4.12 Noise and Vibration

4.12.1 Introduction

This section describes the affected environment and environmental consequences related to noise and vibration from operations of the NEPA Alternatives. The information provided in this discussion is based on *VTA's BART Silicon Valley—Phase II Extension Project Noise and Vibration Technical Report* prepared in 2016 by Wilson, Ihrig & Associates. The analysis also draws upon a study prepared by ATS Consulting LLC prepared in January 2005, the *Station Noise Mitigation and Acoustical Treatment Study*, which outlined the noise and acoustical mitigation measures that need to be considered during the design of the BART stations. The descriptions of existing noise conditions along the BART Extension alignment are based on information and data provided by Wilson Ihrig & Associates.

4.12.2 Existing Conditions and Regulatory Setting

4.12.2.1 Noise and Vibration Terminology

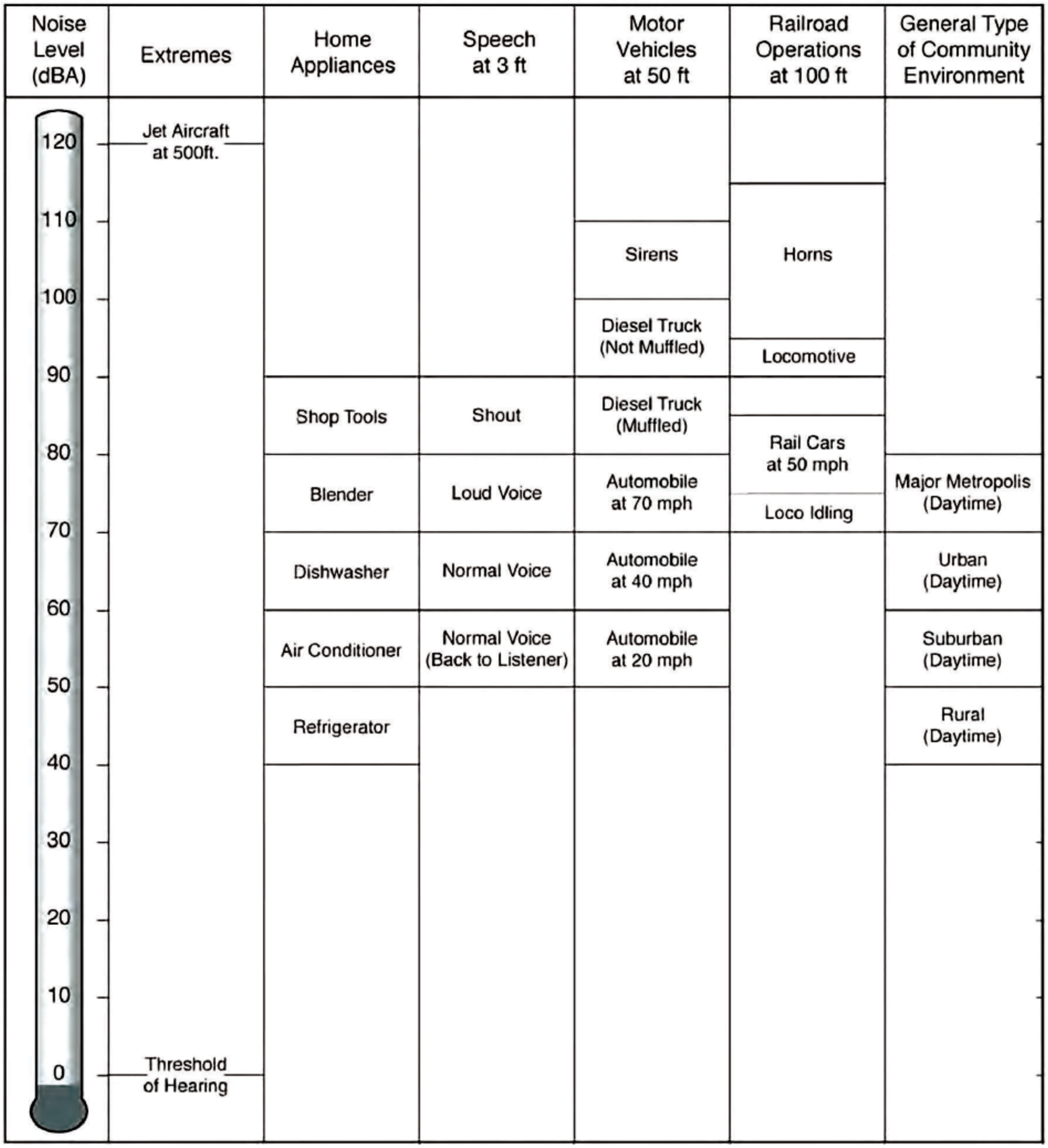
Noise Descriptors

Noise is typically defined as unwanted or undesirable sound, where sound is characterized by small air pressure fluctuations above and below the atmospheric pressure. The basic parameters of environmental noise that affect human subjective response are (1) intensity or level, (2) frequency content, and (3) variation with time. The first parameter is determined by how greatly the sound pressure fluctuates above and below the atmospheric pressure and is expressed on a compressed scale in units of decibels (dB). By using this scale, the range of normally encountered sound can be expressed by values between 0 and 120 dB. On a relative basis, a 3 dB change in sound level generally represents a barely noticeable change outside the laboratory, whereas a 10 dB change in sound level would typically be perceived as a doubling (or halving) in the loudness of a sound.

The frequency content of noise is related to the tone or pitch of the sound and is expressed based on the rate of the air pressure fluctuation in terms of cycles per second (called Hertz [Hz]). The human ear can detect a wide range of frequencies from about 20 to 17,000 Hz. Because the sensitivity of human hearing varies with frequency, the A-weighting system is commonly used when measuring environmental noise to provide a single number descriptor that correlates with human subjective response. Sound levels measured using this weighting system are called *A-weighted sound levels* and are expressed in decibel notation as dBA. The A-weighted sound level is widely accepted for describing environmental noise. Figure 4.12-1 provides a comparison of representative dBA levels for common noise sources and environments. Although the extremes range from 0 dBA (approximate threshold of hearing) to 120 dBA (jet aircraft at 500 feet), most commonly encountered noise levels fall within the range of 40 to 90 dBA.

Because environmental noise fluctuates from moment to moment, it is common practice to condense all of this information into a single number called the *equivalent sound level* (L_{eq}). L_{eq} is a measure of sound energy over a period of time, typically 1 hour or 24 hours. It is referred to as the equivalent sound level because it is equivalent to the level of a steady sound that, over a referenced duration and location, has the same sound energy as the actual fluctuating sound. Often L_{eq} values over a 24-hour period are used to calculate cumulative noise exposure in terms of the *day-night equivalent sound level* (L_{dn}). L_{dn} is the A-weighted L_{eq} for a 24-hour period with an added 10-dB penalty imposed on noise that occurs during the nighttime hours (between 10 p.m. and 7 a.m.). Many surveys have shown that L_{dn} is well correlated with human annoyance, and therefore this descriptor is widely used for environmental noise impact assessment. Figure 4.12-2 provides examples of typical noise environment and criteria in terms of L_{dn}. Although the extremes of L_{dn} range from 35 dBA in a wilderness environment to 85 dBA in noisy urban environments, L_{dn} generally ranges between 55 and 75 dBA in most communities. As shown in Figure 4.12-2, this spans the range between an ideal residential environment and the threshold for an unacceptable residential environment according to the U.S. Department of Housing and Urban Development and the U.S. Environmental Protection Agency.

Environmental noise can also be described statistically using percentile sound levels, L_n, which refer to the sound level exceeded "n" percent of the time. For example, the sound level exceeded 90 percent of the time, denoted as L_{90}, represents the "background" noise in a community. Similarly, the sound level exceeded 33 percent of the time (L_{33}) is often used to approximate the L_{eq} in the absence of loud, intermittent sources such as aircraft and trains.



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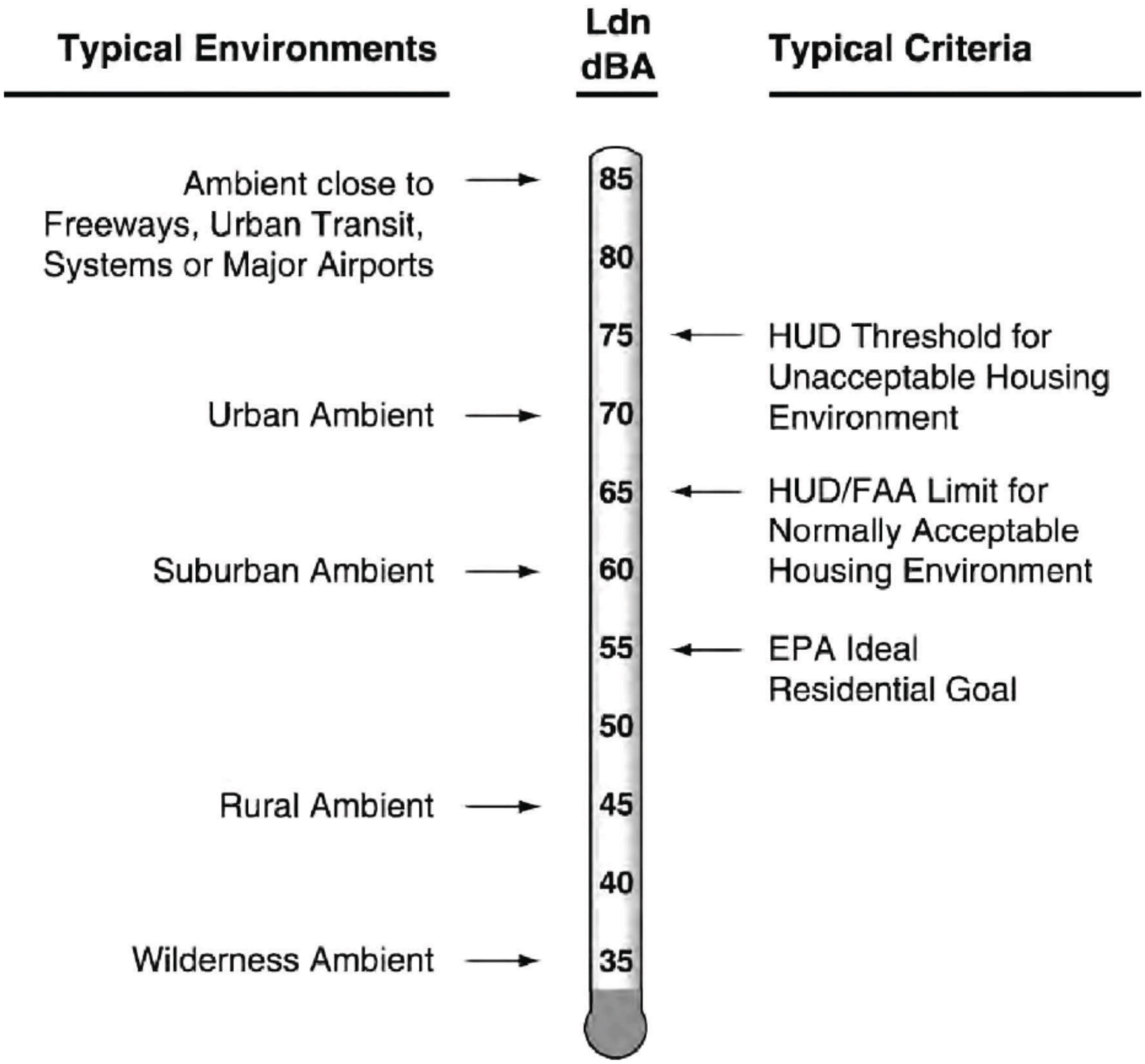
Source: VTA, 2008.

Figure 4.12-1
Comparison of Various Noise Levels
VTA's BART Silicon Valley–Phase II Extension Project



Source: VTA, 2008.

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Figure 4.12-2
Examples of Typical Outdoor Noise Exposure
VTA's BART Silicon Valley–Phase II Extension Project

Groundborne Noise and Vibration Descriptors

Some common sources of groundborne vibration are trains, buses on rough roads, and construction activities such as blasting, pile-driving, and operating heavy earth-moving equipment. The effects of groundborne vibration include the movement of the building floors, rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds. The rumbling sound caused by the vibration of room surfaces is called groundborne noise.

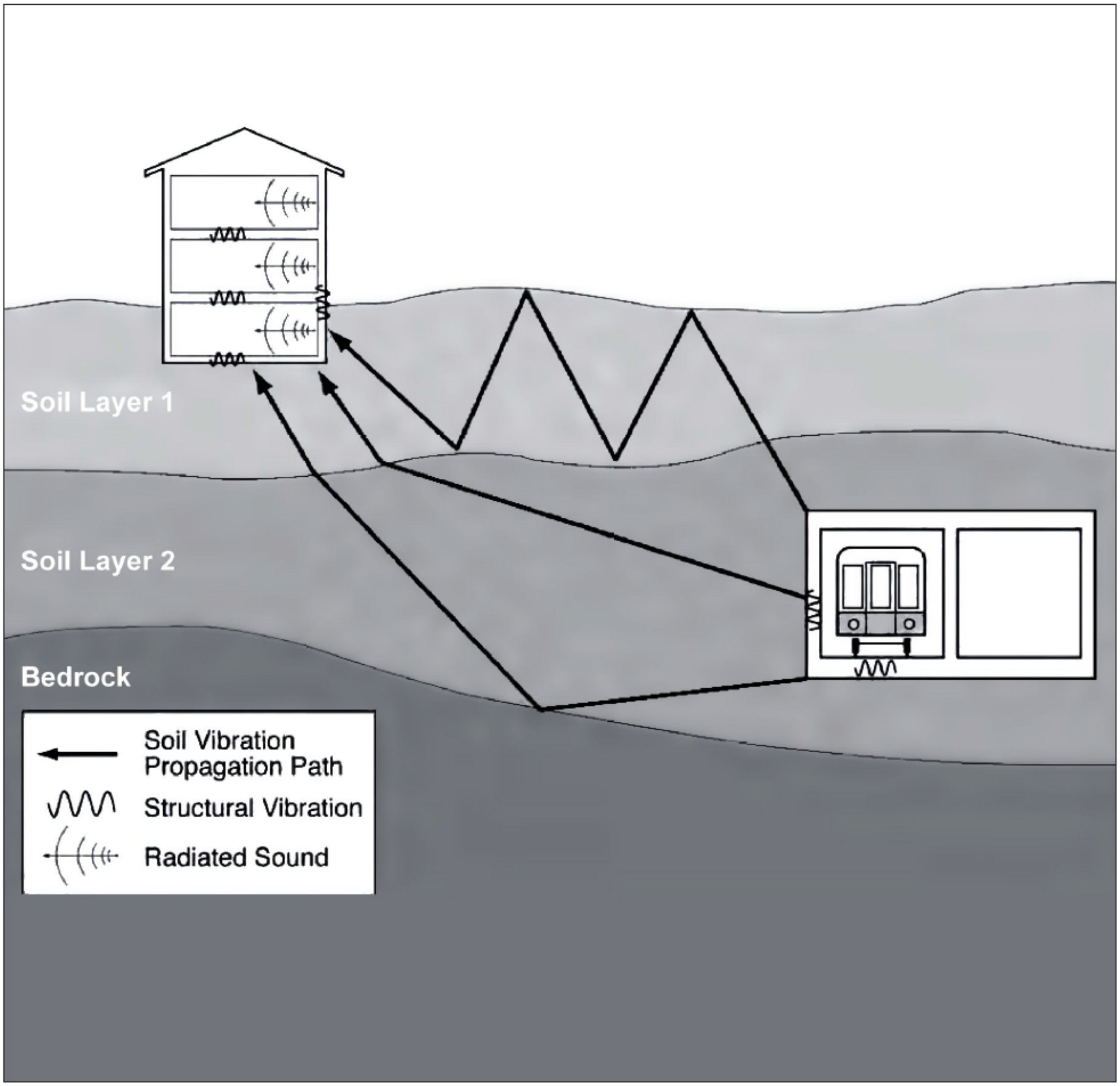
The basic concepts of groundborne vibration and noise are illustrated for a rail system in Figure 4.12-3. The train wheels rolling on the rails create vibration energy that is transmitted through the track support system into the transit structure. The amount of energy that is transmitted into the transit structure is strongly dependent on factors such as how smooth the wheels and rails are and the resonance frequencies of the vehicle suspension system and the track support system. These systems, like all mechanical systems, have resonances that result in increased vibration response at certain frequencies, called *natural frequencies*.

