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acoustics, transportation + strategy

MEMORANDUM

To: Sylvia Novoa, SCRRA

From: Tony Evans
Hugh Saurenman
ATS Consulting

Cc: Gerard Reminiskey, HDR Engineering

Date: March 9,2018

Subject: Central Maintenance Facility Community Noise

1. INTRODUCTION

1.1 Summary of Results

ATS Consulting conducted extensive measurements of noise experienced in the communities surrounding the Metrolink Central Maintenance Facility. Initial measurements were conducted at six locations for seven days with follow-up measurements at two locations for another four days. The measured data was analyzed to isolate the facility noise from that of other sources. The resulting data was compared to the FTA Criteria and found to not exceed the Moderate Impact Threshold. Sound walls were evaluated but rejected due to being cost ineffective.

1.2 Background

The Metrolink Central Maintenance Facility (CMF), also referred to as Taylor Yard, has been a rail yard servicing locomotives and rail cars since the 1920's. The Southern California Regional Rail Authority (Metrolink) began servicing trains at CMF in 1991. Use of the facility was codified in a 1992 Memorandum of Understanding (MOU) with the City of Los Angeles and the Los Angeles County Transportation Commission (Metro).

CMF is one of Metrolink's heavy service facilities and is equipped to fuel our locomotives. Following early morning peak runs, nearly all Metrolink trains arrive at CMF to be inspected, tested, fueled, cleaned and serviced for afternoon departures. Testing usually takes between 30 and 45 minutes. During the inspection and testing process, the locomotives are required to be running to perform various functional tests mandated by federal regulations (Code of Federal Regulations 49 Parts 200 – 299). After equipment is tested and inspected, it is staged in one of the storage tracks prior to departure. For evening service equipment movements, we utilize a car mover designed to be used in place of locomotives. Metrolink makes an effort to utilize car movers to reduce noise levels.

Based upon the MOU with the City of Los Angeles, SCRRA locomotives "will not idle at the site unless for the purpose of being serviced, and will not be moved at the site after 10 p.m. except for returning train sets destined for overnight storage at the facility or to initiate early morning service, thus noise at the CMF site will be reduced from former freight yard operating levels." The current CMF daily operations schedule was developed in accordance with this agreement and balanced concerns regarding the impact on the surrounding community with statutory requirements for maintenance. Metrolink is making significant changes to be a responsible neighbor to the community.

Recently, Metrolink began receiving frequent complaints about the noise emissions of the CMF. This led to hiring ATS Consulting to assess the noise environment in the surrounding communities to determine how it compares to the relevant noise criteria.

2. MEASUREMENTS

Community noise measurements were conducted in two sessions. The first took place over 8 days and had 6 monitoring locations. The second took place over four days and had two monitoring locations. All measurements were conducted with third-octave spectra and one-second sampling. The first round of testing was conducted September 21st through 28th, 2017 at the following locations:

- ***N-1:*** This monitoring location was at the end of Duvall St. at the fence separating the walking path. The monitor was a Larson Davis 831.
- ***N-2:*** This monitoring location was in the side yard of the residence at 2449 Harwood St. The monitor was a Larson Davis 831.
- ***N-3:*** This monitoring location was in the back yard of the residence at 2444 Riverdale Dr. near the deck of the rear building. The monitor was a Larson Davis 831.
- ***N-4:*** This monitoring location was at the fence line of the Taylor Yard Apartments at the nearest point to the Central Maintenance Facility. This measurement is adjacent to the through tracks used by Metrolink, Amtrak, and freight trains. The monitor was a Larson Davis 831.
- ***N-5:*** This monitoring location was in the Central Maintenance Facility near the main building and the load testing area. It was directly across the river from Site N-1. The monitor was a Brüel and Kjær 2250.
- ***N-6:*** This monitoring location was in the Central Maintenance Facility near the Servicing and Inspection area. It was directly across the river from Site N-2. The monitor was a Brüel and Kjær 2270.

