Noise walls
Some Noise Facts

What is noise?
Noise is unwanted sound. Noise is perceived differently by every individual. A noise that is irritating one person may be tolerant to another.

Sound is transmitted by pressure variations in air from its source to the surroundings. Most sounds or noises we encountered in our daily life are from sources which can be characterized as point or line sources.

A **point source** occurs when a sound source is stationary. For point sources, sound is radiated equally in all directions like a pulsing sphere, as illustrated in Figure 1. The noise level for a point source decreases by 6 dB per doubling of distance from the source.

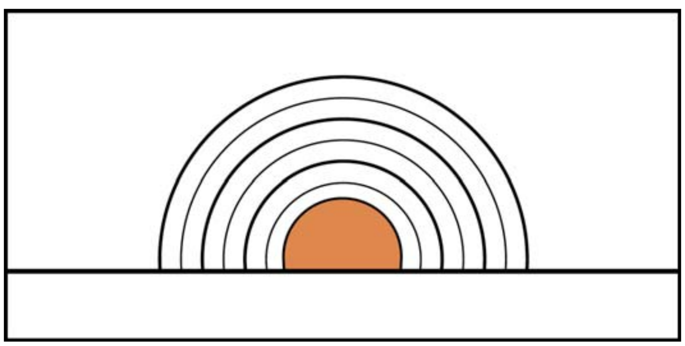


Figure 1: Point Source

A **line source** occurs when many sources are moving in a line, the sound radiates like a pulsing cylinder from the source, as shown in Figure 2. For a line source, the noise level decreases by 3 dB per doubling of distance from it. Traffic noise is generated this way. A stream of cars in the roadway produces noise as a line source.

Noise is measured in decibels (dB) on a logarithmic scale. This scale does not work the same way as most other familiar scales. An increase in 10 decibels will cause the noise to be perceived as sounding twice as

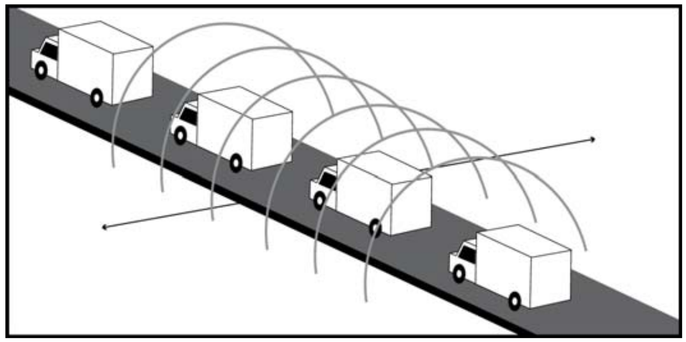


Figure 2: Line Source

loud to the average listener. Therefore, a source will sound twice as loud if the noise is increased from 65 decibels to 75 decibels and four times as loud from 65 decibels to 85 decibels.

Doubling the sound source, such as doubling the number of traffic on the highway causes the noise level to increases by 3 decibels. A 3 decibel change is barely noticeable to most people. Since humans do not have the same sensitivity to all frequencies, the A-weighted scale was developed, and is used for highway traffic noise evaluation.

The chart on the next page indicates common indoor and outdoor noise levels.

