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28 August 2020

Rick Felice
Felice Development Group
4601 N. Fairfax Drive, Ste. 1200
Arlington, Virginia 22203

Reference: 1333 M Street, SE
Railway Noise Reflections
Project No. FDG2001

Dear Mr. Felice:

It is the understanding of Phoenix Noise & Vibration that current residents of L Street, SE have expressed concern over the potential of railway noise impact upon their neighborhood after the construction of the proposed buildings at 1333 M Street. With the CSX railway situated between the two areas, there is fear that railway noise will reflect off the future buildings and increase the noise on the L Street houses. This letter is intended to address in general terms noise reflections from large reflecting surfaces such as a building and specifically how those principles apply to 1333 M Street.

1 Perceived Changes In Noise Level

Generally speaking, the following describes the human ear's subjective perception of changes in overall noise level:

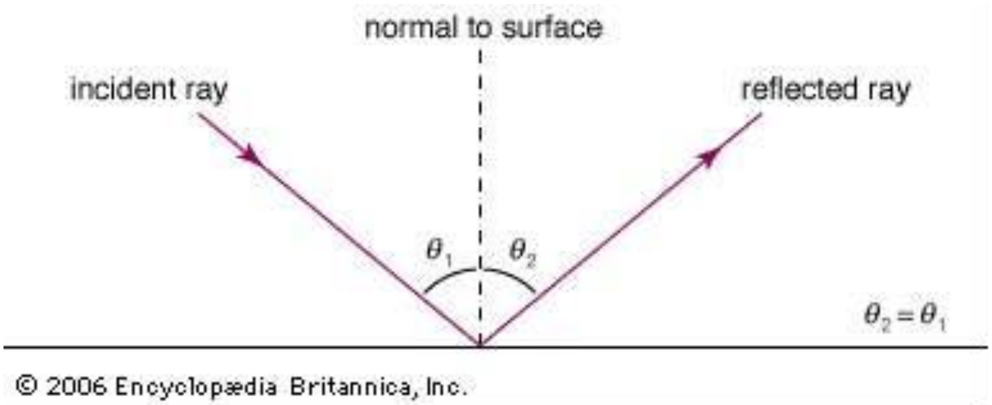
Change in Noise Level	Subjectively Heard As:
1 dBA	Imperceptible
3 dBA	Barely perceptible
5 dBA	Clearly perceptible
10 dBA	Twice as loud

Note that the average human ear cannot detect a 1 dBA change in noise level; i.e. if a radio were at a volume of 60 dBA, then the volume were increased to 61 dBA, the average listener would not notice the slight increase in volume.

2 Surface Reflections

Whenever a noise source is located in close proximity to a large, hard surface (e.g. brick building, masonry wall, etc.) some of the noise striking the surface will be reflected back towards the noise source and into areas away from the reflecting surface. Sound waves striking a flat surface reflect from that surface at an angle (called the "angle of reflection") that is equal to the angle the sound waves approached the surface (angle of incidence). The concept is represented graphically in Figure 1.

Figure 1 - Diagram showing relationship between incident and reflected sound waves



Reflective surfaces can increase the noise level on the building side facing the noise source above the noise level which would result in the same location if the building were not there. However, this is generally in the point when the angle of incidence is equal to zero, making the angle of reflection zero and the two noises sum together.

While reflected noise can increase the noise level directly in front of a reflective surface, the increase is typically insubstantial relative to the noise level resulting in that location from the direct path alone. The direct and reflected noise paths can be thought of as two noise sources, not quite identical although very similar. Two identical noise sources with the same noise level generate a 3 dB increase when emitting noise simultaneously as opposed to one of those sources alone.

Applying this principle to the combined noise level from the direct and reflected paths, the noise level from the reflected path will be equal to or less than the noise level from the direct path; therefore when considering only one reflective surface, the total noise level (direct plus reflected) in front of that surface can be at most 3 dBA greater than the noise level due to the direct path. Furthermore, this maximum 3 dBA increase will only occur if the surface is a perfect reflector, meaning that 100% of the sound energy is reflected back from the reflector. Also recall that a 3 dBA increase is only a barely perceptible difference as measured by the human ear.