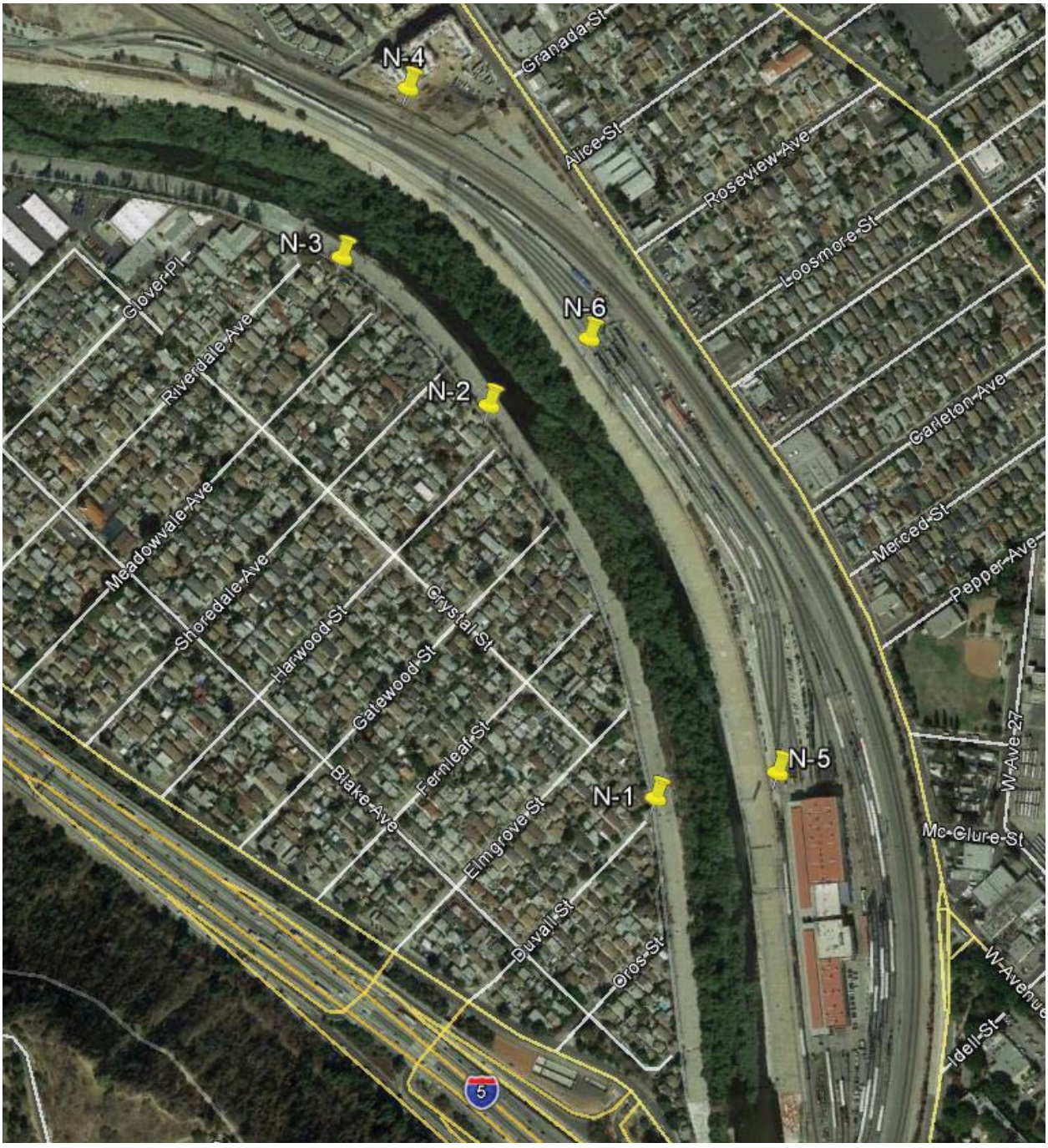

Figure 1: Measurement Locations for the Metrolink Central Maintenance Facility

The additional follow-up measurements were requested by the community to ensure that the sound output of the CMF was not affected by the coordination with the workers of the facility. These measurements were done without communication with the facility workers and occurred from October 27th to October 30th. They were placed at the following locations:

- ***N-2b:*** This monitoring location was in the side yard of the residence at 2449 Harwood St. The monitor was a Brüel and Kjær 2270.
- ***N-3b:*** This monitoring location was in the side yard of the residence at 2444 Riverdale Dr. near the deck of the rear building. The monitor was a Brüel and Kjær 2250.