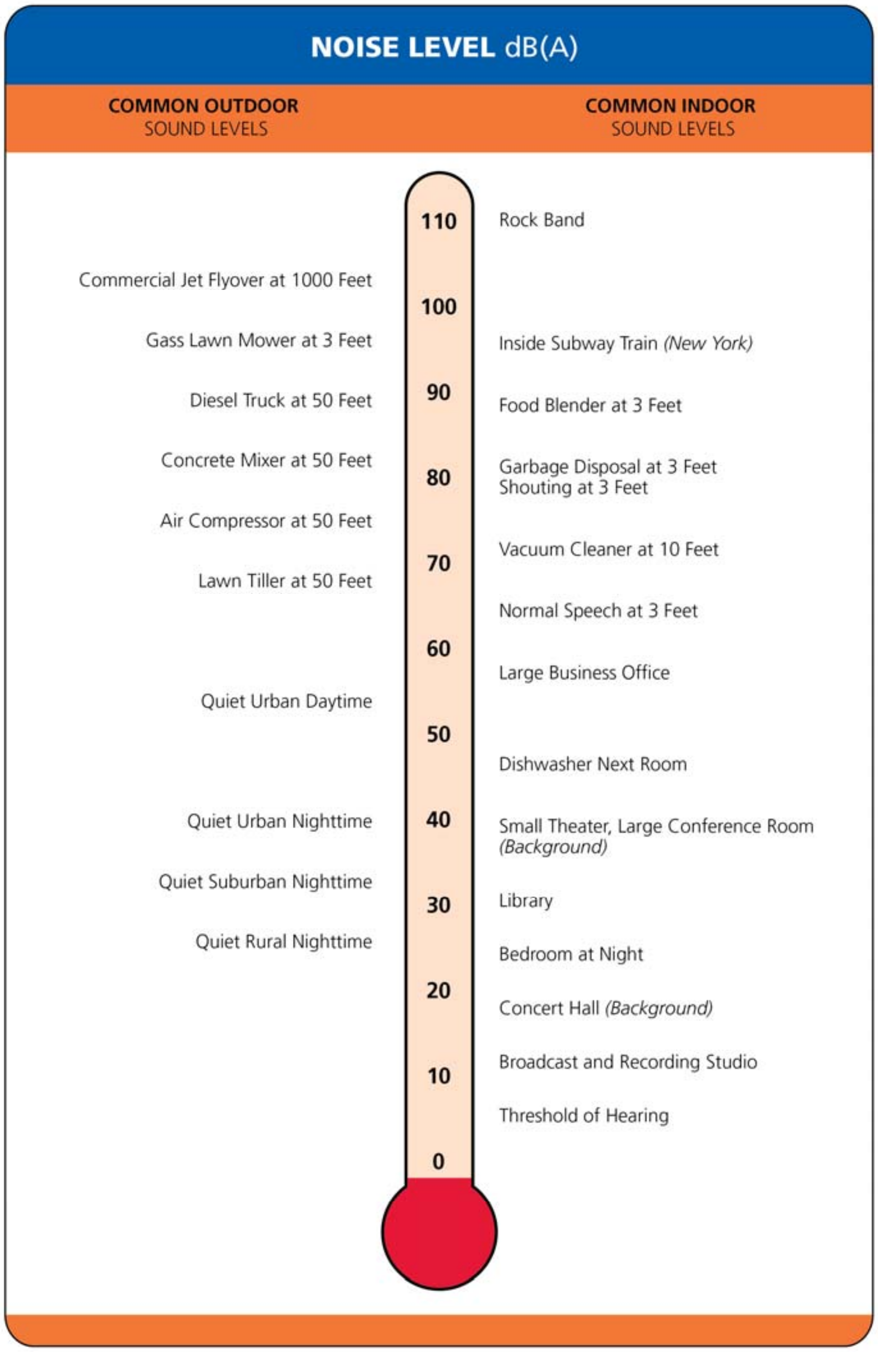


Figure 3: Sound levels for common equipment and activities

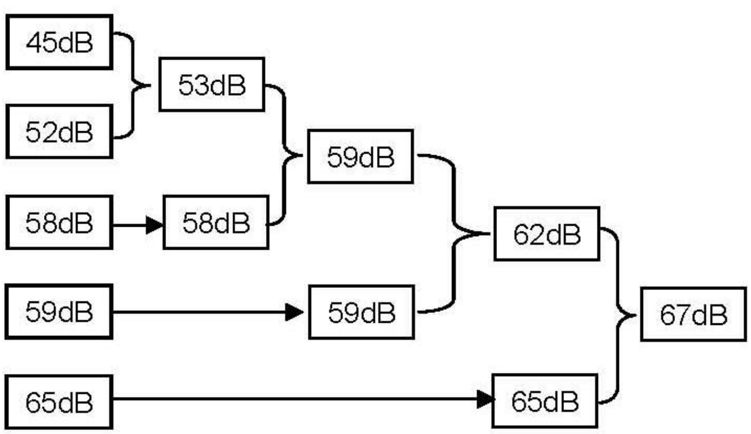
Noise walls

Some Noise Facts

When adding decibels and a calculator is not available, the table below is accurate to 1 decibel. It should be understood, however, that in practical terms noise levels are rarely known to this accuracy. When computer programs produce noise level results in tenths of decibels, it is suggested that they be rounded off to the nearest whole decibel.