3 Noise Reduction Over Distance

It is common knowledge that as a listener gets further away from a noise source the level of that source to the listener is reduced. For noise sources such as railways this reduction can be quantified as noise reduces 3 dBA per doubling of distance when situated over a hard surface such as a parking lot. For example, if one measured the noise level from a railway to be 80 dBA at a distance of 20 feet, the same noise source would measure 77 dBA (80-3) at a distance of 40 feet and 74 dBA at a distance of 80 feet. When the sound propagates across a grassy surface the reduction increases to approximately 4.5 dBA per doubling of distance. This increase in noise reduction due to the grassy surface is called ground effect.

4 NOISE BARRIERS

When a large, solid surface comes between a noise source and a listener a portion of that sound will be blocked from the listener, reducing the noise level. This principal is the basis of the noise barriers seen on local highways to block noise from the source (the highway) to listeners (nearby houses). Note that to be effective the noise barrier must at a minimum block the line of sight to the noise source. Generally speaking, as the barrier height increases more noise is blocked and the noise level at the receiver decreases. If the listener can see the source over the barrier's top edge, the barrier is having no effect on the noise source.

5 1333 M STREET OBSERVATIONS

When considering railway reflections from the future buildings at 1333 M Street and their impact upon residences along L Street, all the of the above acoustic principles must be considered. To illustrate these principles, we have enhanced an architectural drawing showing a cross section from the proposed buildings at 1333 M Street and the residences along L Street. See attached Drawing 1. In order of appearance from left to right, the drawing shows L Street residences, westbound Southeast Boulevard, boulevard median, eastbound Southeast Boulevard, the existing retaining wall along the CSX railway, the CSX railway, M Street, and Building 1- East Tower.

5.1 Reflections

In Drawing 1 red arrows are used to indicate direct sound emanating from the railway and blue arrows to indicate reflected sound. Note that sound from the passing train radiates in all directions and red arrows are used to indicate this. Some of those sounds strike the new building and the blue arrows indicate the reflected sound. Keeping the angle of incidence and reflection principle in mind, one can see that most of the sound reflected from the building radiated up into the atmosphere traveling over the residences at L Street. There is a portion of the sound that reflects from the lower area of the building which may reach the residences, however remember that the reflector is not a perfect reflector and the distance the sound must travel to reach L Street is far greater than the direct path of the same sound.

5.2 Barriers

Also notice the barrier effect of the retaining wall along the CSX railway. After the locomotive passes by, most of the noise from the railway is produced by the train wheels interacting with the tracks. The line of site to the wheels is blocked by the retaining wall reducing the noise from the wheels. This same effect applies to the low-lying reflected noise from the future building. There is a light blue shaded area beneath the lowest direct path arrow to indicate which portions of the L Street Neighborhood are blocked from the railway wheel noise by the retaining wall. The retaining wall is currently acting as a noise barrier to the railway noise.

5.3 Distance

In the cross section drawing the direct path from the railway to the area of the L Street residences measures approximately 350 feet. Following the path of the lowest reflected path from the railway to the building and then to the same point near the residences the distance measures 590 feet. Considering the noise reduction between these two distances, the reflected path is 2 to 3 dBA quieter than the direct path. Under perfect conditions, which will not occur, the reflected path would only add 1 to 2 dBA to the current direct path. Remember table one that this is basically an imperceptible difference.

5.4 Sound Quality

Since there will be some reflections from the building, there will be noise that will be present after construction which may change the quality of the noise but based upon the discussion to this point, will not increase the level. In other words, listeners may perceive a difference in the way the railway noise however the measurable level will not change. Listeners sometime mistake changes in sound quality for changes in level.

5.5 Measurements and Modeling

The above discussion is based upon basic acoustical principles concepts and our general observation of the building plans and section drawings. Showing definitively what the noise level increase, if any, will be requires a more in depth analysis including on site noise measurements at 1333 M Street and along L Street plus 3-D acoustical modeling of the site both with and without the 1333 M Street buildings. Such in depth modeling could also be used to indicate any changes in noise quality after the construction of the buildings.