The vibration of the transit structure creates vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. The vibration propagates from the foundation throughout the building structure. The maximum vibration amplitudes of the floors and walls of a building often will be at the resonance frequencies of various components of the building.

Groundborne vibration is the oscillatory motion of the ground about an equilibrium position. It can be described in terms of displacement, velocity, or acceleration. *Displacement* refers to the distance an object moves away from its equilibrium position, *velocity* refers to the rate of change in displacement or the speed of this motion, and *acceleration* refers to the time rate of change in the velocity of the object.

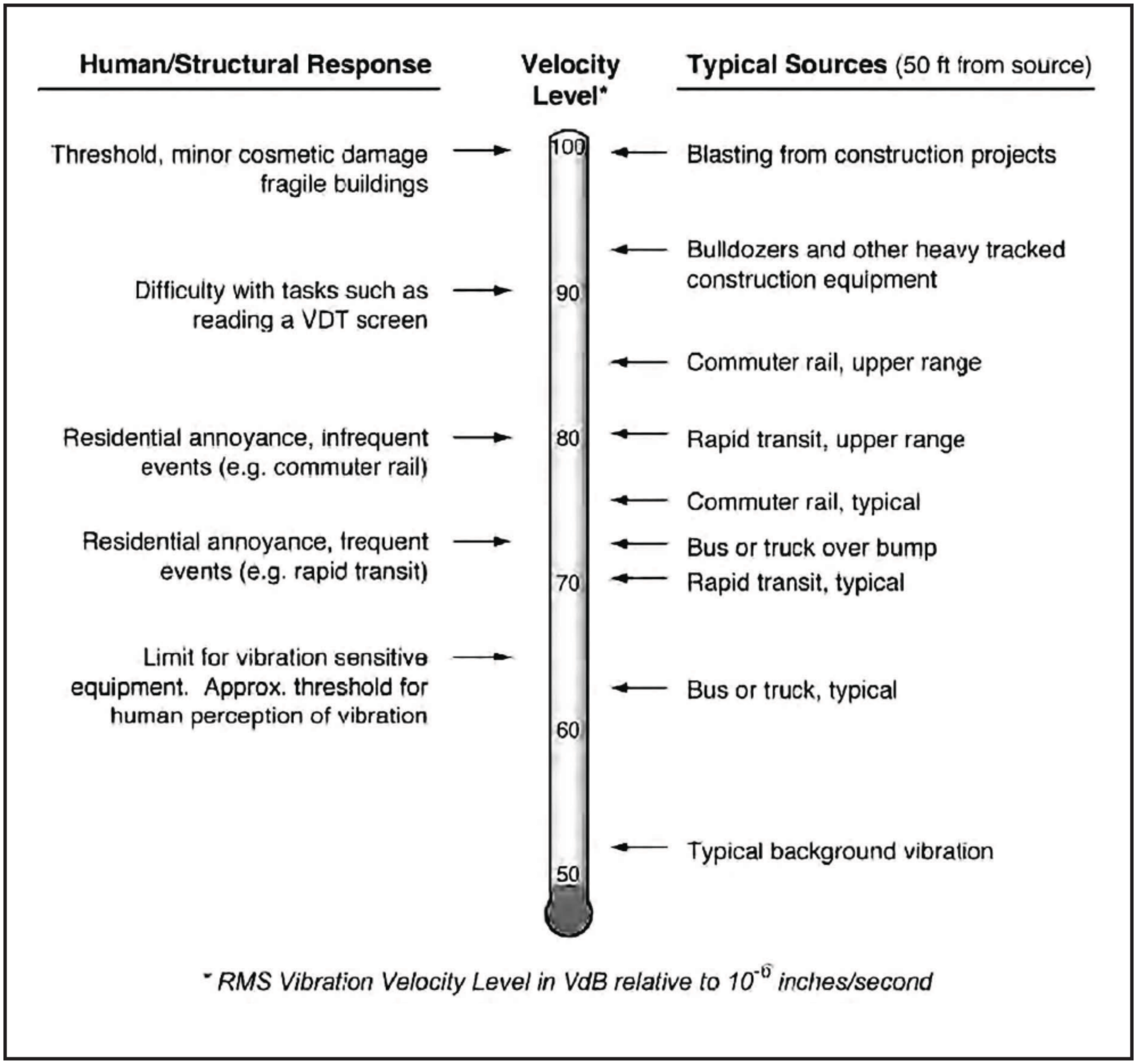
Although displacement is easier to understand than velocity or acceleration, it is rarely used for describing groundborne vibration. One reason for this is that most sensors used for measuring groundborne vibration are designed to provide output signals proportional to either velocity or acceleration. Even more important, the response of humans, buildings, and equipment to vibration is more accurately described using velocity or acceleration. Sensitivity to vibration typically corresponds to the amplitude of vibration velocity within the low frequency range of most concern for environmental vibration (roughly 5 to 100 Hz). Therefore, vibration velocity is used in this analysis as the primary measure to evaluate the effects of vibration.

Vibration velocity level can be expressed in terms of decibels (VdB) relative to one micro-inch (μin) per second (1×10^{-6} inch per second). Figure 4.12-4 illustrates typical groundborne vibration levels for common sources, as well as criteria for human and structural response to groundborne vibration.



Source: Wilson Ihrig Associates, 2008.

Figure 4.12-3
Propogation of Groundborne Vibration into Buildings
VTA's BART Silicon Valley–Phase II Extension Project



Source: VTA, 2008.

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Figure 4.12-4
Typical Groundborne Vibration Levels and Criteria
VTA's BART Silicon Valley–Phase II Extension Project

As shown, the range is from approximately 50 to 100 VdB, from imperceptible background vibration to the threshold of damage. Although the threshold of human perception to vibration is approximately 65 VdB, annoyance is not usually substantial unless the vibration exceeds 70 VdB.

4.12.2.2 Environmental Setting

Existing Land Uses

Existing land uses along the BART Extension alignment include residential uses, commercial uses such as offices and warehouses, and industrial uses. Figures 4.11-1 to 4.11-7 in Section 4.11, *Land Use*, show existing land uses at the station sites. No buildings along the alignment have been identified as being highly sensitive to noise and vibration such as vibration-sensitive manufacturing, research, or special medical facilities. The majority of receivers along the alignment are residential land uses and those places where people sleep at night (e.g., hotels and hospitals). There are also institutional land uses that primarily have daytime uses (e.g., schools and churches), along with parks and other outdoor uses. No facilities such as performing arts facilities and recording studios have been identified that could be affected by groundborne noise or vibration.

No buildings along the alignment have been identified that can be classified as Land Use Category 1. Such receivers would include vibration-sensitive manufacturing, research, or special medical facilities. The majority of receivers within the alignment corridor are Land Use Category 2. Category 2 receivers include residential land uses and those where people sleep at night (e.g., hotels and hospitals). As described in Section 4.11, *Land Use*, there are several sensitive receptors that could be affected by groundborne noise or vibration.

Connection to Phase I Berryessa Extension

At the connection to Phase I Berryessa Extension, sensitive receptors include Anne Darling Elementary School south of Coyote Creek, and single-family residences south of McKee Road.

Alum Rock/28th Street Station

Low- and medium-density residential uses are located across U.S. 101 to the north and east of the Alum Rock/28th Street Station, as well as to the west of 28th Street and the former railroad right-of-way. The Portuguese Band and Social Center is located to the west of the station site, and the Five Wounds National Portuguese Church and associated elementary school are located to the southeast.

Tunnel Alignment near Coyote Creek

There are residential areas to the north and south of Santa Clara Street from 28th to 18th Streets. The East San Jose Carnegie Branch Library is directly south of the alignment at South 23rd Street. Older single-family residential neighborhoods are to the north and south of the alignment. Horace Mann Elementary School is along the north side of the alignment, and San Jose State University and San Jose City Hall are to the south.

Downtown San Jose Station East and West Options

Older residential uses are just beyond the retail corridor along Santa Clara Street. The San Jose State University campus is one block south of Santa Clara Street between 4th and 10th Streets. The San Jose Civic Plaza, including San Jose City Hall, is south of Santa Clara Street, between 4th and 6th Streets. The Museum of Art, Plaza de Cesar Chavez, St. Joseph's Cathedral, San Pedro Square, and several theaters and major hotels are near the new station locations. Low- and medium-density residential uses are to the north of Santa Clara Street, just outside of downtown San Jose.

Diridon Station South and North Options

Sensitive land uses near the Diridon Station South and North Options include Guadalupe River Park and Gardens to the north, and low- to medium-density residential uses to the south. There are low- to medium-density residential uses with some park/open space between Diridon Station and Stockton Avenue. Cahill Park is located one block south of the station on West Fernando Street.

Continuation of Tunnel Alignment

Residential uses are along the alignment before reaching Stockton Avenue, and to the southwest side of the alignment.

Newhall Maintenance Facility

Across the existing railroad tracks, there are single-family and multi-story residences to the southwest and west of the alignment leading to the Newhall Maintenance Facility, along with Santa Clara University. Avaya Stadium, home of the Earthquakes soccer team, is on the northeast side of the facility.

Santa Clara Station

The Santa Clara Police Station is along the western boundary of the station site, and Santa Clara University occupies a substantial portion of the land to the southwest of the station area. There are also medium- and low-density residential developments to the south of the Santa Clara Station site. Mineta San Jose International Airport is to the northeast.

Noise

The existing ambient noise conditions along the alignment are primarily affected by local vehicle traffic on nearby roadways, freeways, aircraft overflights, train activities on the existing Caltrain alignment, train activities north of Interstate (I-) 880 and local activities common to a suburban community. Ambient noise conditions were determined from long-term measurements at 13 sites that would be exposed to wayside noise or ancillary facilities from the BART Extension (Wilson, Ihrig & Associates 2016). The 13 measurement sites were selected to be representative of the different areas adjacent to the alignment where airborne noise impacts might occur.

For each location, the noise survey was conducted by means of a calibrated sound level meter (data logger) programmed to measure and store hourly average noise levels and statistical levels of environmental noise using a slow meter response and A-weighting. They were left unattended for a period of 2 to 4 full days. These noise-measuring instruments meet ANSI S1.4-193 specifications for Type I Sound Level Meters. Table 4.12-1 summarizes existing ambient noise levels. Figures 4.12-5 through 4.12-7 show the measurement locations.

Table 4.12-1: Existing Ambient Noise Levels

Measurement Location Label	Site Description	Primary Noise Sources	Most Recent Survey Dates	Ambient Used In Analysis (L_{dn})
A	N 13th St north of LT-B	Santa Clara St	03/29/08 to 04/01/08	62
B	N 13th St north of Santa Clara St	Santa Clara St	09/22/14 to 09/24/15	71
C	N 12th St north of Santa Clara St	Santa Clara St	04/03/08 to 04/06/08	63
E	S 13th St south of Santa Clara St	Santa Clara St	09/22/14 to 09/24/15	66
H	S 15th St south of Santa Clara St	Santa Clara St	03/27/08 to 03/30/08	60
I	S 16th St south of Santa Clara St	Santa Clara St	03/27/08 to 03/30/08	63
L	NW Corner of Villa Ave and Stockton Ave	Stockton Ave	01/29/14 to 02/03/14	69
N	Stockton Ave, 94 feet north of Schiele Ave	Stockton Ave	01/13/14 to 01/16/14	70
O	Schiele Ave, 197 feet west of Stockton Ave	Stockton Ave	04/05/08 to 04/08/08	62
P	SW Corner of Harding Ave and Stockton Ave	Stockton Ave	01/29/14 to 02/03/14	69
T	1070 Stockton Ave	Stockton Ave, Newhall St, I-880, Caltrain	01/13/14 to 01/16/14	67
U	Newhall St and Elm St	Newhall St, Elm St, I-880, Caltrain	01/29/14 to 02/03/14	62
Source: Wilson, Ihrig & Associates 2016.				

Figure 4.12-5
Long-term Noise Measurement Locations for Wayside Train Noise
VTA's BART Silicon Valley–Phase II Extension Project

Figure 4.12-6
Long-term Noise Measurement Locations at 13th Street Ventilation Structure
VTA's BART Silicon Valley–Phase II Extension Project

Figure 4.12-7

Long-term Noise Measurement Locations at Stockton Avenue Ventilation Structure

VTA's BART Silicon Valley–Phase II Extension Project

Vibration

Existing ambient vibration conditions along the alignment are consistent with a typical urban environment with vibration typically being imperceptible. Train activities on the existing Caltrain alignment are a source of intermittent perceptible vibration at locations in proximity to the track. Vibration-sensitive land uses within the screening zones for the alignment and stations are the same as for noise-sensitive land uses, which are described under *Existing Land Uses* above.

