Final

Noise and Vibration Study

CALTRAIN
REPLACEMENT OR RECONSTRUCTION
OF SEVEN BRIDGES

Prepared for the

PENINSULA CORRIDOR JOINT POWERS BOARD

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EXECUTIVE SUMMARY

The proposed study is to determine noise and vibration impacts from construction and future train operations in the study area which includes three proposed bridge projects. The three proposed projects are 1) San Mateo Bridge Replacement and Grade Separation Project, 2) San Francisquito Creek Bridge knee brace installation, and 3) Quint and Jerrold Street Bridge Replacement Project. The proposed project in San Mateo would replace four bridges at Tilton, Monte Diablo, Santa Inez, and Poplar Avenues; construct retaining walls along the railroad right-of-way; increase the track grade to increase the bridge vertical clearance to 15'-1" at Poplar, Santa Inez, and Monte Diablo Avenues; and modify the track alignment by increasing the track spacing to 16'-10". The proposed project in San Francisco at Quint and Jerrold Streets would replace the existing bridges and improve the street geometry to accommodate the new structures. The proposed project at San Francisquito Creek would modify the existing truss structure by installing knee braces to increase the rail vehicle clearance height. A noise and vibration impact analysis, following the Federal Transit Administration (FTA), *Transit Noise and Vibration Impact Assessment* (FTA, 2006), was performed to determine potential impacts caused by the track realignment and bridge work. The study area is along the Caltrain commuter line between Mile Posts 2.85 and 29.68.

A site visit was conducted by Parsons on June 9, 2006 to identify areas prone to potential noise and vibration impacts as well as conduct a visual assessment for future noise impacts with the proposed change in the vertical alignment of the existing track. Noise sensitive areas near these bridges consist of single- and multi-family residential units along both sides of the corridor.

During the site visit, it was determined that additional operation noise impacts would not occur at non-first row receivers along the proposed Poplar Avenue, Santa Inez Avenue, Monte Diablo Avenue, and Tilton Avenue bridge replacements. However, construction noise impacts are anticipated during the extended work weekend period to replace the bridges, drill soldier piles to install retaining walls, and raise the track grade. The bridge replacemtn work is expected to begin on Friday night and continue around the clock until early Monday morning. Impacts would not occur during construction or train operation near the Jerrold Avenue and Quint Street Bridges since there are no noise sensitive receivers nearby. Noise impacts are also not anticipated during construction or operation at the San Francisquito Creek Bridge since the proposed modifications at this site only include the replacement of a steel truss members (knee braces).

The FTA criterion was used to assess future noise and vibration impacts from the proposed project construction and operations at sensitive areas.

A construction noise and vibration impact assessment was conducted and revealed that impacts are likely to occur during the four major phases of construction for the four bridges in San Mateo. The analysis is based on information provided by such as construction phases, number and type of construction equipment items, and the estimated

duration of operation. Equipment and administrative control measures are recommended to minimize construction impacts and disturbances at the neighboring communities.

A noise impact analysis was performed at one first-row receptors along the west side of the tracks near Poplar Avenue. This location was selected because it represents the worst case noise impact condition due to the distance to the proposed realignment. At this location, trains that are decelerating to stop at the San Mateo station and trains that are accelerating from the San Mateo station are at their highest speeds within the project limits. In addition, residences near this location are closest to the realigned tracks.

Two noise generating alignment conditions were analyzed to determine (1) impacts with one potential alignment which shifts the existing tracks by 10.28 feet towards the west; and (2) the distance at which impacts would no longer occur. The analysis was conducted using FTA's General Transit Noise Assessment spreadsheet. Results of the analysis indicate that shifting the tracks to the preferred location would cause an impact at the property line of homes represented by the analysis site. The results of the noise analysis determined that in order to maintain railroad operation noise levels below impact, the proposed track alignment should shift west by no more than 6 feet.

Operation vibration impacts are not anticipated along the project corridor due to the distance between the proposed tracks and building structures in the area. It is anticipated that vibration generated from train operation would dissipate by the time it reaches any structures. Therefore, human annoyance or building damage would not be expected from train operations along the project corridor.

1.0 INTRODUCTION

The Peninsula Corridor Joint Powers Board (JPB) is proposing improvements to seven bridges along the Caltrain Peninsula Corridor line in Palo Alto, San Mateo, and San Francisco. The purpose of the proposed improvements is to reconstruct bridges to meet current minimum street clearance and seismic standards and or reinforce bridges to provide a larger dynamic load envelope. With the proposed changes, the San Mateo Bridge Replacement and Grade Separation project would also realign the existing tracks. This noise and vibration study assesses impacts during the construction at nearby residences. It also evaluates train noise propagation further into the community as a result of elevating the tracks in San Mateo. In addition, train noise impacts are evaluated in San Mateo where the tracks are proposed to be moved closer to the residences. The procedures outlined in the FTA were used to assess the noise and vibration impacts for the Seven Bridge replacement project. Figure 1-1 shows the bridge replacement locations.

The following further discusses the components of the proposed project improvements:

- Quint Street (MP 3.05) –San Francisco: Replace existing 326-foot bridge with a new two-span bridge approximately 85 feet long while applying current seismic standards, providing street vehicular clearance of 15 feet, install additional soil embankment and retaining walls for remaining trackway, remove and reconstruct train tracks, and reconstruct streets and sidewalks. Figure 1-2 show the location of the bridge replacement in San Francisco.
- Jerrold Avenue (MP 2.85) –San Francisco: Replace existing 191-foot steel bridge with a new single-span bridge approximately 65 feet long while applying current seismic standards, providing street vehicular clearance of 15 feet, install additional soil embankment and retaining walls for remaining trackway, remove and reconstruct train tracks, and reconstruct streets and sidewalks. Figure 1-2 show the location of the bridge replacement work in San Francisco.
- Four Bridges – San Mateo: Reconstructs rail bridges over roadways in San Mateo that currently do not meet current minimum street clearance standards. Figure 1-3 shows the location of the bridge replacement work in San Mateo. Improvements include:

  (a) Poplar Avenue (MP 17.2): Install new railroad bridge girders applying current seismic standards and allowing 1.5-foot, greater clearance while lowering roadway by 0.5 inches.

  (b) Santa Inez Avenue (MP 17.34): Install new railroad bridge girders applying current seismic standards and allowing 3.6-foot, greater clearance.

  (c) Monte Diablo Avenue (MP 17.45): Install new railroad bridge girders applying current seismic standards and allowing 2.9-foot, greater clearance while lowering roadway by 1 foot.

(d) Tilton Avenue (MP 17.58): Install new railroad bridge girders applying current seismic standards and install sacrificial structure to protect bridge from possible vehicle impact.

- San Francisquito Creek Bridge (MP29.68) – Palo Alto: Replace and modify steel truss member (knee braces) near the top of the steel truss bridge to provide a larger dynamic envelope for freight cars. Figure 1-4 shows the location of the bridge work in Palo Alto.