When two decibel Values differ by:	Add the following amount to the higher value
0 or 1 dB	3 dB
2 or 3 dB	2 dB
4 to 9 dB	1 dB
Greater than or equal to 10 dB	0 dB

When there are several noise levels to add such as the example below, the noise levels should be added two at a time, starting with the lower-valued levels. Continue the addition procedure of two at a time until only one value remains. This is illustrated in the example below.



Noise walls
Some Noise Facts

What Causes highway traffic noise?
The principle noise sources of highway vehicles are the engine, the exhaust system and the tires. Exhaust noise is usually controlled by mufflers, assuming they are used and function properly. Engine noise can only be controlled by vehicle manufacturers and proper maintenance, factors that typically beyond the control of VDOT and FHWA. Tire noise is generated by the interaction between each vehicle's tires with the roadway surface. At speeds less than 30 miles per hour, engine and exhaust noise are usually louder than tire noise. At speeds greater than 30 miles per hour, the reverse is true, that is tire noise becomes the dominant noise source. Thus, highways are typically dominated by tire noise while local streets are typically dominated by engine and exhaust noise.

The overall noise level generated by vehicles on a highway depends on the number of factors which include the quantity of vehicles, the speed of the vehicles, and the types of vehicles. Figures 4, 5 and 6 on the pages that follow show generally how these factors influence noise levels.

Noise Barriers
When trying to mitigate a noise problem, we look for practical solutions in terms of treating the **source** of the noise, and the **path** between the noise source and the **receiver**. This concept is illustrated in Figure 7. Since it is often impractical to reduce the noise at the source or at the receiver, the only practical option left would be to reduce the noise along the path between the source and the receiver, thus the use of noise barriers.

The use of Noise barriers is the most common traffic noise mitigation. Barriers can take different forms, as long as they break the line-of-sight (noise path) between the vehicles on the highway and affected residential communities. Barriers can be in the form of walls, berm, or combination.

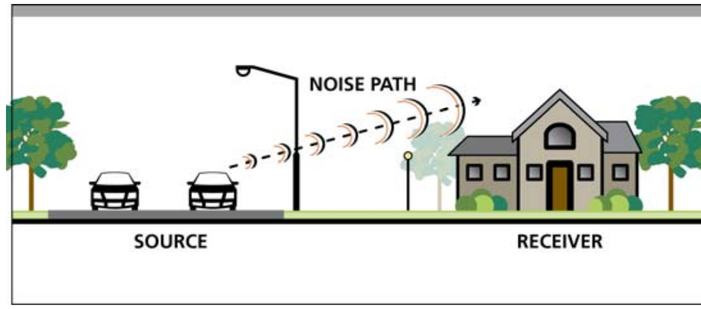


Figure 7: Source-path-receiver concept

Barriers are a popular solution because they have been proven effective at reducing noise impacts for transportation improvement projects and are typically available to the Department to provide noise mitigation for Type I projects.

Reflective/Absorptive wall
Noise walls reduce noise by shielding receivers from the noise source. Sound that reaches a noise barrier is either reflected or absorbed by the noise barrier. In situations where noise-sensitive land uses exist on only one side of a roadway, walls are designed to adequately shield those receivers. Reflective barriers are often used in such situations, as they have the capability to reflect the sound to the opposite side of the roadway. This situation can become more complex where noise sensitive land uses exist on both sides of the roadway. Attempts to provide barriers for both communities can create what is referred to as a "parallel barrier" condition. In those situations, reflective noise from a barrier on one side of the roadway can increase noise levels reaching the receivers on the opposite side of the roadway by as much as 3 dBA. To combat this situation, noise barriers can be designed with greater sound-absorbing characteristics to offset the affects of reflective noise. Sound-absorbing noise barriers allow sound waves to enter the wall. As the sound travels through the sound absorbing material the sound waves change direction and follow a longer path. <cont.to page 8>