4.12.2.3 Regulatory Setting

Federal

The environmental noise and vibration impact evaluation for the BART Extension is based on criteria defined in the Federal Transit Administration's (FTA) *Transit Noise and Vibration Impact Assessment* (2006) also referred to as the FTA Guidance Manual. The FTA Guidance Manual provides criteria to evaluate construction and operational impacts for projects. The noise and vibration criteria are based on studies that examined community reactions to noise and vibration from construction activity and transit operations. Local noise and vibration regulations do not apply to regional transit operations and are therefore not used in the impact assessment.

Airborne Noise Criteria

For transit operations aboveground, the FTA Guidance Manual provides noise criteria that evaluates impacts based on potential changes to the existing ambient noise environment. For higher levels of existing ambient noise, less of a change is needed to cause impacts due to transit operations, which are long-term. Operational noise impacts are classified as No Impact, Moderate Impact, or Severe Impact depending on the amount of change in noise level relative to the existing ambient noise level. These terms only apply to operational train noise and cannot be directly applied to noise from other sources such as vehicle traffic and ancillary facilities.

For both a General Assessment and Detailed Analysis, the FTA provides guidelines to assess project noise levels from mass transit system operations, as well as noise criteria to assess impacts. Table 4.12-2 provides the FTA noise-sensitive land-use categories: Category 1, Category 2, and Category 3. The FTA guidelines specify a particular noise metric to be used depending on the specific land use (e.g., residential). Table 4.12-2 describes the FTA land-use categories, and specifies the noise metric to be used and the criterion for each Category.

Table 4.12-2: FTA Land Use Category and Noise Metric for Transit Impact Criteria

Land Use Category	Noise Metric (dBA)	Description of Land Use Category
1	Outdoor L_{eq}(h)	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use.
2	Outdoor L_{dn}	Residences and buildings where people normally sleep. This category includes homes, hospitals, and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor L_{eq} (h)	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, and churches where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Buildings with interior spaces where quiet is important, such as medical offices, conference rooms, recording studios, and concert halls fall into this category. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.

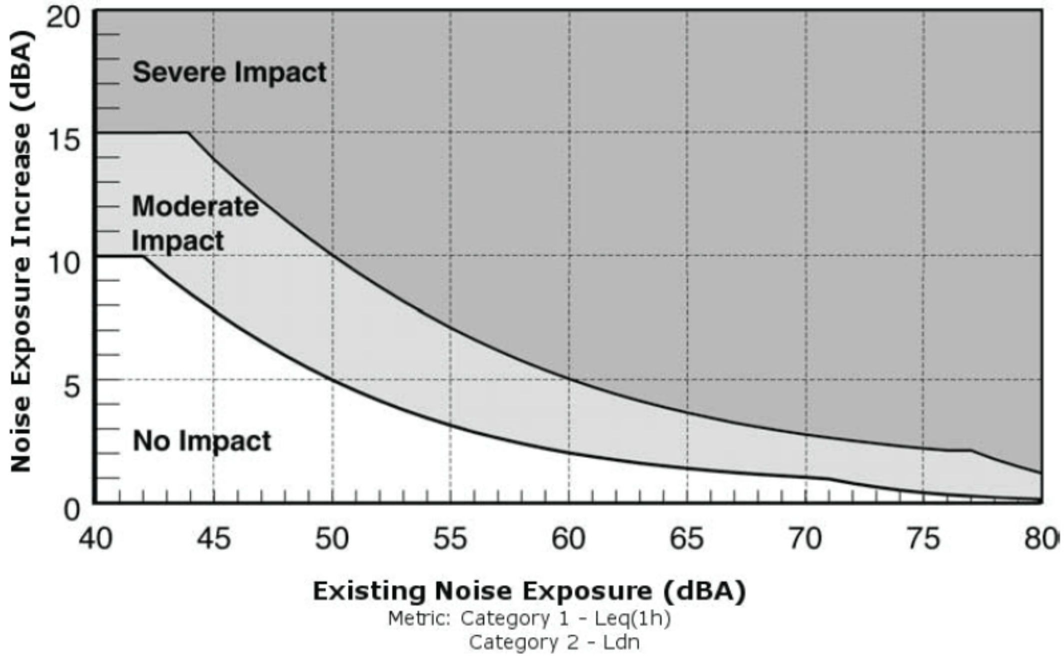
Three levels of noise impact are defined by the FTA guidelines: *No Impact*, *Moderate Impact*, and *Severe Impact*. These levels of impact are shown graphically in Figure 4.12-8 (Land Use Categories 1 and 2) and Figure 4.12-9 (Land Use Category 3).

The FTA noise impact thresholds are presented in Table 4.12-3. They are based on the existing ambient noise exposure level and the projected increase in noise level created by a project or combination of new projects. The noise thresholds in Table 4.12-3 reflect the graphic data presented in Figures 4.12-8 and Figure 4.12-9.

Table 4.12-3: Cumulative Increase Thresholds for Transit Noise Impact

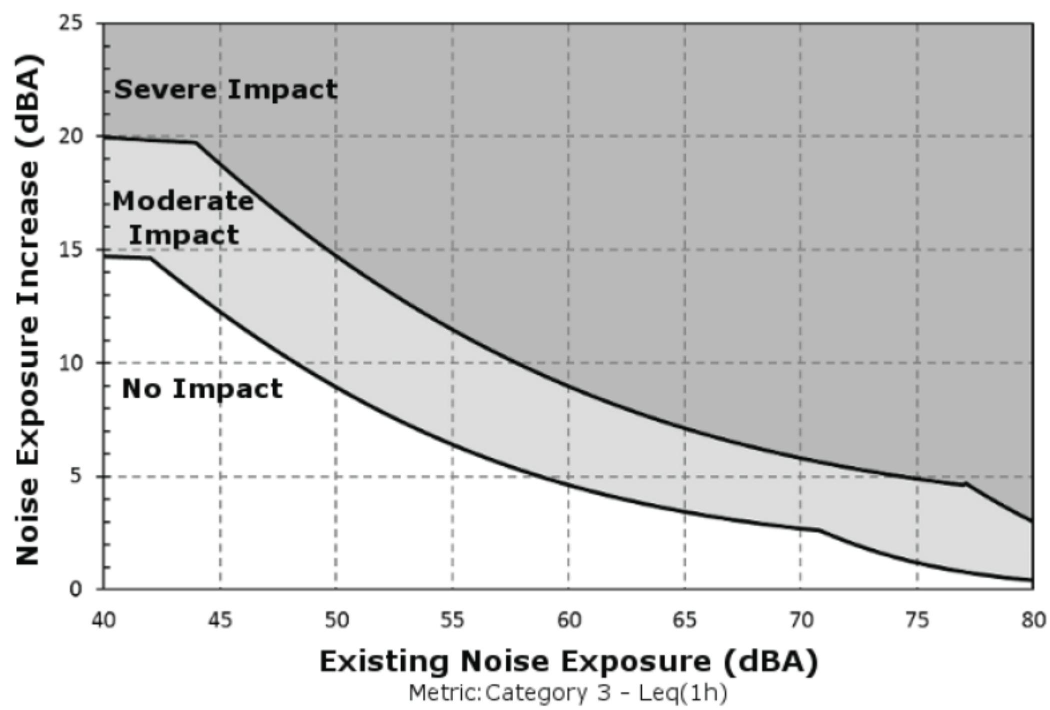
Existing Noise Exposure, L_{eq} or L_{dn}	Impact Threshold for Increase in Cumulative Noise Exposures (dBA)			
	Category 1 or 2 Sites		Category 3 Sites	
	Impact	Severe Impact	Impact	Severe Impact
45	8	14	12	19
46	7	13	12	18
47	7	12	11	17
48	6	11	10	16
49	5	11	10	15
50	5	10	9	15
51	5	9	8	14
52	4	9	8	13
53	4	8	7	13
54	3	8	7	12
55	3	7	6	11
56	3	7	6	11
57	3	6	6	10
58	2	6	5	10
59	2	5	5	9
60	2	5	5	9
61	1.9	5	4	9
62	1.7	4	4	8
63	1.6	4	4	8
64	1.5	4	4	7
65	1.4	4	3	7
66	1.3	3	3	7
67	1.2	3	3	7
68	1.2	3	3	6
69	1.1	3	3	6
70	1.0	3	3	6
71	1.0	3	3	6
72	0.8	3	2	5
73	0.6	2	1.8	5
74	0.5	2	1.5	5
75	0.4	2	1.2	5

Source: Federal Transit Administration Transit Noise and Vibration Impact Assessment, May 2006.
Note: Maximum 1-hour L_{eq} is used for land use involving only daytime activities; L_{dn} is used for land uses where nighttime sensitivity is a factor.



Source: Wilson Ihrig Associates, 2016.

Figure 4.12-8
Increase in Noise Levels Allowed by Criteria (Land Use Categories 1 and 2)
VTA's BART Silicon Valley–Phase II Extension Project



Source: Wilson Ihrig Associates, 2016.

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Figure 4.12-9
Increase in Noise Levels Allowed by Criteria (Land Use Category 3)
VTA's BART Silicon Valley–Phase II Extension Project

Noise generated by a project that falls in the No Impact range requires no mitigation. At the other extreme, noise projections in the Severe Impact range represent the most compelling need for mitigation. Noise generated by a project in the Moderate Impact range will also require consideration and adoption of mitigation measures where considered reasonable. The mitigation policy adopted by VTA for the BART Extension is to mitigate Moderate Impacts when the increase in noise levels is greater than 5 dBA and mitigation is feasible.

The FTA Guidance Manual does not directly address ancillary facilities that do not operate continuously. However, there is a local regulation that can be used to assess infrequently occurring noises. The tunnel ventilation fans (TVF) are the main example of this. TVF are used primarily in emergencies. They also need to be tested occasionally and will occasionally be used to ventilate tunnel sections during nighttime maintenance work. An applicable criterion for this infrequent, operational noise source is provided by a City of San Jose code (2011). Although this code is intended to apply to emergency power, the operation of and need for of TVF are similar in that they are primarily for emergencies, but also need to be operated infrequently for short periods of time. The noise limit for a commercial land use adjacent to a residential land use is 55 dBA (see Table 20-105 in City of San Jose Department of Planning, Building and Code Enforcement [2011]).

Transit Groundborne Noise and Vibration Criteria

Predicted levels of groundborne noise and vibration have been evaluated using the FTA criteria, according to the Land Use Categories defined in Table 4.12-4. The vibration criteria for the three Land Use Categories are also indicated in Table 4.12-4. If the overall vibration level does not exceed the relevant criterion, then neither do any of the 1/3-octave band levels. It is sufficient to evaluate the predicted overall vibration levels, unless the criteria are exceeded, in which case an evaluation of the 1/3-octave band levels is warranted.

The FTA noise and vibration criteria are affected by the number of events, which in this case corresponds to the number of train passbys per day. Because the plan for BART Extension operations calls for more than 70 train movements a day, the *Frequent Events* criteria would apply.

Table 4.12-4: Indoor Groundborne Noise and Vibration Impact Criteria

	GBV Impact Levels (VdB re 1 micro-inch/sec)			**GBN Impact Levels (dBA re 20 micro Pascals)**		
Land Use Category	**Frequent Events[a]**	**Occasional Events[b]**	**Infrequent Events[c]**	**Frequent Events[a]**	**Occasional Events[b]**	**Infrequent Events[c]**
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB*	65 VdB*	65 VdB*	N/A[d.e]$_{4,5}$	N/A[d.e]	N/A[d.e]
Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

[a] *Frequent Events* is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category

[b] *Occasional Events* is defined as 30 to 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.

[c] *Infrequent Events* is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.

[d] This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.

[e] Vibration-sensitive equipment is not sensitive to groundborne noise.

No buildings along the alignment have been identified that can be classified as Land Use Category 1. The FTA noise and vibration criteria for Category 2 receivers are 35 dBA for groundborne noise and 72 VdB (re: 10-6 in/sec) for vibration.

The criteria for Institutional land uses under Category 3 with daytime uses only (e.g., schools and churches) are 40 dBA for groundborne noise and 75 VdB for vibration. The criteria do not apply to most commercial or industrial uses because, in general, the activities within these buildings are compatible with higher noise levels. They do apply to business uses which that depend on quiet as an important part of operations, such as sound and motion picture recording studios. If the buildings or structures are used for commercial or industrial purposes and are located in busy commercial areas, they are not considered noise-sensitive and the noise impact criteria do not apply.

FTA also provides criteria for Special Buildings, which include concert halls, TV studios, recording studios, auditoriums, and theaters. There no facilities along the alignment that have been identified as potentially being affected by groundborne noise or vibration that meet the definition of a Special Building.

