APPENDIX 8: NOISE AND VIBRATION MODELING MATERIALS

APPENDICES

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Appendix 1: Noise Monitoring Results

Field Noise Survey

The project corridor is in a densely developed urban area consisting almost entirely of mid- to high-rise structures. The present noise environment is largely controlled by surface transportation noise consisting of bus, auto and truck traffic, as well as fixed-guideway electric streetcar operations.

A noise measurement survey was performed for the dual purpose of characterizing the existing noise environment along Market Street and providing data to validate the transportation noise modeling. This survey consisted of:

1. Attended and unattended noise level monitoring of the prevailing ambient noise along the project corridor, and
2. Measurements of passby[1] noise from individual historic rail cars operating along the SFMTA F-line on Market Street.

Noise Monitoring Results

Noise monitoring was performed between April 30 and May 1, 2018, at four long-term and nine short-term measurement locations. Table 1 provides locations and descriptions of the sites. Locations were selected following a walking soundscape survey of Market Street and were chosen to provide both uniform spatial coverage and to capture the range of noise exposure along the project corridor.

TABLE 1: NOISE MONITORING LOCATIONS

Site ID	Site Location	Latitude	Longitude	Primary Noise Source(s)
Long-term Measurements (24 hours)				
LT-1	Between Brady and 12th Streets, south side	37.7740	-122.4206	Streetcars and traffic
LT-2	Between 7th and 8th Streets, on UN Plaza	37.7801	-122.4142	Traffic on side streets
LT-3	Between Montgomery and Kearny Streets, north side	37.7885	-122.4026	Streetcars and traffic
LT-4	Between Spear and Steuart Streets, south side	37.7942	-122.3951	Streetcars and traffic
Short-term Measurements (20–30 minutes)				
ST-1	Market Street at 11th Street, north side	37.7757	-122.4188	Streetcars and traffic
ST-2	S/W corner, 10th and Market Streets	37.7764	-122.4175	Streetcars and traffic
ST-3	N/W corner of McAllister and Jones Streets	37.7812	-122.4122	Streetcars and traffic
ST-4	East side of Hallidie Plaza	37.7845	-122.4079	Streetcars and traffic
ST-5	S/W corner of Market Street and Yerba Buena	37.7862	-122.4050	Streetcars and traffic
ST-6	Yerba Buena, 300 feet from Market Street	37.7856	-122.4042	Traffic on side streets
ST-7	Yerba Buena, south side of Mission Street	37.7850	-122.4035	Traffic on side streets
ST-8	North side of Market Street, 100 feet east of 2nd Street	37.7896	-122.4012	Streetcars and traffic
ST-9	Between Fremont and 1st Streets, south side	37.7914	-122.3985	Streetcars and traffic

[1] *Passby* is the noise or vibration from a single vehicle in motion (approaching, passing by, or receding) that is observed to be audible above ambient levels. Noise or vibration levels from passbys are often expressed in terms of sound exposure level and L_{max}.

Site ID	Site Location	Latitude	Longitude	Primary Noise Source(s)
Streetcar Passby Noise Measurements				
TR-1A	Southeast corner of Castro and Market Streets	37.7626	-122.4349	Streetcar curve squeal
TR-1B	S/E corner of Market and Noe Streets	37.7642	-122.4330	Streetcar curve squeal
TR-1C	Corner of Market and Steuart Streets	37.7946	-122.3948	Streetcar curve squeal
TR-2	S/W corner of Market and 12th Streets	37.7741	-122.4204	Streetcars, tangent track over asphalt
TR-3A	N/E corner of Market Street and Van Ness Avenue	37.7755	-122.4190	Streetcars, tangent track over asphalt
TR-3B	Market between Van Ness Avenue and 10th Street, north side	37.7759	-122.4186	Streetcars, tangent track over asphalt
TR-4	Market between 9th and 10th Streets, north side	37.7771	-122.4171	Streetcars, tangent track over asphalt
TR-5A	N/W corner of Market Street and Charles J. Brenham Place	37.7803	-122.4130	Streetcars, tangent track over BART grates
TR-5B	Market Street at Powell Street, south side	37.7847	-122.4071	Streetcars, tangent track over BART grates
TR-5C	N/W corner of Market and Montgomery Street	37.7886	-122.4025	Streetcars, tangent track over BART grates

The unattended noise monitors ("long-term" in the table) were mounted on existing utility poles, at an approximate height of 10 feet. The attended ("short-term") measurements were made using portable sound level meters, mounted on tripods and set at ear height.

The short-term measurements provided supporting detail about the existing noise environment and served as "infill" measurements to complement the long-term monitoring results. The long-term measurements each covered a 24-hour period, and short-term measurements were either 20 or 30 minutes in duration. The daily noise levels are summarized in Table 2. Two sets of daily metrics are reported:

1. Calculated using hourly L_{eq} values. These give the conventional, overall daily average levels.
2. Calculated using hourly L_{50} values. These exclude the influence of transient noise events were used a proxy for the traffic noise contribution to the overall level.

Measured noise levels along Market Street were fairly uniform, with L_{dn} values at the four long-term monitoring sites ranging from 73 to 77 dBA. L_{dn} values at the short-term locations[2] ranged from 69 dBA to 77 dBA. The hour-by-hour variation in level covered a range of 9-14 dB depending on the location. Figure 1 shows measured hourly average noise level values at each of the long-term sites. At three of the four sites, the hourly average noise levels remained above 70 dBA for the majority of the day. (Site 2 was the expected exception to this, being located 230 feet from the Market Street centerline *vs*. about 45 feet for the other monitoring locations).

[2] Daily metrics at the short-term positions were inferred by adjusting the nearest long-term level by the difference between the short-term level and the corresponding HNL at that long-term site.

TABLE 2: SUMMARY OF LONG- AND SHORT-TERM NOISE MONITORING

Site ID	Calculated Using Hourly L_{eq} Levels				Calculated Using Hourly L_{50} Levels			
	$L_{eq}(24)$	Peak Hr	L_{dn}	CNEL	$L_{eq}(24)$	Peak Hr	L_{dn}	CNEL
Long-Term (24 hr) Levels (Measured)								
LT-1	70.8	78.3	75.1	75.6	66.9	70.2	71.5	71.9
LT-2	67.0	74.3	72.9	73.1	64.1	68.9	71.0	71.1
LT-3	71.9	75.2	77.0	77.5	68.7	71.4	73.0	73.4
LT-4	70.2	73.1	74.7	75.0	68.3	71.2	72.3	72.7
Short-term Levels (Inferred)								
ST-1	67.8	75.2	72.0	72.5	64.2	67.5	68.8	69.2
ST-2	69.5	77.0	73.7	74.3	66.4	69.7	71.0	71.4
ST-3	65.0	72.5	69.3	69.8	68.9	72.2	73.5	73.9
ST-4	70.6	73.9	75.7	76.2	65.8	68.5	70.1	70.5
ST-5	70.6	73.9	75.7	76.2	68.3	71.0	72.6	73.0
ST-6	65.3	68.6	70.4	70.9	63.2	65.9	67.5	67.9
ST-7	63.7	66.9	68.8	69.3	60.2	62.9	64.5	64.9
ST-8	70.4	73.7	75.5	76.0	66.5	69.2	70.8	71.2
ST-9	72.5	75.4	77.0	77.3	65.8	68.7	69.8	70.2

FIGURE 1: HOURLY NOISE LEVELS AT LONG-TERM SITES

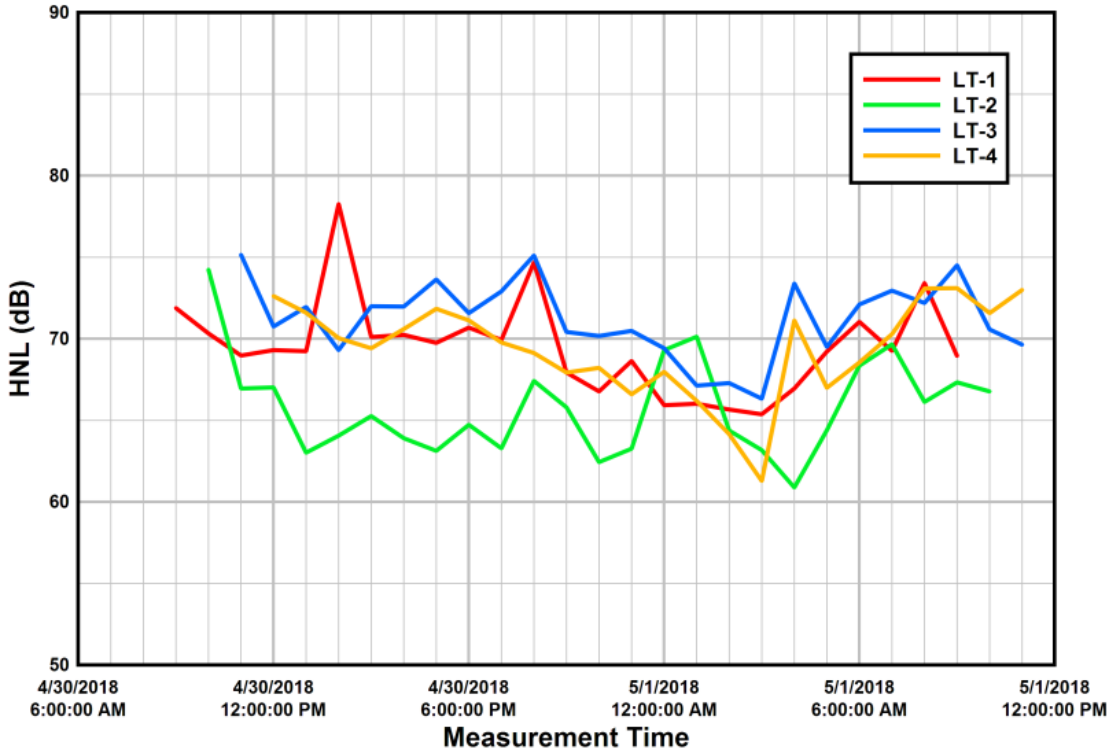


Figure 2 and Figure 3 show the L_{eq} and L_{50} noise levels respectively for just the Market Street locations (i.e., excluding LT-2, ST-6, and ST-7). The diurnal variation in L_{eq} is discernable but not particularly pronounced: hourly noise levels almost never fell below 65 dBA. Examining the L_{50} levels[3] (Figure 3), the results are more uniform. Even here, the levels fall below 65 dBA for just six to eight hours during the late evening/early morning hours.