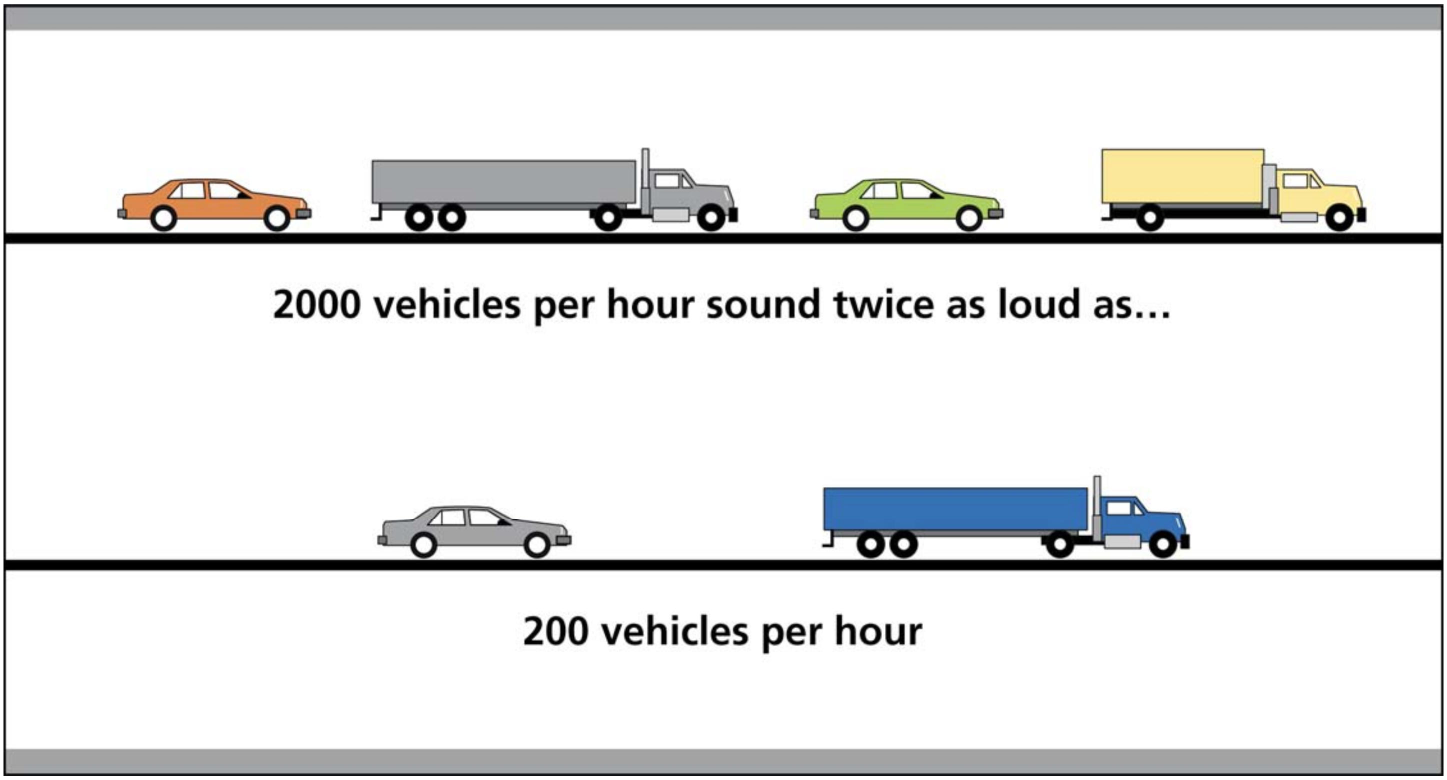


Figure 4: Effect of traffic volume on noise levels

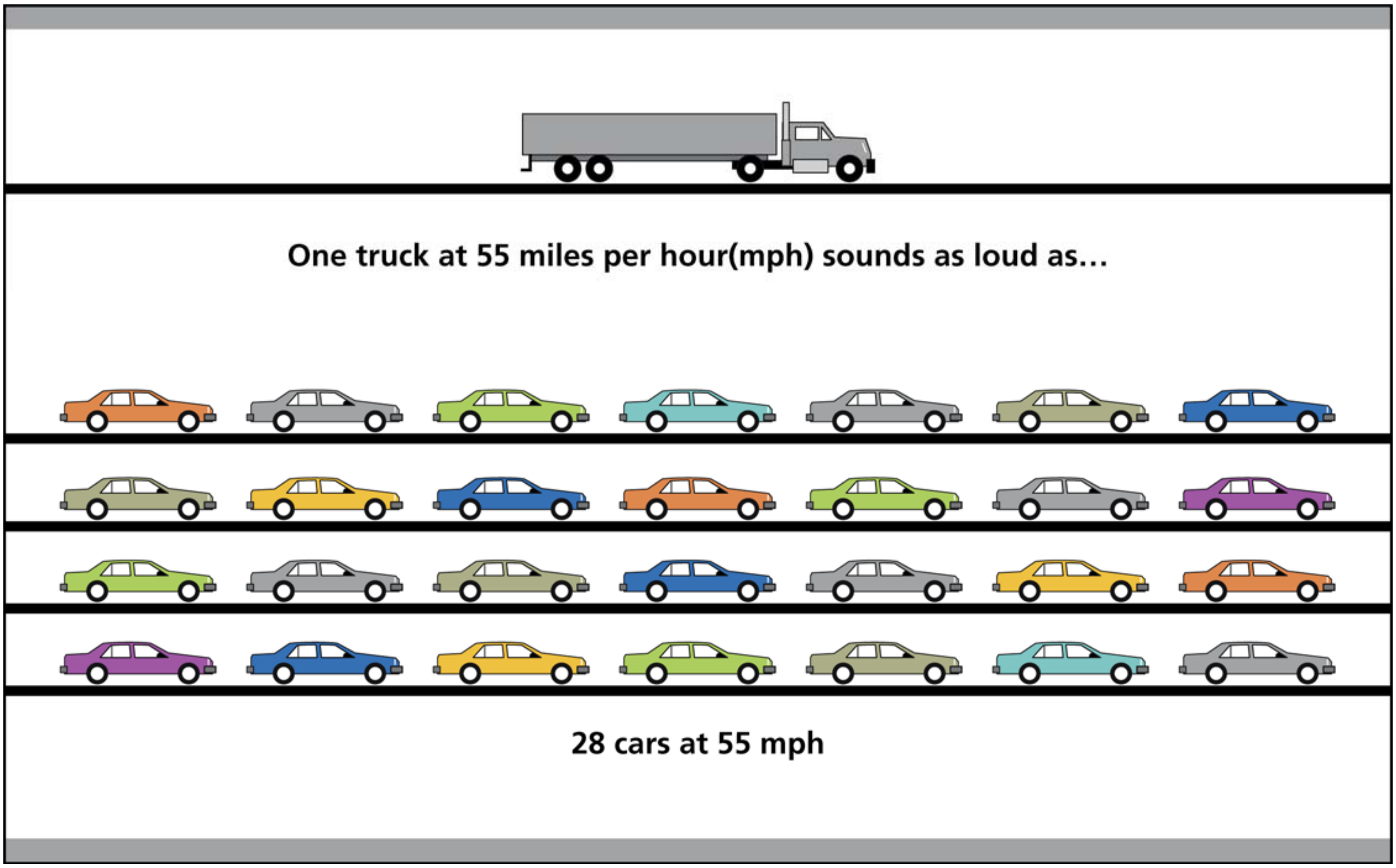


Figure 5: Effect of truck volume on noise levels

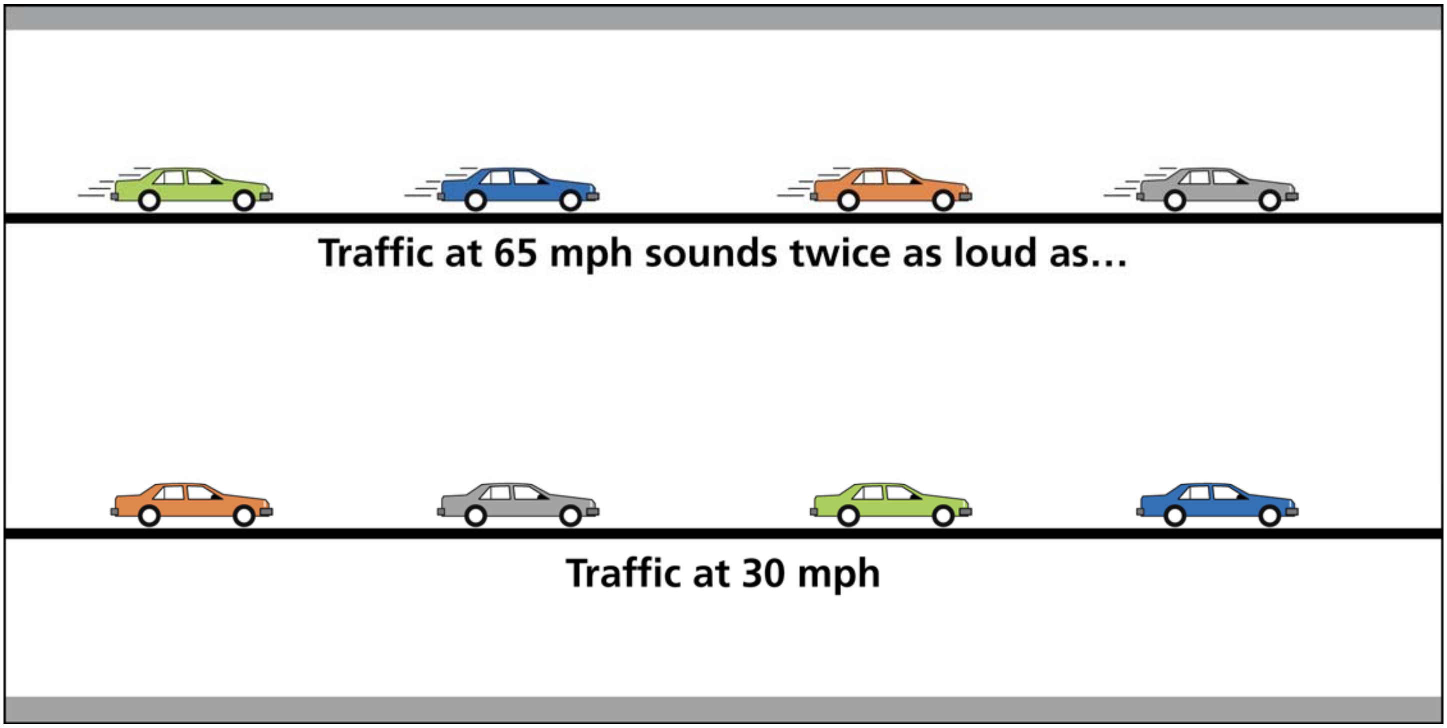


Figure 6: Effect of traffic speed on noise levels

<cont from page 4> Every change in direction decreases the sound waves' energy, limiting the amount of sound that reenters the environment as reflective sound. Figure 8 provides examples of situations that can increase reflective noise and identifies how absorptive barriers can reduce