2.6 Noise

This section assesses the potential noise/vibration impacts associated with implementation of the proposed Plan. The following includes acoustical terminology and background information relevant to the proposed Plan, a presentation of applicable regulatory standards, assessment of acoustical impacts related to implementation of the proposed Plan, and identification of potentially feasible noise mitigation measures where appropriate.

Environmental Setting

PHYSICAL SETTING

Acoustical Terminology

Sound can be described as the mechanical energy of a vibrating object transmitted by pressure waves through a liquid or gaseous medium (e.g., air). Noise is generally defined as unwanted sound (i.e., loud, unexpected, or annoying sound). Acoustics is defined as the physics of sound. In acoustics, the fundamental scientific model consists of a sound (or noise) source, a receiver, and the propagation path between the two. The loudness of the noise source and obstructions or atmospheric factors affecting the propagation path to the receiver determines the sound level and characteristics of the noise perceived by the receiver. Acoustics addresses primarily the propagation and control of sound.

Frequency

The number of sound pressure peaks travelling past a given point in a single second is referred to as the frequency, expressed in cycles per second or Hertz (Hz). A given sound may consist of energy at a single frequency (pure tone) or in many frequencies over a broad frequency range (or band). Human hearing is generally affected by sound frequencies between 20 Hz and 20,000 Hz. (20 kHz).

Amplitude

The amplitude of pressure waves generated by a sound source determines the perceived loudness of that source. Sound pressure amplitude is measured in micro-Pascals (μPa). One μPa is approximately one hundred billionths (0.00000000001) of normal atmospheric pressure. Sound pressure amplitudes for different kinds of noise environments can range from less than 100 μPa to 100,000,000 μPa. Because of this huge range of values, sound is rarely expressed in terms of pressure. Instead, a logarithmic scale is used to describe sound pressure level (SPL) in terms of decibels (dB). The threshold of human hearing (near total silence) is approximately 0 dB which corresponds to 20 μPa.

Addition of Decibels

Because decibels are logarithmic units, SPL cannot be added or subtracted through ordinary arithmetic means. Under the decibel scale, a doubling of sound energy corresponds to a 3 dB increase. In other words, when two sources are each producing sound of the same loudness, the resulting sound level at a given distance would be approximately 3 dB higher than one of the sources under the same conditions. For example, if one automobile produces an SPL of 70 dB when it passes an observer, two cars passing simultaneously would not produce 140 dB—rather, they would combine to produce 73 dB. Under the decibel scale, three sources of equal loudness together produce a sound level of approximately 5 dB louder than one source, and 10 sources of equal loudness together produce a sound level of approximately 10 dB louder than the single source.