Areas of possible impacts in San Mateo include single- and multi-family residential units between Villa Terrace Avenue and the San Mateo station. Areas around the Quint Street and Jerrold Avenue Bridges would not be considered sensitive to noise or vibration impacts during construction or operation. Also, due to the minimal work proposed to the San Francisquito Creek Bridge, noise or vibration impacts are not anticipated in this area. Figures 1-1 outlines the study area.

Figure 1-1 – Bridge Replacement Locations

Figure 1-2 – Quint Street and Jerrold Avenue Bridges

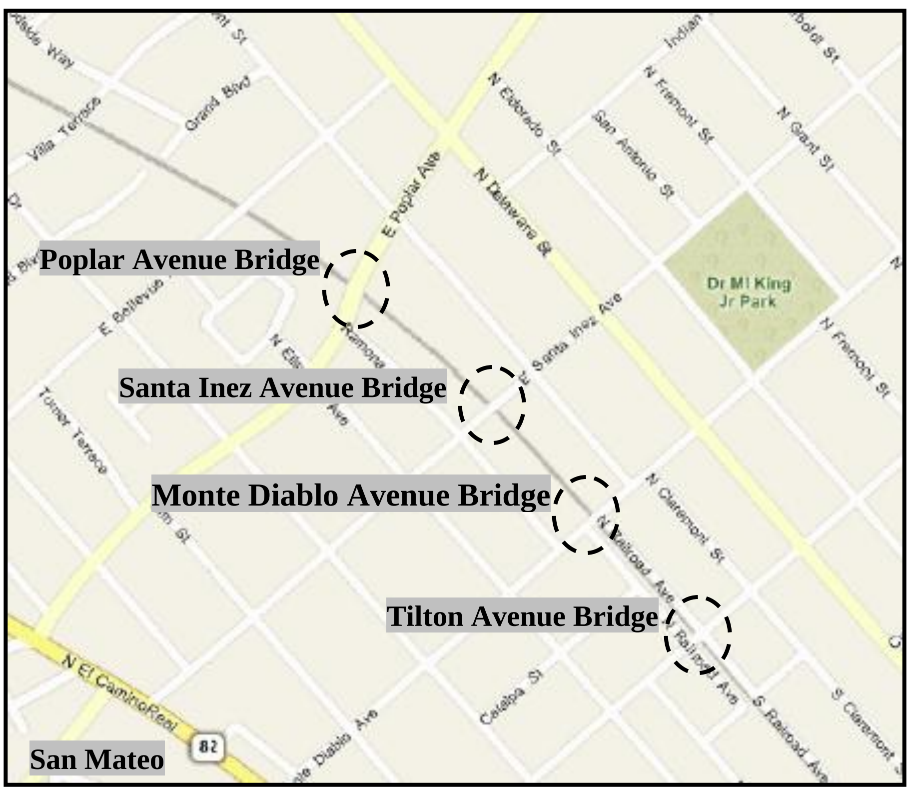


Figure 1-3 – San Mateo Bridges

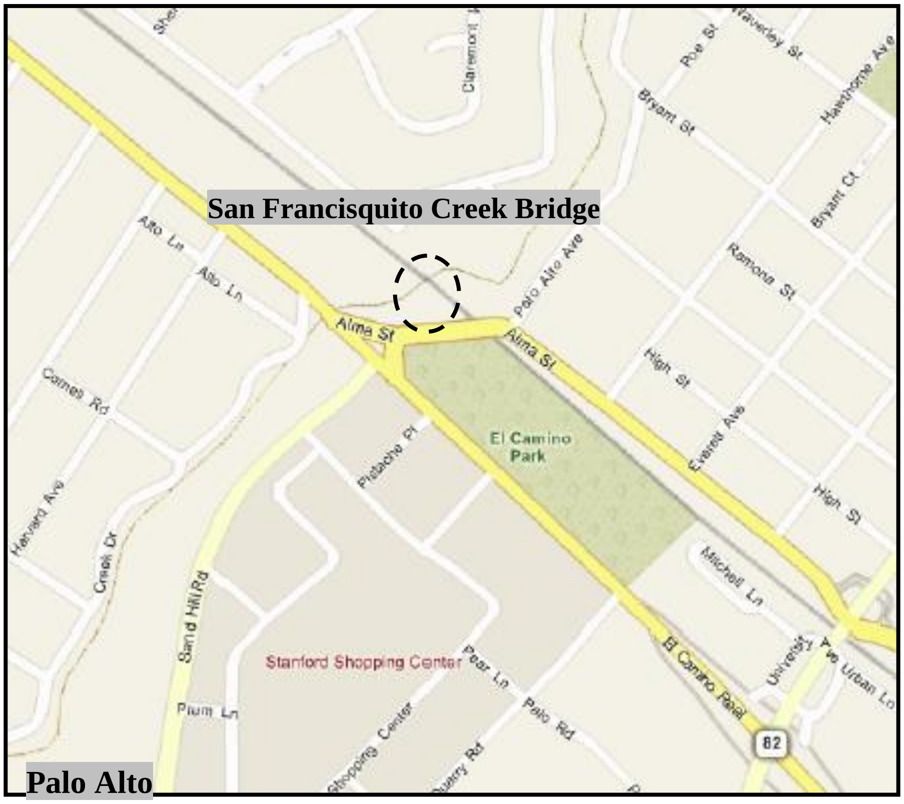


Figure 1-4 – San Francisquito Creek Bridge

2.0 TERMINOLOGIES

This section describes the basic terminologies of noise and vibration to provide background for the assessment procedures in the later sections.

2.1 Noise Descriptors

Noise is usually defined as sound that is undesirable because it interferes with speech communication and hearing, or is otherwise annoying. Under certain conditions, noise may cause hearing loss, interfere with human activities, and in various ways may affect people's health and well being.

The decibel (dB) is the accepted standard unit for measuring the amplitude of sound because it accounts for the large variations in sound pressure amplitude. When describing sound and its effect on a human population, A-weighted (dBA) sound pressure levels are typically used to account for the response of the human ear. The term "A-weighted" refers to a filtering of the noise signal in a manner corresponding to the way the human ear perceives sound. The A-weighted noise level has been found to correlate well with people's judgments of the noisiness of different sounds and has been used for many years as a measure of community noise. Figure 2-1 illustrates typical A-weighted sound pressure levels for various noise sources.

The primary descriptor of rail noise and the reference noise level used for calculating rail noise is the Sound Exposure Level (SEL). SEL describes a receiver's cumulative noise exposure from a single noise event. It is represented by the total A-weighted sound energy during the event, normalized to a one-second interval.

Community noise levels usually change continuously during the day. The equivalent continuous A-weighted sound pressure level (L_{eq}) is normally used to describe community noise. The L_{eq} is the equivalent steady-state A-weighted sound pressure level that would contain the same acoustical energy as the time-varying A-weighted sound pressure level during the same time interval. The maximum sound pressure level (L_{max}) is the greatest instantaneous sound pressure level observed during a single noise measurement interval.