this influence. Absorptive noise barriers can effectively offset the affects of reflective noise, often reducing reflective noise by 2 to 3 dBA at receivers on the opposite side of the road as a noise barrier.

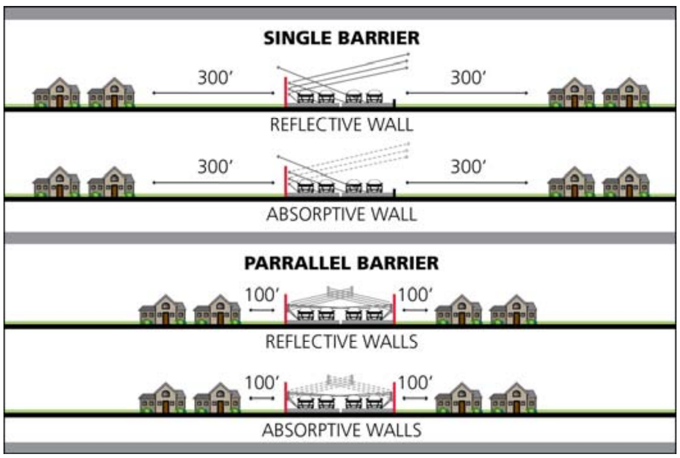


Figure 8: Reflective/Absorptive walls

Horizontal placement of noise walls
The horizontal placement of a noise barrier in relation to the source and the receiver can also impact the overall effectiveness of that barrier. In general, noise barriers are most effective when placed as close to the noise source or as close to the noise receiver as possible. The relationship of roadway, barrier, and receiver elevations can also influence the effectiveness of noise barriers, and in certain situations can render a noise barrier ineffective. If noise-sensitive land uses adjacent to a roadway corridor are significantly above the roadway grade it may be impossible to effectively block the line-of sight (noise path) with a noise barrier. Receivers that are effectively shielded by a noise barrier are considered to be in the "**shadow zone**" of the barrier. Figure 9 illustrates this.