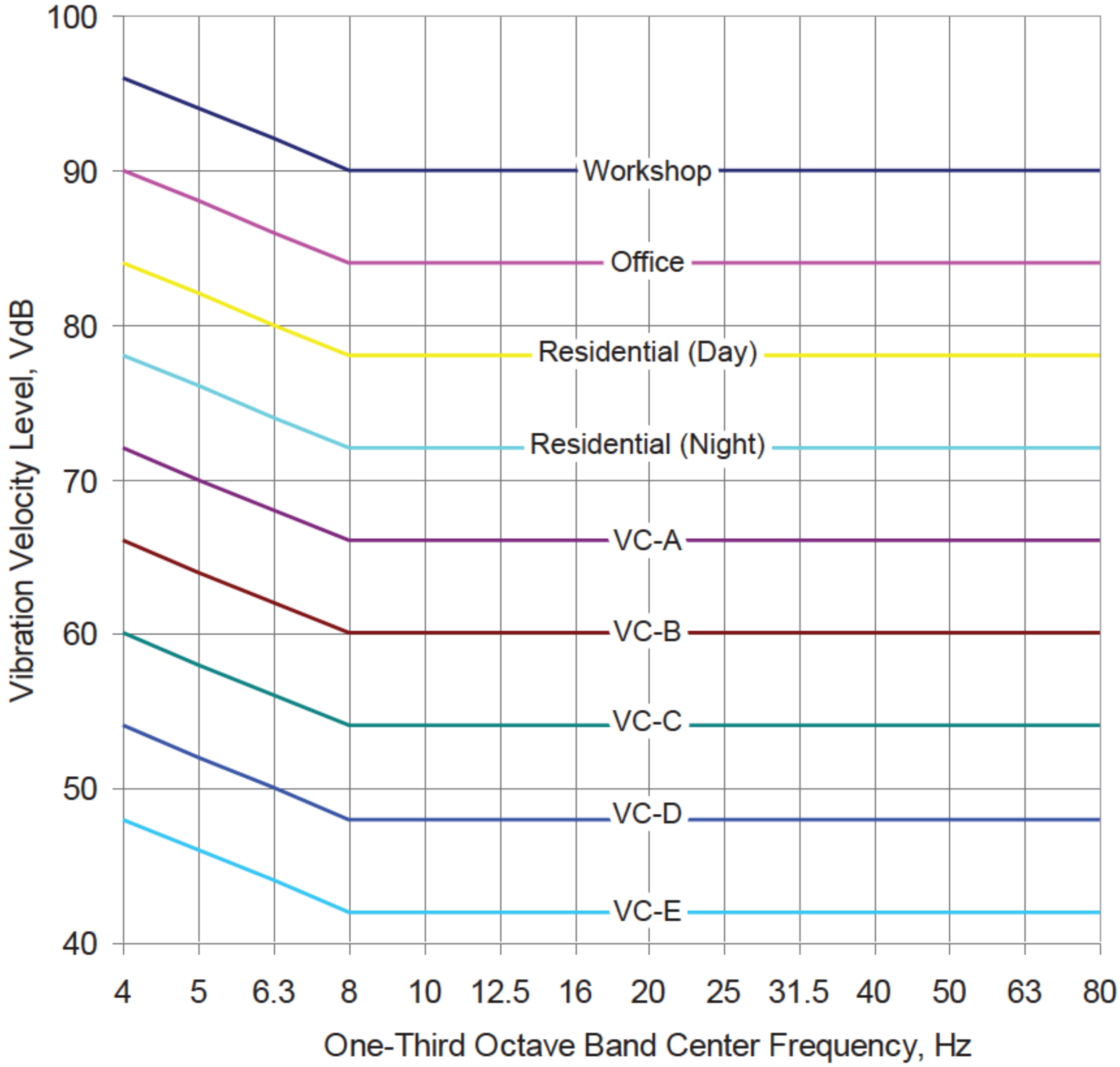
FTA vibration criteria for detailed analysis are presented in terms of 1/3-octave bands as shown in Figure 4.12-10. The projected vibration levels are compared to the spectral criteria curves, and if the applicable curve is not exceeded, then no impact is projected to occur. For example, the criterion curve for residences (night) is 72 VdB above 8 Hz. Below 8 Hz the sensitivity of humans decreases as reflected in the higher threshold, although below 8 Hz transit systems typically produce little vibration.

Interpretation of the various vibration criteria levels shown in Figure 4.12-10 are presented below in Table 4.12-5. Frequency band levels that exceed a particular criterion curve indicate the need for mitigation. The frequency range(s), over which the exceedance occurs, is important for determining the type and extent of mitigation. To be effective, the vibration mitigation must be able to reduce the vibration levels to achieve criteria over the frequency range of exceedance. In general, the lower the frequency at which exceedance occurs, the more difficult it is to mitigate vibration impacts and more substantial are the measures necessary to accomplish the reductions.

Table 4.12-5: Interpretation of Vibration Criteria for Detailed Analysis

Criterion Curve	Max L_v (VdB)[a]	Description of Use
Workshop	90	Distinctly feelable vibration. Appropriate to workshops and non-sensitive areas.
Office	84	Feelable vibration. Appropriate to offices and non-sensitive areas.
Residential Day	78	Barely feelable vibration. Adequate for computer equipment and low-power optical microscopes (up to 20X).
Residential Night, Operating Rooms	72	Vibration not feelable, but groundborne noise may be audible inside quiet rooms. Suitable for medium-power optical microscopes (100X) and other equipment of low sensitivity.
VC-A	66	Adequate for medium-to high-power optical microscopes (400X), microbalances, optical balances, and similar specialized equipment.
VC-B	60	Adequate for high-power optical microscopes (1000X), inspection and lithography equipment to 3 micron line widths.
VC-C	54	Appropriate for most lithography and inspection equipment to 1 micron detail size.
VC-D	48	Suitable in most instances for the most demanding equipment, including electron microscopes operating to the limits of their capability.
VC-E	42	The most demanding criterion for extremely vibration-sensitive equipment.

[a] As measured in 1/3-octave bands of frequency over the frequency range 8 to 80 Hz.
L_v = vibration velocity level



Source: Wilson Ihrig Associates, 2016.

Figure 4.12-10
Criteria for Detailed Vibration Analysis
VTA's BART Silicon Valley–Phase II Extension Project

4.12.3 Methodology

An *adverse effect* would be a change in the cumulative noise level that would cause a substantial percentage of people to be highly annoyed by project-related noise. For train operational noise only, each the levels of effect generally correspond to the impacts levels of *No Impact, Moderate Impact,* and *Severe Impact.* For other noise sources such as surface traffic and ancillary facility, terms such as *no effect*, *no adverse effect,* and *adverse effect* are used.

4.12.3.1 Transit Operations

Transit vehicle operations produce airborne noise that is projected to the wayside when tracks are above grade and can produce groundborne noise and/or vibration inside adjacent buildings for alignment segments that are in a tunnel, if the buildings are close enough and other conditions are conducive to these phenomena. The FTA Guidance Manual provides methodologies for predicting levels of noise and vibration for both configurations. Section 3.3 in *VTA's BART Silicon Valley—Phase II Extension Project Noise and Vibration Technical Report* provides the parameters used in the noise analysis (wayside train noise) for above-grade operations. The key parameters for BART train wayside noise analysis are summarized in Table 4.12-6. Section 3.3.4 in *VTA's BART Silicon Valley—Phase II Extension Project Noise and Vibration Technical Report* provides the derivation of the groundborne noise and vibration prediction model parameters.

Table 4.12-6: Summary of Key Parameters for BART Train Wayside Noise Analysis

Parameter	2035 Forecast Year
Reference Sound Exposure Level (SEL_{ref}) at 50 feet[a]	82 dBA
Number of cars per train (N_{pk}) during peak hours	10
Average number of cars per train (N_d) during the daytime (between 7 a.m. and 10 p.m.)	10
Average number of cars per train (N_n) during the nighttime (between 10 p.m. and 7 a.m.)	10
Peak hour volume of trains (V_{pk}) – one direction	10
Off-peak hour volume of trains (V_{opk}) – one direction	3
Peak hours service	6 a.m.–7:30 p.m.
Off-peak hours of service	4 a.m.–6 a.m. and 7:30 p.m.–1 a.m.
Average hourly daytime volume of trains (V_d) (between 7 a.m. and 10 p.m.) – one direction	8.83
Average hourly nighttime volume of trains (V_n) (between 10 p.m. and 7 a.m.) – one direction	2.78
Maximum train speed (S)	70 mph
Track type (e.g., welded, jointed)	Welded

[a] The FTA Guidance Manual provides a reference Sound Exposure Level (SEL) of 82 dBA for a single transit car traveling at 50 mph on ballast-and-tie track at a distance of 50 feet from the receptor. Specific wayside noise data have been measured for the BART system over the past years and have been used for previous BART extensions and have been found to be consistent with this noise emission level.

Prediction Model for Transit Vehicle Wayside Noise

The FTA Guidance Manual provides a detailed methodology for modeling airborne train noise, which is often referred to as wayside noise. Depending on the adjoining land use, projections of wayside noise are either based on an exposure over one hour (L_{eq}) or a daily exposure (L_{dn}). When evaluating noise effects on institutional land uses, the "peak hour" L_{eq} (hour with the greatest number of trains) is used to compare to the FTA criteria. When evaluating residential land uses, the L_{dn} is used to compare to the FTA criteria. The FTA wayside noise model accounts for several factors, such as the speed and length of each train and any noise shielding topography and sound walls. Section 3.3.4 in *VTA's BART Silicon Valley—Phase II Extension Project Noise and Vibration Technical Report* provides the derivation of the groundborne noise and vibration prediction model.

The FTA Guidance Manual provides a reference Sound Exposure Level (SEL) of 82 dBA for a single transit car traveling at 50 mph at a distance of 50 feet from the receptor. Specific wayside noise data have been obtained for the BART system over the past years and have been used for previous BART extensions. The noise emission level for a BART trains is consistent with the emission level suggested in the FTA Guidance Manual.

Prediction Model for Transit Vehicle Groundborne Vibration

The methodology used for predicting interior groundborne vibration and noise levels from future transit train operations was developed during an extensive research project conducted for the United States Department of Transportation. The methodology is discussed in detail in *A Prediction Procedure for Transportation Groundborne Noise and Vibration* (Nelson and Saurenman 1987). The methodology has been used successfully in the United States for over 30 years to evaluate the environmental effects of groundborne noise and vibration for numerous transit projects. This prediction procedure is the basis for the methodology recommended by in the FTA Guidance Manual. Refer to the *Silicon Valley Rapid Transit Project, Tunnel Segment Design Report* (HMM/Bechtel and Wilson, Ihrig & Associates 2005) for BART Extension–specific data related to vibration and used in the groundborne noise and vibration model.

The prediction methodology is based on the fact that vibration is generated by a train's wheels rolling on steel rails. The resulting vibration is caused by the inherent roughness and irregularities in the rail, which forces the wheels to move up and down, thus imparting a force in the rail. The vibration generated by the resulting forces propagates through the underlying structure of the transit system that supports the track and subsequently into the surrounding soil until it encounters nearby buildings, at which point the vibration is transmitted into the building through its foundation. Section 3.3.4 in *VTA's BART Silicon Valley—Phase II Extension Project Noise and Vibration Technical Report* provides the derivation of the groundborne noise and vibration prediction model.

Prediction Model for Transit Vehicle Operational Groundborne Noise

Groundborne noise is the noise generated inside a building due to vibration of the building's interior surfaces such as floors, walls, and ceilings. This vibration causes sound to be radiated inside rooms within the buildings. In the case of the BART Extension, the source of groundborne vibration is the transit system operating in a tunnel. Because groundborne noise is generally characterized by low frequency sound, it is commonly described as a rumble such as one might hear from a subway train in a large city. The level of groundborne noise in a particular room is affected by the level of vibration of the room's surfaces and the amount of acoustic absorption in the room. Section 3.3.4 in *VTA's BART Silicon Valley—Phase II Extension Project Noise and Vibration Technical Report* provides the derivation of the groundborne noise and vibration prediction model.

4.12.4 Environmental Consequences

This section identifies impacts and evaluates whether they would be adverse according to NEPA, using the criteria (i.e., context and intensity) identified in Section 4.12.3, *Methodology*.

4.12.4.1 No Build Alternative

The No Build Alternative consists of the existing transit and roadway networks and planned and programmed improvements in the study area (see Chapter 2, Section 2.2.1, *NEPA No Build Alternative*, for a list of these projects). There would be a general increase in traffic associated with the No Build Alternative due to increased population and development in the region. Projects planned under the No Build Alternative would, however, undergo separate environmental review to determine whether the projects would result in adverse noise and vibration effects. Several of these projects have already been programmed in the Regional Transportation Plans. Review would include an analysis of impacts and identification of mitigation measures to mitigate potential project impacts.

4.12.4.2 BART Extension Alternative

Wayside Noise Impacts from Train Operations

Airborne noise impacts from train operations can occur where trains are running on track aboveground, at ventilation facilities where train noise is transmitted to the surface from the tunnel below, and from storage yard tracks and maintenance facility activities.

Wayside Train Noise from At-Grade Alignment

The segment of BART track that is aboveground on at-grade track north of I-880 has the potential to affect sensitive receptors. The tunnel portal is approximately 600 feet north of I-880. Beyond the portal, airborne noise from running trains would be emitted to the wayside on both sides of the alignment. The land use in this area is a mixture of residences, offices, and warehouses. The noise-sensitive receivers in this area are residences; and they are shielded by noise walls along the existing railroad right-of-way or are located approximately 220 feet away. The screening distance for a rail rapid transit system is 700 feet. In this particular circumstance the screening distance for BART is 220 feet. The noise walls are estimated to be from 10 to 12 feet high, and provide a substantial amount of noise reduction from existing railroad operations.

Table 4.12-7 presents the projected wayside noise levels for ground-floor receivers. Wayside noise for these receivers is projected to result in *no effect* for all but one receiver (Candlewood Suites). For the others, the projected increase is 0.8 dBA or less and the threshold for Moderate Impact for these receptors is 1.2 or greater based on existing ambient noise ranges from 62 to 67 dBA.

With an existing L_{dn} of 65 dBA at Candlewood Suites, the threshold for Moderate Impact is 1.4 dBA. The increase in noise level for this receptor is projected to be 2 dBA. The mitigation policy adopted for the BART Extension is to mitigate Moderate Impacts only when the increase in noise levels is greater than 5 dBA. Therefore, no mitigation is required for this impact.

Table 4.12-8 presents the projected wayside noise levels for second-story receivers. For second story receivers, wayside noise is projected to impact two receivers (Dahlia Loop SFR complex and Candlewood Suites) with Moderate Impacts. The threshold for Moderate Impact for Dahlia Loop SFR is 1.2 dBA. The increase in noise level at the second story of this receptor is 1.7 dBA. For Candlewood Suites, the increase in noise level is projected to be 2 dBA. Because the mitigation policy adopted for the BART Extension is to mitigate Moderate Impacts only when the increase in noise levels is greater than 5 dBA, no mitigation is proposed.