Another descriptor, the day-night average sound pressure level (L_{dn}), was developed to evaluate the total daily community noise environment. The L_{dn} is a 24-hour average sound pressure level with a 10-dB time-of-day weighting added to sound pressure levels in the nine nighttime hours from 10:00 p.m. to 7:00 a.m. This nighttime 10-dB adjustment is an effort to account for the increased sensitivity to nighttime noise events. The FTA uses L_{dn} and L_{eq} to evaluate train noise impacts at the surrounding communities.

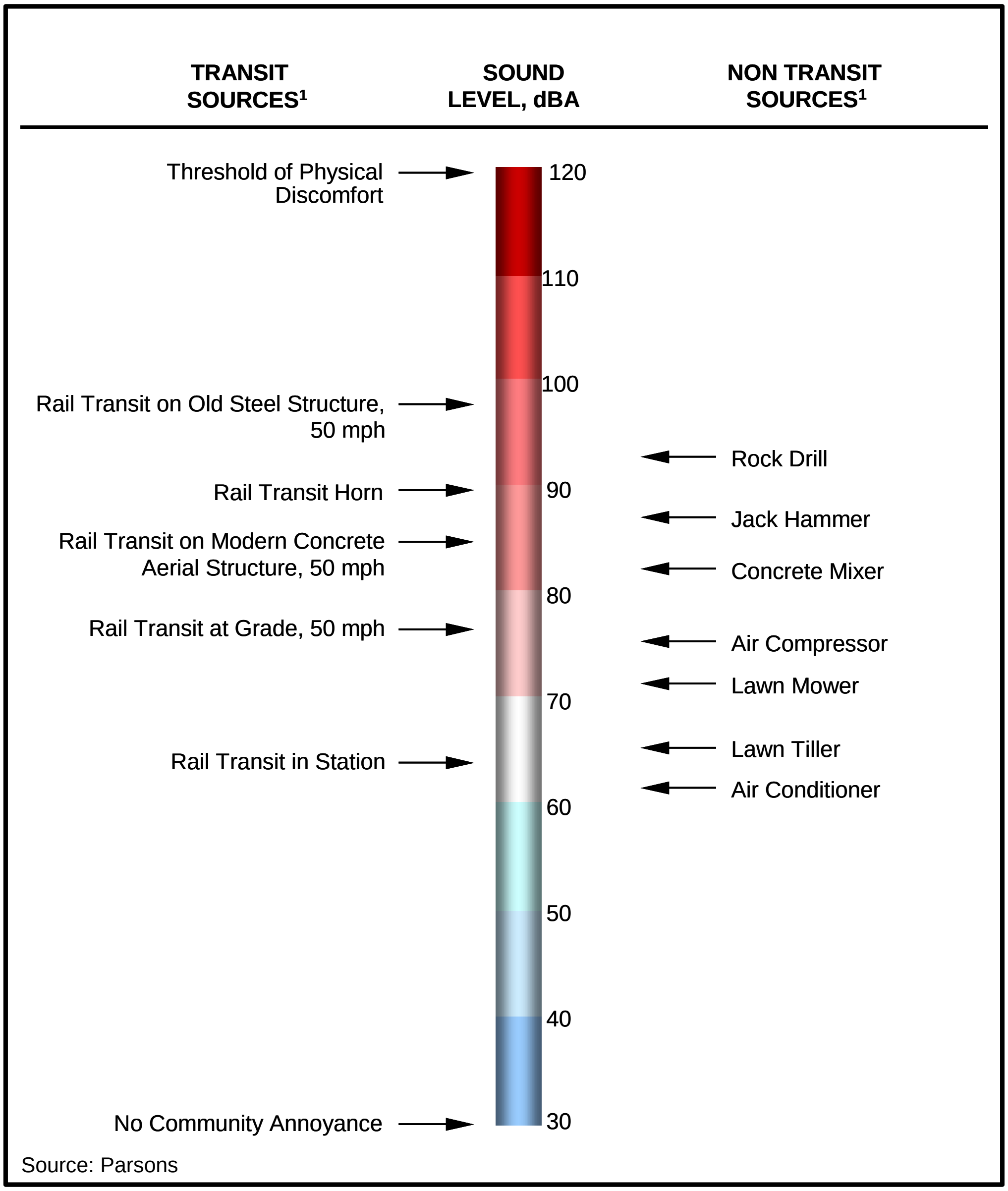


Figure 2-1 – Typical A-Weighted Sound Levels

2.2 Vibration Descriptors

Vibration is an oscillatory motion, which can be described in terms of displacement, velocity, or acceleration. Displacement, in the case of a vibrating floor, is simply the distance that a point on the floor moves away from its static position. The velocity represents the instantaneous speed of the floor movement and acceleration is the rate of change of the speed. The response of humans, buildings, and equipment to vibration is normally described using velocity or acceleration. In this report, velocity will be used in describing ground-borne vibration.

Vibration amplitudes are usually expressed as either peak particle velocity (PPV) or the root mean square (RMS) velocity. The PPV is defined as the maximum instantaneous peak of the vibration signal in inches per second. The RMS of a signal is the average of the squared amplitude of the signal. RMS vibration levels are often expressed in decibel notation (L_v) so as to compress the range of numbers. Decibel notation in this report uses the reference quantity of 1 micro-inch per second and notation VdB. Although PPV is appropriate for evaluating the potential of building damage, it is not suitable for evaluating human response. Since it takes some time for the human body to respond to vibration signals, RMS amplitude is more appropriate to evaluate human response to vibration than PPV. For sources such as truck or motor vehicle, peak vibration levels are typically 6 to 14 dB higher than RMS levels. FTA uses the abbreviation, “VdB” for vibration decibels to reduce the potential for confusion with sound decibel.

Figure 2-2 illustrates common vibration sources as well as the human and structural responses to ground-borne vibration. As shown in Figure 2-2, the threshold of perception for human response is approximately 65 dB; however, human response to vibration is not usually significant unless the vibration exceeds 70 dB. Vibration tolerance limits for sensitive instruments such as MRI or electron microscopes could be much lower than the human vibration perception threshold.