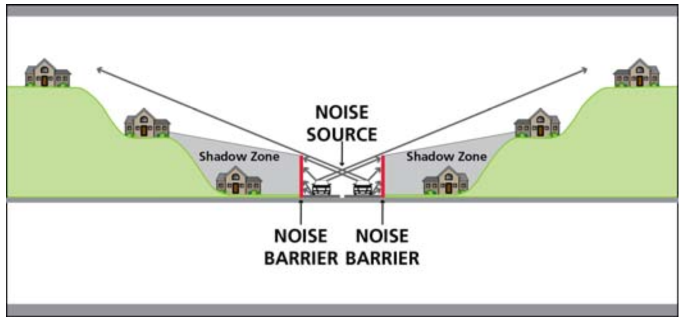


Figure 9: Shadow zone

<u>Cut/Fill</u>
Roadway design features can also dictate noise barrier placement. In roadway cut conditions, where the roadway is located below the natural grade, barriers are typically most effective when placed at the top of the cut slope, to take advantage of natural terrain, reduce barrier costs and increase barrier base elevations.

In roadway fill conditions, where the highway is above the natural grade, noise barriers are typically most effective when placed on the edge of the roadway shoulder or on top of the fill slope. Figure 10 demonstrates how barrier placement can affect barrier effectiveness.

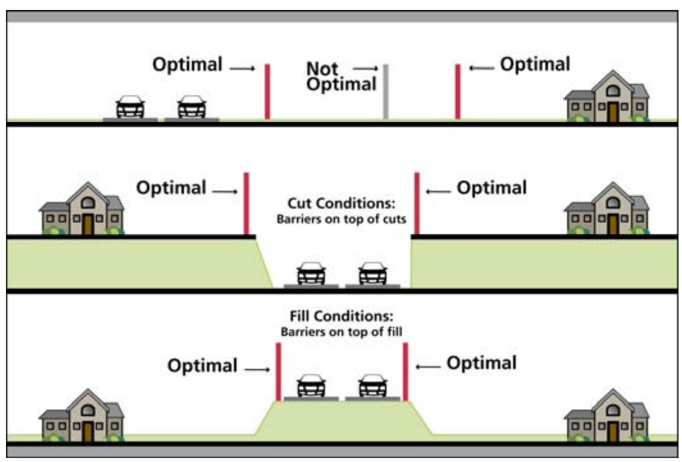


Figure 10: Barrier placement

Noise walls
Some Noise Facts

Wall Length/Flanking Noise
Flanking noise refers to the noise component that diffracts around the ends of a noise barrier, as compared to over the barrier, as illustrated in Figure 11.

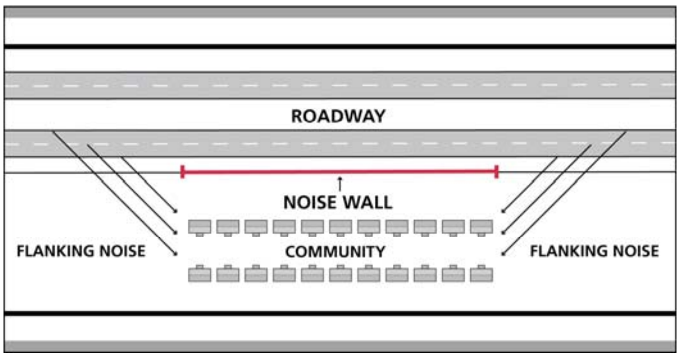


Figure 11: Flanking Noise

Flanking noise must also be considered so as to effectively mitigate for highway-noise with noise barriers. When considering the design of noise barriers to avoid flanking noise, barriers should extend well beyond the noise-sensitive land uses they are designed to protect. FHWA recommends barriers to extend beyond impacted receivers by as much as four-times the distance from the road to the receiver to offset the effects of flanking noise. Often physical features or logical termini exist, such as hill sides or bridge structures that dictate the horizontal-limits and termini of noise barrier designs. This is illustrated in Figure 12.