3. ANALYSIS

The measurement program described above resulted in over 1000 hours of measured data. This caused a unique challenge in that it was not feasible to manually inspect all of the data to isolate possible noise events caused by the CMF. This led to the development of a new analysis method that could scale more easily to large datasets:

1. The selected community monitoring location was paired with a corresponding monitoring location within the CMF.
2. Spectrograms of the measured data were generated for each monitor for each day of the measurements. Example spectrograms can be seen in Figure 2. The X-axis is the hour of the day (from 0 to 23), the Y-axis is the frequency in 1/3-octave bands, and the color indicates the measured sound level (with red being high noise and blue being low noise).

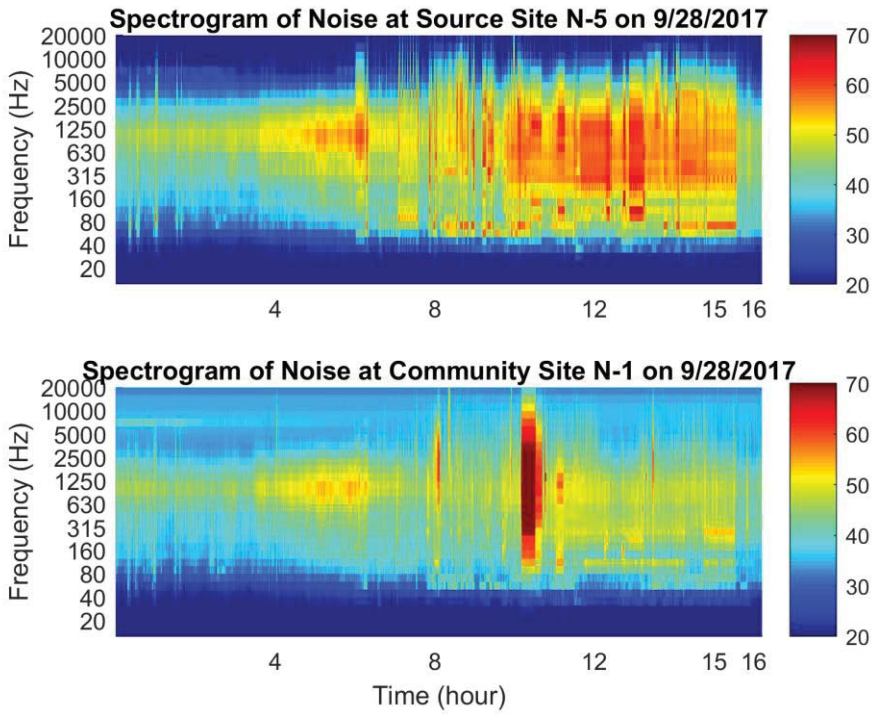

Figure 2: Spectrograms of measured noise at two monitoring sites for 9/28/17

3. The community monitoring spectrogram was then subtracted from that of the CMF monitoring site. This created a new spectrogram of the difference between the noise levels in each frequency band at every second of the day (the example is of a partial day). This difference spectrogram can be seen in the upper plot of Figure 4.

4. An attenuation model was developed to give a range of possible measurement differences from noise sources located within the CMF.

5. A binary mask was generated using the difference spectrogram from Step 3 and the attenuation range from Step 4. For each point in the difference spectrogram, the sound level was compared to the attenuation range. If the sound level was within the attenuation range, the corresponding point on the binary mask was set to 1 and, if not, the corresponding point was set to 0. Figure 3 shows a sample mask from a different day's measurement. In the plot, the yellow represents 1 and the violet represents 0. The other colors are artifacts in the visual representation of the data.