FIGURE 2: MARKET STREET L_{EQ} LEVELS AT LONG- AND SHORT-TERM MEASUREMENT SITES

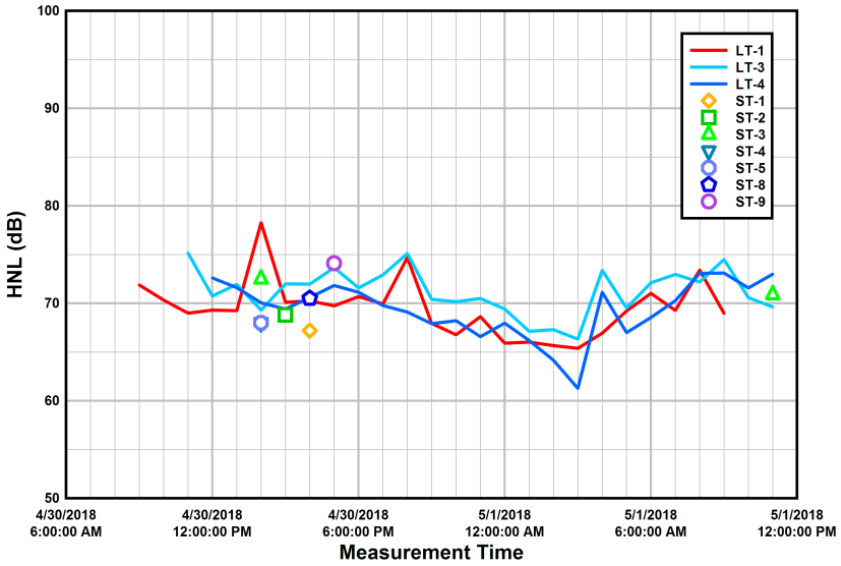
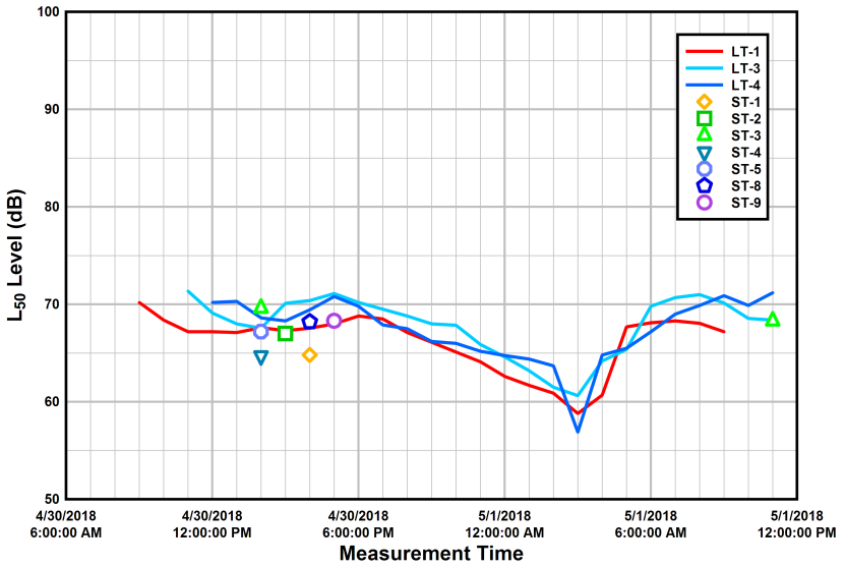


FIGURE 3: MARKET STREET L_{50} LEVELS AT LONG- AND SHORT-TERM MEASUREMENT SITES



[3] The L_{50} levels reflect the influence of relatively continuous and/or spatially distributed contributors such as traffic noise and exclude more transient elements such as horns and sirens. For this reason, L_{50} levels were used in validating the baseline Market Street noise model

Streetcar Passby Noise Measurements

Streetcar passby measurements were performed on April 19, 2018, using the in-service historic F-line cars. By prior arrangement, these included a sampling of "Milan" streetcars, considered by SFMTA staff to be among the noisier vehicles in their inventory. A total of 43 passby measurements were obtained at 10 locations identified in Table 1 and the 11 different streetcars identified in Table 3. The measurements were made at a nominal distance of 30 feet from the rail centerline. The 10 passby measurement locations were selected to characterize track sections along Market Street that might be expected to differ acoustically. The analysis showed no significant differences among some of these sites, so for modeling purposes the measurements were pooled into three categories:

1. Straight (tangent) track sections.
2. Short-radius curves (with a turn radius of 100 feet or less).
3. Tangent track over BART grates.

TABLE 3: HISTORIC STREETCARS MEASURED

No.	Livery	Car No.	Passbys
Non-Milan Streetcars (Presidents' Conference Committee [PCC] Streetcars)			
1	San Francisco	1040	7
2	San Francisco	1051	3
3	Philadelphia	1055	5
4	Kansas City	1056	2
5	Boston	1059	4
6	Mexico City	1072	4
7	San Diego	1078	3
8	Detroit	1079	2
9	Los Angeles	1080	5
Milan Streetcars			
10	Milan	1814	4
11	Milan	1856	6

To supplement Figure 4.C-4, which shows maximum passby noise levels of streetcars, Figure 4 summarizes passby single-event levels (SEL) from the 43 streetcar measurements, with the "Milan" cars shown separately from the remainder of the fleet. The SEL levels form the basis of source levels used in the noise modeling of streetcars. The observations of note here are:

1. When running at speed, the Milan cars consistently exhibited passby levels 10 dB higher than any of the non-Milan (the Presidents' Conference Committee [PCC]) streetcars,
2. For the non-Milan fleet (nine cars), passby levels varied considerably, with an overall range of 7 to 8 dB,
3. On short-radius curves the difference between Milan and PCC streetcar types was smaller, 5 dB on average, and a range of about 5 dB within type.

The differences between the Milan and other streetcars in service on April 19 are quite evident in the one-third octave band noise level data (spectra) collected during passby noise measurements. Figure 5 compares spectra at the passby maximum for streetcar 1856 (Milan) and 1040 (PCC).

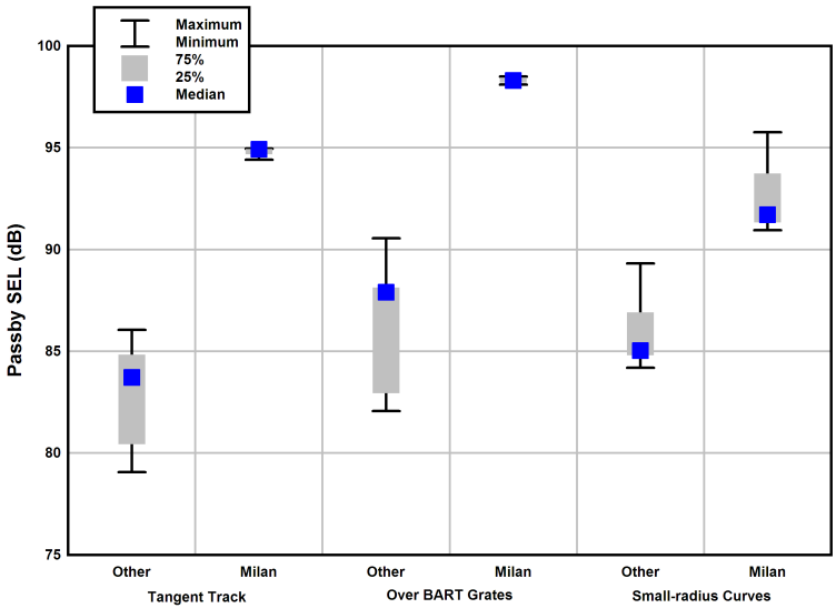


FIGURE 4: SUMMARY OF STREETCAR PASSBY SINGLE-EVENT LEVELS (SELS)

One-third octave band levels for the Milan car were 5 to 15 dB higher between 50 Hz and 8 kHz. Spectrograms comparing the two passbys are shown in Figure 6. The A-weighted levels at the passby maximum were 88.6 vs. 74.9 dB.

FIGURE 5: MAXIMUM PASSBY ONE-THIRD OCTAVE BAND LEVELS FOR MILAN AND PCC STREETCAR EXEMPLARS

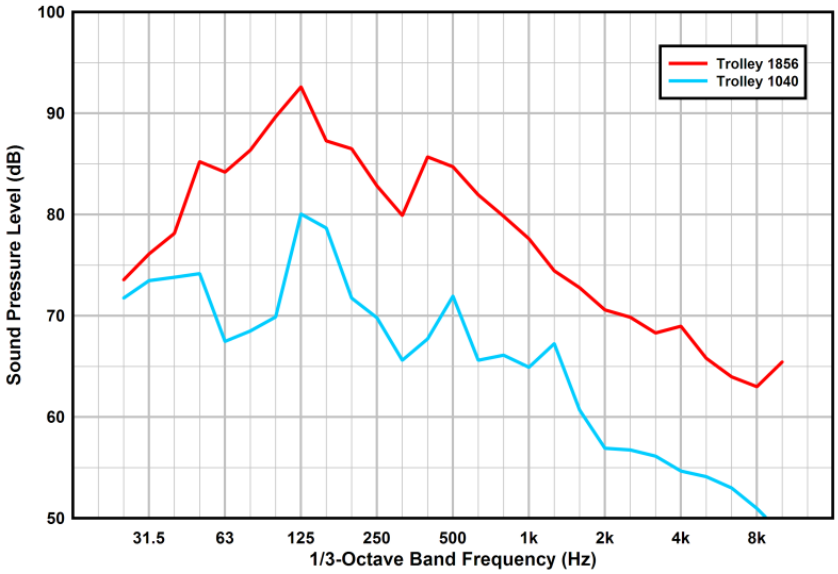
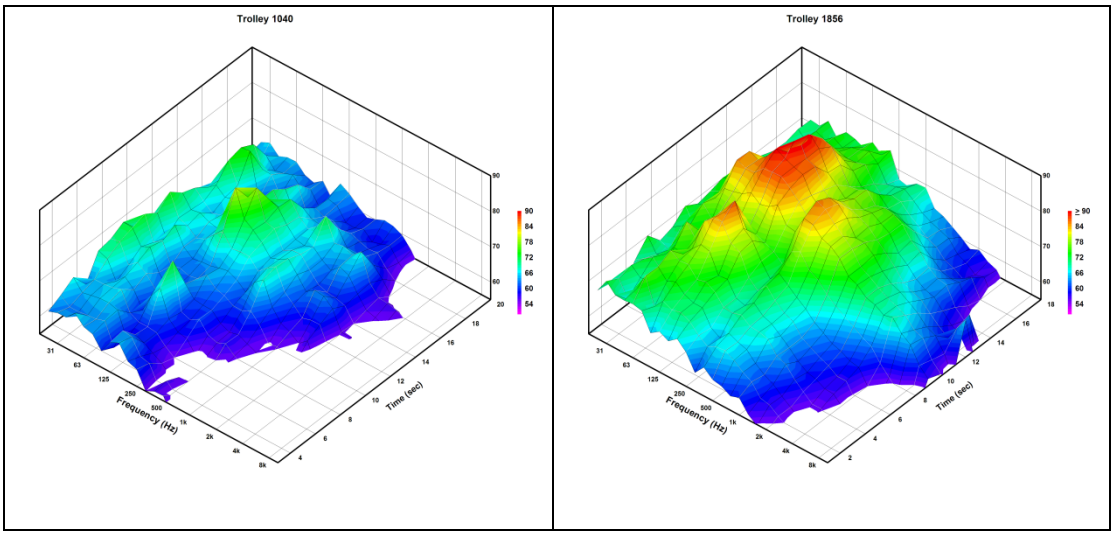