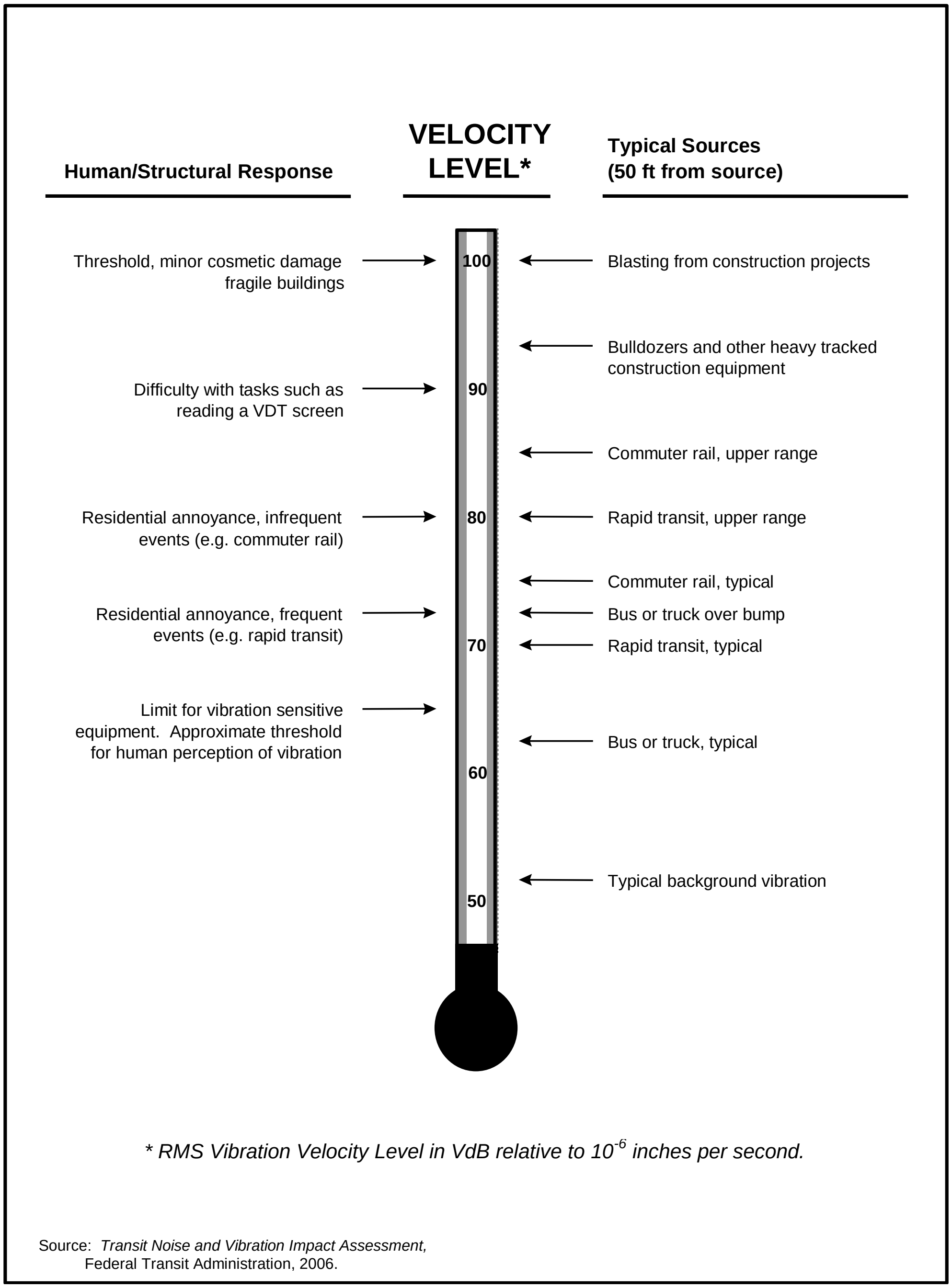


Figure 2-2 – Typical Levels of Ground-borne Vibration

3.0 IMPACT CRITERIA

This section presents the guidelines, criteria, and regulations used to assess noise impacts associated with the proposed project.

3.1 Construction Noise and Vibration

There are three jurisdictions in the area of the project improvements, Palo Alto, San Mateo County, and the City of San Francisco. San Mateo County has an ordinance which limits construction activities during nighttime and on weekends. Coordination with the County may be need when nighttime and weekend construction is planned. FTA daytime and nighttime construction noise limits are used for this project. Table 3-1 summarizes the FTA allowable construction noise levels. These limits are for 8-hour average noise levels (L_{eq}) at the property line of the nearest location to the construction site.

Table 3-1 – Allowable Construction Noise Levels at 50 feet

Land Use	**Daytime** (7 AM to 10 PM) L_{eq}, dBA	**Nighttime** (10 PM to 7 AM) L_{eq}, dBA
Residential	80	70
Commercial	85	85
Industrial	90	90

Source: FTA, 2006.

Construction vibration damage and human annoyance criteria from FTA are also used to assess impacts for this project. In addition, Table 3-2 presents the FTA construction vibration damage criteria (FTA, 2006). The human annoyance vibration assessment for this study area is determined using FTA's criteria which is 80 VdB.

Table 3-2 – Construction Vibration Damage Criteria

Building Category	**PPV (in/sec)**	**Approximate L_v [1]**
I. Reinforced-concrete, steel or timber (no plaster)	0.50	102
II. Engineered concrete and masonry (no plaster)	0.30	98
III. Non-engineered timber and masonry buildings	0.20	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

Source: FTA, 2006.

Note: 1 – RMS velocity in (VdB) re. 1 μinch/sec.

3.2 Operation Noise Impact Criteria

The FTA criteria were used to assess existing ambient noise levels and future noise impacts from train operations. They are founded on well-documented research on community reaction to noise and are based on change in noise exposure using a sliding scale. The amount that transit projects are allowed to change the overall noise environment is reduced with increasing levels of existing noise. The FTA noise impact criteria applicable to three categories of land use are summarized in Table 3-3.

L_{dn} is used to characterize noise exposure for residential areas and hotels (Category 2). The maximum 1-hour L_{eq} during the period that the facility is used for other noise sensitive land uses such as school buildings and parks (Categories 1 and 3). There are two levels of impact included in the FTA criteria, as shown in Figure 3-1. The interpretation of these two levels of impact are as follows:

- Severe: Severe noise impacts are considered "significant" as this term is used in the National Environmental Policy Act (NEPA) and implementing regulations. Noise mitigation will normally be specified for severe impact areas unless there is no practical method of mitigating the noise.
- Moderate: In this range, other project-specific factors must be considered to determine the magnitude of the impact and the need for mitigation. These other factors can include the predicted increase over existing noise levels, the types and number of noise-sensitive land uses affected, existing outdoor-indoor sound insulation, and the cost effectiveness of mitigating noise to more acceptable levels.

