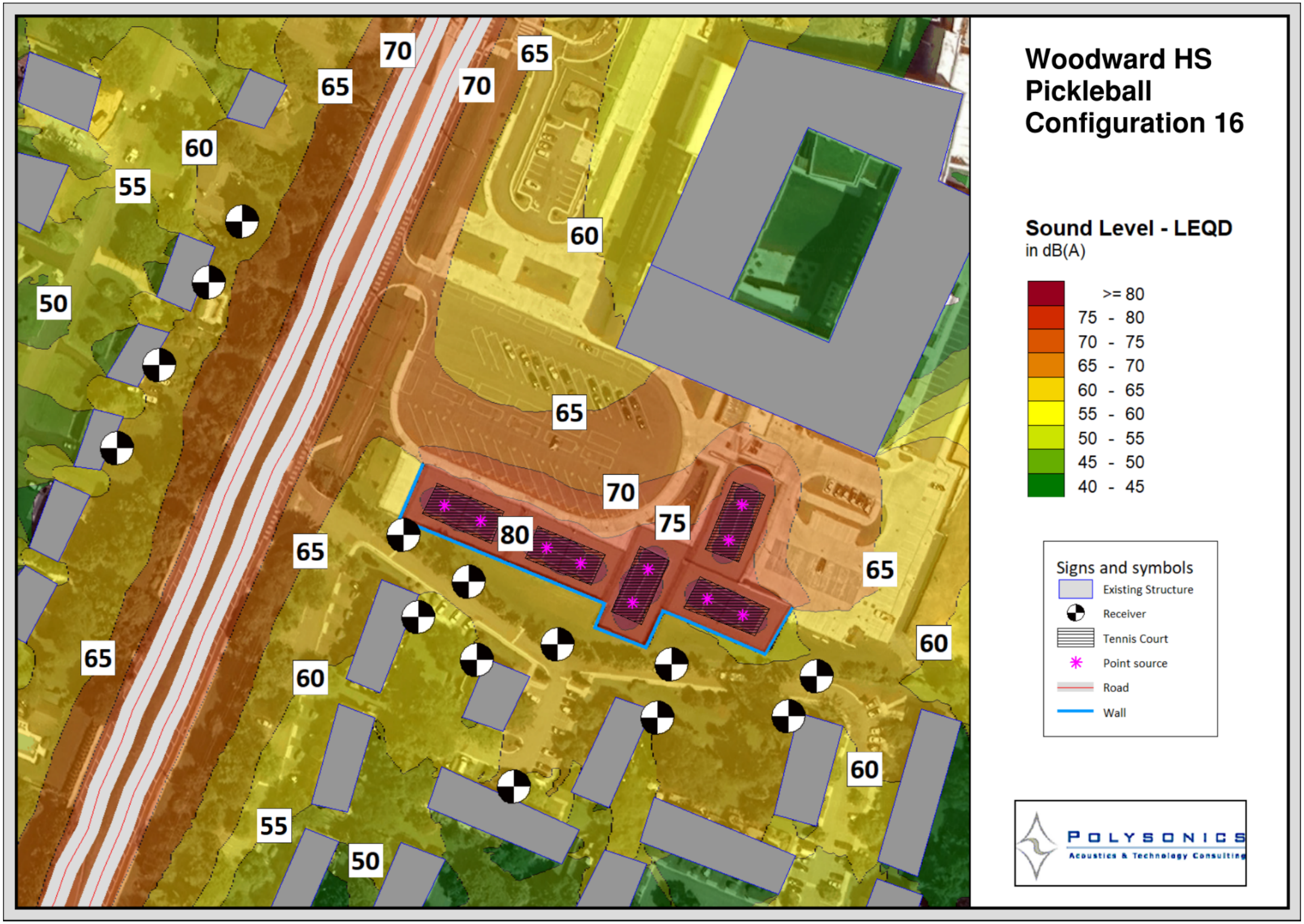


Figure 29: Site Noise Contour Plot for Configuration 17