FIGURE 6: PASSBY SPECTRA FOR MUNI AND MILAN STREETCARS

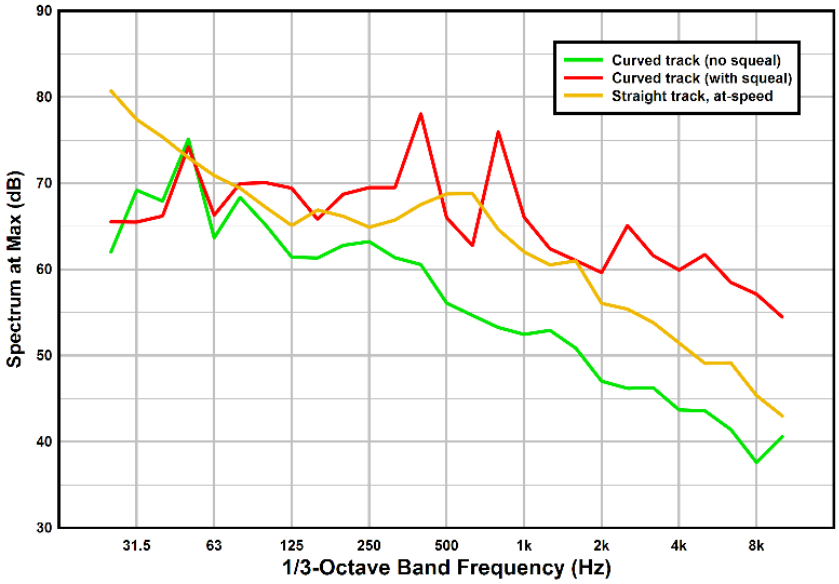


For the occasional cases where multiple passbys of individual streetcars were measured, the levels were repeatable within 3 dB.

Wheel Squeal Noise

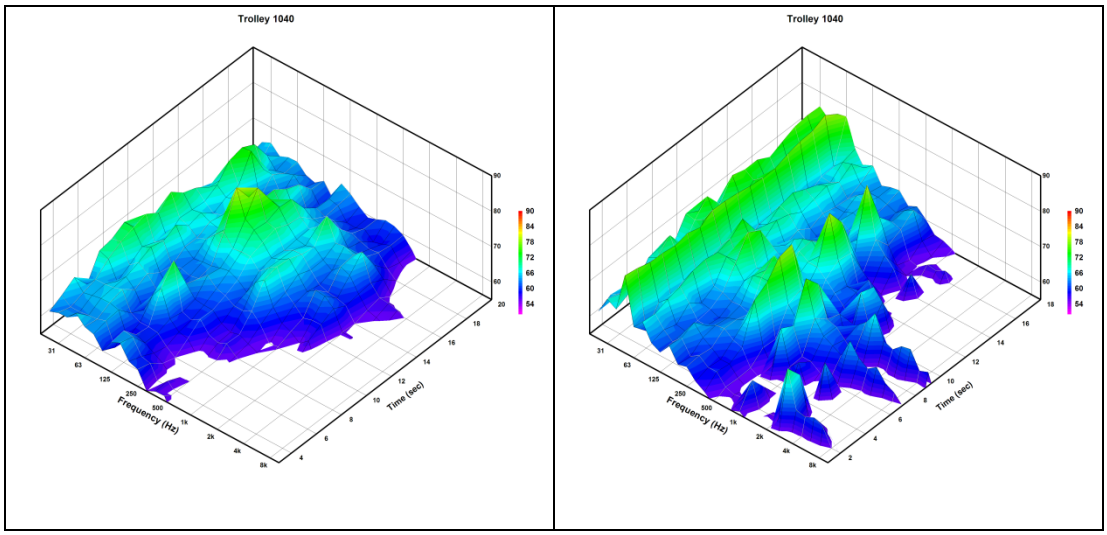
A number of passby measurements were made to characterize the flanging/wheel squeal noise produced by the streetcars when negotiating short radius turns. This noise is caused when the streetcar wheel flanges rub against the rail or in the case of squeal, by the transverse slip-stick forces that excite wheel vibration modes. Measurements to capture this effect were made at Steuart Street and at the Castro Street loop and are assumed to be representative of the conditions at the planned turn-around at McAllister Street. On these curves streetcar speeds were substantially reduced and - absent squeal - overall noise levels were lower compared to running on tangent track (by 5-10 dBA). However, when present, wheel squeal would typically increase levels by 10-15 dBA, equaling or often exceeding the at-speed running levels. Figure 7 shows passby spectra for car 1040 with and without wheel squeal present, as well as the max passby spectrum for the tangent track condition.

FIGURE 7: SPECTRA SHOWING FLANGING/WHEEL SQUEAL NOISE



Wheel squeal levels were rather variable and typically intermittent, and the limited number of samples did not allow clear pattern of behavior to be identified. However, all streetcars were observed to produce some degree of flanging and/or wheel squeal noise on short radius turns. Figure 8 illustrates this typically intermittent nature of the squeal.

FIGURE 8: EXAMPLE PASSBY SPECTRA WITH AND WITHOUT WHEEL SQUEAL PRESENT



Appendix 2: Noise Modeling Assumptions

Noise Modeling Approach

Fixed-guideway streetcar operations were modeled as acoustic line noise sources using SoundPLAN, a standards-based environmental noise program for calculating community noise exposure from a wide range of noise sources. Reference noise levels for F-Line streetcar operations were derived from the calibrated passby noise levels from noise measurements described in the previous section.

All roads, curbs, and building footprints were imported into SoundPLAN from GIS shapefiles provided by the City. Other City-provided GIS data such as the Land Use layer were used for supporting information and analysis but were not used by the noise model directly. The project corridor contains a number of high-rise structures: the noise calculations took into account sound reflections from, and the acoustic shielding and scattering caused by these buildings.

Modeling Assumptions

For modeling purposes, the project corridor was assumed to be flat (i.e., no topographic effects). Elevation changes along Market Street project corridor are gradual and amount to less than 100 feet along the 2.2-mile corridor.

Reference Streetcar Noise Levels

Streetcar noise was modeled as an acoustic line source. SELs for individual streetcars were calculated directly from the passby noise data, then averaged to provide reference source noise levels and spectra for the PCC and Milan-type streetcars. Reference streetcar passby levels were calculated for the two vehicle types and for three track conditions: straight (tangent) track over asphalt, tangent track over BART ventilation grates, and curved track sections at Steuart Street. Using the reference source levels, frequency of service per hour for each streetcar type was applied to obtain hourly noise levels over a daily distribution of streetcar trips, based on the F-Line schedule (as of October 2018). The model assumes operating hours along the F-Line would be the same as existing F-Line service. The model assumes streetcars would operate on the F-loop and F-Short between 7:00 a.m. and 7:00 p.m. The F-Short line would add up to 6 streetcars per hour in 2020. The combined headways on the F-Short would be 5 minutes in both directions (including 10-minute headways in each direction on the F-Line and 10-minute headways on the F-Short in each direction), east of the F-loop.

Streetcar Noise on the F-loop

Straight sections of track on the F-loop were modeled similar to tangent track passbys on Market Street. The straight sections on the F-loop account for approximately 370 feet of track along McAllister Street and 140 feet along Charles J. Brenham Place, with an assumed travel speed of 15 mph.

There would be 6 curved sections of track on the F-loop, each about 100 to 150 feet long. Passby source levels on curves were modeled similar to measurements on existing curves, as described in the previous section, as the operating noise was assumed to be similar to the measurements. Curve squeal noise was based on measured octave-band frequency spectra of PCC and Milan streetcars traveling across existing curves at Steuart Street and the Castro Street loop. The model assumes that streetcar noise on F-loop curves would be the same as noise levels measured from streetcar passbys on similar

existing curves (estimated 5 miles per hour), and as such, curve passby levels were not adjusted for speed.

Streetcar Noise on Crossovers

The SoundPLAN model uses the Federal Transit Administration source level for a standard crossover. Noise levels from crossovers assumed a travel speed of 5 mph for diverging movements entering or exiting the F-loop and 25 mph for non-diverging movements on the F-Line. A total of 8 new crossovers were modeled to allow for diverging movements between the F-Line and the F-loop.

Traffic Model Inputs

Traffic noise levels along side-streets were calculated using peak-hour traffic volume data provided by the Fehr & Peers (2018), and traffic noise emissions from data tables developed from the Federal Highway Administration TNM.

Traffic data along Market Street and adjacent side streets along the corridor were taken from the Better Market Street vehicle volumes spreadsheet provided by Fehr & Peers. These represented traffic volumes for the peak (p.m.) traffic hour. A factor of 10 was used to convert peak hour values to assumed ADT values. The model assumed hard ground attenuation and no noise barriers.

Appendix 3: Traffic Noise Modeling Results

Five model conditions were developed to predict traffic noise levels on side streets adjacent to Market Street, according to the following conditions:

1. 2018 (Present Traffic)
2. 2020 (Opening Year) No Project
3. 2020 Plus Project
4. 2040 (Design Year) No Project
5. 2040 Plus Project

Table 4 shows the predicted traffic noise levels for 2018 baseline, 2020, and 2040 traffic conditions. Negative values indicate that plus-project levels are predicted to be lower than the no-project condition. Based on the data in Table 4, opening-year plus-project conditions would have a maximum increase of 2.2 dB (in terms of L_{dn}) compared to no-project conditions. Design-year plus-project conditions would have a maximum increase of 2.4 dB compared to no-project conditions.