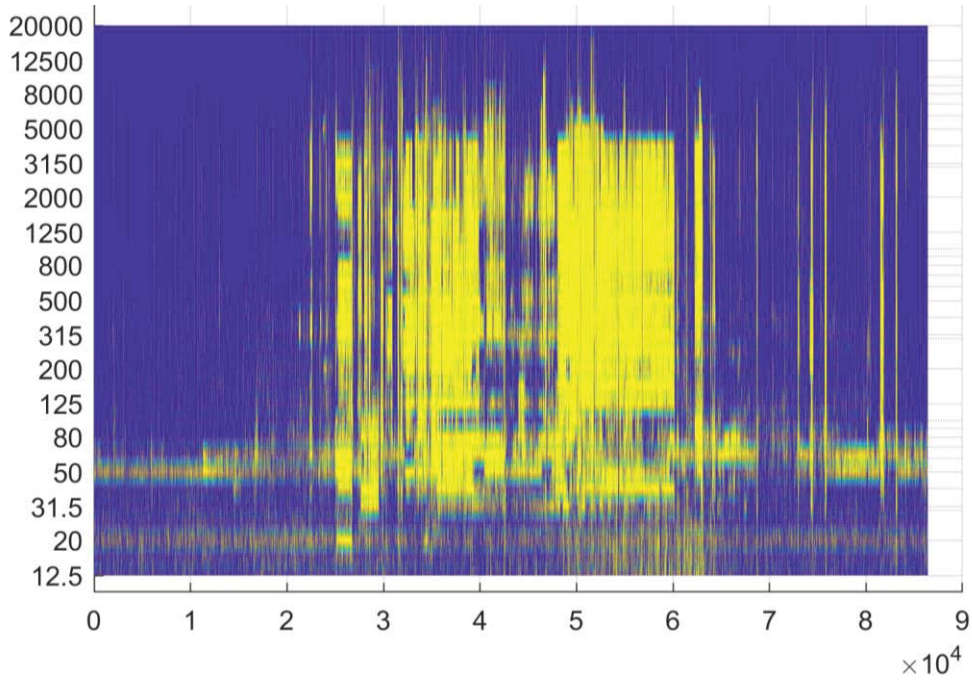

Figure 3: A sample binary mask from 9/22/17.

6. The binary mask was then used to eliminate extraneous noise sources from the community measurement. This was done by taking each point of the community measurement and, if the corresponding data point in the binary mask was 0, setting its sound level to -100dB (a level that is effectively nonexistent). This resulted in a masked spectrogram of community noise that only included noise sources that could plausibly be coming from the CMF. As can be seen in the lower plot of Figure 4, this process results in a spectrogram that has noise primarily during the operating hours of the CMF and also effectively removed the intrusive community noise event.