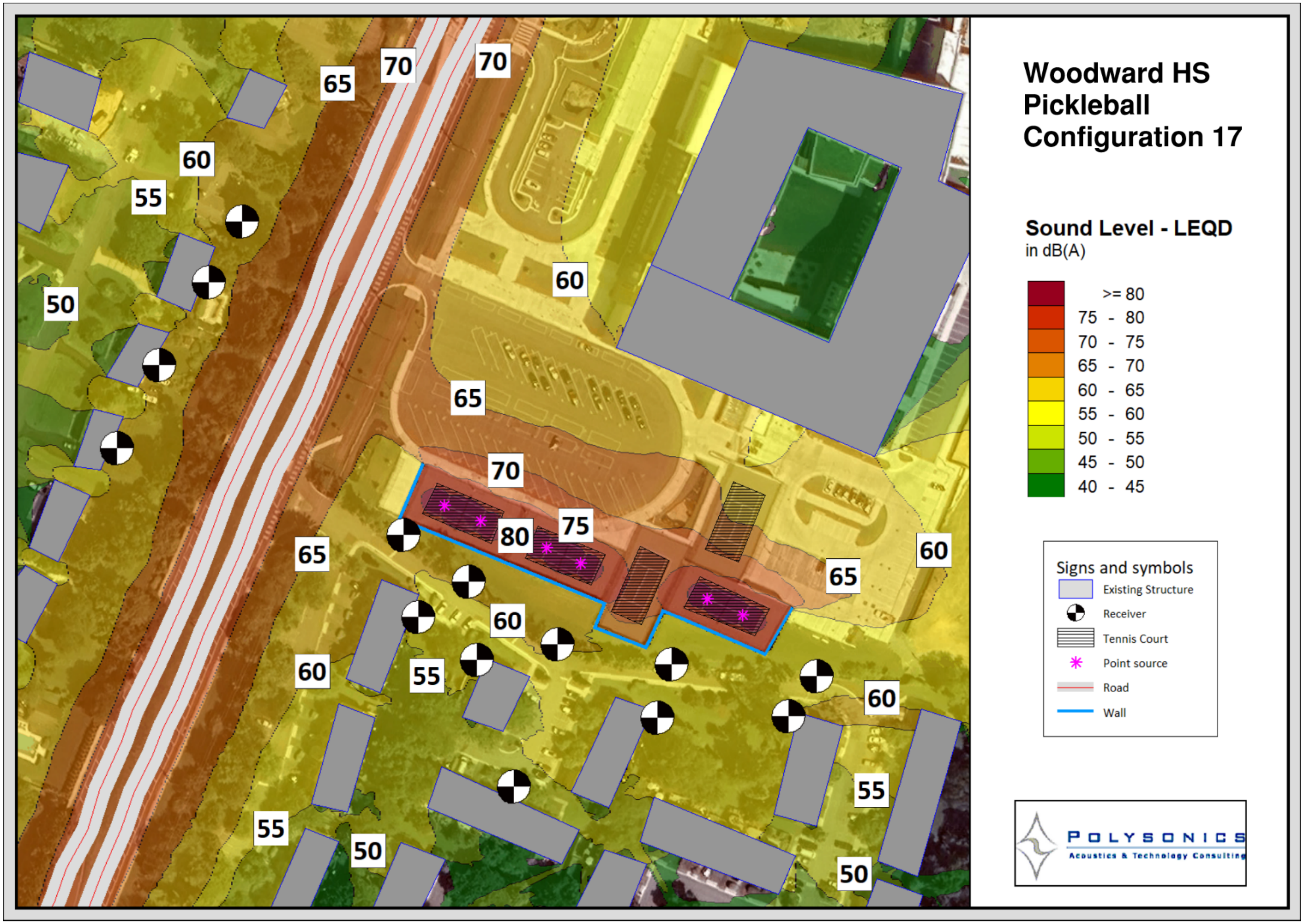


Figure 30: Site Noise Contour Plot for Configuration 18