TABLE 4: TRAFFIC NOISE LEVELS ON SIDE STREETS OFF MARKET STREET

Intersection Number	Street	Segment location	Traffic Volume, Calculated Segment ADT					Traffic Noise Level, L_{dn}				L_{dn}		
			Existing Year 2018	Year 2020 No Project	Year 2020 Plus Project	Year 2040 No Project	Year 2040 Plus Project	Existing Year 2018	Year 2020 No Project	Year 2020 Plus Project	Difference, 2020 Plus Project and 2020 No Project	Year 2040 No Project	Year 2040 Plus Project	Difference, 2040 Plus Project and 2040 No Project
1	Steuart Street	south of Market Street	2,740	3,200	1,700	3,600	2,100	55.2	55.9	53.3	- 2.6	56.3	54.2	- 2.1
2	Spear Street	south of Market Street	3,230	2,200	1,200	2,400	1,400	55.9	54.3	52.0	- 2.3	54.7	52.6	- 2.1
3	Drumm Street	north of Market Street	6,990	7,100	7,500	7,800	8,700	59.1	59.2	59.4	+ 0.2	59.6	60.0	+ 0.4
3	Main Street	south of Market Street	6,440	7,400	4,400	8,000	5,000	58.8	59.3	57.2	- 2.1	59.7	57.7	- 2.0
4	Davis Street	north of Market Street	16,040	17,100	16,100	18,500	17,500	62.6	62.9	62.7	- 0.2	63.3	63.0	- 0.3
4	Beale Street	south of Market Street	14,050	14,800	15,000	16,100	16,200	62.1	62.3	62.4	+ 0.1	62.7	62.7	0.0
5	Front Street	north of Market Street	13,190	10,500	13,700	11,300	14,500	61.8	60.8	62.0	+ 1.2	61.1	62.2	+ 1.1
5	Fremont Street	south of Market Street	13,900	11,200	13,700	12,100	14,600	62.0	61.1	62.0	+ 0.9	61.4	62.2	+ 0.8
6	Battery Street	north of Market Street	9,760	11,500	9,500	12,600	10,400	60.5	61.2	60.4	- 0.8	61.6	60.8	- 0.8
6	1st Street	south of Market Street	11,680	14,200	11,500	15,600	12,800	61.3	62.1	61.2	- 0.9	62.5	61.7	- 0.8
7	Sansome Street	north of Market Street	2,200	2,000	1,100	2,100	1,200	54.3	54.0	51.7	- 2.3	54.2	52.0	- 2.2
8	2nd Street	south of Market Street	5,160	5,000	100	5,500	100	57.8	57.7	45.3	- 12.4	58.1	45.3	- 12.8
9	New Montgomery	north of Market Street	8,100	15,000	13,000	15,800	13,800	59.7	62.4	61.7	- 0.7	62.6	62.0	- 0.6
9	New Montgomery	south of Market Street	9,080	15,700	15,700	16,900	16,900	60.2	62.6	62.6	0.0	62.9	62.9	0.0
10	Kearney Street	northeast of Market Street	13,150	12,300	12,700	13,400	13,800	61.8	61.5	61.6	+ 0.1	61.9	62.0	+ 0.1
10	Geary Street	northwest of Market Street	5,280	4,200	3,600	4,800	4,100	57.9	57.0	56.3	- 0.7	57.5	56.9	- 0.6
10	3rd Street	south of Market Street	17,010	15,500	16,000	17,100	17,600	62.9	62.5	62.6	+ 0.1	62.9	63.0	+ 0.1
11	O'Farrell Street	north of Market Street	3,250	2,100	2,000	2,400	2,300	55.9	54.2	54.0	- 0.2	54.7	54.5	- 0.2
12	Stockton Street	north of Market Street	14,920	15,900	10,400	17,200	11,300	62.3	62.6	60.8	- 1.8	62.9	61.1	- 1.8
12	4th Street	south of Market Street	12,760	9,500	9,500	10,300	10,300	61.7	60.4	60.4	0.0	60.8	60.8	0.0
14	Cyril Magnin Street	north of Market Street	12,630	15,600	16,800	17,100	18,300	61.6	62.5	62.8	+ 0.3	62.9	63.2	+ 0.3
14	5th Street	south of Market Street	13,000	15,700	17,100	17,300	18,600	61.7	62.6	62.9	+ 0.3	63.0	63.3	+ 0.3
15	Mason Street	northeast of Market Street	4,370	1,600	2,300	1,800	2,700	57.1	53.1	54.5	+ 1.4	53.5	55.2	+ 1.7
15	Turk Street	northwest of Market Street	3,050	3,100	1,800	3,600	2,300	55.7	55.7	53.5	- 2.2	56.3	54.5	- 1.8
16	Golden Gate	north of Market Street	19,250	22,500	22,700	24,400	24,600	63.4	64.1	64.1	0.0	64.5	64.5	0.0
16	6th Street	south of Market Street	20,170	24,200	22,300	26,000	24,100	63.6	64.4	64.1	- 0.3	64.7	64.4	- 0.3
17	Jones Street	northeast of Market Street	2,360	2,000	1,700	2,200	2,000	54.6	54.0	53.3	- 0.7	54.3	54.0	- 0.3
17	McAllister Street	northwest of Market Street	4,670	3,000	1,800	3,600	2,200	57.4	55.6	53.5	- 2.1	56.3	54.3	- 2.0
18	7th Street	south of Market Street	15,390	16,000	16,800	17,500	18,300	62.5	62.6	62.8	+ 0.2	63.0	63.2	+ 0.2
20	8th Street	south of Market Street	14,470	14,500	17,500	16,000	19,000	62.2	62.2	63.0	+ 0.8	62.6	63.4	+ 0.8
20	Grove Street	northwest of Market Street	14,050	14,200	16,600	15,300	17,800	62.1	62.1	62.8	+ 0.7	62.4	63.1	+ 0.7
20	Hyde Street	northeast of Market Street	2,030	2,100	1,700	2,400	2,000	54.0	54.2	53.3	- 0.9	54.7	54.0	- 0.7
21	9th Street	south of Market Street	32,550	39,500	36,900	44,100	41,500	65.7	66.5	66.2	- 0.3	67.0	66.7	- 0.3
21	Hayes Street	northwest of Market Street	15,350	17,700	17,700	19,500	19,800	62.5	63.1	63.1	0.0	63.5	63.6	+ 0.1
21	Larkin Street	northeast of Market Street	15,360	17,700	19,200	19,900	21,700	62.5	63.1	63.4	+ 0.3	63.6	63.9	+ 0.3
22	10th Street	south of Market Street	20,050	20,600	20,800	23,000	23,100	63.6	63.7	63.8	+ 0.1	64.2	64.2	0.0
22	Fell Street	northwest of Market Street	9,030	10,000	9,000	11,300	10,300	60.2	60.6	60.2	- 0.4	61.1	60.8	- 0.3
22	Polk Street	northeast of Market Street	8,610	8,600	8,600	9,300	9,300	60.0	60.0	60.0	0.0	60.3	60.3	0.0
23	11th Street	south of Market Street	1,400	1,300	500	1,500	500	52.6	52.3	49.0	- 3.3	52.8	49.0	- 3.8
24	Van Ness Avenue	north of Market Street	31,690	33,900	32,100	36,400	34,600	65.6	65.9	65.6	- 0.3	66.2	66.0	- 0.2
24	Van Ness Avenue	south of Market Street	30,540	32,700	28,500	35,000	30,800	65.4	65.7	65.1	- 0.6	66.0	65.5	- 0.5
25 or 26	12th Street	south of Market Street	1,350	1,200	800	1,300	900	52.4	52.0	50.5	- 1.5	52.3	50.9	- 1.4
25 or 26	Page Street	northwest of Market Street	1,620	1,800	1,200	2,000	1,400	53.1	53.5	52.0	- 1.5	54.0	52.6	- 1.4
25 or 26	Franklin Street	northeast of Market Street	9,470	10,600	10,500	11,600	11,500	60.4	60.9	60.8	- 0.1	61.3	61.2	- 0.1