Table 4.12-7: First-Story, Wayside Noise Impacts from Train Operations

Civil Station	Receiver Location	Track Direction	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Estimated Sound Wall Height (feet)	Existing Ambient L_{dn} (dBA)	Future L_{dn} (dBA)	Increase Level (dBA)	Moderate Impact Increase Threshold (dBA)	Impact Type	# of Impacted Receptors
826	697 Hamline S	S1	MFR	67	690	--	67	67.0	0.0	1.2	NI	--
829	Stockton Ave East of Alignment	S1	SFR	67	660	--	67	67.1	0.1	1.2	NI	--
835	Campbell Ave	S2	SFR	67	750	--	62	62.1	0.1	1.7	NI	--
835	Newhall and Elm St SFR	S2	SFR	67	430	--	62	62.2	0.2	1.7	NI	--
834 to 845	De Altura Commons	S2	SFR	67	235	10	64	64.8	0.8	1.5	NI	--
846 to 853	Dahlia Loop SFR	S2	SFR	67	223	12	64	64.5	0.5	1.5	NI	--
855 to 860	1270 Campbell Ave	S2	MFR	45	270	10	64	64.5	0.5	1.5	NI	--
871	Candlewood Suites Hotel	S2	HOTEL	45	290	--	65	67.0	2.0	1.4	MI	1

CL = Center Line
NB = Northbound side of alignment
SB = Southbound side of alignment
MFR = Multifamily residence
SFR = Single family residence
NI = No Impact
MI = Moderate Impact

Table 4.12-8: Second-Story, Wayside Noise Impacts from Train Operations

Civil Station	Receiver Location	Track Direction	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Estimated Sound Wall Height (feet)	Existing Ambient L_{dn} (dBA)	Future L_{dn} (dBA)	Increase Level (dBA)	Moderate Impact Increase Threshold (dBA)	Impact Type	# of Impacted Receptors
834 to 845	De Altura Commons, 2nd Floor	S2	SFR	67	235	10	67	68.3	1.3	1.2	MI	26
846 to 853	Dahlia Loop SFR, 2nd Floor	S2	SFR	67	223	12	67	68.7	1.7	1.2	MI	14
855 to 860	1270 Campbell Ave, 2nd Floor	S2	MFR	45	270	10	67	68.2	1.2	1.2	NI	--
871	Candlewood Suites Hotel, 2nd Floor	S2	HOTEL	45	290	--	65	67.0	2.0	1.4	MI	1

CL = Center Line
NB = Northbound side of alignment
SB = Southbound side of alignment
MFR = Multifamily residence
SFR = Single family residence
NI = No Impact
MI = Moderate Impact

Airborne Noise Impacts from Motor Vehicle Traffic

Traffic noise would increase over the existing ambient conditions due to an increase in the volume of traffic. The magnitude of increase in noise is proportional to the increase in traffic as presented in Chapter 7, Section 7.1.4, *Cumulative Environmental Impacts*. For the BART Extension Alternative, traffic associated with BART stations would also contribute to ambient noise in the future. However, the increase in noise both for the No Build Alternative and the BART Extension Alternative is projected to be relatively small and would result in *no adverse effect*, and no mitigation would be required. The increase in noise was quantified on a cumulative basis and is presented in Chapter 7, *Other NEPA and CEQA Considerations*.

Ancillary Facilities

BART ancillary facility noise impacts were analyzed in a memorandum prepared by Wilson, Ihrig & Associates (2006). Additional ambient noise measurements were performed in 2008 and 2014 and confirmed that the background noise level had not changed significantly. Therefore, the analysis from 2006 still was valid. Ancillary facilities include tunnel ventilation shafts, pressure relief shafts, traction power substations, and emergency backup generators. Analyses for ventilation shafts at the Santa Clara and 13th Street and Stockton Avenue were reevaluated in *VTA's BART Silicon Valley—Phase II Extension Project Noise and Vibration Technical Report.* The results of these analyses are summarized below and assume all ancillary facilities are above ground for both tunnel options as a worst case for noise impacts. If some of the facilities are located underground, they would be within the Single-Bore tunnel or within the Twin-Bore station box.

Tunnel Ventilation Shafts

Emergency Ventilation Fan Noise

Untreated ventilation shafts and ventilation structures could produce a noise level of 67 to 77 dB at 50 feet. This could result in exceedance of the City of San Jose's noise limit of 55 dBA at residences located within 200 to 630 feet of these facilities. With implementation of Mitigation Measure NV-A the impact would be reduced and there would be *no adverse effect*.

Mitigation Measure NV-A: Implement noise reduction treatments at ancillary facilities

Noise reduction treatments will be implemented at ancillary facilities such as tunnel ventilation shafts, pressure relief shafts, traction power substations, and emergency backup generators such that noise levels comply with applicable Cities of San Jose and Santa Clara noise criteria at nearby developed land uses. Treatments that will be implemented, if necessary, include but are not limited to:

- Sound attenuators and acoustical absorptive treatments in ventilation shafts and facilities.

- Sound attenuators for the tunnel emergency ventilation fans.
- perimeter noise walls (nominally an 8 feet high wall) placed around emergency generators.

Train Noise

Noise from BART trains operating in the subway tunnels can be transmitted to the surface via the ventilation shafts.

Santa Clara and 13th Streets Ventilation Facility

Long-term ambient noise measurements were conducted near the Santa Clara and 13th Streets Ventilation Facility in 2008. Ambient noise measurements were conducted in 2015 at two of the same locations studied in 2008. Table 4.12-9 summarizes the results of the 2008 and 2015 ambient noise measurements. Measurement locations are depicted in Figure 4.12-6.

Table 4.12-9: Ambient Noise in Santa Clara and 13th Street Neighborhood

Measurement Location Label	Ambient L_{dn} (dBA)				
	2008		2015		Ambient Used in Analysis
	Range	Average	Range	Average	
A	61–62	61.5	--	--	62
B	70–71	70.5	67	67	71
C	62–64	63	62–63	62.5	63
E	64–67	65.5	--	--	66
H	59–60	59.5	--	--	60
I	61–64	62.5	--	--	63

The ambient noise at Location B was measured to be 3.5 dBA lower in 2015 than in 2008. The ambient noise at Location C did not change. Because higher existing ambient noise levels are more critical (more likely to require mitigation) and there is no consistent trend, the greater of the ambient readings from 2008 and 2015 was used in the impact analysis to characterize the ambient noise at the six locations.

There are two noise sources associated with ventilation facilities: noise from trains running in the tunnel and the testing of emergency ventilation fans. Trains run continuously during revenue hours and have potential for impacting ambient noise over the course of a day.

Table 4.12-10 presents the projected noise from train noise exiting the tunnel from the ventilation shaft. The train noise emitted from the Santa Clara/13th Street ventilation shaft is minimal. No noise impacts are projected to occur from this source of operational noise. Therefore, no mitigation is required for train noise that exits the tunnel from the ventilation shaft.

Table 4.12-10: Airborne Train Noise from Santa Clara/13th Street Ventilation Structure

Civil Station	Receiver Location Address	Land Use	Vehicle Speed (mph)	Distance to Vent Structure (feet)	Existing Ambient L_{dn}/L_{eq} (dBA)	Total L_{dn}/L_{eq} (dBA)	Increase over Existing Ambient (dBA)	Moderate Impact Increase Threshold (dBA)	Impact Type
657	30 N 13th St	MFR	67	85	67	67.1	0.1	1.2	NI
658	602 Santa Clara St - Indian Health Center of Santa Clara Valley	Institutional	67	145	69	69.0	0.0	1.1	NI
658	28 S 13th St	SFR	67	280	63	63.0	0.0	1.6	NI
660	29 S 13th St - Duong Bich-Hai Thi, DDS	Institutional	67	260	63	63.0	0.0	1.6	NI
660	26 S 12th St	SFR	67	250	63	63.0	0.0	1.6	NI
661	551 Santa Clara St - Holistic Health Care Clinic (Chiropractic)	Institutional	67	80	69	69.1	0.1	1.1	NI
661	32 N 12th St	MFR	67	100	66	66.1	0.1	1.3	NI
662	15 S 12th St	SFR	67	270	64	64.0	0.0	1.5	NI
663	12 S 11th St	MFR	67	395	64	64.0	0.0	1.5	NI
665	32 N 11th St	MFR	67	360	66	66.0	0.0	1.3	NI

MFR = Multifamily residence
SFR = Single family residence
NI = No Impact

Stockton Avenue Ventilation Facility

Long-term ambient measurements were conducted near the site of the Stockton Avenue Ventilation Facility in 2008 to characterize the existing conditions. In 2015, ambient noise measurements were repeated at three of the four locations to determine changes that might have occurred. Table 4.12-11 summarizes the results of the 2008 and 2015 ambient noise measurements. Measurement locations are depicted in Figure 4.12-7.

Table 4.12-11: Ambient Noise in Stockton Avenue Neighborhood

Measurement Location Label	Ambient L_{dn} (dBA)				
	2008		2015		Ambient Used in Analysis
	Range	Average	Range	Average	
L	66–68	67	68–70	69	69
N	64–66	65	69–70	69.5	70
O	60–63	61.5	--	--	62
P	67–70	68.5	68–70	69	69

The ambient noise levels at Location N increased by 4.5 dBA. Because higher existing ambient noise levels are more critical (more likely to require mitigation) and there is no consistent trend, the greater of the ambient readings from 2008 and 2015 was used in the impact analysis to characterize the ambient noise at the four locations.

Table 4.12-12 presents the projected noise from train noise exiting the tunnel from the ventilation shaft. The train noise emitted from the Stockton ventilation shaft is minimal. No noise impacts are projected to occur for this source of operational noise. Therefore, no mitigation is required for train noise that exits the tunnel from the ventilation shaft.

Table 4.12-12: Airborne Train Noise from Stockton Ventilation Shaft

Civil Station	Receiver Location Address	Land Use	Vehicle Speed (mph)	Distance to Vent Structure (feet)	Existing Ambient L_{dn} / L_{eq} (dBA)	Total L_{dn} / L_{eq} (dBA)	Increase over Existing Ambient (dBA)	Moderate Impact Increase Threshold (dBA)	Impact Type
782	701 Harding Ave	SFR	67	345	70	70.0	0.0	1.0	NI
784	551 Stockton Ave	SFR	67	195	70	70.0	0.0	1.0	NI
785	599 Stockton Ave	SFR	67	115	70	70.0	0.0	1.0	NI
787	733 Schiele Ave	SFR	67	250	63	63.0	0.0	1.6	NI
788	623 Stockton Ave	SFR	67	165	69	69.0	0.0	1.1	NI
788	635 Stockton Ave	SFR	67	180	69	69.0	0.0	1.1	NI
789	641 Stockton Ave	SFR	67	140	69	69.0	0.0	1.1	NI
794	647 Stockton Ave	SFR	67	120	69	69.0	0.0	1.1	NI
796	759 Villa St	SFR	67	330	62	62.0	0.0	1.7	NI
796	745 W Taylor St	SFR	67	340	63	63.0	0.0	1.6	NI
797	727 Stockton Ave	SFR	67	400	70	70.0	0.0	1.0	NI

SFR = Single family residence
NI = No Impact

Pressure Relief Shaft

The ventilation shafts act as pressure relief shafts as well. The ventilation shafts will have large emergency ventilation fans. Based on previous BART projects, the sound attenuators that would be required to reduce the noise from tunnel emergency ventilation fans would be more than adequate to reduce the sound of trains. Introducing two silencers in the pressure relief shaft as specified in Mitigation Measure NV-A (one to control noise within the tunnel and station, the other to control noise at the surface) can reduce the train noise by more than 15 dBA. Accordingly, there will be *no adverse effect* from train sound that travels through the shaft.

Traction Power Substations

Based on previous BART projects (e.g., BART SFO) Traction Power Substations (TPSS) that are beyond 250 feet from residences will not require noise mitigation, as they are projected to result in No Impact based on the criteria used. There are TPSS that lie within 250 feet of receptors at the Downtown San Jose West and Diridon Station South and North Options. The TPSS at the Downtown San Jose West Station is on the corner of Santa Clara Street and 3rd Street. There are multi-family residential uses within 250 feet to the north of the TPSS location. At the Diridon Station South Option, the TPSS is on the west side of the station between Autumn Street and Los Gatos Creek. The TPSS is on the southeast corner of the station at the Diridon Station North Option on Autumn Street. There is a single-family residence within 250 feet of both the Diridon Station South and North Options’ TPSS. Tables 4.12-13 through 4.12-15 summarize the noise analysis at each location. The FTA Guidance Manual provides a reference L_{max} noise level of 63 dBA for substations with an analysis of the closest receptor at each location. Using a noise level criterion of 55 dBA, there is one projected impact each at the Downtown San Jose West and Diridon Station South and North Options. With implementation of Mitigation Measure NV-A the impact would have *no adverse effect*.

Older residential uses are just behind the retail uses along Santa Clara Street. The San Jose State University campus is one block south of Santa Clara Street between 4th and 10th Streets. The San Jose Civic Plaza, including San Jose City Hall, is south of Santa Clara Street, between 4th and 6th Streets. The Museum of Art, Plaza de Cesar Chavez, St. Joseph’s Cathedral, San Pedro Square, and several theaters and major hotels are near the new station locations. Low- and medium-density residential uses are to the north of Santa Clara Street, just outside of downtown San Jose.

Table 4.12-13: Predicted TPSS Noise Levels Near the Downtown San Jose West Station

Receptor	Land Use	Distance to TPSS (feet)	Projected Maximum Noise Level (dBA)	Impact Threshold (dBA)	Impact Type
97 Santa Clara St	MFR	20	71.0	55	Impact
101 Santa Clara St	MFR	125	55.0	55	No Impact
60 N 3rd St	MFR	175	52.1	55	No Impact
100 Santa Clara St	MFR	166	52.6	55	No Impact
126 Santa Clara St	MFR	220	50.1	55	No Impact
20 S 2nd St	MFR	210	50.5	55	No Impact
MFR = Multifamily residence					

Table 4.12-14: Predicted TPSS Noise Levels Near the Diridon Station South Option

Receptor	Land Use	Distance to TPSS (feet)	Projected Maximum Noise Level (dBA)	Impact Threshold (dBA)	Impact Type
35 S Autumn St	Single-family residence	90	57.9	55	Impact

Table 4.12-15: Predicted TPSS Noise Levels Near the Diridon Station North Option

Receptor	Land Use	Distance to TPSS (feet)	Projected Maximum Noise Level (dBA)	Impact Threshold (dBA)	Impact Type
35 S Autumn St	Single-family residence	90	57.9	55	Impact

Emergency Backup Generators

Emergency backup generators would be located at the Alum Rock/28th Street and Downtown San Jose Stations. Generators for Phase II would be expected to be quieter than existing generators on the BART system and are typically located within enclosures that reduce noise levels.

Alum Rock/28th Street Station Generator

The Alum Rock/28th Street Station generator would be located at grade, within a concrete structure. Although specific details on the size of the generator are not available it is anticipated that noise from operation of the generator could exceed 55 dBA at nearby receptors and result in an adverse effect. With implementation of Mitigation Measure NV-A this impact would have *no adverse effect*.