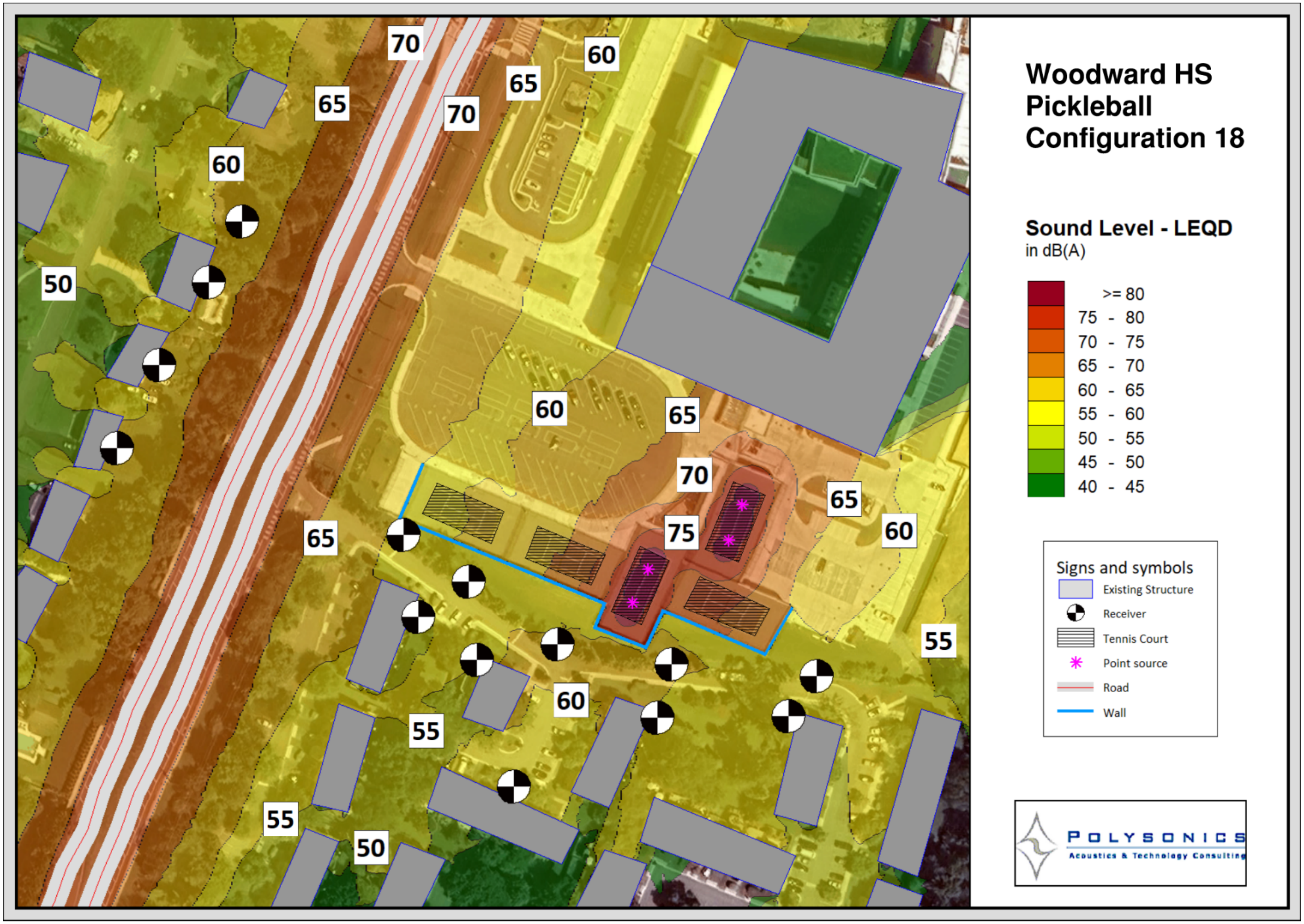


Figure 31: Site Noise Contour Plot for Configuration 19

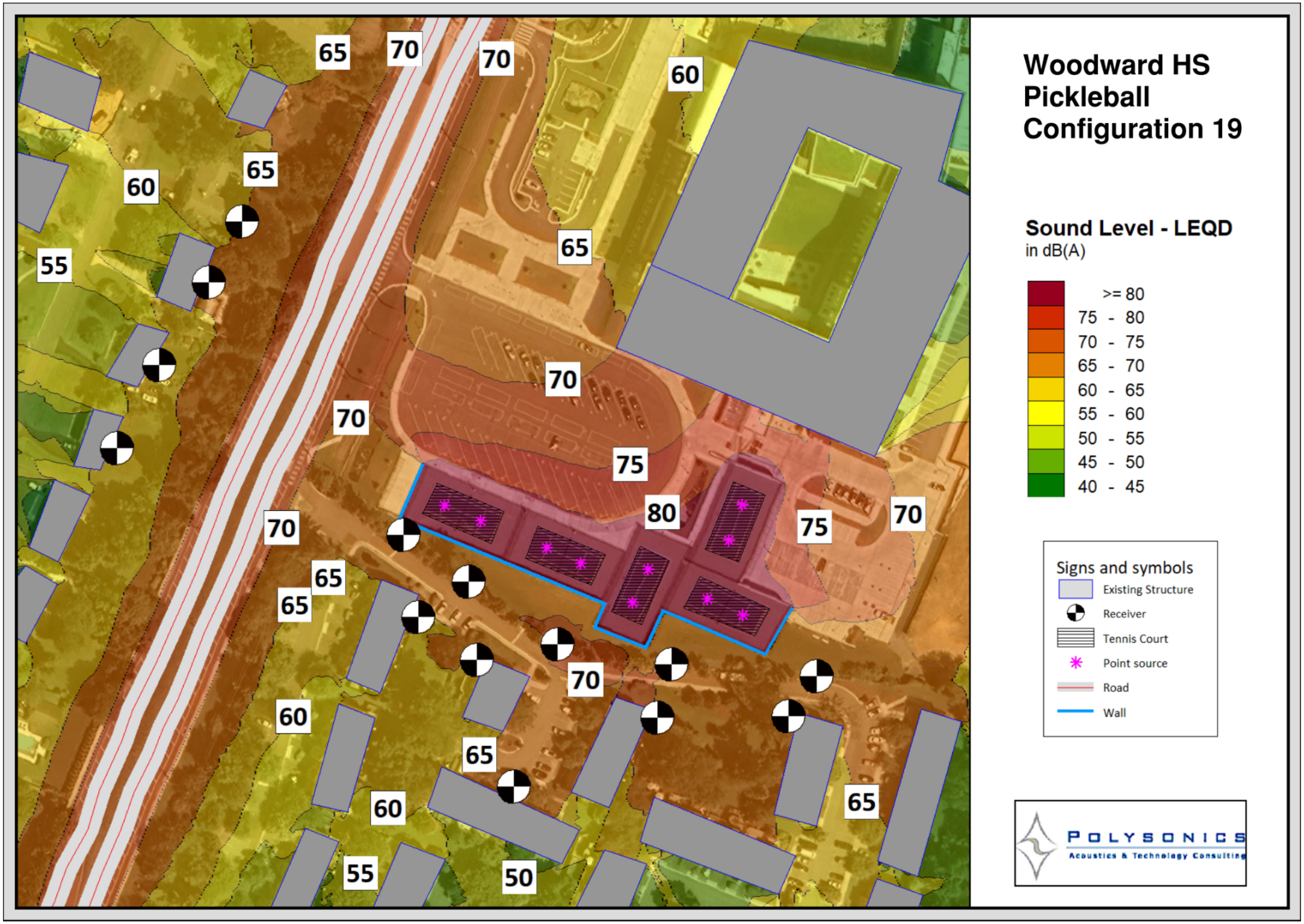