A-Weighted Decibels

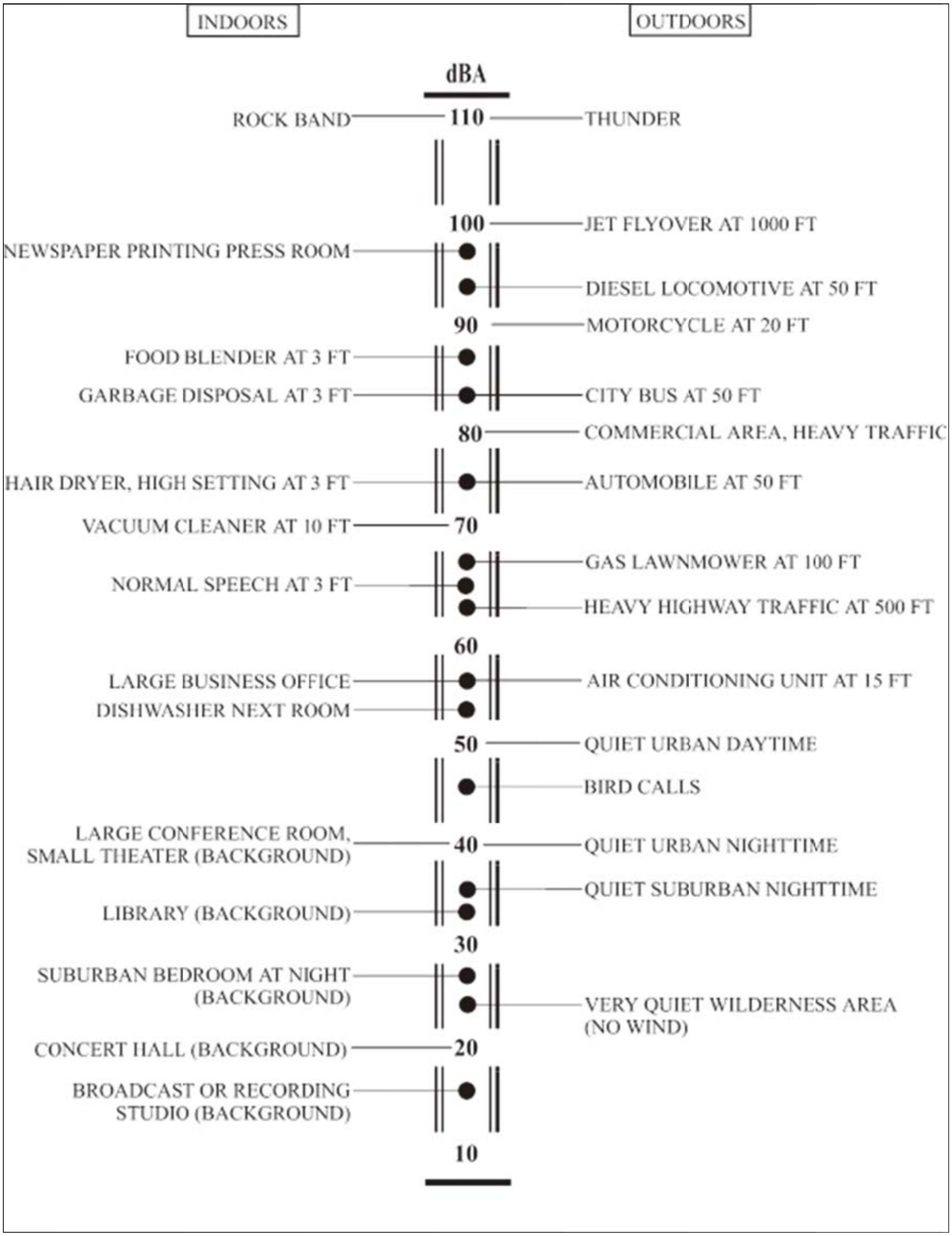
Figure 2.6-1 illustrates sound levels associated with common sound sources. The perceived loudness of sounds is dependent on many factors, including sound pressure level and frequency content. However, within the usual range of environmental sound levels, perception of loudness is relatively predictable, and can be approximated by frequency filtering using the standardized A-weighting network. There is a strong correlation between A-weighted sound levels (expressed as dBA) and community response to noise. For this reason, the A-weighted sound level has become the standard descriptor for environmental noise assessment. All noise levels reported in this section are in terms of A-weighting.

HUMAN RESPONSE TO CHANGES IN NOISE LEVELS

As discussed above, doubling sound energy results in a 3 dB increase in sound. However, given a sound level change measured with precise instrumentation, the subjective human perception of a doubling of loudness will usually be different than what is measured.

Under controlled conditions in a laboratory setting, the trained, healthy human ear is able to discern 1 dB changes in sound levels when exposed to steady, single-frequency ("pure-tone") signals in the mid-frequency range (1,000 Hz–8,000 Hz). In typical noisy environments, changes in noise of 1 to 2 dB are generally not perceptible. However, it is widely accepted that people are able to begin to detect sound level increases of 3 dB in typical noisy environments. Further, a 5 dB increase is generally perceived as a distinctly noticeable increase, and a 10 dB increase is generally perceived as a doubling of loudness. Therefore, a doubling of sound energy that would result in a 3 dB increase in sound pressure level would generally be perceived as barely detectable. Please refer to **Table 2.6-1.**

Figure 2.6-1: Decibel Scale and Common Noise Sources



Source: Caltrans TeNS, 2009.

TABLE 2.6-1: APPROXIMATE RELATIONSHIP BETWEEN INCREASES IN ENVIRONMENTAL NOISE LEVEL AND HUMAN PERCEPTION

Noise level increase, dB	*Human perception (typical)*
Up to about 3	Not perceptible
About 3	Barely perceptible
About 6	Distinctly noticeable
About 10	Twice as loud
About 20	Four times as loud

Source: Egan, D. (1988). Architectural acoustics. New York: McGraw-Hill.