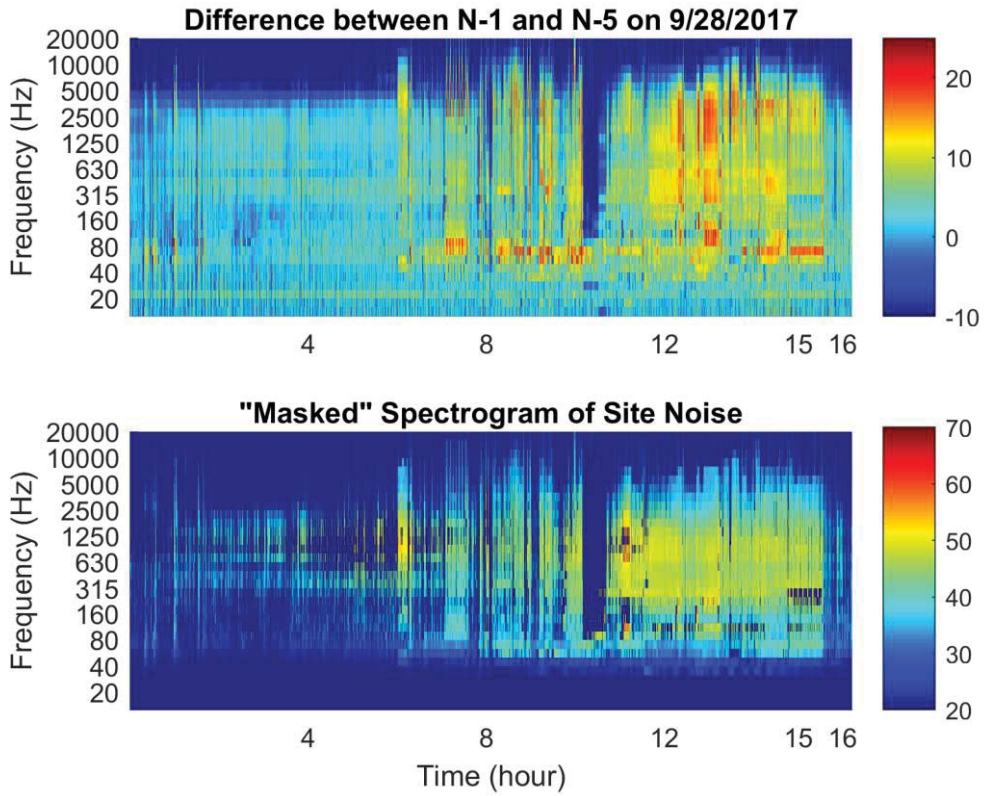

Figure 4: The top plot shows the difference spectrogram calculate from those of N-1 and N-5. The lower plot shows the masked spectrogram of noise at N-1 after extraneous events have been removed.

7. The resulting masked spectrogram could then be used to calculate overall noise levels for each hour of the day to determine how much of the noise experienced at the community monitoring location might be a result of CMF noise sources. Figure 5 shows the resulting hourly levels for site N-1 on 9/28/17.

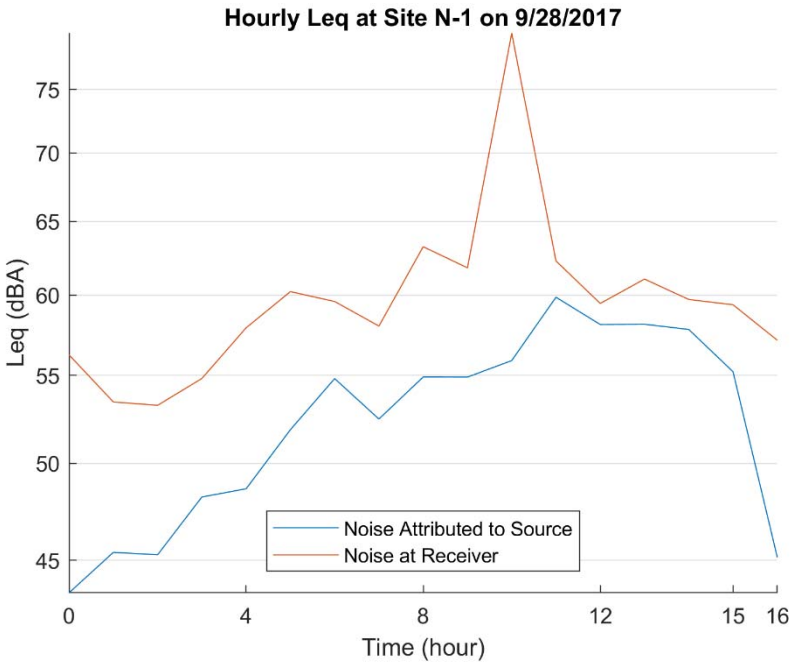

Figure 5: The hourly noise levels at N-1 for 9/28/17. The orange line is the raw measured data while the blue represents the noise levels attributed to the CMF.

This analysis method proved useful for estimating the noise levels that could reasonably be attributed to the CMF. However, it did have some limitations:

- Noise from too far to the sides (when looking from one monitor to the other) and could not be easily isolated. Figure 6 shows lines of continuous noise difference between two monitoring locations. In this analysis method, any point along a given line would result in the same difference between the noise levels measured at the monitors. For noise sources on the far side of the source monitor, the circles are fairly small, but sources between the monitors are part of lines that cover a very large area and are not easily included without including vast amounts of extraneous noise. This problem posed a challenge when analyzing the data from monitors N-3 and N-4.
- Noise sources near the community monitor could cover up noise from the facility. This is a fairly minor problem as most noise sources on the CMF take place over a longer period of time so most of the noise from the CMF would remain.