Figure 32: Site Noise Contour Plot for Configuration 22

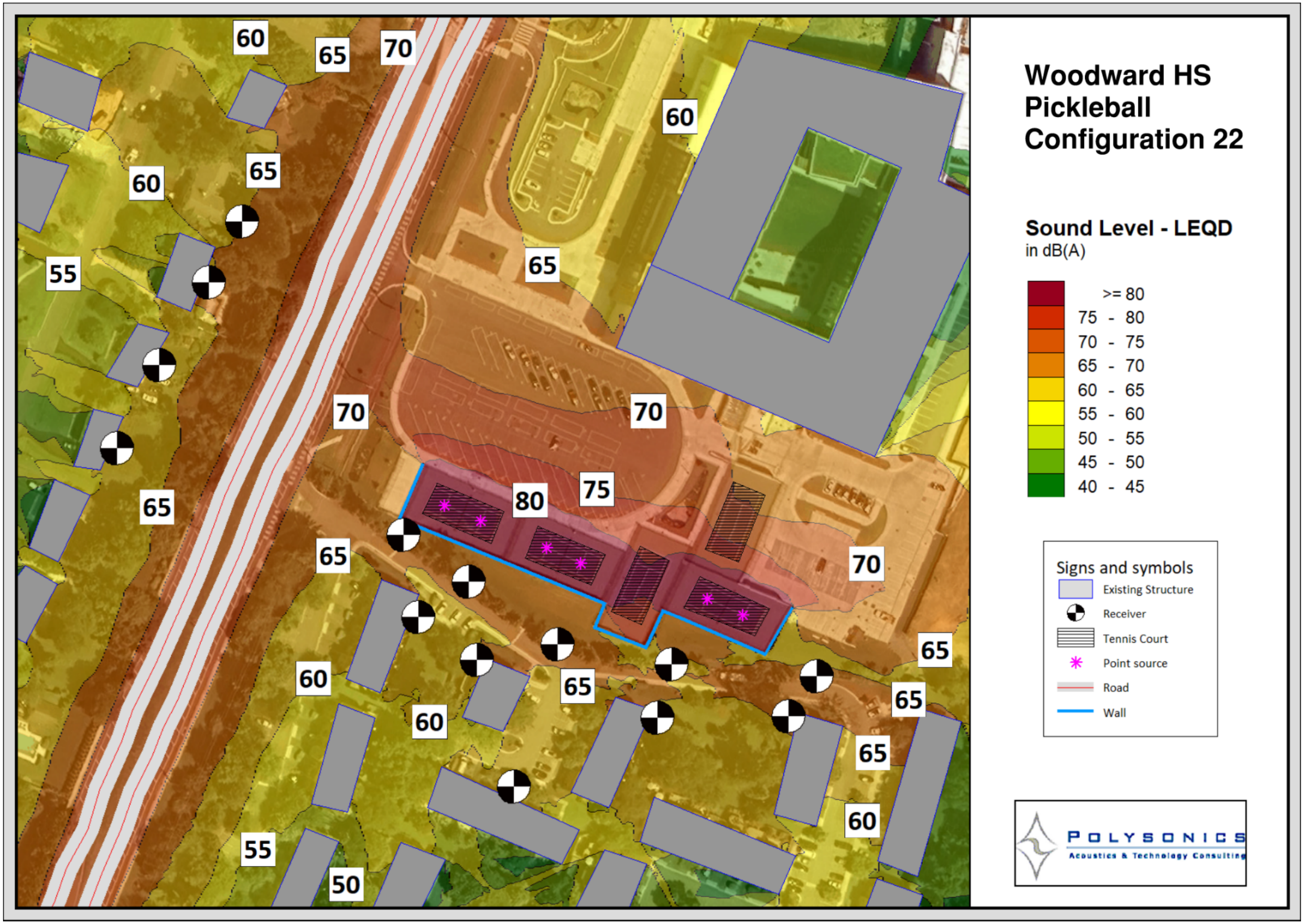