Downtown San Jose Station Generator

The generator for the Downtown San Jose Station would be fully enclosed by the station structure. Although specific details on the size of the generator are not available, it is anticipated that noise from operation of the generator could exceed 55 dBA at nearby receptors and result in an adverse effect. With implementation of Mitigation Measure NV-A this impact would have *no adverse effect*.

Newhall Maintenance Facility

The Newhall Maintenance Facility were studied in 2006 as part of the preliminary engineering design process. The Newhall Maintenance Facility location and usage have not changed significantly since 2006. Therefore, the previous noise analysis (ATS Consulting 2006a, 2006b) conclusions remain valid, and there would be *no effect* on noise from train activity within the yard or from facility activity. Accordingly, no mitigation would be required.

4.12.4.3 Groundborne Noise and Vibration Impacts from Operations

The groundborne noise and vibration impacts along the tunnel alignment were evaluated using the FTA criteria. All residential land uses identified along the alignment were treated individually in the groundborne noise and vibration prediction model. Institutional land uses (e.g., schools) were also treated individually in the calculations. The Screening Distance for groundborne noise and vibration for a rail rapid transit system such as BART is 200 feet.

At-grade Segment

All sensitive receptors adjacent to the at-grade segment of the alignment, which starts approximately 600 feet north of I-880, would be over 200 feet (i.e., 223 feet and greater) from the nearest track. The Screening Distance for a rail rapid transit system such as BART is 200 feet. Consequently, no groundborne noise and vibration impacts would be expected for the at-grade segment.

Tunnel Segment

The projected levels of groundborne noise and vibration for BART train operations within the tunnel were calculated using the vibration prediction models described in Section 4.12.3.1, *Transit Operations*, and the measured data in *VTA's BART Silicon Valley—Phase II Extension Project Noise and Vibration Technical Report.*

Groundborne vibration and groundborne noise levels are presented as a range of projected values reflecting the use of a modeling factor, which conservatively accounts for the various uncertainties in the model. The levels at each receptor location are based on distance to and depth of the track, train design speed, wheel/rail interaction forces, dynamic characteristics of rail support system, soil conditions, and the dynamic response of the receptor building. The baseline analysis (i.e., before mitigation) assumes a rail support system that is referred to as a resiliently supported tie (RST) system with a standard pad stiffness similar to the design implemented on the BART Colma Extension. Determinations of noise and vibration impacts are based on the upper value of the predicted range.

Twin-Bore Option

No vibration impacts are projected for the tunnel alignment when the predicted levels of vibration are compared to the FTA 1/3-octave band criteria. Refer to Tables 4.8 through 4.10 in *VTA's BART Silicon Valley—Phase II Extension Project Noise and Vibration Technical Report* for the projected levels of groundborne vibration for the Twin-Bore Option. The analysis does indicate that groundborne noise levels are projected to exceed the FTA criteria (35 dBA for residences and 40 dBA for institutional uses) for many receptors, as shown in Tables 4.12-16 through 4.12-20. Groundborne noise mitigation has been evaluated for those receptors indicated as potentially impacted.

Where the unmitigated groundborne noise levels from the prediction model exceed the FTA criteria, the use of an Isolated Slab Track (IST) (Mitigation Measure NV-B) was evaluated. This type of mitigation can be installed at track level to reduce vibration transmitted into the tunnel invert, thereby reducing vibration that would otherwise be emitted from the tunnel structure into the surrounding soil. This method has been used extensively in Europe with various degrees of effectiveness depending on the design to reduce higher frequency vibration and would be effective at reducing groundborne noise from the BART system operations.

An IST can also be used with special trackwork (i.e., crossover). The IST system is constructed with a continuous elastomeric mat instead of discrete elastomeric pads that are typically used for an FST system. An IST can be designed to provide from 10 to 13 dBA of noise reduction.

Tables 4.12-16 through 4.12-20 indicate whether an impact is projected with standard track design (i.e., standard RST) and where an IST would be needed as mitigation. Tables 4.12-21 through 4.12-25 indicate where mitigation is required. Depending on the options selected, 20,600–22,700 linear feet of IST groundborne mitigation would be required.

Table 4.12-16: Groundborne Noise Mitigation -Twin-Bore Option Alignment

S1 Track	S2 Track
617+50 to 638+75	618+00 to 639+50
645+75 to 656+00	646+25 to 656+50
662+25 to 677+50	663+00 to 678+00
For Downtown San Jose Station East and West Options see Tables 4.12-17 and 4.12-18, respectively	
708+00 to 713+00	708+50 to 713+50
For Diridon Station South and North Options see Tables 4.12-19 and 4.12-20, respectively	
782+00 to 802+75	783+00 to 803+75
Total IST: 14,500 feet	
IST = Isolated Slab Track	

Table 4.12-17: Groundborne Noise Mitigation - Twin-Bore, Downtown San Jose Station East Option

S1 Track	S2 Track
682+25 to 695+50	682+75 to 696+00
Total IST: 2,650 feet	
IST = Isolated Slab Track	

Table 4.12-18: Groundborne Noise Mitigation - Twin-Bore, Downtown San Jose Station West Option

S1 Track	S2 Track
692+00 to 697+50	692+50 to 698+00
Total IST: 1,100 feet	
IST = Isolated Slab Track	

Table 4.12-19: Groundborne Noise Mitigation – Twin-Bore, Diridon Station South Option

S1 Track	S2 Track
744+25 to 761+75	744+75 to 763+00
767+25 to 773+25	769+00 to 774+50
777+75 to 782+00	779+00 to 783+00
Total IST: 5,550 feet	
IST = Isolated Slab Track	

Table 4.12-20: Groundborne Noise Mitigation – Twin-Bore, Diridon Station North Option

S1 Track	S2 Track
745+75 to 758+75	746+50 to 760+00
761+50 to 769+25	762+75 to 770+50
773+00 to 777+00	774+00 to 778+00
Total IST: 5,000 feet	
IST = Isolated Slab Track	

With implementation of Mitigation Measure NV-B, impacts would have *no adverse effect.*

Mitigation Measure NV-B: Reduce groundborne noise levels

The mitigation strategy for groundborne noise is an Isolated Slab Track (IST), An IST is a form of floating slab track (FST). The IST system is constructed with a continuous elastomeric mat instead of discrete elastomeric pads that are typically used for an FST system. An IST can be designed to provide from 10 to 13 dBA of noise reduction. Mitigation Measure NV-B can also be used under a crossover. The locations for implementing this mitigation are shown in Tables 4.12-21 through 4.12-25. The specific mitigation strategy will be determined in final design and could include alternative strategies that similarly achieve the FTA groundborne noise criteria.

Table 4.12-21: Projected Levels of Groundborne Noise for Twin-Bore Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
584	433 N 33rd St	MFR	48	156	54	35	20 to 24	--	--
585	1500 Marburg Way	SFR	48	0	52	35	24 to 28	--	--
590	333 N 33rd St - Anne Darling Elementary School	Institutional	48	155	49	40	20 to 24	--	--
593	290 N 31st St	SFR	48	184	50	35	25 to 29	--	--
595	269 N 31st St	SFR	48	53	50	35	29 to 33	--	--
595	263 N 31st St	SFR	48	120	50	35	27 to 31	--	--
595	261 N 31st St	SFR	48	125	50	35	27 to 31	--	--
610	5 Wounds Lane - 5 Wounds School	Institutional	48	280	49	40	21 to 25	--	--
614	24 N 26th St - SF Nova Alliance Community Center	Institutional	48	0	50	40	35 to 39	--	--
615	26 N 26th St	SFR	48	150	52	35	30 to 34	--	--
617	23 N 26th St	SFR	48	140	52	35	31 to 35	--	--
618	1245 Santa Clara St - Alum Rock Counseling Center	Institutional	48	0	52	40	33 to 37	--	--
618	9 S 26th St	SFR	48	178	52	35	29 to 33	--	--
619	30 N 25th St	SFR	48	200	53	35	28 to 32	--	--
619	20 N 25th St	SFR	48	160	53	35	21 to 25	--	--
619	1236 Santa Clara St	SFR	48	68	53	35	29 to 33	--	--
619	1241 Shortridge Ave	MFR	48	197	53	35	21 to 25	--	--
619	1211 Santa Clara St	MFR	48	21	53	35	35 to 39	4	23 to 27
619	1226 Santa Clara St	SFR	48	68	53	35	36 to 40	1	25 to 29
620	1220 Santa Clara St - Sociedad Filharmonica	Institutional	48	45	53	40	31 to 35	--	--
620	1210 Santa Clara St	SFR	48	35	53	35	39 to 43	1	28 to 32
622	45 N 25th St	SFR	48	171	55	35	29 to 33	--	--
622	16 S 24th St	SFR	48	114	55	35	32 to 36	1	22 to 26
623	1169 Santa Clara St	SFR	48	60	56	35	37 to 41	1	26 to 30

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
623	1161 Santa Clara St	SFR	48	70	56	35	29 to 33	--	--
623	16 N 24th St	SFR	48	90	56	35	34 to 38	1	23 to 27
624	11 S 24th St	SFR	48	137	56	35	22 to 26	--	--
625	13 Carnegie Sq	SFR	48	149	56	35	30 to 34	--	--
626	1102 Santa Clara St - East San Jose Carnegie Branch Library	Institutional	48	25	57	40	33 to 37	--	--
627	1115 Santa Clara St - Portuguese Community Center	Institutional	48	45	57	40	31 to 35	--	--
627	11 S 23rd St	MFR	48	132	57	35	23 to 27	--	--
627	15 S 23rd St	SFR	48	163	57	35	30 to 34	--	--
627	9 S 23rd St	MFR	48	103	57	35	24 to 28	--	--
627	1098 Santa Clara St - Casa Do Benfica	Institutional	48	18	57	40	33 to 37	--	--
628	1082 Santa Clara St	MFR	48	19	57	35	35 to 39	5	23 to 27
628	16 S 22nd St	SFR	48	119	57	35	32 to 36	1	22 to 26
628	1072 Santa Clara St	MFR	48	19	57	35	35 to 39	10	23 to 27
629	1075 Santa Clara St - Santa Clara County Multi Service Center	Institutional	48	85	58	40	28 to 32	--	--
630	15 S 22nd St	SFR	48	160	58	35	30 to 34	--	--
630	1050 Santa Clara St - Daniel B Martinez, MD	Institutional	48	37	58	40	39 to 43	1	27 to 31
631	1049 Santa Clara St	SFR	48	72	58	35	36 to 40	1	25 to 29
631	1026 Santa Clara St	SFR	48	45	58	35	38 to 42	1	27 to 31
631	1047 Santa Clara St	SFR	48	70	58	35	36 to 40	1	25 to 29
632	8 S 21st St	SFR	48	140	59	35	31 to 35	--	--
633	16 N 21st St	SFR	48	135	59	35	31 to 35	--	--
633	19 S 21st St	SFR	48	160	59	35	30 to 34	--	--
633	990 Santa Clara St - Trinh Hung Quoc, MD	Institutional	48	60	59	40	37 to 41	1	26 to 30
634	20 S 20th St	SFR	48	181	60	35	29 to 33	--	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
635	966 Santa Clara St	MFR	48	56	60	35	31 to 35	--	--
636	19 S 20th St	SFR	48	222	61	35	24 to 28	--	--
637	961 Santa Clara St -- Roosevelt Youth Center	Institutional	48	0	62	40	30 to 34	--	--
637	901 Santa Clara St - Roosevelt Youth Center	Institutional	48	0	62	40	30 to 34	--	--
640	896 Santa Clara St	MFR	48	150	67	35	26 to 30	--	--
640	884 Santa Clara St	MFR	48	200	67	35	24 to 28	--	--
644	802 Santa Clara - Fire Station - Battalion 1	MFR	67	110	65	35	31 to 35	--	--
645	90 N 17th St	SFR	67	240	65	35	25 to 29	--	--
647	765 Santa Clara St	Institutional	67	0	65	35	33 to 37	1	22 to 26
648	765 Santa Clara St	Institutional	67	0	63	40	43 to 47	1	30 to 34
648	10 N 16th St	Institutional	67	0	63	40	43 to 47	1	30 to 34
649	675 Santa Clara St	Hospital	67	0	62	35	35 to 39	1	23 to 27
649	748 Santa Clara St	MFR	67	95	62	35	31 to 35	--	--
649	31 S 16th St	SFR	67	236	62	35	18 to 22	--	--
651	22 S 15th St	SFR	67	218	58	35	25 to 29	--	--
651	716 Santa Clara St	MFR	67	100	58	35	31 to 35	--	--
651	675 Santa Clara St	Hospital	67	0	58	35	30 to 34	--	--
652	12 S 15th St #206 - Bay Area College of Nursing: Cagampan Bu	Institutional	67	78	58	40	27 to 31	--	--
654	25 S 15th St - Dr Viet-Hong Bui	Institutional	67	59	57	40	29 to 33	--	--
654	678 Santa Clara St - Buena Vista Eyecare Group	Institutional	67	54	57	40	36 to 40	--	--
655	652 Santa Clara St - Elite Dental	Institutional	67	48	56	40	37 to 41	1	25 to 29
656	25 N 14th St #Ste 55 - Norcal Care	Institutional	67	19	56	40	30 to 34	--	--
657	30 N 13th St	MFR	67	122	57	35	22 to 26	--	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
658	602 Santa Clara St - Indian Health Center of Santa Clara Vall	Institutional	67	31	57	40	33 to 37	--	--
658	28 S 13th St	SFR	67	171	57	35	26 to 30	--	--
660	55 N 13th St - Ming Li, MD	Institutional	67	119	57	40	29 to 33	--	--
660	26 S 12th St	SFR	67	169	57	35	26 to 30	--	--
660	29 S 13th St - Duong Bich-Hai Thi, DDS	Institutional	67	169	57	40	26 to 30	--	--
661	551 Santa Clara St - Holistic Health Care Clinic (Chiropractic)	Institutional	67	31	57	40	33 to 37	--	--
661	32 N 12th St	MFR	67	196	57	35	18 to 22	--	--
662	15 S 12th St	SFR	67	128	56	35	29 to 33	--	--
663	12 S 11th St	MFR	67	146	56	35	28 to 32	--	--
665	32 N 11th St	MFR	67	182	54	35	19 to 23	--	--
665	478 Santa Clara St - Santa Clara Dental	Institutional	67	29	54	40	41 to 45	1	28 to 32
667	35 N 11th St	MFR	67	180	53	35	25 to 29	--	--
667	23 S 11th St	SFR	67	167	53	35	26 to 30	--	--
668	471 Santa Clara St - Darling & Fischer Garden Chapel Mortuary	Institutional	67	50	54	40	34 to 38	--	--
668	30 N 10th St	MFR	67	167	54	35	26 to 30	--	--
668	22 S 10th St	MFR	67	167	54	35	26 to 30	--	--
669	11 S 10th St	MFR	67	30	55	35	43 to 47	6	30 to 34
669	25 S 10th St	MFR	67	120	55	35	43 to 47	8	30 to 34
670	425 Elizabeth St	SFR	67	121	55	35	30 to 34	--	--
670	425 Santa Clara St - San Jose Fire Fighters Local 230	MFR	67	33	55	35	42 to 46	1	29 to 33
670	39 N 10th St	SFR	67	168	55	35	26 to 30	--	--
670	421 Elizabeth St	SFR	67	121	55	35	30 to 34	--	--
671	417 Elizabeth St	SFR	67	121	54	35	30 to 34	--	--
672	401 Santa Clara St	MFR	67	33	53	35	42 to 46	6	29 to 33