Table 3-3 – Land Use Categories and Metrics for Transit Noise Impact Criteria

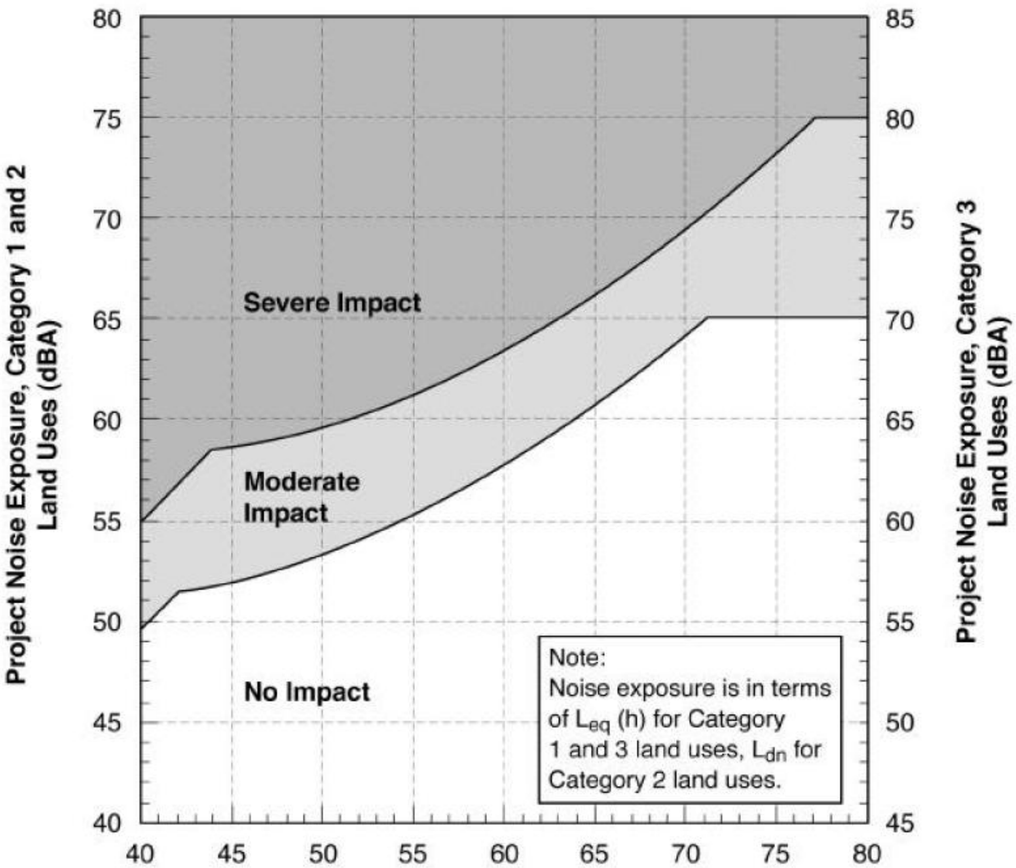
Land Use Category	Noise Metric, dBA	Description of Land Use Category
1	Outdoor L_{eq}(h)*	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as 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, and museums. Certain historical sites, parks, and recreational facilities are also included.

Note: * L_{eq} for the noisiest hour of transit-related activity during hours of noise sensitivity.
Source: FTA, 2006.

The abscissa (x-axis) in Figure 3-1 is the existing L_{dn} without any project noise, and the ordinate (y-axis, right side) is the L_{dn} at residential land uses caused by the project.

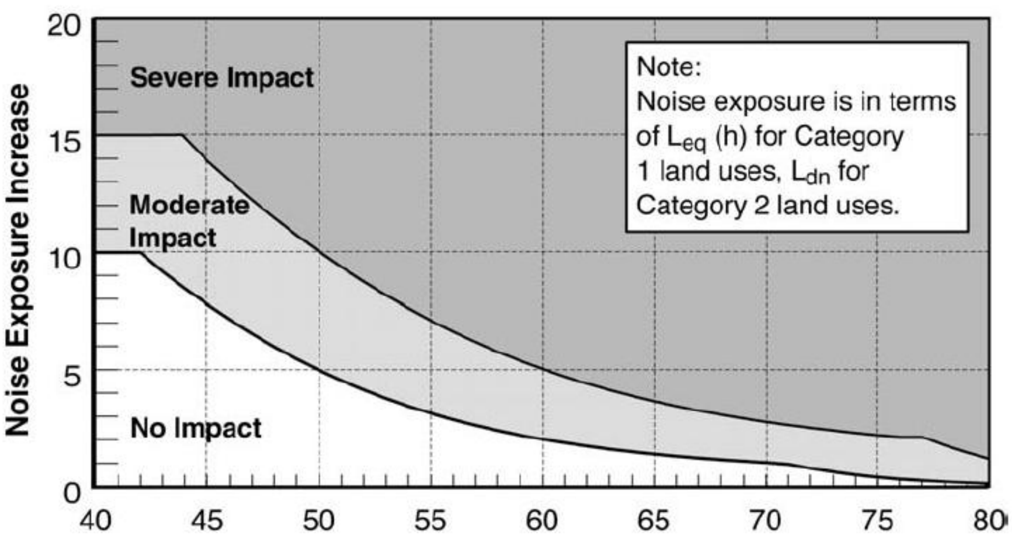
Although the curves in Figure 3-1 are defined in terms of the project noise exposure and the existing noise exposure, it is important to emphasize that the increase in the cumulative noise - when the project noise is added to existing noise - is the basis for the criteria. Figure 3-2 shows the noise impact criteria for Category 1 and 2 land uses in terms of the allowable increase in the cumulative noise exposure.

Figure 3-2 shows that the criterion for impact allows a noise exposure increase of 10 dBA if the existing noise exposure is 42 dBA or less but only a 1 dBA increase when the existing noise exposure is 70 dBA. As the existing level of ambient noise increases, the allowable level of project noise increases, but the total allowable increase in community noise exposure is reduced. This reduction accounts for the unexpected result - project noise exposure levels that are less than the existing noise exposure can still cause impact.



Source: FTA, 2006.

Figure 3-1 – Noise Impact Criteria for Transit Projects



Source: FTA, 2006.

Figure 3-2 – Increase in Cumulative Noise Levels Allowed by Criteria

4.0 EXISTING SETTINGS

There are single-family and multi-family residences along the proposed project alignment in the City of San Mateo where four of the bridges are located. These areas are considered Category 2 land use in accordance with the FTA guidelines. There are commercial and light industrial facilities at the surrounding areas of the two bridges in the City of San Francisco. The closest facilities to the proposed work at the Quint Street and Jerrold Avenue Bridges are at an approximate distance of 80 and 255 feet, respectively. In addition, these areas are not considered noise sensitive. Residences and a park surround the area of the San Francisquito Bridge in the City of Palo Alto but they are located at least 125 feet away from the bridge.

Noise measurements were not conducted to determine existing noise conditions. However, during the site visit it was determined that the dominant noise source along the project area would be the existing train operations. Therefore, existing noise levels at the City of San Mateo were calculated using the FTA General Transit Noise Assessment spreadsheet. Noise levels for other part of the project were not calculated because there are no noise sensitive receivers that would be impacted by the proposed project. Noise levels were calculated at the residence near Poplar Avenue where the train noise would be highest. Train noise levels at the residences located west of Poplar Avenue would be lower because train speeds will be less as they approach or depart from the San Mateo Station. Sheet 1 in Appendix A shows the distance to the existing and future track from the property line of the location where the noise level was calculated. The FTA spreadsheet estimates the existing train noise levels based on inputs such as number of train operation, the receiver to track distance, train operating speed, and number of cars per train. Table 4-1 shows the input parameters used to calculate existing noise levels while results are presented in Table 4-2.

Table 4-1 – Existing Conditions near Poplar Avenue

	Commuter Express		Commuter		Freight	
	NB	SB	NB	SB	NB	SB
Distance to Track (ft)	44	29	44	29	44	29
Train Speed (mph)	79	79	57[1]	70[2]	45	45
Avg. number of trains per hour (Daytime)	0.6	2.13	0.73	2.07	0	0
Avg. number of trains per hour (Nighttime)	0.22	0.55	0	0.77	0.11	0.11
Avg. number of cars per train	4.5	4.5	4.5	4.5	40	40

Notes:
1 - Train is accelerating.
2 - Train is decelerating.