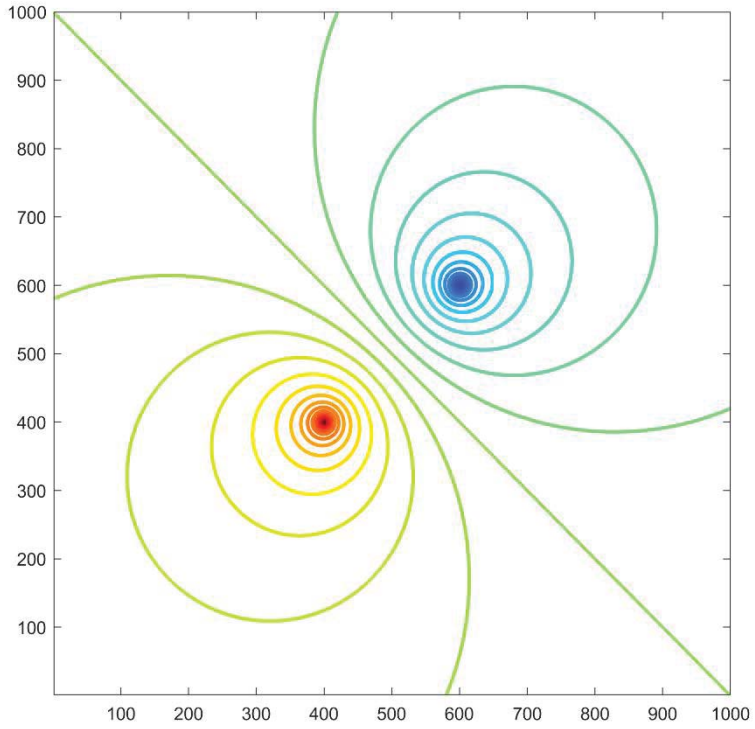

Figure 6: Contour plot of lines of equal noise difference between two monitoring locations

4. ANALYSIS RESULTS

When looking at relevant noise regulations that apply to the CMF, it was determined that the local noise ordinances did not include noise emitted by railways. Although the FTA Criteria technically only apply to new construction or changes to existing alignments and the CMF began use in 1991, the FTA Criteria were still selected as the most relevant criteria to compare to for the purposes of evaluating the noise effects on the surrounding community. Because the FTA Criteria use the L_{dn} metric, the hourly noise levels calculated were then used to calculate the L_{dn} overall noise, facility noise, and community noise, for each day of the measurements. The results of these calculations can be seen in Table **1** through Table **4**. In the FTA Criteria, a Moderate Impact would require consideration of mitigation, while a Severe Impact would require mitigation. As can be seen in the tables below, there were occasional exceedances of the FTA Moderate Impact Threshold at N-2 and N-4, while initial calculations showed daily Moderate Impact at N-3. The results at N-3 seemed out of keeping with the other monitoring locations, so those results were investigated further.

Table 1: Measurement Results for N-1							
Date	L_{dn}	Est CMF L_{dn}	Bgnd L_{dn}	FTA Moderate	FTA Severe	Mod Diff	Sev Diff
9/22/2017	62.6	55.8	61.6	58.7	64.2	-2.9	-8.5
9/23/2017	61.0	48.0	60.7	58.2	63.8	-10.2	-15.8
9/24/2017	62.3	50.1	62.0	59.0	64.5	-8.9	-14.4
9/25/2017	63.3	57.4	62.0	59.0	64.5	-1.6	-7.1
9/26/2017	63.1	51.3	62.8	59.4	64.9	-8.1	-13.6
9/27/2017	63.2	56.2	62.2	59.1	64.6	-2.9	-8.4

Table 2: Measurement Results for N-2							
Date	L_{dn}	Est CMF L_{dn}	Bgnd L_{dn}	FTA Moderate	FTA Severe	Mod Diff	Sev Diff
9/22/2017	61.3	57.6	59.0	57.2	62.9	0.4	-5.3
9/23/2017	56.5	47.2	55.9	55.7	61.5	-8.5	-14.3
9/24/2017	58.7	48.9	58.2	56.8	62.5	-7.9	-13.6
9/25/2017	60.0	54.7	58.5	57.0	62.6	-2.3	-8.0
9/26/2017	61.2	56.4	59.5	57.5	63.1	-1.2	-6.8
9/27/2017	59.9	54.8	58.2	56.8	62.5	-2.0	-7.7

Table 3: Measurement Results for N-3							
Date	L_{dn}	Est CMF L_{dn}	Bgnd L_{dn}	FTA Moderate	FTA Severe	Mod Diff	Sev Diff
9/22/2017	61.3	58.4	46.9	52.4	59.0	6.0	-0.5
9/23/2017	56.5	56.5	49.6	53.2	59.5	3.3	-3.0
9/24/2017	58.7	57.1	53.3	54.6	60.6	2.5	-3.5
9/25/2017	60.0	58.7	44.2	51.8	58.7	6.9	0.0
9/26/2017	61.2	59.3	51.3	53.8	59.9	5.5	-0.6
9/27/2017	59.9	58.1	52.5	54.3	60.3	3.9	-2.2