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
672	24 N 9th St	SFR	67	156	53	35	27 to 31	--	--
672	18 S 9th St	SFR	67	135	53	35	29 to 33	--	--
672	23 S 9th St	MFR	67	166	53	35	26 to 30	--	--
673	390 Santa Clara St	MFR	67	31	53	35	43 to 47	4	29 to 33
674	26 S 8th St	MFR	67	166	53	35	26 to 30	--	--
674	389 Santa Clara St - St. Patrick's Proto-Cathedral	Institutional	67	60	53	40	32 to 36	--	--
675	365 Santa Clara St - Our Lady of La Vang Parish	Institutional	67	65	53	40	31 to 35	--	--
676	25 S 8th St	MFR	67	160	52	35	27 to 31	--	--
677	345 Santa Clara St - 420 Medical Doctor	Institutional	67	40	52	40	42 to 46	1	31 to 35
679	24 S 7th St	MFR	48	200	51	35	22 to 26	--	--
680	1295 Santa Clara St - Horace Mann Elementary	Institutional	48	33	50	40	33 to 37	--	--
For Downtown San Jose Station East and West Options, see Tables 4.12-22 and 4.12-23, respectively									
707	101 Santa Clara St - Chamber of Commerce Silicon Valley	Institutional	33	30	50	40	23 to 27	--	--
709	20 N Almaden Ave		33	29	52	35	32 to 36	10	18 to 22
710	161 Santa Clara St - Masson Apartments	MFR	33	29	53	35	32 to 36	16	19 to 23
712	22 Almaden Ave	MFR	33	144	57	35	29 to 33	--	--
715	233 Santa Clara St - Hotel De Anza	Hotel	33	29	60	35	19 to 23	--	--
716	38 N Almaden Blvd - Axis Apartments	MFR	33	112	63	35	27 to 31	--	--
For Diridon Station South and North Alignment Options, see Tables 4.12-24 and 4.12-25, respectively									
782	762 Harding Ave	SFR	67	285	68	35	32 to 36	1	23 to 27
782	750 Harding Ave	SFR	67	240	68	35	32 to 36	1	23 to 27
782	714 Harding Ave	SFR	67	95	68	35	36 to 40	1	25 to 29
782	738 Harding Ave	SFR	67	188	68	35	32 to 36	1	23 to 27
782	701 Harding Ave	SFR	67	35	68	35	39 to 43	1	28 to 32

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
782	726 Harding Ave	SFR	67	135	68	35	34 to 38	1	24 to 28
784	551 Stockton Ave	SFR	67	35	69	35	38 to 42	1	27 to 31
784	713 Harding Ave	SFR	67	85	69	35	35 to 39	1	25 to 29
784	761 Harding Ave	SFR	67	280	69	35	32 to 36	1	23 to 27
784	749 Harding Ave	SFR	67	235	69	35	32 to 36	1	23 to 27
784	737 Harding Ave	SFR	67	185	69	35	32 to 36	1	23 to 27
784	725 Harding Ave	SFR	67	135	69	35	34 to 38	1	24 to 28
785	714 Schiele Ave	SFR	67	85	70	35	36 to 40	1	26 to 30
785	750 Schiele Ave	SFR	67	245	70	35	32 to 36	1	23 to 27
785	738 Schiele Ave	SFR	67	190	70	35	32 to 36	1	23 to 27
785	726 Schiele Ave	SFR	67	145	70	35	26 to 30	--	--
785	599 Stockton Ave	SFR	67	35	70	35	38 to 42	1	27 to 31
786	762 Schiele Ave	SFR	67	275	70	35	32 to 36	1	23 to 27
787	733 Schiele Ave	SFR	67	170	70	35	32 to 36	1	22 to 26
787	745 Schiele Ave	SFR	67	217	70	35	32 to 36	1	23 to 27
787	757 Schiele Ave	SFR	67	265	70	35	32 to 36	1	23 to 27
788	623 Stockton Ave	SFR	67	50	70	35	37 to 41	1	26 to 30
788	766 Villa Ave	SFR	67	290	70	35	32 to 36	1	23 to 27
788	635 Stockton Ave	SFR	67	55	70	35	37 to 41	1	26 to 30
789	641 Stockton Ave	SFR	67	40	69	35	38 to 42	1	27 to 31
789	647 Stockton Ave	SFR	67	55	69	35	37 to 41	1	26 to 30
790	744 Villa Ave	SFR	67	195	68	35	32 to 36	1	23 to 27
790	756 Villa Ave	SFR	67	240	68	35	32 to 36	1	23 to 27
790	732 Villa Ave	SFR	67	155	68	35	33 to 37	1	24 to 28
794	759 Villa St	SFR	67	260	64	35	25 to 29	--	--
795	765 W Taylor St	SFR	67	270	65	35	32 to 36	1	23 to 27
795	755 W Taylor St	SFR	67	235	65	35	32 to 36	1	23 to 27
796	745 W Taylor St	SFR	67	185	66	35	32 to 36	1	23 to 27
796	724 Laurel St	SFR	67	290	66	35	32 to 36	1	23 to 27
797	727 Stockton Ave	SFR	67	60	66	35	30 to 34	--	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
797	733 Stockton Ave	SFR	67	35	66	35	39 to 43	1	28 to 32
798	732 Asbury St	SFR	67	160	63	35	33 to 37	1	23 to 27
798	742 Asbury St	SFR	67	200	63	35	32 to 36	1	23 to 27
798	702 Asbury St	SFR	67	35	63	35	39 to 43	1	28 to 32
798	764 Asbury St	SFR	67	260	63	35	24 to 28	--	--
798	722 Asbury St	SFR	67	120	63	35	34 to 38	1	24 to 28
798	712 Asbury St	SFR	67	80	63	35	37 to 41	1	26 to 30
799	755 Asbury St	SFR	67	245	62	35	32 to 36	1	23 to 27
801	779 Stockton Ave	SFR	67	55	60	35	37 to 41	1	26 to 30

Shaded cells indicate impacts.
CL = Center Line; SFR = Single--Family Residential, MFR = Multi--Family Residential, GBN = Groundborne Noise, IST = Isolated Slab Track

Table 4.12-22: Projected Levels of Groundborne Noise for the Twin-Bore Option – Downtown San Jose Station East Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
683	235 Santa Clara St - Vintage Tower (X-Over)	MFR	48	28	50	35	37 to 41	60	26 to 30
684	24 N 5th St - First United Methodist Church (X-Over)	Institutional	48	28	49	40	42 to 46	1	31 to 35
685	200 Santa Clara St - San Jose City Hall (X-Over)	Institutional	48	33	49	40	41 to 45	1	30 to 34
691	148 Santa Clara St	MFR	48	34	49	35	29 to 33	--	--
691	138 Santa Clara St	MFR	48	34	49	35	29 to 33	--	--
692	134 Santa Clara St	MFR	48	34	48	35	29 to 33	--	--
693	118 Santa Clara St	MFR	48	34	48	35	29 to 33	--	--
693	101 Santa Clara St	MFR	48	27	48	35	31 to 35	--	--
693	100 Santa Clara St	MFR	48	34	48	35	29 to 33	--	--
693	60 N 3rd St - Town Park Towers	MFR	48	203	48	35	12 to 16	--	--
694	97 Santa Clara St	MFR	48	31	49	35	36 to 40	4	23 to 27
697	20 S Second St	MFR	48	141	50	35	24 to 28	--	--
701	15 S 1st St - MFR above Commercial	MFR	48	90	51	35	29 to 33	--	--
701	1 N 1st St - Lincoln Law School	Institutional	48	30	51	40	28 to 32	--	--

Shaded cells indicate impacts.
CL = Center Death; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBN = Groundborne Noise, IST = Isolated Slab Track

Table 4.12-23: Projected Levels of Groundborne Noise for Twin-Bore Option – Downtown San Jose Station West Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
683	235 Santa Clara St - Vintage Tower	MFR	48	28	50	35	29 to 33	--	--
684	24 N 5th St - First United Methodist Church	Institutional	48	28	49	40	34 to 38	--	--
685	200 Santa Clara St - San Jose City Hall	Institutional	48	33	49	40	33 to 37	--	--
691	148 Santa Clara St	MFR	48	30	49	35	29 to 33	--	--
691	138 Santa Clara St	MFR	48	30	49	35	29 to 33	--	--
692	134 Santa Clara St (X-Over)	MFR	48	30	48	35	31 to 35	--	--
693	118 Santa Clara St (X-Over)	MFR	48	30	48	35	33 to 37	6	22 to 26
693	101 Santa Clara St (X-Over)	MFR	48	27	48	35	40 to 44	4	28 to 32
693	100 Santa Clara St (X-Over)	MFR	48	30	48	35	38 to 42	3	27 to 31
693	60 N 3rd St - Town Park Towers	MFR	48	203	48	35	12 to 16	--	--
694	97 Santa Clara St (X-Over)	MFR	48	31	49	35	44 to 48	4	31 to 35
697	20 S Second St (X-Over)	MFR	48	141	50	35	27 to 31	--	--
701	15 S 1st St - MFR above Commercial	MFR	48	90	51	35	29 to 33	--	--
701	1 N 1st St - Lincoln Law School	Institutional	48	30	51	40	28 to 32	--	--

Shaded cells indicate impacts.
CL = Center Line; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBN = Groundborne Noise, IST = Isolated Slab Track

Table 4.12-24: Projected Levels of Groundborne Noise for Twin-Bore Option – Diridon Station South Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
736	35 S Autumn St	SFR	33	35	48	35	30 to 34	-	-
737	56 S Montgomery St - Templo La Hermosa	Institutional	48	189	46	40	27 to 31	-	-
745	88 Bush St - Plant 51	MFR	48	0	49	35	32 to 36	265	20 to 24
748	754 The Alameda - Avalon at Cahill Park	MFR	48	0	49	35	32 to 36	218	20 to 24
750	53 Wilson Ave	SFR	48	80	54	35	26 to 30	-	-
750	51 Wilson Ave	SFR	48	35	54	35	33 to 37	1	22 to 26
750	49 Wilson Ave	SFR	48	0	54	35	36 to 40	1	24 to 28
751	40 Sunol St	MFR	48	90	54	35	25 to 29	-	-
752	34 Sunol St	SFR	48	50	54	35	30 to 34	-	-
752	30 Sunol St	SFR	48	0	55	35	36 to 40	1	24 to 28
752	24 Sunol St	SFR	48	0	56	35	36 to 40	1	24 to 28
753	830 The Alameda	MFR	48	38	56	35	28 to 32	-	-
753	20 Sunol St	SFR	48	0	56	35	36 to 40	1	24 to 28
753	33 Sunol St	SFR	48	85	56	35	26 to 30	-	-
753	27 Sunol St	SFR	48	40	56	35	32 to 36	1	21 to 25
754	24 Cleaves Ave	SFR	48	115	57	35	23 to 27	-	-
756	938 The Alameda - Billy Defrank LGBT Community Center	Institutional	48	125	58	40	17 to 21	-	-
758	925 The Alameda - Lofts on The Alameda	MFR	48	0	62	35	33 to 37	40	20 to 24
759	87 Rhodes Ct	SFR	48	115	64	35	24 to 28	-	-
758	128 Rhodes Ct	SFR	48	250	62	35	20 to 24	-	-
759	152 Rhodes Ct	SFR	48	276	64	35	20 to 24	-	-
759	109 Rhodes Ct	SFR	48	130	64	35	23 to 27	-	-
760	133 Rhodes Ct	SFR	48	107	61	35	25 to 29	-	-
760	157 Rhodes Ct	SFR	48	132	61	35	31 to 35	-	-
760	176 Rhodes Ct	SFR	48	0	61	35	30 to 34	-	-
760	179 Rhodes Ct	SFR	48	151	61	35	21 to 25	-	-

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
760	200 Rhodes Ct	SFR	48	0	61	35	30 to 34	-	-
761	176 N Morrison Ave	MFR	48	20	62	35	31 to 35	-	-
761	201 Rhodes Ct	SFR	48	169	62	35	30 to 34	-	-
761	229 Rhodes Ct	SFR	48	186	62	35	30 to 34	-	-
761	204 N Morrison Ave	SFR	48	40	62	35	31 to 35	-	-
761	224 Rhodes Ct	0	48	0	62	35	30 to 34	-	-
761	248 Rhodes Ct	0	48	0	62	35	30 to 34	-	-
762	173 N Morrison Ave	Institutional	48	45	62	40	32 to 36	-	-
762	253 Rhodes Ct	SFR	48	200	62	35	30 to 34	-	-
762	197 N Morrison Ave	SFR	48	30	62	35	31 to 35	-	-
762	225 N Morrison Ave	MFR	48	15	62	35	31 to 35	-	-
762	272 Rhodes Ct	0	48	0	62	35	30 to 34	-	-
762	275 Rhodes Ct	SFR	48	213	62	35	30 to 34	-	-
763	800 W Julian St	0	48	0	62	35	30 to 34	-	-
763	264 N Morrison Ave - Support Systems Homes Recovery Center	MFR	48	40	62	35	31 to 35	-	-
763	295 Rhodes Ct	SFR	48	263	62	35	30 to 34	-	-
763	908 W Julian St	SFR	48	224	62	35	30 to 34	-	-
763	920 W Julian St	SFR	48	182	62	35	30 to 34	-	-
763	936 W Julian St	SFR	48	141	62	35	31 to 35	-	-
764	909 W Julian St	SFR	48	246	62	35	30 to 34	-	-
763	950 W Julian St - Family and Children Services San Jose of	MFR	48	0	62	35	24 to 28	-	-
766	379 N Morrison Ave	SFR	48	70	62	35	31 to 35	-	-
766	962 Cinnabar St	SFR	48	175	62	35	30 to 34	-	-
766	956 Cinnabar St	SFR	48	140	62	35	31 to 35	-	-
766	899 Morrison Park Dr - Avalon Morrison Park	MFR	48	0	62	35	24 to 28	-	-
768	910 Cinnabar St	SFR	48	0	63	35	31 to 35	-	-
768	945 Cinnabar St	SFR	48	110	63	35	31 to 35	-	-