Table 4-2 – FTA Noise Model Results for Existing Conditions

Calculated Day-Night Level L_{dn}, (dBA)[1]						
Commuter Express		Commuter		Freight		
NB	SB	NB	SB	NB	SB	Overall
62	61	65	70	60	62	**72.7**

Note: 1 - At the property line of the closest house to the tracks.

5.0 FUTURE IMPACTS

Noise and vibration impacts during the construction and future operations are likely to cause impacts only in areas near the bridges in the City of San Mateo. This section discusses impacts from construction and future operations with the track horizontal alignment shift and vertical alignment shift (raising tracks).

5.1 Construction Noise

Rail and bridge construction for the San Mateo bridges will be accomplished in four phases. These phases and their estimated overall noise levels at distances of 50 and 100 feet from the acoustic center of the source are presented in Table 5-1. The calculated noise levels are based on equipment operating conditions and types provided as well as equipment noise emission levels collected by Parsons on numerous projects. Some of the construction activity would be conducted from street level. Other construction activity, such as the installation of soldier piles and precast panels for retaining walls, rising of the tracks, and superstructure replacement would be conducted from the track elevation.

Retaining wall work would be conducted during nighttime (midnight to 5 AM) from a work train; which would carry an auger, a crane, and a concrete pump. The work train is intended to move along the track as piles are installed. The proposed pile installation would advance at the rate of approximately 100 feet per night. Therefore, noise sensitive receivers would be exposed to construction noise for approximately four nights (two per side of track).

Impacts are anticipated during the four major phases of construction of bridges in San Mateo; therefore, calculations were conducted to determine the extent of the impacts that are likely to occur. Table 5-2 shows the calculated distance at which daytime and nighttime construction activity would no longer exceed FTA allowable construction limits. The calculations assume a -3 dBA noise adjustment for shielding from building in the vicinity of the project and that the distance is from the acoustic center of the construction activity. It is anticipated that some of the larger commercial and apartment buildings will provide more noise attenuation. It is anticipated that construction activity during these phases will be of short-term duration (less than 30 days) in any given area.

The only construction work on the San Francisquito Creek Bridge in Palo Alto will be replacement of the diagonal members (knee braces). This activity would produce minimal noise and because the closest sensitive area is located approximately 125 feet away from the bridge, there would not be construction related noise impacts.

Construction noise levels at Quint Street and Jerrold Avenue Bridges will be similar to the noise level from the four bridges in the City of San Mateo. However, because there are no noise sensitive receivers in the vicinity of the bridges, no construction related noise impacts are anticipated.

5.2 Construction Vibration

Two types of construction vibration impact were analyzed: (1) human annoyance and (2) building damage. Human annoyance occurs when construction vibration rises significantly above the threshold of human perception for extended periods of time. Building damage can be cosmetic or structural. Fragile buildings such as historical structures or ancient ruins are generally more susceptible to damage from ground vibration. Normal buildings that are not particularly fragile would not experience any cosmetic damage (e.g., plaster cracks) at distances beyond 26 feet from the source based on typical construction equipment vibration levels from the FTA manual listed in Table 5-3. This distance is based on a point source calculation under normal propagation conditions and can vary substantially depending on the soil composition and underground geological layer. In addition, not all buildings respond similarly to vibration generated by construction equipment.

The potential for vibration annoyance and building damage was analyzed for major vibration producing construction equipment that would be used on the project. Construction vibration calculations were performed to determine the distances at which vibration impacts would occur according to the criteria discussed in Section 3.2 and the FTA procedures. Table 5-4 shows the results of those calculations. The distances shown in Table 5-4 are the minimum distances at which short-term construction vibration impacts may occur.

Based on the minimum distances calculated, human annoyance impacts would occur in some areas during the four phases of bridge construction in the City of San Mateo. In some areas, human annoyance impacts would occur during the four major construction phases due to the type of vibration generating equipment used. Table 5.5 shows the results of the construction vibration impact analysis conducted for the proposed construction phases 1, 3, and 4. The results indicate that building damage is not anticipated anywhere along the project alignment during these three construction phases due to the distance to any vibration sensitive buildings. Retaining wall construction along the east and west sides of the alignment conducted during phase 2 of the project would generate vibration impacts in areas between Belleview Avenue and Monte Diablo Avenue. Retaining wall construction south of Monte Diablo Avenue would not be close enough to buildings to generate vibration impacts.

Table 5-1 – Construction Operation Noise Levels

San Mateo Bridge Replacement Project

No. of Items	Equipment Type	Maximum Equipment Noise Levels at 50 ft dBA	Hourly Equivalent Noise Levels at 50 ft, dBA [1]	Hourly Equivalent Noise Levels at 100 ft, dBA [1]
Phase 1: Rehabilitation/Retrofit of Abutments				
2	Dump Truck	73	70	64
1	Jackhammer	93	90	84
1	Hoe Ram	98	95	89
1	Generator/Compressor	65	62	56
1	Truck (Delivery)	73	70	64
1	Crane (Small)	76	73	67
1	Tieback Drill Rig	80	77	71
8	Concrete Truck	72	69	63
1	Concrete Pump Truck	84	81	75
1	Pile Drill Rig	80	77	71
1	Excavator/Backhoe	75	72	66
1	Front Loader	75	72	66
1	Tamper/Liner	82	79	73
1	Ballast Regulator	93	90	84
		Combined L_{eq}(h)	98	92
Phase 2: Construct Longitudinal Approach Retaining Walls				
	Soldier Piles			
1	Pile Drill Rig	70	67	61
1	Crane (Small)	76	73	67
1	Concrete Pump	84	81	75
4	Concrete Truck	72	69	63
1	Light Plant	61	58	52
		Combined L_{eq}(h)	83	77
	Precast Panel Installation			
2	Dump Truck	73	70	64
1	Crane (Small)	76	73	67
1	Generator/Compressor	65	62	56
3	Truck (Delivery)	73	70	64
1	Excavator/Backhoe	75	72	66
1	Front Loader	75	72	66
		Combined L_{eq}(h)	80	74

No. of Items	Equipment Type	Maximum Equipment Noise Levels at 50 ft, dBA	Hourly Equivalent Noise Levels at 50 ft, dBA [1]	Hourly Equivalent Noise Levels at 100 ft, dBA [1]
Phase 3: Removal/Replacement of Superstructure, Raise and Widen Space of Tracks				
3	Dump Truck	73	70	64
1	Generator/Compressor	65	62	56
2	Truck (Delivery)	73	70	64
1	Crane (Large)	85	82	76
2	Excavator/Backhoe	75	72	66
1	Front Loader	75	72	66
1	Tamper/Liner	82	79	73
1	Dynamic Track Stabilizer	85	82	76
1	Ballast Regulator	93	90	84
1	Dozer	77	74	68
1	Grader	73	70	64
		Combined L_{eq}(h)	92	86
Phase 4: Raise Superstructure and Tracks				
2	Dump Truck	73	70	64
1	Generator/Compressor	65	62	56
1	Truck (Delivery)	73	70	64
1	Paving Machine	79	76	70
1	Earth and Pavement Compactor	76	73	67
1	Concrete Truck	72	69	63
1	Concrete Pump Truck	84	81	75
1	Pile Drill Rig	80	77	71
1	Excavator/Backhoe	75	72	66
1	Front Loader	75	72	66
1	Tamper/Liner	82	79	73
1	Ballast Regulator	93	90	84
1	Jackhammer	93	90	84
1	Hoe Ram	98	95	89
1	Compactor	74	71	65
		Combined L_{eq}(h)	98	92

Note: 1- Calculated construction noise levels use the following three assumptions: (1) all equipment operates for 6 hours out of an 8-hour day; (2) all equipment is operated at full load 70% of the time; and (3) the location of the acoustic center for all equipment is assumed at the center of the construction activity.