NOISE SENSITIVE LAND USES

Noise-sensitive land uses are generally defined as locations where people reside or where the presence of unwanted sound could adversely affect the use of the land. Noise-sensitive land uses typically include residences, hospitals, schools, transient lodging, libraries, and certain types of recreational uses. Noise-sensitive, residential receivers are found throughout the study area.

NOISE DESCRIPTORS

Noise in our daily environments fluctuates over time. Some fluctuations are minor, but some are substantial. Some noise levels occur in regular patterns, but others are random. Some noise levels fluctuate rapidly, but others slowly. Some noise levels vary widely, but others are relatively constant. Various noise descriptors have been developed to describe time-varying noise levels. The following are the noise descriptors most commonly used in environmental noise analysis, and may be applicable to this study:

- **Equivalent Sound Level (L_{eq}):** The L_{eq} represents an average of the sound energy occurring over a specified time period. In effect, the L_{eq} is the steady-state sound level containing the same acoustical energy as the time-varying sound that actually occurs during the same period. The 1-hour, A-weighted equivalent sound level (L_{eq}[h]) is the energy average of A-weighted sound levels occurring during a 1-hour period, and is the basis for noise abatement criteria (NAC) used by the California Department of Transportation (Caltrans) and the Federal Highway Administration (FHWA).
- **Percentile-Exceeded Sound Level (L_n):** The L_n represents the sound level exceeded "n" percentage of a specified period (e.g., L_{10} is the sound level exceeded 10 percent of the time, and L_{90} is the sound level exceeded 90 percent of the time).
- **Maximum Sound Level (L_{max}):** The L_{max} is the highest instantaneous sound level measured during a specified period.
- **Day-Night Average Level (L_{dn}):** The L_{dn} is the energy-average of A-weighted sound levels occurring over a 24-hour period, with a 10 dB penalty applied to A-weighted sound levels occurring during nighttime hours (10 p.m.-7 a.m.). The L_{dn} is often noted as the DNL.
- **Community Noise Equivalent Level (CNEL):** Similar to L_{dn}, CNEL is the energy-average of the A-weighted sound levels occurring over a 24-hour period, with a 10 dB penalty applied to A-weighted sound levels occurring during the nighttime hours (10 p.m.-7 a.m.), and a 5 dB penalty

applied to the A-weighted sound levels occurring during evening hours (7 p.m.-10 p.m.). The CNEL is usually within 1 dB of the L_{dn}, and for all intents and purposes, the two are interchangeable. As it is easier to compute, and of more common use, the L_{dn} is used as the long-term noise measure in this study.

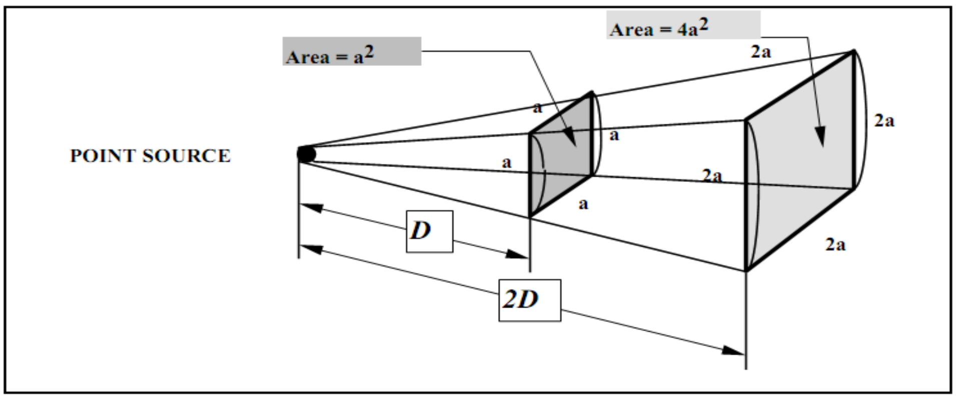
SOUND PROPAGATION

When sound propagates over a distance, it changes in level and frequency content. The manner in which noise reduces with distance depends on the following factors:

Geometric Spreading

Sound from a localized source (i.e., point source) propagates uniformly outward in a spherical pattern; therefore, this type of propagation is called *spherical spreading*. The sound level attenuates (or decreases) at a rate of 6 dB for each doubling of distance from a point/stationary source as its energy is continuously spread out over a spherical surface (see **Figure 2.6-2**).