Intersection Number	Street	Segment location	Traffic Volume, Calculated Segment ADT					Traffic Noise Level, L_{dn}				L_{dn}		
			Existing Year 2018	Year 2020 No Project	Year 2020 Plus Project	Year 2040 No Project	Year 2040 Plus Project	Existing Year 2018	Year 2020 No Project	Year 2020 Plus Project	Difference, 2020 Plus Project and 2020 No Project	Year 2040 No Project	Year 2040 Plus Project	Difference, 2040 Plus Project and 2040 No Project
27	Gough Street	north of Market Street	8,650	9,800	10,600	10,900	11,700	60.0	60.5	60.9	+ 0.4	61.0	61.3	+ 0.3
27	Gough Street	south of Market Street	15,130	16,500	19,300	18,100	20,900	62.4	62.8	63.4	+ 0.6	63.2	63.8	+ 0.6
28	Valencia Street	south of Market Street	6,550	10,500	10,500	11,200	11,200	58.8	60.8	60.8	0.0	61.1	61.1	0.0
29	Octavia Blvd	north of Market Street	34,780	41,500	42,300	46,000	46,800	66.0	66.7	66.8	+ 0.1	67.2	67.3	+ 0.1
29	Octavia Blvd	south of Market Street	34,350	40,600	40,600	44,800	44,800	65.9	66.6	66.6	0.0	67.1	67.1	0.0
30	The Embarcadero	north of Mission Street	45,170	51,700	52,600	57,600	58,500	67.1	67.7	67.8	+ 0.1	68.2	68.2	0.0
30	The Embarcadero	south of Mission Street	44,330	49,700	49,900	55,600	55,800	67.0	67.5	67.5	0.0	68.0	68.0	0.0
30	Mission Street	west of The Embarcadero	4,740	6,000	6,900	6,400	7,300	57.5	58.5	59.1	+ 0.6	58.7	59.3	+ 0.6
31	Steuart Street	north of Mission Street	2,740	3,200	1,700	3,600	2,100	55.2	55.9	53.3	- 2.6	56.3	54.2	- 2.1
31	Steuart Street	south of Mission Street	1,630	1,800	1,700	2,000	1,900	53.2	53.5	53.3	- 0.2	54.0	53.8	- 0.2
31	Mission Street	west of Steuart Street	4,440	4,800	5,600	5,200	6,000	57.2	57.5	58.2	+ 0.7	57.9	58.5	+ 0.6
32	Spear Street	north of Mission Street	3,530	2,300	1,400	2,500	1,600	56.3	54.5	52.6	- 1.9	54.9	53.1	- 1.8
32	Spear Street	south of Mission Street	4,680	3,400	2,800	3,800	3,200	57.4	56.1	55.3	- 0.8	56.6	55.9	- 0.7
32	Mission Street	west of Spear Street	5,850	6,300	7,500	6,900	8,100	58.4	58.7	59.4	+ 0.7	59.1	59.7	+ 0.6
33	Main Street	north of Mission Street	5,620	6,600	3,600	7,100	4,100	58.2	58.9	56.3	- 2.6	59.2	56.9	- 2.3
33	Main Street	south of Mission Street	7,030	8,600	6,500	9,400	7,300	59.1	60.0	58.8	- 1.2	60.4	59.3	- 1.1
33	Mission Street	west of Main Street	7,040	7,600	7,900	8,300	8,600	59.1	59.5	59.6	+ 0.1	59.8	60.0	+ 0.2
34	Beale Street	north of Mission Street	14,290	15,000	15,200	16,300	16,400	62.2	62.4	62.4	0.0	62.7	62.7	0.0
34	Beale Street	south of Mission Street	14,510	14,800	15,100	16,100	16,300	62.2	62.3	62.4	+ 0.1	62.7	62.7	0.0
34	Mission Street	west of Beale Street	9,260	9,800	10,200	10,700	11,100	60.3	60.5	60.7	+ 0.2	60.9	61.1	+ 0.2
35	Fremont Street	north of Mission Street	12,280	9,100	11,600	9,700	12,200	61.5	60.2	61.3	+ 1.1	60.5	61.5	+ 1.0
35	Fremont Street	south of Mission Street	13,430	9,600	11,600	10,200	12,200	61.9	60.5	61.3	+ 0.8	60.7	61.5	+ 0.8
35	Mission Street	west of Fremont Street	9,170	9,500	9,600	10,200	10,300	60.3	60.4	60.5	+ 0.1	60.7	60.8	+ 0.1
36	1st Street	north of Mission Street	12,490	15,000	12,300	16,400	13,600	61.6	62.4	61.5	- 0.9	62.7	61.9	- 0.8
36	1st Street	south of Mission Street	12,960	16,200	14,100	17,700	15,700	61.7	62.7	62.1	- 0.6	63.1	62.6	- 0.5
36	Mission Street	west of First Street	13,220	14,500	14,800	15,700	16,200	61.8	62.2	62.3	+ 0.1	62.6	62.7	+ 0.1
37	2nd Street	north of Mission Street	6,450	5,200	1,700	5,900	2,200	58.8	57.9	53.3	- 4.6	58.4	54.3	- 4.1
37	2nd Street	south of Mission Street	8,970	4,300	3,700	4,900	4,100	60.2	57.1	56.4	- 0.7	57.6	56.9	- 0.7
37	Mission Street	west of 2nd Street	14,270	13,000	13,000	14,000	14,000	62.1	61.7	61.7	0.0	62.1	62.1	0.0
38	New Montgomery	north of Mission Street	10,120	17,400	18,300	18,700	19,600	60.7	63.0	63.2	+ 0.2	63.3	63.5	+ 0.2
38	New Montgomery	south of Mission Street	10,690	19,100	19,800	20,800	21,500	60.9	63.4	63.6	+ 0.2	63.8	63.9	+ 0.1
38	Mission Street	west of New Montgomery	16,400	16,700	16,300	18,500	18,100	62.7	62.8	62.7	- 0.1	63.3	63.2	- 0.1
39	3rd Street	north of Mission Street	18,900	15,900	16,400	17,700	18,200	63.4	62.6	62.7	+ 0.1	63.1	63.2	+ 0.1
39	3rd Street	south of Mission Street	18,910	19,900	20,300	22,200	22,600	63.4	63.6	63.7	+ 0.1	64.0	64.1	+ 0.1
39	Mission Street	west of 3rd Street	13,410	15,700	15,800	17,300	17,400	61.9	62.6	62.6	0.0	63.0	63.0	0.0
40	4th Street	north of Mission Street	13,240	13,400	10,200	14,400	10,900	61.8	61.9	60.7	- 1.2	62.2	61.0	- 1.2
40	4th Street	south of Mission Street	12,800	11,800	9,400	12,600	9,900	61.7	61.3	60.4	- 0.9	61.6	60.6	- 1.0
40	Mission Street	west of 4th Street	15,560	17,500	17,400	19,000	18,900	62.5	63.0	63.0	0.0	63.4	63.4	0.0
41	5th Street	north of Mission Street	12,820	15,600	17,000	17,200	18,500	61.7	62.5	62.9	+ 0.4	62.9	63.3	+ 0.4
41	5th Street	south of Mission Street	12,230	14,200	14,800	15,800	16,300	61.5	62.1	62.3	+ 0.2	62.6	62.7	+ 0.1
41	Mission Street	west of 5th Street	15,470	16,800	17,900	18,600	19,700	62.5	62.8	63.1	+ 0.3	63.3	63.5	+ 0.2
42	6th Street	north of Mission Street	21,310	25,500	23,600	27,400	25,500	63.9	64.6	64.3	- 0.3	65.0	64.6	- 0.4
42	6th Street	south of Mission Street	21,460	24,900	23,000	26,700	24,800	63.9	64.5	64.2	- 0.3	64.8	64.5	- 0.3
42	Mission Street	west of 6th Street	15,710	16,000	16,900	17,800	18,700	62.6	62.6	62.9	+ 0.3	63.1	63.3	+ 0.2
43	7th Street	north of Mission Street	15,490	16,100	16,900	17,600	18,400	62.5	62.7	62.9	+ 0.2	63.0	63.2	+ 0.2
43	7th Street	south of Mission Street	16,120	17,800	18,500	19,600	20,300	62.7	63.1	63.3	+ 0.2	63.5	63.7	+ 0.2
43	Mission Street	west of 7th Street	13,920	14,600	15,400	16,200	17,000	62.0	62.2	62.5	+ 0.3	62.7	62.9	+ 0.2

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44	8th Street	north of Mission Street	17,570	18,000	19,400	19,900	21,100	63.0	63.1	63.5	+ 0.4	63.6	63.8	+ 0.2
44	8th Street	south of Mission Street	15,180	15,500	17,900	17,300	19,500	62.4	62.5	63.1	+ 0.6	63.0	63.5	+ 0.5
44	Mission Street	west of 8th Street	14,870	15,400	16,800	17,000	18,400	62.3	62.5	62.8	+ 0.3	62.9	63.2	+ 0.3
45	9th Street	north of Mission Street	31,240	37,800	35,200	42,100	39,500	65.5	66.3	66.0	- 0.3	66.8	66.5	- 0.3
45	9th Street	south of Mission Street	29,790	36,000	34,100	40,200	38,300	65.3	66.1	65.9	- 0.2	66.6	66.4	- 0.2
45	Mission Street	west of 9th Street	11,860	11,800	12,700	13,200	14,100	61.4	61.3	61.6	+ 0.3	61.8	62.1	+ 0.3
46	10th Street	north of Mission Street	21,510	22,100	22,300	24,700	24,800	63.9	64.0	64.1	+ 0.1	64.5	64.5	0.0
46	10th Street	south of Mission Street	17,610	18,800	18,800	20,900	20,800	63.0	63.3	63.3	0.0	63.8	63.8	0.0
46	Mission Street	west of 10th Street	10,450	11,100	12,000	12,400	13,300	60.8	61.1	61.4	+ 0.3	61.5	61.8	+ 0.3
47	11th Street	north of Mission Street	4,660	5,200	4,600	5,900	5,100	57.4	57.9	57.4	- 0.5	58.4	57.8	- 0.6
47	11th Street	south of Mission Street	5,020	5,700	5,400	6,600	6,100	57.7	58.2	58.0	- 0.2	58.9	58.5	- 0.4
47	Mission Street	west of 11th Street	10,870	13,400	14,200	14,900	15,700	61.0	61.9	62.1	+ 0.2	62.3	62.6	+ 0.3
48	Van Ness Avenue	north of Mission Street	31,240	33,400	29,200	35,800	31,600	65.5	65.8	65.2	- 0.6	66.1	65.6	- 0.5
48	Van Ness Avenue	south of Mission Street	23,580	25,300	22,100	26,600	23,400	64.3	64.6	64.0	- 0.6	64.8	64.3	- 0.5
48	Mission Street	west of Van Ness Avenue	17,110	20,100	19,900	22,700	22,500	62.9	63.6	63.6	0.0	64.1	64.1	0.0
49	13th Street	west of Mission Street	12,770	14,200	14,100	15,600	15,500	61.7	62.1	62.1	0.0	62.5	62.5	0.0
49	13th Street	east of Mission Street	20,160	22,100	21,900	24,500	24,300	63.6	64.0	64.0	0.0	64.5	64.4	- 0.1
49	Mission Street	south of 13th Street	15,540	17,000	17,300	19,000	19,300	62.5	62.9	63.0	+ 0.1	63.4	63.4	0.0
50	Gough Street	north of Mission Street	8,280	9,500	10,300	10,500	11,300	59.8	60.4	60.8	+ 0.4	60.8	61.1	+ 0.3
50	Otis Street	south of Mission Street	13,260	15,000	15,700	16,800	17,500	61.8	62.4	62.6	+ 0.2	62.8	63.0	+ 0.2
50	McCoppin Street	west of Gough Street	1,700	3,000	2,900	3,300	3,200	53.3	55.6	55.5	- 0.1	56.0	55.9	- 0.1
50	Mission Street	east of Gough Street	6,360	8,700	8,500	9,800	9,600	58.7	60.0	59.9	- 0.1	60.5	60.5	0.0
51	Cyril Magnin Street	north of Ellis Street	3,100	3,500	4,500	3,900	5,000	55.7	56.2	57.3	+ 1.1	56.7	57.7	+ 1.0
51	Cyril Magnin Street	south of Ellis Street	7,560	8,400	7,100	9,100	7,700	59.4	59.9	59.2	- 0.7	60.2	59.5	- 0.7
51	Ellis Street	west of Cyril Magnin Street	6,180	6,700	6,900	7,300	7,500	58.6	58.9	59.1	+ 0.2	59.3	59.4	+ 0.1
51	Ellis Street	east of Cyril Magnin Street	3,140	3,600	1,500	3,900	1,600	55.8	56.3	52.8	- 3.5	56.7	53.1	- 3.6
52	Grant Avenue	north of Geary Street	2,720	3,200	3,500	3,600	3,900	55.2	55.9	56.2	+ 0.3	56.3	56.7	+ 0.4
52	Grant Avenue	south of Geary Street	2,130	2,100	2,100	2,400	2,400	54.2	54.2	54.2	0.0	54.7	54.7	0.0
52	Geary Street	west of Grant Avenue	5,810	6,300	7,200	7,200	8,000	58.3	58.7	59.2	+ 0.5	59.2	59.7	+ 0.5
52	Geary Street	east of Grant Avenue	3,520	4,000	5,200	4,600	5,700	56.2	56.8	57.9	+ 1.1	57.4	58.2	+ 0.8
53	Grant Avenue	north of Post Street	3,270	3,500	4,300	3,900	4,700	55.9	56.2	57.1	+ 0.9	56.7	57.4	+ 0.7
53	Grant Avenue	south of Post Street	3,430	3,200	3,500	3,600	3,900	56.1	55.9	56.2	+ 0.3	56.3	56.7	+ 0.4
53	Post Street	west of Grant Avenue	7,260	6,500	6,300	6,900	6,700	59.3	58.8	58.7	- 0.1	59.1	58.9	- 0.2
53	Post Street	east of Grant Avenue	7,200	4,800	4,100	5,200	4,500	59.2	57.5	56.9	- 0.6	57.9	57.3	- 0.6
54	Kearney Street	north of Post Street	15,830	14,000	14,000	15,100	15,100	62.6	62.1	62.1	0.0	62.4	62.4	0.0
54	Kearney Street	south of Post Street	14,200	12,500	12,600	13,600	13,700	62.1	61.6	61.6	0.0	61.9	62.0	+ 0.1
54	Post Street	west of Kearney Avenue	6,060	4,800	4,100	5,200	4,500	58.5	57.5	56.9	- 0.6	57.9	57.3	- 0.6
54	Post Street	east of Kearney Avenue	4,430	3,300	2,700	3,700	3,100	57.2	56.0	55.2	- 0.8	56.4	55.7	- 0.7
55	Stockton Street	north of O'Farrell Street	8,250	7,200	8,600	7,700	9,100	59.8	59.2	60.0	+ 0.8	59.5	60.2	+ 0.7
55	Stockton Street	south of O'Farrell Street	10,190	9,200	10,500	9,700	11,000	60.7	60.3	60.8	+ 0.5	60.5	61.0	+ 0.5
55	O'Farrell Street	west of Stockton Street	6,560	4,000	5,400	4,300	5,700	58.8	56.8	58.0	+ 1.2	57.1	58.2	+ 1.1
55	O'Farrell Street	east of Stockton Street	4,620	2,000	3,500	2,300	3,800	57.4	54.0	56.2	+ 2.2	54.5	56.6	+ 2.1
56	Mason Street	north of Eddy Street	4,530	4,300	4,300	4,800	4,900	57.3	57.1	57.1	0.0	57.5	57.6	+ 0.1
56	Mason Street	south of Eddy Street	2,660	1,300	2,300	1,500	2,700	55.1	52.3	54.5	+ 2.2	52.8	55.2	+ 2.4
56	Eddy Street	west of Mason Street	4,340	4,200	5,000	4,700	5,500	57.1	57.0	57.7	+ 0.7	57.4	58.1	+ 0.7
56	Eddy Street	east of Mason Street	6,210	7,200	9,000	8,000	9,900	58.6	59.2	60.2	+ 1.0	59.7	60.6	+ 0.9
57	Jones Street	north of Golden Gate Street	6,250	5,400	4,900	5,800	5,300	58.6	58.0	57.6	- 0.4	58.3	57.9	- 0.4