Source: Parsons

Table 5-2 – Construction Noise Distance to No Impact

Construction Phase/Description	Distance to No Impact (ft) [1]	
	Daytime	Nighttime
Phase 1: Rehabilitation/Retrofit of Abutments	290	910
Phase 2: Construct Longitudinal Approach Retaining Walls		
Soldier Piles	--	160
Precast Panel Installation	60	120
Phase 3: Removal/Replacement of Superstructures, Raise and Widen Space of Tracks	150	480
Phase 4: Raise Superstructure and Tracks	280	900

Note: 1 - Assumes a -3 dBA adjustment for shielding from buildings in the area.

Table 5-3 – Vibration Source Levels for Construction Equipment

Equipment	PPV [1] at 25 feet (in/sec)	Approximate Velocity Level [2] at 25 ft (VdB)
Large bulldozer	0.089	87
Loaded trucks	0.076	86
Small bulldozer	0.003	58
Auger/drill rigs	0.089	87
Hoe ram	0.089	87
Pile driver	0.089	87
Vibratory compactor/roller	0.210	94

Source: FTA, 2006.

Notes:

1. Peak particle ground velocity measured at 25 feet unless noted otherwise.
2. RMS ground velocity in VdB referenced to 1 micro-inch/second.

Table 5-4 – Construction Equipment Vibration Impact Distances

Equipment	Distance to Vibration Annoyance [1], feet	Distance to Vibration Building Damage [2], feet
Large bulldozer	43	15
Loaded trucks	40	13
Small bulldozer	--	--
Auger/drill rigs	43	15
Hoe ram	43	15
Pile driver	43	15
Vibratory compactor/roller	73	26

Notes:
1. This is the distance at which the RMS velocity level is 80 VdB or less at the inside of the building structure. When propagating from the ground surface to the building structure foundation, there is a vibratory coupling loss of approximately 5 dB; however, this loss is offset by the building amplification in light-frame construction. Thus, no additional adjustments are applied.
2. This is the distance at which the peak particle velocity is 0.20 in/sec or less.

-- Distance is less than 10 feet.

Table 5-5 – Construction Vibration Impacts Near San Mateo Bridges

Bridge Structure	Distance to Building[1]	Vibration Impacts		
		Phase 1 Annoyance/ Damage[2]	Phase 3 Annoyance/ Damage[2]	Phase 4 Annoyance/ Damage[2]
Poplar Avenue	43	Yes/ No	Yes/ No	Yes/ No
Santa Inez Avenue	31	Yes/ No	Yes/ No	Yes/ No
Monte Diablo Avenue	52	Yes/ No	No/ No	Yes/ No
Tilton Avenue	69	No/ No	No/ No	Yes/ No

Notes:

1 - Distance from construction activity to nearest buildings.

2 - Based on vibration human annoyance and building damage criteria of 80 VdB and 0.2 in/sec, respectively.

5.3 Operation Noise Impacts

Operation noise impacts were evaluated from the replacement of the bridges at Poplar Avenue, Santa Inez Avenue, Monte Diablo Avenue, and Tilton Avenue in San Mateo. Train noise impacts are not anticipated near the Quint Street, Jerrold Avenue, and San Francisquito Bridges due to the proposed project. The following paragraphs discuss noise impact in the City of San Mateo due to (1) the horizontal realignment to the west of the existing track; and (2) raising the tracks in the area by 2 to 4 feet:

Track Horizontal Alignment Shift

A noise impact analysis was performed for the first row receptors at station 1102+00 on the west side of tracks near Poplar Avenue for the Seven Bridges Project. The analysis was conducted at the location along the project alignment that represents the worst case noise impact condition due to the proposed realignment. At this location, trains that are decelerating to stop at the San Mateo station and trains that are accelerating from the San Mateo station are at their highest speeds within the project limits. In addition, residences are closest to the realigned tracks. Other locations along the project corridor, south of Poplar Avenue to Tilton Avenue, will experience less noise impact due to slower local commuter train speeds and from being slightly farther away from the tracks. Sheet 1 of Appendix A shows the noise analysis location.

The noise analysis was conducted in accordance with FTA procedures. One potential design alignment which shifts tracks by 10.28 feet towards the west was used for the noise analysis. Table 5-5 shows the specific input parameters for the worst case noise sensitive site. Table 5-6 presents the existing noise level, the future noise level generated by the train operations, and the change in the overall noise level between existing and future conditions.

The noise analysis revealed that moving the tracks 10.28 feet would increase noise level at the first row of residences by 2 dB. The increase in noise level would only occur at the areas west of the tracks where tracks are planned to move closer to residences. However, this slight increase in the noise level would exceed FTA moderate noise impact criteria in the project vicinity, because the existing L_{dn} is in the seventies. In this area, the allowed increase to go from non-impact to moderate impact is only 1 dB

Further, the noise analysis also determines the maximum track shift that would generate a noise level that is considered non-impact per FTA noise criteria. This analysis was conducted by increasing the distances between the tracks and the property line until the noise level increase was only 1 dB. The farthest that the tracks can be displaced from their original alignment and not cause an impact is 6 feet for the southbound track and 7 feet for the northbound track. Tables 5-7 and 5-8 show input data and results of the analysis, respectively.

Track Vertical Alignment Change

A general assessment was also made during the site visit conducted by Parsons personnel on June 9, 2006 to determine if additional noise impacts would occur at non-first row residences as a result of raising the tracks in the vicinity of the bridge replacements for Poplar Avenue, Santa Inez Avenue, Monte Diablo Avenue, and Tilton Avenue in San Mateo. The assessment was made based on a visual inspection of the site where the track vertical alignment change would occur. Pictures were taken at the location used for the visual assessment and are presented in Appendix B. Sheets 1 to 4 of Appendix C show the location and camera angle of the pictures as well as the land use mix in the area.