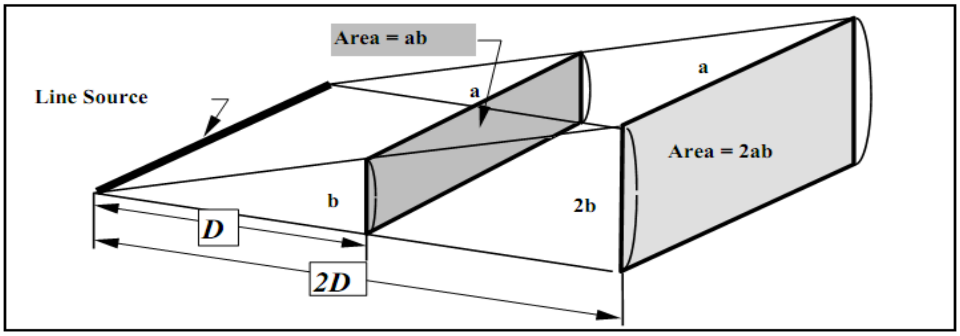
Figure 2.6-2: Point Source Spreading with Distance



Source: Caltrans TeNS, 2009.

Roadways and highways, and to some extent, moving trains, consist of several localized noise sources on a defined path, and hence are treated as “line” sources, which approximate the effect of several point sources (see **Figure 2.6-3**). Noise from a line source propagates over a cylindrical surface, often referred to as *cylindrical spreading*. Sound levels attenuate at a rate of 3 dB for each doubling of distance from a line source. Therefore, noise due to a line source attenuates less with distance than that of a point source with increased distance.

Figure 2.6-3: Line Source Spreading with Distance



Source: Caltrans TeNS, 2009.

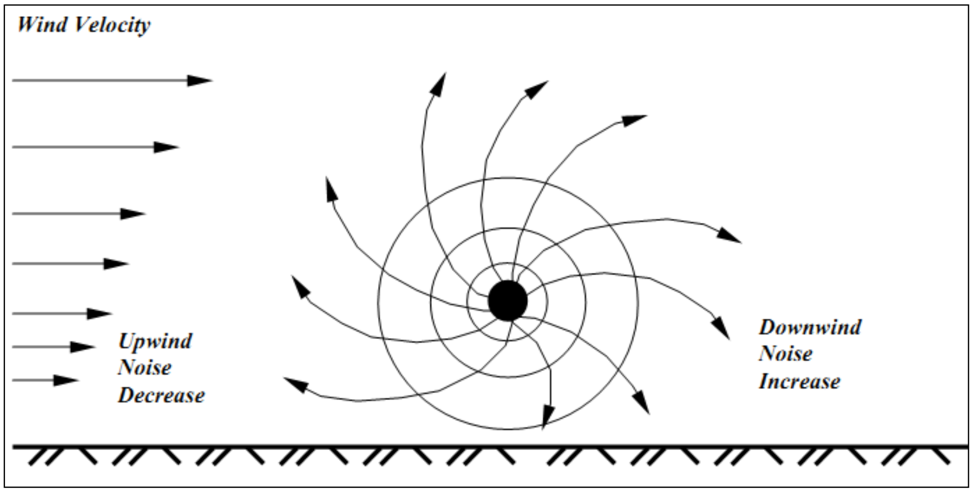
Ground Absorption

The propagation path of noise from many typical sources such as roadways to a receiver is usually very close to the ground. Noise attenuation from ground absorption and reflective-wave canceling adds to the attenuation associated with geometric spreading. Traditionally, the excess attenuation has also been expressed in terms of attenuation per doubling of distance. For acoustically hard sites (i.e., sites with a reflective surface between the source and the receiver, such as a paved parking lot or body of water,), no excess ground attenuation is generally assumed. For acoustically absorptive or soft sites (i.e., those sites with an absorptive ground surface between the source and the receiver, such as soft dirt, grass, or scattered bushes and trees), an excess ground-attenuation value of 1.5 decibels per doubling of distance is typically assumed. When added to cylindrical spreading from traffic noise sources, the excess ground attenuation results in an overall drop-off rate of 4.5 dB per doubling of distance. When added to spherical spreading (point sources), it results in overall drop-off rates of approximately 7.5 dB. These approximations are generally only applicable for receivers within 300 feet of the noise source(s), and should not be applied to sound path lengths of more than 300 feet.