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57	Jones Street	south of Golden Gate Street	2,520	1,500	1,700	1,700	1,900	54.9	52.8	53.3	+ 0.5	53.3	53.8	+ 0.5
57	Golden Gate Street	west of Jones Street	6,620	6,400	5,600	7,100	6,300	58.9	58.7	58.2	- 0.5	59.2	58.7	- 0.5
57	Golden Gate Street	east of Jones Street	10,350	10,300	9,200	11,200	10,100	60.8	60.8	60.3	- 0.5	61.1	60.7	- 0.4
58	Franklin Street	north of Oak Street	23,320	24,200	24,400	26,200	26,200	64.3	64.4	64.5	+ 0.1	64.8	64.8	0.0
58	Franklin Street	south of Oak Street	12,200	10,800	11,000	11,500	11,500	61.5	61.0	61.0	0.0	61.2	61.2	0.0
58	Oak Street	west of Franklin Street	10,710	12,900	12,900	14,200	14,200	60.9	61.7	61.7	0.0	62.1	62.1	0.0
58	Oak Street	east of Franklin Street	410	500	500	500	500	48.4	49.0	49.0	0.0	49.0	49.0	0.0
59	Franklin Street	north of Fell Street	14,020	16,000	16,200	17,300	17,300	62.1	62.6	62.7	+ 0.1	63.0	63.0	0.0
59	Franklin Street	south of Fell Street	21,190	24,200	24,400	26,200	26,200	63.8	64.4	64.5	+ 0.1	64.8	64.8	0.0
59	Fell Street	west of Franklin Street	5,070	7,200	7,400	8,300	8,500	57.8	59.2	59.3	+ 0.1	59.8	59.9	+ 0.1
59	Fell Street	east of Franklin Street	8,000	10,600	10,800	11,800	12,000	59.7	60.9	61.0	+ 0.1	61.3	61.4	+ 0.1
60	Gough Street	north of Oak Street	14,350	15,500	17,800	17,200	19,500	62.2	62.5	63.1	+ 0.6	62.9	63.5	+ 0.6
60	Gough Street	south of Oak Street	15,560	16,900	19,800	18,600	21,500	62.5	62.9	63.6	+ 0.7	63.3	63.9	+ 0.6
60	Oak Street	west of Gough Street	13,000	14,300	14,900	15,600	16,200	61.7	62.2	62.3	+ 0.1	62.5	62.7	+ 0.2
60	Oak Street	east of Gough Street	11,790	12,900	12,900	14,200	14,200	61.3	61.7	61.7	0.0	62.1	62.1	0.0
61	Van Ness Avenue	north of Fell Street	32,910	34,300	31,800	36,800	34,200	65.7	65.9	65.6	- 0.3	66.2	65.9	- 0.3
61	Van Ness Avenue	south of Fell Street	30,910	33,900	31,700	36,500	34,200	65.5	65.9	65.6	- 0.3	66.2	65.9	- 0.3
61	Fell Street	west of Van Ness Avenue	8,900	10,600	10,800	11,800	12,000	60.1	60.9	61.0	+ 0.1	61.3	61.4	+ 0.1
61	Fell Street	east of Van Ness Avenue	8,740	9,000	8,700	10,100	9,800	60.1	60.2	60.0	- 0.2	60.7	60.5	- 0.2
62	1st Street	north of Howard Street	12,890	16,200	14,500	17,600	15,900	61.7	62.7	62.2	- 0.5	63.0	62.6	- 0.4
62	1st Street	south of Howard Street	12,800	14,800	13,500	16,200	14,900	61.7	62.3	61.9	- 0.4	62.7	62.3	- 0.4
62	Howard Street	west of 1st Street	17,000	19,700	19,400	21,500	21,200	62.9	63.5	63.5	0.0	63.9	63.8	- 0.1
62	Howard Street	east of 1st Street	16,910	18,300	18,400	20,100	20,200	62.9	63.2	63.2	0.0	63.6	63.6	0.0
63	3rd Street	north of Howard Street	19,050	18,200	18,700	20,300	20,800	63.4	63.2	63.3	+ 0.1	63.7	63.8	+ 0.1
63	3rd Street	south of Howard Street	19,470	18,700	18,500	20,900	20,700	63.5	63.3	63.3	0.0	63.8	63.7	- 0.1
63	Howard Street	west of 3rd Street	20,960	21,900	21,300	24,100	23,500	63.8	64.0	63.9	- 0.1	64.4	64.3	- 0.1
63	Howard Street	east of 3rd Street	20,540	21,400	21,500	23,500	23,600	63.7	63.9	63.9	0.0	64.3	64.3	0.0
64	5th Street	north of Howard Street	16,500	14,200	15,300	15,600	16,200	62.8	62.1	62.4	+ 0.3	62.5	62.7	+ 0.2
64	5th Street	south of Howard Street	14,670	13,800	14,600	15,200	15,500	62.3	62.0	62.2	+ 0.2	62.4	62.5	+ 0.1
64	Howard Street	west of 5th Street	15,980	16,400	16,600	18,100	18,300	62.6	62.7	62.8	+ 0.1	63.2	63.2	0.0
64	Howard Street	east of 5th Street	14,670	16,600	17,300	18,300	19,000	62.3	62.8	63.0	+ 0.2	63.2	63.4	+ 0.2
65	7th Street	north of Howard Street	11,970	13,300	13,700	14,600	15,000	61.4	61.8	62.0	+ 0.2	62.2	62.4	+ 0.2
65	7th Street	south of Howard Street	12,360	13,600	13,800	14,900	15,100	61.5	61.9	62.0	+ 0.1	62.3	62.4	+ 0.1
65	Howard Street	west of 7th Street	16,120	17,800	18,300	19,600	20,100	62.7	63.1	63.2	+ 0.1	63.5	63.6	+ 0.1
65	Howard Street	east of 7th Street	15,730	17,500	18,200	19,300	20,000	62.6	63.0	63.2	+ 0.2	63.4	63.6	+ 0.2
66	9th Street	north of Howard Street	8,860	9,900	10,100	10,900	11,100	60.1	60.6	60.7	+ 0.1	61.0	61.1	+ 0.1
66	9th Street	south of Howard Street	12,570	14,800	15,100	16,200	16,500	61.6	62.3	62.4	+ 0.1	62.7	62.8	+ 0.1
66	Howard Street	west of 9th Street	28,600	36,000	33,500	40,200	37,700	65.1	66.1	65.8	- 0.3	66.6	66.3	- 0.3
66	Howard Street	east of 9th Street	24,890	31,100	28,500	34,900	32,300	64.5	65.5	65.1	- 0.4	66.0	65.7	- 0.3
67	2nd Street	north of Folsom Street	13,910	15,100	15,100	16,600	16,600	62.0	62.4	62.4	0.0	62.8	62.8	0.0
67	2nd Street	south of Folsom Street	13,660	13,600	13,600	15,000	15,000	62.0	61.9	61.9	0.0	62.4	62.4	0.0
67	Folsom Street	west of 2nd Street	10,830	9,500	8,700	10,400	9,600	61.0	60.4	60.0	- 0.4	60.8	60.5	- 0.3
67	Folsom Street	east of 2nd Street	10,840	10,800	10,000	11,800	11,000	61.0	61.0	60.6	- 0.4	61.3	61.0	- 0.3
68	4th Street	north of Folsom Street	19,140	21,200	21,200	23,300	23,300	63.4	63.8	63.8	0.0	64.3	64.3	0.0
68	4th Street	south of Folsom Street	18,270	20,000	20,200	22,000	22,200	63.2	63.6	63.6	0.0	64.0	64.0	0.0
68	Folsom Street	west of 4th Street	15,840	15,500	15,700	17,100	17,300	62.6	62.5	62.6	+ 0.1	62.9	63.0	+ 0.1
68	Folsom Street	east of 4th Street	16,710	16,700	16,700	18,400	18,400	62.8	62.8	62.8	0.0	63.2	63.2	0.0