Figure 33: Site Noise Contour Plot for Configuration 23

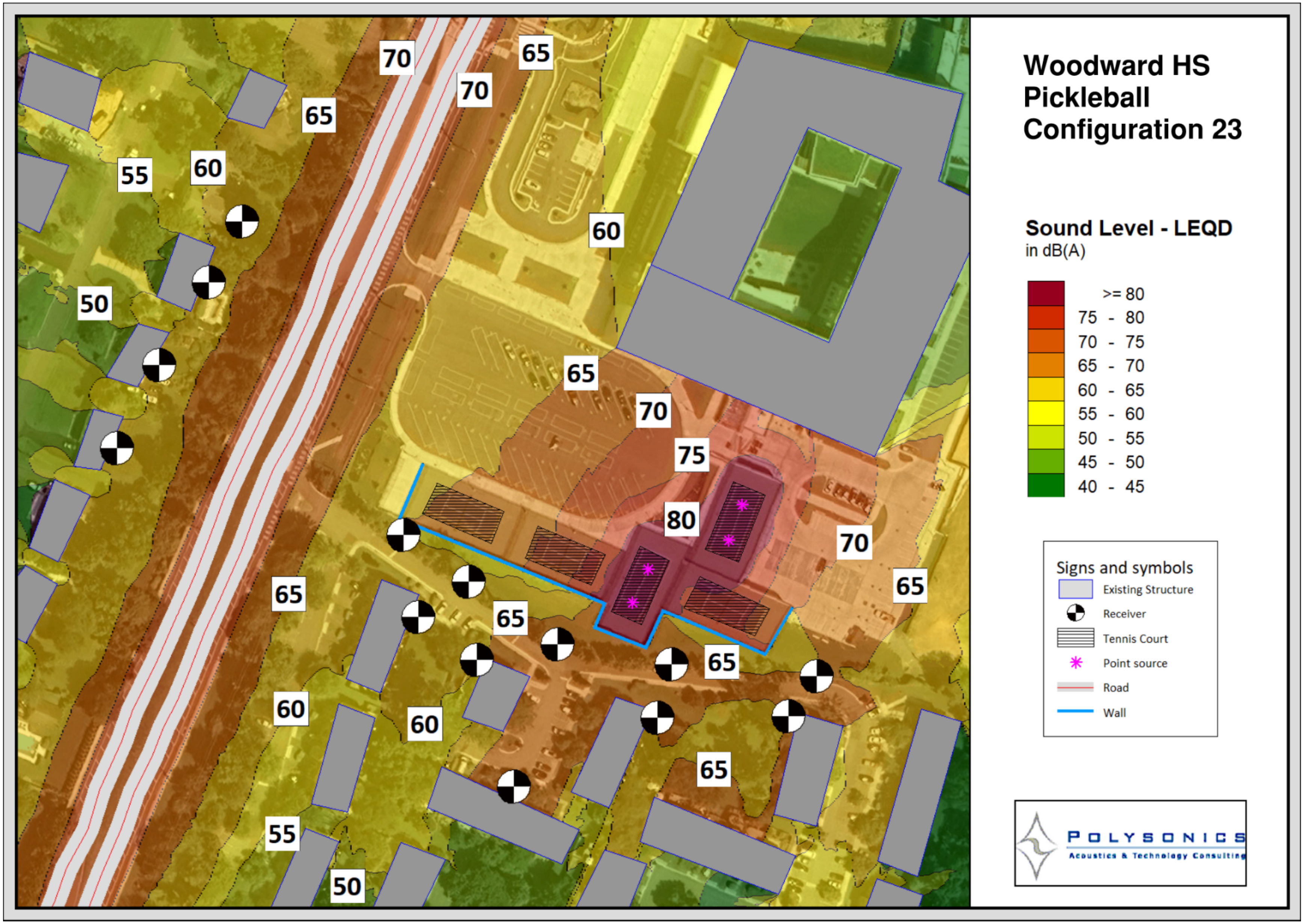