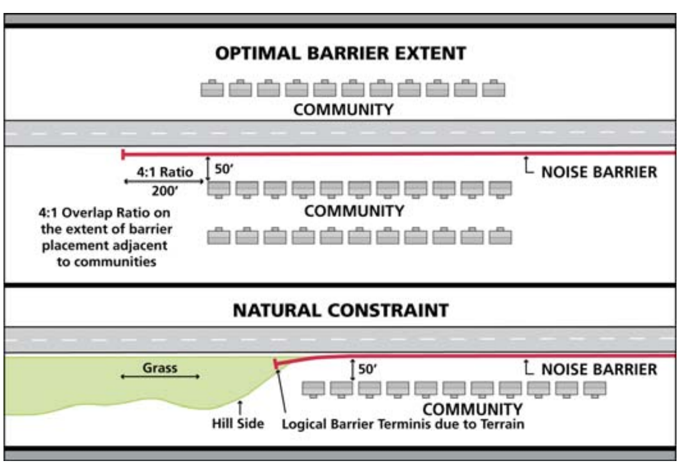


Figure 12: Barrier design, minimizing flanking noise

Wall Height
Effective noise barriers are both tall enough and long enough to significantly eliminate the line-of-sight from the roadway to the noise-sensitive sites. Generally, noticeable noise reductions (in the range of 5 dBA) are not achieved until the line-of-sight between the source to the receiver is effectively broken. Once that point is reached, additional 1-dBA reductions can typically be achieved with each 2-foot step of additional barrier height, illustrated in Figure 13. While the maximum theoretical limit of noise reduction in real-world application is 10 to 15 dBA.

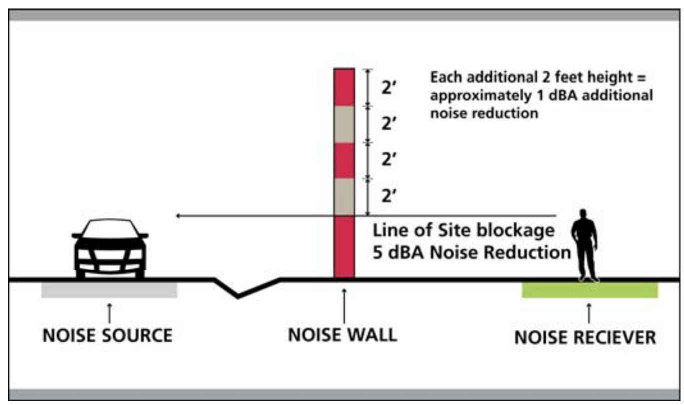


Figure 13: Line of site blockage

Berm vs. Wall

Earth berms are often used as a practical alternative to noise walls. An earth berm is generally created from earthen-material that has been moved to a specific location during the highway construction process. Earth berms are often a preferred alternative to freestanding noise walls since they can provide comparable (or greater) noise reductions, require less maintenance, provide a natural appearance, and can typically be constructed at much lower cost than typical post-and-panel noise wall systems. However, earth berms require considerably more space than noise walls, often precluding them from consideration.

Often, typical berm designs include 2:1 slopes on each side of the berm, with a level top. Assuming this standard design cross-section, a berm with a total height of 12-feet above the roadway surface would require approximately 48-feet of horizontal width, as shown in Figure 14. These space requirements can often limit the use of berms, especially in developed corridors with limited space between the highway and adjacent noise-sensitive land uses. This space requirement becomes even more of a challenge on projects, where the roadway right-of-way is already established.

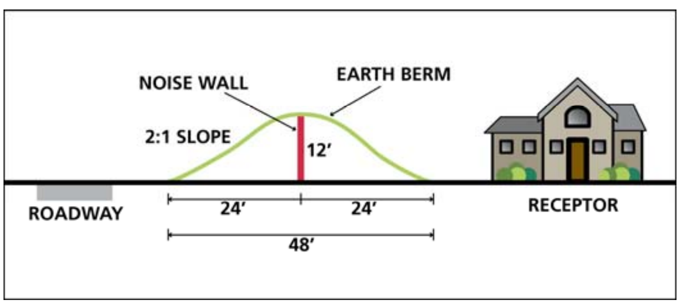


Figure 14: Berm vs. Wall

Noise walls options available in Virginia

As a way to ensure high quality noise walls, VDOT only uses noise walls that have been approved through an extensive product evaluation process. The pictures on the next pages show some of the several different types of noise wall options VDOT has available.

Roadway side-SanDiego DryStack

Roadway side-NewEngland DryStack

Roadway side-Fluted (Concrete)

Homeowner's side-Riverstone (Concrete)

Homeowners side-Fuzzy raked (Concrete)

Plastic used for light weight on structure e.g. Bridges

Metal used for light weight on structure e.g. Bridges

Roadway side Wooden barrier