Intersection Number	Street	Segment location	Traffic Volume, Calculated Segment ADT					Traffic Noise Level, L_{dn}				L_{dn}		
			Existing Year 2018	Year 2020 No Project	Year 2020 Plus Project	Year 2040 No Project	Year 2040 Plus Project	Existing Year 2018	Year 2020 No Project	Year 2020 Plus Project	Difference, 2020 Plus Project and 2020 No Project	Year 2040 No Project	Year 2040 Plus Project	Difference, 2040 Plus Project and 2040 No Project
69	6th Street	north of Folsom Street	18,240	19,800	19,800	21,800	21,800	63.2	63.6	63.6	0.0	64.0	64.0	0.0
69	6th Street	south of Folsom Street	20,670	22,200	22,000	24,500	24,300	63.7	64.0	64.0	0.0	64.5	64.4	- 0.1
69	Folsom Street	west of 6th Street	19,840	20,900	23,200	23,100	25,400	63.6	63.8	64.2	+ 0.4	64.2	64.6	+ 0.4
69	Folsom Street	east of 6th Street	22,870	24,300	26,800	26,800	29,300	64.2	64.4	64.9	+ 0.5	64.9	65.2	+ 0.3
70	8th Street	north of Folsom Street	16,780	17,600	17,600	19,400	19,400	62.8	63.0	63.0	0.0	63.5	63.5	0.0
70	8th Street	south of Folsom Street	18,420	19,100	18,700	21,000	20,600	63.2	63.4	63.3	- 0.1	63.8	63.7	- 0.1
70	Folsom Street	west of 8th Street	14,250	15,300	17,400	16,800	18,900	62.1	62.4	63.0	+ 0.6	62.8	63.4	+ 0.6
70	Folsom Street	east of 8th Street	12,610	13,800	16,300	15,200	17,700	61.6	62.0	62.7	+ 0.7	62.4	63.1	+ 0.7
71	10th Street	north of Folsom Street	12,860	13,600	13,600	15,000	15,000	61.7	61.9	61.9	0.0	62.4	62.4	0.0
71	10th Street	south of Folsom Street	16,880	17,700	17,500	19,500	19,300	62.9	63.1	63.0	- 0.1	63.5	63.4	- 0.1
71	Folsom Street	west of 10th Street	23,420	24,400	23,900	26,800	26,300	64.3	64.5	64.4	- 0.1	64.9	64.8	- 0.1
71	Folsom Street	east of 10th Street	19,400	20,300	20,000	22,300	22,000	63.5	63.7	63.6	- 0.1	64.1	64.0	- 0.1

Source: ICF 2018; Fehr & Peers 2018, Better Market Street Vehicle Volumes.

Appendix 4: Construction Equipment

A list of the off-road construction equipment for each phase and sub-phase of the project is shown in Table 5.

TABLE 5. CONSTRUCTION PHASES AND OFF-ROAD EQUIPMENT

Phase	Sub-phase	Off-Road Equipment Type	Quantity	Hours/Day	Horsepower
Center Lanes and Rail Track Replacement	Grubbing/Land Clearing (Demolition)	Excavator	2	8	300
	Grading/Excavation (Earthwork and Grading)	Loader	2	8	100
	Drainage/Utilities/Sub-Grade (Utility Infrastructure: Track and Sewer)	Excavator	1	8	300
		Backhoe	1	8	90
		Skid-Steer Loader	1	8	50
		Loader	2	8	100
		Backhoe	1	8	90
	Paving (Roadbed and Curb Construction and Paving and Painting)	Tractors/Loaders/Backhoes	3	8	98
Outside/Curbside Lanes	Grubbing/Land Clearing (Demolition)	Excavator	2	8	300
	Grading/Excavation (Earthwork and Grading)	Loader	2	8	100
	Drainage/Utilities/Sub-Grade (Utility Infrastructure)	Excavator	1	8	300
		Backhoe	1	8	90
		Skid-Steer Loader	1	8	50
	Paving (Roadbed and Curb Construction and Paving and Painting/Coating)	Asphalt Paver	1	8	175
		Roller	2	8	125
		Sweeper	1	8	200
Sidewalks	Grubbing/Land Clearing (Demolition)	Backhoe	1	8	90
		Skid-Steer Loader	1	8	50
	Grading/Excavation (Earthwork and Grading)	Backhoe	1	8	90
		Skid-Steer Loader	1	8	50
	Drainage/Utilities/Sub-Grade (Utility Infrastructure)	Backhoe	2	8	90
		Boom Truck	1	8	250
		Bucket Truck	1	8	200
	Paving (Roadbed and Curb Construction and Paving and Painting/Coating)	Tractors/Loaders/Backhoes	3	8	98

Phase	Sub-phase	Off-Road Equipment Type	Quantity	Hours/Day	Horsepower
Intersections	Grubbing/Land Clearing (Demolition)	Crawler Tractors	1	8	208
		Excavators	2	8	163
		Signal Boards	1	8	6
	Grading/Excavation (Earthwork and Grading)	Crawler Tractors	1	8	208
		Excavators	3	8	163
		Graders	2	8	175
		Rollers	2	8	81
		Rubber-Tired Loaders	1	8	200
		Scrapers	2	8	362
		Signal Boards	1	8	6
		Tractors/Loaders/Backhoes	4	8	98
	Drainage/Utilities/Sub-Grade (Utility Infrastructure)	Air Compressors	1	8	78
		Generator Sets	1	8	84
		Graders	1	8	175
		Plate Compactors	1	8	8
		Pumps	1	8	84
		Rough-Terrain Forklifts	1	8	100
		Scrapers	1	8	362
		Signal Boards	1	8	6
		Tractors/Loaders/Backhoes	3	8	98
	Paving (Roadbed and Curb Construction and Paving and Painting/Coating)	Pavers	1	8	126
		Paving Equipment	1	8	131
		Rollers	2	8	81
		Signal Boards	1	8	6
		Tractors/Loaders/Backhoes	3	8	98

Phase	Sub-phase	Off-Road Equipment Type	Quantity	Hours/Day	Horsepower
Traction Power	Grubbing/Land Clearing (Demolition)	Crawler Tractors	1	8	208
		Excavators	2	8	163
		Signal Boards	1	8	6
	Grading/Excavation (Earthwork and Grading)	Crawler Tractors	1	8	208
		Excavators	3	8	163
		Graders	2	8	175
		Rollers	2	8	81
		Rubber-Tired Loaders	1	8	200
		Scrapers	2	8	362
		Signal Boards	1	8	6
		Tractors/Loaders/Backhoes	4	8	98
	Drainage/Utilities/Sub-Grade (Utility Infrastructure)	Air Compressors	1	8	78
		Generator Sets	1	8	84
		Graders	1	8	175
		Plate Compactors	1	8	8
		Pumps	1	8	84
		Rough-Terrain Forklifts	1	8	100
		Scrapers	1	8	362
		Signal Boards	1	8	6
		Tractors/Loaders/Backhoes	3	8	98
	Paving (Roadbed and Curb Construction and Paving and Painting/Coating)	Pavers	1	8	126
		Paving Equipment	1	8	131
		Rollers	2	8	81
		Signal Boards	1	8	6
		Tractors/Loaders/Backhoes	3	8	98

Phase	Sub-phase	Off-Road Equipment Type	Quantity	Hours/Day	Horsepower
Special Track Construction	Grubbing/Land Clearing (Demolition)	Excavator	2	8	300
	Grading/Excavation (Earthwork and Grading)	Loader	1	8	100
		Roller	1	8	100
		Bulldozer	1	8	100
	Drainage/Utilities/Sub-Grade (Utility Infrastructure)	Loader	1	8	100
		Excavator	1	8	300
		Boom Truck	1	8	125
	Paving (Roadbed and Curb Construction and Paving and Painting/Coating)	Asphalt Paver	1	8	175
		Roller	1	8	125
		Sweeper	1	8	200
2nd Street Connection	Grubbing/Land Clearing (Demolition)	Crawler Tractors	1	8	208
		Excavators	2	8	163
		Signal Boards	1	8	6
	Grading/Excavation (Earthwork and Grading)	Crawler Tractors	1	8	208
		Excavators	3	8	163
		Graders	2	8	175
		Rollers	2	8	81
		Rubber-Tired Loaders	1	8	200
		Scrapers	2	8	362
		Signal Boards	1	8	6
		Tractors/Loaders/Backhoes	4	8	98
	Drainage/Utilities/Sub-Grade (Utility Infrastructure)	Air Compressors	1	8	78
		Generator Sets	1	8	84
		Graders	1	8	175
		Plate Compactors	1	8	8
		Pumps	1	8	84
		Rough-Terrain Forklifts	1	8	100
		Scrapers	1	8	362
		Signal Boards	1	8	6
		Tractors/Loaders/Backhoes	3	8	98

Phase	Sub-phase	Off-Road Equipment Type	Quantity	Hours/Day	Horsepower
	Paving (Roadbed and Curb Construction and Paving and Painting/Coating)	Pavers	1	8	126
		Paving Equipment	1	8	131
		Rollers	2	8	81
		Signal Boards	1	8	6
		Tractors/Loaders/Backhoes	3	8	98

Appendix 5: MTA Market Street Streetcar Vibration

Streetcar Vibration Measurements

To model the potential future vibration generated by operation of the Better Market Street proposed project, first the existing vibration from streetcar operations was measured and compared to the generalized curve developed by the Federal Transit Administration for streetcar operations. Measurements were conducted at one or two distances per location, one at the façade and/or one at the curb or similar intermediate distance between the building to obtain a range of data. This data is shown in Figure 4.C-5 in Section 4.C, *Noise*. At each location, the actual speed varied, not always achieving 25 mph. Also, there was a range of vibration that is likely related to wheel and suspension design, with the Milan cars generating vibration in the higher end of the range; some PCC streetcars also fell at the upper end of the range. Lastly, while crossovers were identified, there seemed to be several places where joints or wheel flats caused vibration to occur higher than anticipated. Thus, the envelope identified for SFMTA streetcars moving through crossovers (solid blue) is closer than usual to the non-crossover curve (dotted blue). In general, with standard direct-fixation track fasteners there is no difference expected compared to ballasted track. In particular much of the existing F-Line has been constructed with embedded ballasted track which is even stiffer. Therefore, the future condition with direct fixation track is expected to be similar to the existing condition.