Table 4: Measurement Results for N-4							
Date	**L_{dn}**	**Est CMF L_{dn}**	**Bgnd L_{dn}**	**FTA Moderate**	**FTA Severe**	**Mod Diff**	**Sev Diff**
9/22/2017	61.3	60.9	65.1	60.9	66.3	0.0	-5.3
9/23/2017	56.5	58.1	63.5	59.8	65.3	-1.7	-7.2
9/24/2017	58.7	57.5	70.1	64.4	69.5	-6.9	-12.1
9/25/2017	60.0	61.0	66.2	61.6	66.9	-0.6	-5.9
9/26/2017	61.2	62.4	65.8	61.3	66.7	1.1	-4.2
9/27/2017	59.9	61.2	66.6	61.9	67.2	-0.7	-6.0

As can be seen in Table **3**, the calculated background noise L_{dn} at N-3 was significantly lower than any of the other monitoring locations. Because the background L_{dn} was calculated by removing the estimated CMF L_{dn} from the overall measured L_{dn}, it was suspected that the previously described analysis was overattributing noise to the CMF. One would expect that the background Ldn at N-3 would be very similar to that of N-2 and fairly similar to N-1 because they have similar non-CMF noise sources at similar distances. In fact, N-3 was only about 700 feet away from N-2. Table **5** shows the results of each community measurement location described as an average L_{dn}. Because we expect the L_{dn} at N-3 to be roughly the same as that of N-2, we conducted an analysis assuming that the background noise level at site N-3 was only one dB lower than that of N-2. Working with this assumption, we then calculated the remaining noise levels and criteria. The results of this calculation are shown in parentheses in Table **5** and are much more in line with the levels measured at N-2. In addition, the recalculated levels are well below the Moderate Impact Threshold.

Table 5: Overall Average Results							
Date	**L_{dn}**	**Est CMF L_{dn}**	**Bgnd L_{dn}**	**FTA Moderate**	**FTA Severe**	**Mod Diff**	**Sev Diff**
N-1	62.6	54.4	61.9	58.9	64.4	-4.5	-10.1
N-2	59.9	54.6	58.3	56.9	62.6	-2.3	-8.0
N-3*	58.8	58.1(53.5)	50.6(57.3)	53.6(56.4)	59.7(62.1)	4.6(-2.9)	-1.6(-8.6)
N-4	67.7	60.5	66.7	62.0	67.3	-1.5	-6.7

There were concerns that, because the original measurements were conducted in coordination with CMF Operations, that the day to day operations might have been modified to reduce the noise levels. Because of these concerns, a second round of measurements was conducted at sites N-2 and N-3 without consulting CMF Operations. The results of these measurements are shown in Table **6**. Each day was compared with the equivalent weekday from the original measurements. The daily differences were then

averaged. The N-2 site found an increase of 0.7dB and the N-3 site found a decrease of 1.1dB. These results are within the expected day-to-day variation and don't show a significant trend.

Table 6: Follow-up Measurement Results

Date	N-2b Ldn	N-2 Change	N-3b Ldn	N-3 Change
10/27/2017	61.5	0.1	59.8	1.0
10/28/2017	59.4	2.9	56.9	-0.4
10/29/2017	57.0	-1.6	55.0	-3.5
10/30/2017	61.4	1.4	57.4	-1.5
Average		**0.7**		**-1.1**

5. CONCLUSIONS

Although the FTA Criteria don't technically apply to this situation, they were selected as the most appropriate metrics to evaluate the noise emitted by the Metrolink Central Maintenance Facility. Approximately 1200 hours of data was recorded in the CMF and the surrounding community. The analysis indicates that none of the community measurement locations regularly exceeded the FTA Moderate Impact Threshold at which mitigation should be evaluated. Nonetheless, sound walls were evaluated both at the property line and specifically shielding the Load Testing Area. Both sound wall configurations were not found to be cost effective for the amount of noise mitigation they would provide.