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
768	890 Cinnabar St	SFR	48	0	63	35	31 to 35	-	-
768	927 Cinnabar St	SFR	48	75	63	35	32 to 36	1	23 to 27
768	870 Cinnabar St	SFR	48	29	63	35	31 to 35	-	-
769	909 Cinnabar St	SFR	48	45	63	35	32 to 36	1	23 to 27
769	850 Cinnabar St	SFR	48	62	63	35	32 to 36	1	23 to 27
769	875 Cinnabar St - Cinnabar Commons Apartments	MFR	48	0	63	35	25 to 29	-	-
769	434 N Morrison Ave	SFR	48	150	63	35	30 to 34	-	-
771	417 Stockton Ave	SFR	48	41	62	35	32 to 36	1	22 to 26
772	808 Lenzen Ave	MFR	48	240	63	35	32 to 36	5	24 to 28
773	790 Lenzen Ave	MFR	48	20	63	35	25 to 29	-	-
775	777 Lenzen Ave	SFR	67	278	63	35	24 to 28	-	-
776	476 Lenzen Ct	SFR	67	280	63	35	24 to 28	-	-
778	774 Pershing Ave	SFR	67	310	64	35	32 to 36	1	23 to 27
778	762 Pershing Ave	SFR	67	250	64	35	32 to 36	1	23 to 27
778	489 Stockton Ave	SFR	67	10	64	35	39 to 43	1	28 to 32
778	750 Pershing Ave	SFR	67	210	64	35	32 to 36	1	23 to 27
778	738 Pershing Ave	SFR	67	160	64	35	33 to 37	1	23 to 27
779	726 Pershing Ave	SFR	67	115	65	35	35 to 39	1	25 to 29
779	714 Pershing Ave	SFR	67	70	65	35	37 to 41	1	27 to 31
779	495 Stockton Ave	MFR	67	10	65	35	39 to 43	2	28 to 32
780	749 Pershing Ave	SFR	67	220	65	35	32 to 36	1	23 to 27
780	761 Pershing Ave	SFR	67	270	65	35	32 to 36	1	23 to 27
780	737 Pershing Ave	SFR	67	170	65	35	33 to 37	1	23 to 27
780	711 Pershing Ave	SFR	67	70	65	35	37 to 41	1	27 to 31
780	725 Pershing Ave	SFR	67	120	65	35	34 to 38	1	24 to 28
780	501 Stockton Ave	SFR	67	26	65	35	40 to 44	1	28 to 32

Shaded cells indicate impacts.
CL = Center Line; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBN = Groundborne Noise, IST = Isolated Slab Track

Table 4.12-25: Projected Levels of Groundborne Noise for Twin-Bore Option – Diridon Station North Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
734	35 S Autumn St	SFR	33	270	55	35	24 to 28	-	-
735	56 S Montgomery St - Templo La Hermosa	Institutional	48	450	55	40	21 to 25	-	-
745	88 Bush St - Plant 51	MFR	48	210	58	35	13 to 17	-	-
748	754 The Alameda - Avalon At Cahill Park	MFR	48	25	58	35	33 to 37	218	20 to 24
748	53 Wilson Ave	SFR	48	425	60	35	19 to 23	-	-
748	51 Wilson Ave	SFR	48	375	60	35	19 to 23	-	-
749	49 Wilson Ave	SFR	48	325	61	35	19 to 23	-	-
749	40 Sunol St	MFR	48	420	61	35	19 to 23	-	-
749	34 Sunol St	SFR	48	380	61	35	19 to 23	-	-
749	30 Sunol St	SFR	48	330	61	35	19 to 23	-	-
749	24 Sunol St	SFR	48	280	61	35	19 to 23	-	-
750	830 The Alameda	MFR	48	80	61	35	22 to 26	-	-
750	20 Sunol St	SFR	48	245	61	35	19 to 23	-	-
751	33 Sunol St	SFR	48	400	61	35	19 to 23	-	-
751	27 Sunol St	SFR	48	350	61	35	19 to 23	-	-
752	24 Cleaves Ave	SFR	48	420	62	35	19 to 23	-	-
753	938 The Alameda - Billy Defrank LGBT Community Center	Institutional	48	415	64	40	13 to 17	-	-
755	925 The Alameda - Lofts on The Alameda	MFR	48	120	65	35	17 to 21	-	-
754	87 Rhodes Ct	SFR	48	53	64	35	30 to 34	-	-
754	128 Rhodes Ct	SFR	48	40	65	35	32 to 36	1	22 to 26
754	152 Rhodes Ct	SFR	48	60	65	35	30 to 34	-	-
754	109 Rhodes Ct	SFR	48	25	64	35	37 to 41	1	25 to 29
755	133 Rhodes Ct	SFR	48	25	64	35	37 to 41	1	25 to 29
755	157 Rhodes Ct	SFR	48	25	64	35	31 to 35	-	-
755	176 Rhodes Ct	SFR	48	100	64	35	31 to 35	-	-
755	179 Rhodes Ct	SFR	48	25	64	35	24 to 28	-	-
755	200 Rhodes Ct	SFR	48	130	64	35	31 to 35	-	-

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
756	176 N Morrison Ave	MFR	48	118	64	35	30 to 34	-	-
756	201 Rhodes Ct	SFR	48	25	64	35	31 to 35	-	-
756	229 Rhodes Ct	SFR	48	25	64	35	31 to 35	-	-
757	204 N Morrison Ave	SFR	48	86	64	35	31 to 35	-	-
755	224 Rhodes Ct	SFR	48	160	64	35	30 to 34	-	-
756	248 Rhodes Ct	SFR	48	180	64	35	30 to 34	-	-
757	173 N Morrison Ave	Institutional	48	292	64	40	30 to 34	-	-
757	253 Rhodes Ct	SFR	48	35	64	35	31 to 35	-	-
757	197 N Morrison Ave	SFR	48	250	64	35	28 to 32	-	-
757	225 N Morrison Ave	MFR	48	235	64	35	28 to 32	-	-
757	272 Rhodes Ct	SFR	48	200	64	35	30 to 34	-	-
757	275 Rhodes Ct	SFR	48	35	64	35	31 to 35	-	-
758	800 W Julian St	SFR	48	240	62	35	30 to 34	-	-
758	264 N Morrison Ave - Support Systems Homes Recovery Center	MFR	48	25	62	35	31 to 35	-	-
758	295 Rhodes Ct	SFR	48	77	62	35	32 to 36	1	23 to 27
758	908 W Julian St	SFR	48	25	62	35	31 to 35	-	-
758	920 W Julian St	SFR	48	25	62	35	31 to 35	-	-
758	936 W Julian St	SFR	48	25	62	35	31 to 35	-	-
764	909 W Julian St	SFR	48	197	63	35	30 to 34	-	-
759	950 W Julian St - Family and Children Services San Jose of	MFR	48	210	63	35	20 to 24	-	-
760	379 N Morrison Ave	SFR	48	250	61	35	28 to 32	-	-
761	962 Cinnabar St	SFR	48	340	61	35	30 to 34	-	-
761	956 Cinnabar St	SFR	48	300	61	35	30 to 34	-	-
759	899 Morrison Park Dr - Avalon Morrison Park	MFR	48	25	63	35	24 to 28	-	-
762	910 Cinnabar St	SFR	48	85	61	35	32 to 36	1	23 to 27
763	945 Cinnabar St	SFR	48	245	60	35	30 to 34	-	-
762	890 Cinnabar St	SFR	48	30	61	35	31 to 35	-	-

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
763	927 Cinnabar St	SFR	48	210	60	35	30 to 34	-	-
763	870 Cinnabar St	SFR	48	30	60	35	31 to 35	-	-
763	909 Cinnabar St	SFR	48	173	60	35	30 to 34	-	-
763	850 Cinnabar St	SFR	48	25	60	35	31 to 35	-	-
764	875 Cinnabar St - Cinnabar Commons Apartments	MFR	48	25	60	35	25 to 29	-	-
764	434 N Morrison Ave	SFR	48	275	60	35	30 to 34	-	-
766	417 Stockton Ave	SFR	48	39	59	35	31 to 35	-	-
768	808 Lenzen Ave	MFR	48	335	61	35	32 to 36	5	24 to 28
767	790 Lenzen Ave	MFR	48	105	61	35	23 to 27	-	-
771	777 Lenzen Ave	SFR	67	300	61	35	24 to 28	-	-
772	476 Lenzen Ct	SFR	67	310	62	35	24 to 28	-	-
774	774 Pershing Ave	SFR	67	320	64	35	32 to 36	1	23 to 27
774	762 Pershing Ave	SFR	67	285	64	35	32 to 36	1	23 to 27
773	489 Stockton Ave	SFR	67	40	63	35	38 to 42	1	27 to 31
774	750 Pershing Ave	SFR	67	240	64	35	32 to 36	1	23 to 27
774	738 Pershing Ave	SFR	67	190	64	35	32 to 36	1	23 to 27
774	726 Pershing Ave	SFR	67	135	64	35	34 to 38	1	24 to 28
774	714 Pershing Ave	SFR	67	92	64	35	36 to 40	1	26 to 30
774	495 Stockton Ave	MFR	67	37	64	35	38 to 42	2	27 to 31
776	749 Pershing Ave	SFR	67	230	65	35	32 to 36	1	23 to 27
776	761 Pershing Ave	SFR	67	280	65	35	32 to 36	1	23 to 27
776	737 Pershing Ave	SFR	67	185	65	35	32 to 36	1	23 to 27
776	711 Pershing Ave	SFR	67	84	65	35	36 to 40	1	26 to 30
776	725 Pershing Ave	SFR	67	133	65	35	34 to 38	1	24 to 28
776	501 Stockton Ave	SFR	67	37	65	35	39 to 43	1	27 to 31

Shaded cells indicate impacts.
CL = Center Line; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBN = Groundborne Noise, IST = Isolated Slab Track

Single-Bore Option

The second tunnel option is a single bore with bi-level tracks. Typically, the single-bore tunnel would be approximately 70 feet below ground compared to 40 feet with the Twin-Bore Option. On the lower level of the single-bore tunnel the tracks would be supported on the tunnel invert similar to twin-bore tunnel. On the upper level the tracks would be supported on a structural concrete slab spanning the width of the tunnel. Based on analyses for a similar bi-level tunnel, groundborne noise from the upper level is projected to be less than for the lower level.

Groundborne noise and vibration level projections were projected for the train operation on the lower track level of the Single-Bore Option for a limited number of receptors and compared to the levels for the Twin-Bore Option. The vibration projection model for the deeper tunnel was somewhat hindered due to the lack of vibration propagation test data at deeper depths since the tests did not, at the time (2004), envision a deeper tunnel.

Due to the greater depth of the single-bore tunnel, the projected groundborne noise levels would be less than those from the twin-bore tunnel. However, the difference is only in the range of 1 to 2 dBA. In the engineering phase of the Phase II Project, vibration propagation test data will be required for tunnel depths of the single-bore tunnel to define the specific mitigation required, if this is the preferred alternative. For purposes of this analysis, where groundborne noise levels in Tables 4.12-16 through 4.12-20 exceed the noise criterion by 1 dBA for the Twin-Bore Option, similar mitigation would be required for the Single-Bore Option.

Tables 4.12-26 through 4.12-28 indicate where mitigation is required. Depending on the options selected, 13,525–16,150 linear feet of IST groundborne mitigation would be required.

Table 4.12-26: Groundborne Noise Mitigation – Single-Bore Alignment

S1 Track	S2 Track
618+00 to 632+50	618+25 to 633+00
645+00 to 653+50	645+75 to 654+00
662+25 to 677+50	663+00 to 678+00
For Downtown San Jose Station East and West Options see Tables 4.12-17 and 4.12-18, respectively	
For Diridon Station South and North Options see Tables 4.12-19 and 4.12-20, respectively	
782+00 to 791+00	783+00 to 792+00
796+00 to 801+00	797+00 to 802+00
Total IST: 10,425 feet	
IST = Isolated Slab Track	

Table 4.12-27: Groundborne Noise Mitigation – Single-Bore, Diridon Station North Option

S1 Track	S2 Track
745+75 to 757+00	746+50 to 758+00
773+00 to 777+00	774+00 to 778+00
Total IST: 3,075 feet	
IST = Isolated Slab Track	

Table 4.12-28: Groundborne Noise Mitigation – Single-Bore, Diridon Station South Option

S1 Track	S2 Track
749+25 to 755+00	750+00 to 756+00
777+75 to 782+00	779+00 to 783+00
Total IST: 2,000 feet	
IST = Isolated Slab Track	

4.12.5 NEPA Conclusion

Aboveground BART Extension Alternative operations on at-grade track north of I-880 would result in a Moderate Impact at one ground-floor receiver and two second-story receivers. However, the increases are 2 dBA or less, which is not a readily perceived amount. Therefore, no mitigation is proposed.

Operation of emergency ventilation fans, piston relief shafts, traction power substations, and emergency backup generators could result in exceedances of Cities of San Jose and Santa Clara noise criteria at nearby residence, which is considered an adverse effect. Implementation of Mitigation Measure NV-A will reduce this impact to *no adverse effect*.

Train operations in the tunnel are predicted to result in exceedances of FTA groundborne noise criteria at many receptor locations. Implementation of Mitigation Measure NV-B would reduce this impact to *no adverse effect*.

All other noise and vibration effects would have *no effect* or *no adverse effect* under NEPA.

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