6 Conclusion

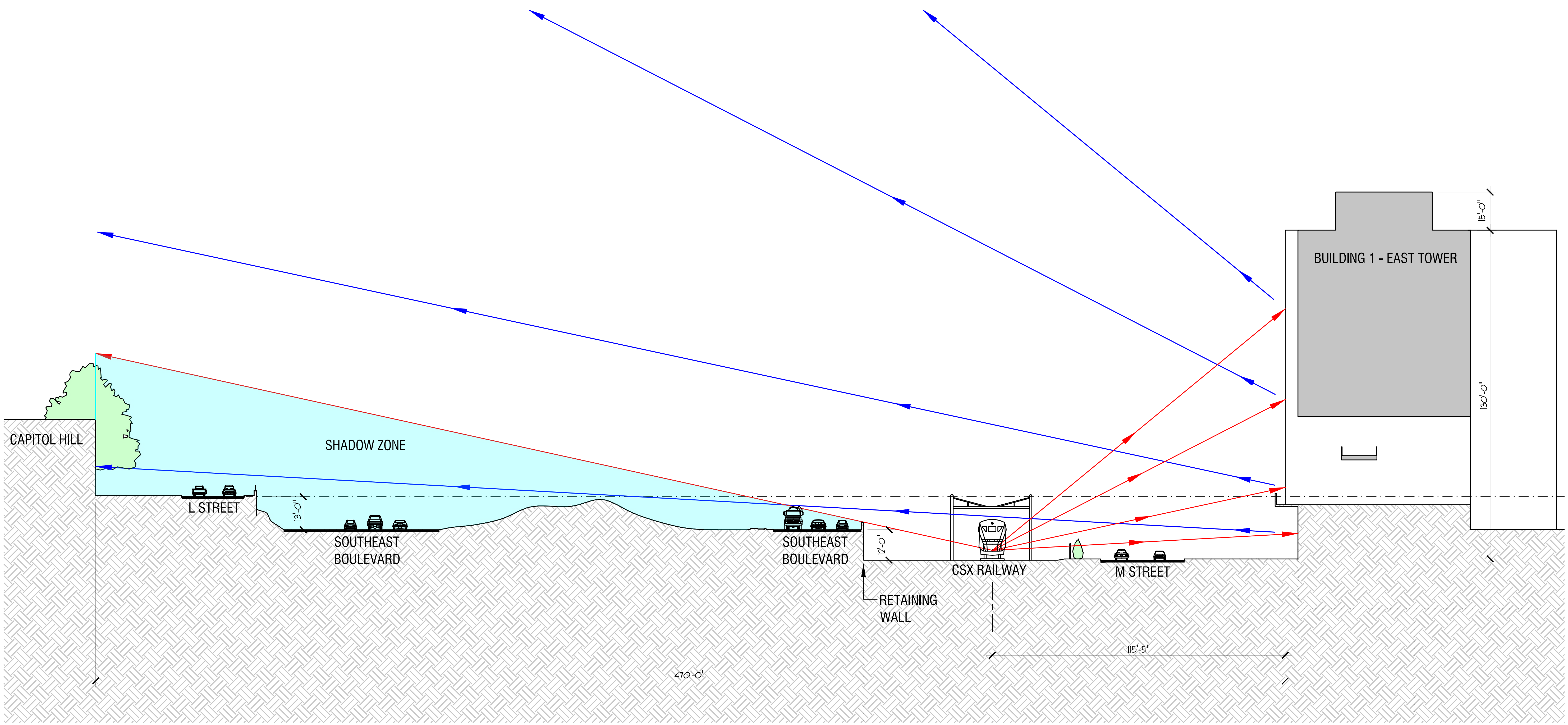
Given the above discussion we conclude that the noise level increase at the L Street residences from the construction of the buildings at 1333 M Street will be imperceptible and most likely immeasurable. Reflections from the buildings will not be significantly directed toward the residences along L Street, the retaining wall will serve as a noise barrier to the residences, and the added distance the reflected sound must travel further reduces any residual reflected noise. Because of reflections there may be a change in the quality of the noise, but the overall measurable noise level is not expected to increase.

If you have any questions, please contact me directly.

Sincerely,

Scott Harvey, PE, INCE Bd. Cert.
Chief Engineer

Encl: Drawing 1: 1333 M Street Railway Reflections



LEGEND

	SHADOW ZONE FROM RETAINING WALL
	DIRECT SOUND PATH
	REFLECTED SOUND PATH

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1333 M Street SE

REFLECTED NOISE ANALYSIS

DWG. No.	PRJ. No.	DATE
1	FDG2001	26-Aug-2020

SCALE	DRAWN BY
NOT TO SCALE	WCC