The proposed bridge replacement and track work in the area will not change the train operations; therefore, this visual impact assessment was conducted by determining if raising the tracks from the existing elevation by 2 to 4 feet would increase the number of impacted noise sensitive receptors in the area that would be exposed to additional noise from the train. The existing tracks in this area are currently elevated and, in some areas, retaining walls were built at the right-of-way. Although some of the retaining walls are tall, as illustrated in Picture 4 near the Monte Diablo Avenue Bridge, they do not create a hinge point that could possibly break the line-of-sight for first-row receivers. First-row receivers either abut the right-of-way or are across the street from Railroad Avenue, which runs parallel to the existing tracks. Picture 7 shows the existing track elevation and residences that abut the right-of-way. Pictures 4, 15, 17, 18 and 19 also illustrate receivers that are separated from the right-of-way by Railroad Avenue.

At non-first row receivers, no additional noise impacts would occur because the line-of-sight to these receivers would still be blocked by first-row buildings. Pictures 2, 3, 8 through 14, 16, and 20 show representative non-first row receivers in the area. Pictures 1 and 5 show representative non-first row receivers along streets running perpendicular to the tracks which currently have a window of exposure to train operations. The vertical alteration of the tracks would not increase the level of exposure to these receivers since the majority of their line-of-sight to train pass-bys would still be intercepted by buildings adjacent the corridor.

Table 5-5 – FTA Noise Model Input Parameters for the Preferred Alignment Shift

	FTA Noise Model Parameters											
	Existing						Future					
	Commuter Express		Commuter		Freight		Commuter		Commuter Express		Freight	
	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
Distance to Track (ft)	44	29	44	29	44	29	37	19	37	19	37	19
Train Speed (mph)	79	79	57[1]	70[2]	45	45	79	79	57[1]	70[2]	45	45
Avg. number of trains per hour (Daytime)	0.6	2.13	0.73	2.07	0	0	0.6	2.13	0.73	2.07	0	0
Avg. number of trains per hour (Nighttime)	0.22	0.55	0	0.77	0.11	0.11	0.22	0.55	0	0.77	0.11	0.11
Avg. number of cars per train	4.5	4.5	4.5	4.5	40	40	4.5	4.5	4.5	4.5	40	40

Note:
1 - Train is accelerating.
2 - Train is decelerating.

Table 5-6 – FTA Noise Model Results for the Preferred Alignment Alternative

	Existing							Future							
	Commuter Express		Commuter		Freight		Overall	Commuter Express		Commuter		Freight		Overall	Delta
	NB	SB	NB	SB	NB	SB		NB	SB	NB	SB	NB	SB		
L_{dn} (dBA)	62	61	65	70	60	62	**72.7**	63	64	66	73	61	65	**75.2**	2

Table 5-7 – FTA Noise Model Input Parameters for the Non-Impact Alignment Shift

	FTA Noise Model Parameters											
	Existing						Future					
	Commuter Express		Commuter		Freight		Commuter Express		Commuter		Freight	
	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
Distance to Track (ft)	44	29	44	29	44	29	37	23	37	23	37	23
Train Speed (mph)	79	79	57[1]	70[2]	45	45	79	79	57[1]	70[2]	45	45
Avg. number of trains per hour (Daytime)	0.6	2.13	0.73	2.07	0	0	0.6	2.13	0.73	2.07	0	0
Avg. number of trains per hour (Nighttime)	0.22	0.55	0	0.77	0.11	0.11	0.22	0.55	0	0.77	0.11	0.11
Avg. number of cars per train	4.5	4.5	4.5	4.5	40	40	4.5	4.5	4.5	4.5	40	40

Note:
1 - Train is accelerating.
2 - Train is decelerating.

Table 5-8 – FTA Noise Model Results for the Preferred Alignment Alternative

	Existing							Future							
	Commuter Express		Commuter		Freight		Overall	Commuter Express		Commuter		Freight		Overall	Delta
	NB	SB	NB	SB	NB	SB		NB	SB	NB	SB	NB	SB		
L_{dn} (dBA)	62	61	65	70	60	62	**72.7**	63	63	66	71	61	64	**73.9**	1

6.0 MITIGATION MEASURES

This section discusses the possible mitigation measures that can be implemented to either reduce or mitigate the impacts generated by the construction and operation of the proposed project.

6.1 Construction Noise Mitigation Measures

Construction activity for phase 1 and a portion of phase 2 would likely be conducted during daytime hours. In an attempt to minimize train service and local traffic interruptions some of the construction activities will be conducted between midnight and 5 AM when there are no revenue operations. The proposed construction work for soldier pile installation work from phase 2 would be conducted during week day and wee end nights. Phases 3 and 4 work would be conducted on weekends starting on Friday evening and will extend until early Monday morning. The construction activities for these phases are likely to generate substantial noise and cause impacts. Furthermore, because the existing and future tracks are elevated in the project area and work would be conducted at this elevation, temporary noise barriers will not effectively mitigate construction generated noise. Therefore, the following abatement measures are recommended to minimize the number of impacts and disturbances during construction:

Equipment Noise Control

- Use newer equipment with improved noise muffling and ensure that all equipment items have the manufacturers' recommended noise abatement measures, such as mufflers, engine enclosures, and engine vibration isolators intact and operational. Newer equipment will generally be quieter in operation than older equipment. All construction equipment should be inspected at periodic intervals to ensure proper maintenance and presence of noise control devices (e.g., mufflers and shrouding, etc.).
- Utilize construction methods or equipment that will provide the lowest level of noise and ground vibration impact such as alternative low noise pile installation methods.
- Turn off idling equipment.

Administrative Noise Control Measures

- Keep noise levels relatively uniform and avoid impulsive noises.
- Maintain good public relations with the community to minimize objections to the unavoidable construction impacts.

6.2 Construction Vibration Mitigation Measures

It is expected that ground-borne vibration from construction activities would cause only intermittent localized intrusion along the project area. The operation of heavy equipment listed in Table 5-3 can create annoying vibration. There are cases where it may be necessary to use this type of equipment in close proximity to residential buildings. Following are some procedures that can be used to minimize the potential for annoyance in the project area:

- When possible, limit the use of construction equipment that creates high vibration levels, such as vibratory rollers and hammers, operating in the proximity of residential structures.
- Restrict the hours of vibration-intensive equipment or activities such as vibratory rollers so that impacts to residents are minimal

A combination of the mitigation techniques for equipment noise and vibration control as well as administrative measures, when properly implemented, can be selected to provide the most effective means to minimize the effects of construction activity impacts. Application of the mitigation measures will reduce the construction impacts; however, temporary increases in noise and vibration would likely occur at some locations.

6.3 Operation Noise Mitigation Measures

Train operation noise at the worst case analysis location indicated that impacts would occur with the proposed track alignment shift of 10.28 feet. In order to mitigate noise impacts in this area, the tracks should be shifted west no more than 6 feet.

7.0 REFERENCE

FTA, 2006. Federal Transit Administration "*Transit Noise and Vibration Impact Assessment*," Office of Planning/Federal Transportation Administration, FTA-VA-90-1003-06, May.

APPENDIX A – NOISE ANALYSIS LOCATION MAP
(TRACK HORIZONTAL ALIGNMENT SHIFT)

APPENDIX B – PICTURES FOR VISUAL IMPACT ASSESSMENT

APPENDIX C –PICTURE LOCATIONS AND LAND USE MIX