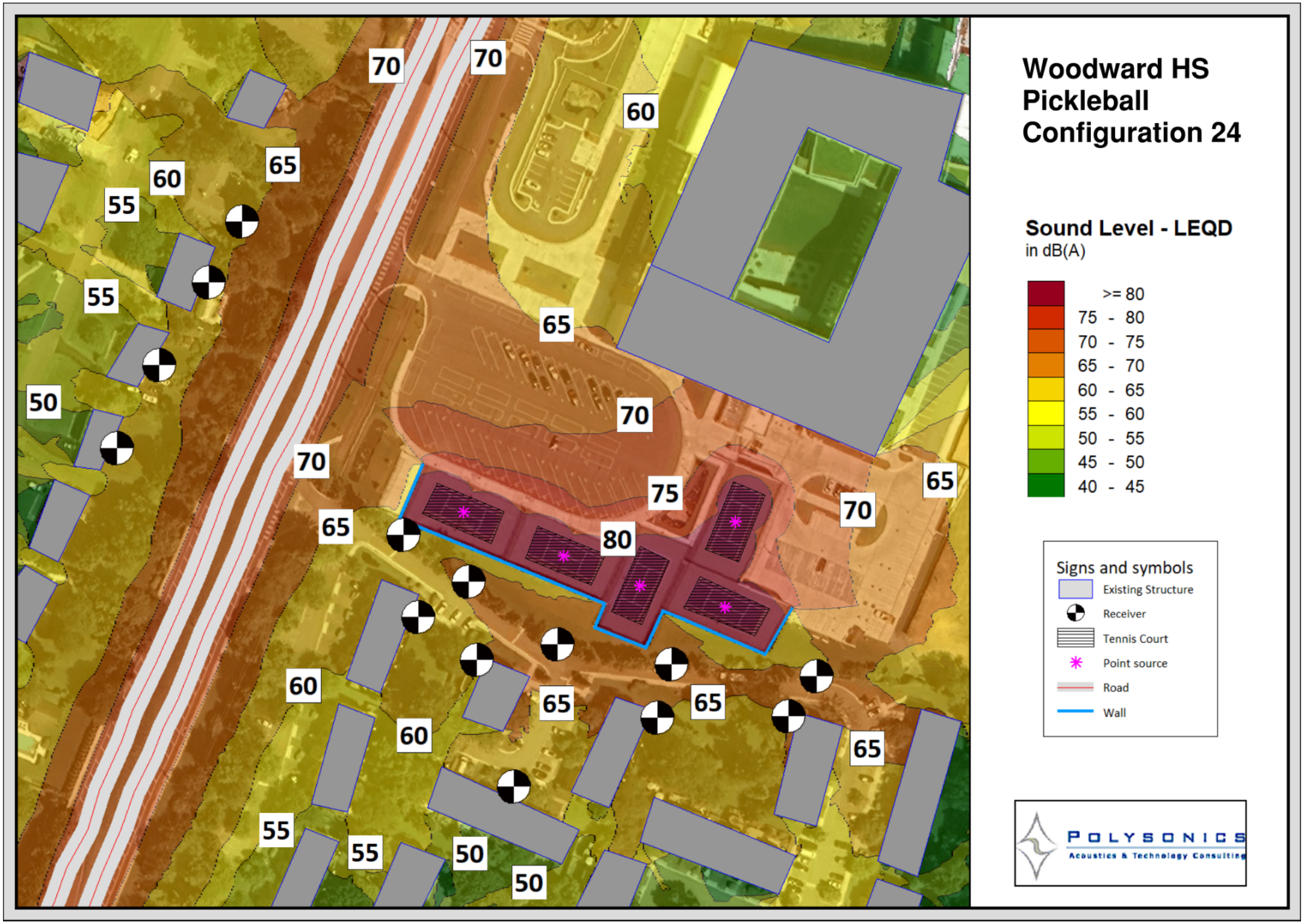


Figure 34: Site Noise Contour Plot for Configuration 24



POLYSONICS
Acoustics & Technology Consulting

555 Hospital Drive
Warrenton, VA 20186
540.341.4988
www.polysonics.com