Appendix 6: Buffer Differences for Building Damage from Vibration

Buffer Distances for Vibration Impact

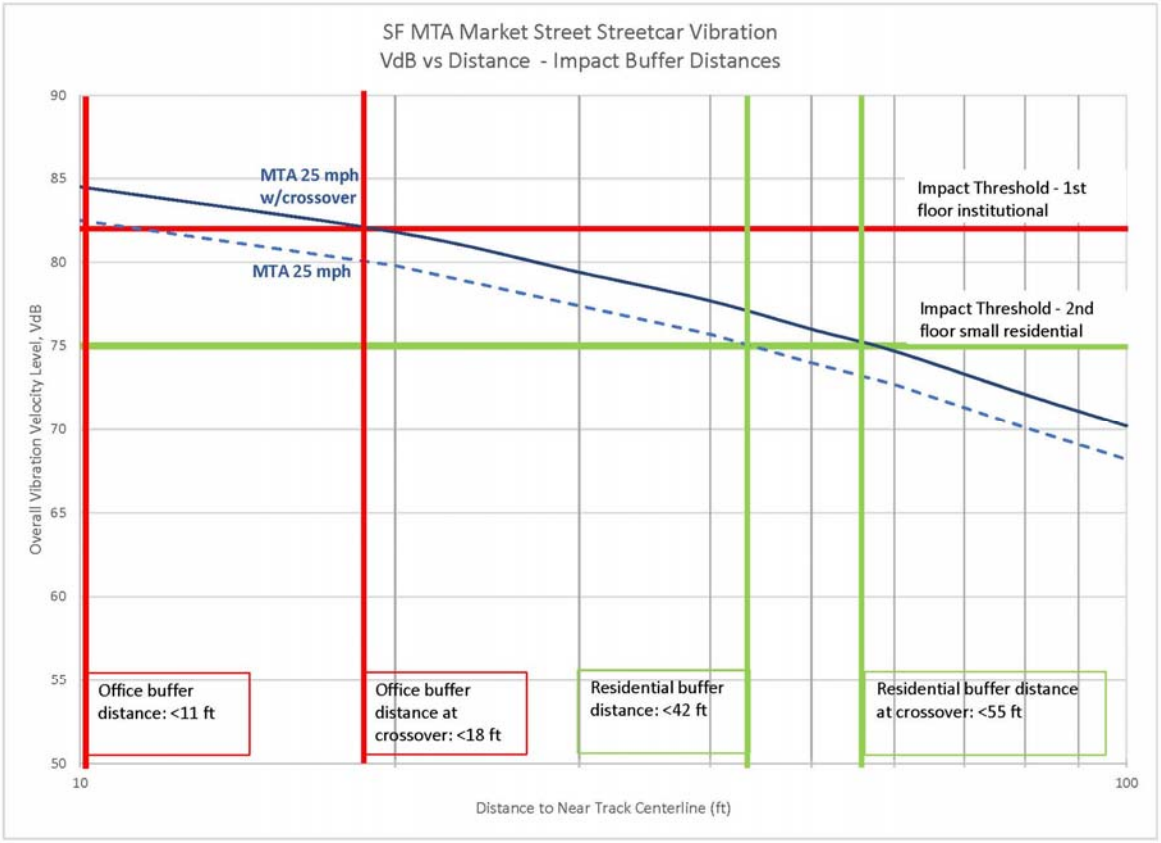
The blue curves shown in Figure 4.C-5 were used to establish impact buffer distances and evaluate the potential annoyance of occupants at residential buildings under existing and project conditions. Impact buffer distances are the same for existing and future conditions. Although there can be site-specific differences in the way vibration propagates through the soil or subsurface strata, at close distances (i.e., less than 100 feet), those differences are small. The "vibration vs. distance" curve shown in Figure 9 was developed from the SFMTA streetcar data, and takes into account the worst-case vibration sources (i.e., Milan and several other streetcars). These impact buffer distances for the proposed project are based on Federal Transit Administration thresholds and SFMTA streetcar data.

The method for determining the vibration impact at any specific building is as follows:

1. Identify the distance from the building façade to the near-track centerline.
2. Apply that distance to Figure 9 to determine the expected ground vibration (exterior).
3. Apply speed correction at the proposed F-loop area (5 mph): -14 dB at curves and special trackwork, -4 dB at tangent track
4. Apply analysis adjustments, based on the Federal Transit Administration methodology:
    a. Building coupling loss: -7 dB for one- to two-story masonry buildings; -10 dB, and even more, for larger buildings
    b. Floor resonance: +6 dB
    c. Floor-to-floor loss: -2 dB per floor up to 5 floors, -1 dB per floor up to 10th floor
    d. The net adjustment for estimating interior vibration on the second floor of a small residential building is 3 dB below the vibration expected on the ground level outside the building. For larger buildings, the net adjustment is 6 dB below ground-level vibration.
    e. If applicable, calculate the ground-borne noise level in dBA by adding -35 dB to the vibration level.

The corresponding buffer distances for small residential buildings (e.g., one- or two-story masonry buildings) from track without and with crossovers are 42 feet and 55 feet, respectively at 25 mph operating speed. These are shown in Figure 9. This is a conservative approach, as the many larger buildings would provide even more coupling loss and possibly less floor resonance. An impact buffer distance of 55 feet was developed based on the potential impact for small residential structures with these building adjustment factors: -7 dB coupling loss, -2 dB to the second floor, +6 dB floor amplification. Combined with the interior vibration criterion of 72 VdB for residences, the exterior ground vibration would have to be 75 VdB or greater to generate vibration impact at the small residential structures, which corresponds to a 55-foot distance from the near track centerline from crossovers or special trackwork; 42 feet distance for tangent (straight) track. However, for larger residential buildings, that buffer distance reduces to 35 feet from special trackwork and 25 feet from tangent track, respectively. For office buildings, which are all substantial structures, the net negative adjustment is 10 dB to the interior vibration on the ground floor; so even with a crossover, the buffer distance for impacts is 18 feet at 25 mph.

FIGURE 9: VIBRATION IMPACT BUFFER DISTANCES



The construction vibration impact assessment was conducted in accordance with Caltrans guidance, which identifies the source vibration and scales the vibration amplitude with distance to the sensitive receptor, as discussed below. The construction equipment associated with the construction phasing and work zones developed by the project sponsor was reviewed in consideration of source vibration values for the different types of construction equipment in Table 4.C-13 in Section 4.C, *Noise*, which were then used to estimate construction vibration levels. Table 4.C-13 summarizes the source vibration values, which were adjusted for distance using the equation below. For this analysis, the hoe ram vibration value was also applied to the backhoe, excavator and tractor; the large bulldozer vibration value was also applied to the scraper and grader; and the jackhammer vibration value was also applied to the plate compactor. The following equation was applied to determine buffer distances from construction vibration for each applicable criteria value. The analysis assumes that the proposed project would comply with the requirements of Public Works' standard construction measures.

Buffer Distance (feet) = $(PPV_{ref}/PPV_{limit})^{1/n}$ x 25

PPV_{ref} = source reference vibration at 25 feet

PPV_{limit} = target criteria limit

n = soil attenuation rate (non-dimensional)

The Federal Transit Administration recommends the use of n=1.5 for "typical soils." Caltrans suggests the use of 1.3 for competent soils (e.g., most sands, sandy clays, silty clays), and this value was used in this analysis because it assumes a slower attenuation rate with distance and it is more conservative.

This information was used to develop buffer distances for building damage, as shown in Figure 10 for historic structures and Figure 11 for all structures.

FIGURE 10: BUFFER DISTANCES FOR BUILDING DAMAGE (HISTORIC STRUCTURES)

				Criteria Categories and Vibration Limits (PPV in/sec)			
				Criteria: Fragile Historic (PPV In/s)		Criteria: Historic (PPV in/s)	
				Transient	Continuous/Freq Intermittent	Transient	Continuous/Freq Intermittent
				0.2	0.1	0.5	0.25
Phase	Subphase	Maximum Vibration Sources	Character	Buffer distance	Buffer distance	Buffer distance	Buffer distance
Center Lanes/Rail Track	Demolition, Utilities	Backhoe, Excavtor	Transient	13		7	
Outside/Curb Lanes	Demolition, Utilities	Backhoe, Excavtor	Transient	13		7	
	Paving	Roller	Continuous/Freq. Intermittment		44		22
Sidewalks	Demolition, Gradiing, Utilities	Backhoe	Transient	13		7	
Intersections	Demolition, Gradiing, Utilities	Backhoe, Excavtor	Transient	13		7	
	Paving	Roller	Continuous/Freq. Intermittment		44		22
	Utilities	Plate Compactors	Continuous/Freq. Intermittment		11		6
Traction Power	Demolition, Gradiing, Utilities	Backhoe, Excavtor	Transient	13		7	
	Paving	Roller	Continuous/Freq. Intermittment		44		22
	Utilities	Plate Compactors	Continuous/Freq. Intermittment		11		6
Special Track Construction	Demolition, Gradiing, Utilities	Backhoe, Excavtor	Transient	13		7	
	Paving and Grading	Roller	Continuous/Freq. Intermittment		44		22
	Utilities	Plate Compactors	Continuous/Freq. Intermittment		11		6

FIGURE 11: BUFFER DISTANCES FOR BUILDING DAMAGE (ALL STRUCTURES)

				Criteria Categories and Vibration Limits (PPV in/sec)											
			1.3	Criteria: Extremely Fragile		Criteria: Fragile		Criteria: Historic		Criteria: Older residential		Criteria: New residential		Criteria: Modern Industrial	
				Transient	Continuous/Freq Intermittent	Transient	Continuous/Freq Intermittent	Transient	Continuous/Freq Intermittent	Transient	Continuous/Freq Intermittent	Transient	Continuous/Freq Intermittent	Transient	Continuous/Freq Intermittent
				0.12	0.08	0.2	0.1	0.5	0.25	0.5	0.3	1	0.5	2	0.5
Phase	Subphase	Maximum Vibration Sources	Character	Buffer distance	Buffer distance	Buffer distance	Buffer distance	Buffer distance	Buffer distance	Buffer distance	Buffer distance	Buffer distance	Buffer distance	Buffer distance	Buffer distance
Center Lanes/Rail Track	Demolition, Utilities	Backhoe, Excavator	Transient	20		13		7		7		4		2	
Outside/Curb Lanes	Demolition, Utilities	Backhoe, Excavator	Transient	20		13		7		7		4		2	
	Paving	Roller	Continuous/Freq. Intermittent		53		44		22		19		13		13
Sidewalks	Demolition, Grading, Utilities	Backhoe	Transient	20		13		7		7		4		2	
Intersections	Demolition, Grading, Utilities	Backhoe, Excavator	Transient	20		13		7		7		4		2	
	Paving	Roller	Continuous/Freq. Intermittent		53		44		22		19		13		13
	Utilities	Plate Compactors	Continuous/Freq. Intermittent		13		11		6		5		3		3
Traction Power	Demolition, Grading, Utilities	Backhoe, Excavator	Transient	20		13		7		7		4		2	
	Paving	Roller	Continuous/Freq. Intermittent		53		44		22		19		13		13
	Utilities	Plate Compactors	Continuous/Freq. Intermittent		13		11		6		5		3		3
Special Track Construction	Demolition, Grading, Utilities	Backhoe, Excavator	Transient	20		13		7		7		4		2	
	Paving and Grading	Roller	Continuous/Freq. Intermittent		53		44		22		19		13		13
	Utilities	Plate Compactors	Continuous/Freq. Intermittent		13		11		6		5		3		3