Atmospheric Effects

Receivers located downwind from a source can be exposed to increased noise levels relative to calm conditions, whereas receivers upwind from the source can have lowered noise levels. This is illustrated in **Figure 2.6-4**.

Figure 2.6-4: Wind Effects on Noise Levels

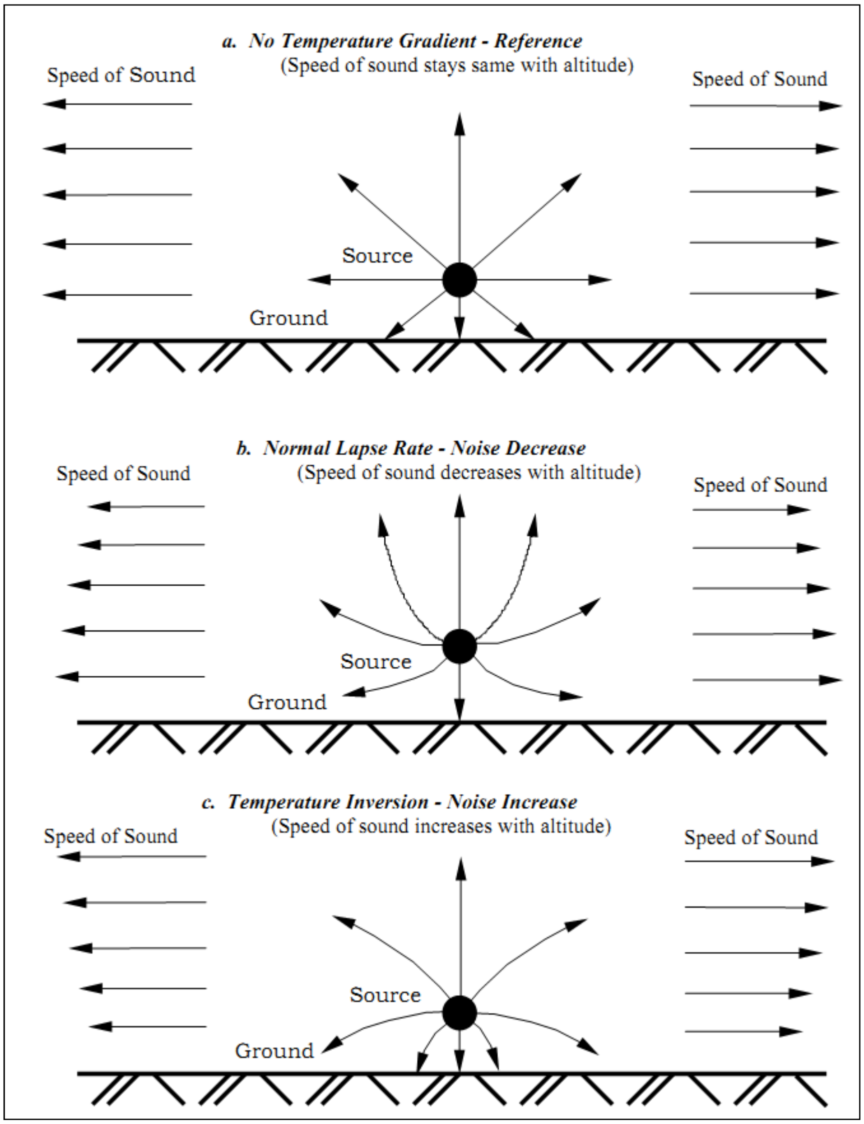


Source: Caltrans TeNS, 2009.

In addition to the enhancing effect produced by wind, sound levels can increase at large distances from the source (e.g., more than 500 feet) due to atmospheric temperature inversions (i.e., increasing temperature with elevation) or can decrease with distance from the source at a higher rate than the typical spreading loss with distance rate (see above) due to a temperature lapse condition (i.e., decreasing temperature with elevation).

Temperature inversions are a common part of the meteorological environment in California. During a temperature inversion the air temperature at the ground is cooler than that several hundred feet above the ground. These temperature inversions are typically caused when a warm, sunny day is followed by a cold, clear night; generally this occurs more frequently and with higher intensity in the fall and the spring seasons. The sun warms the earth surface during the day and generally the air temperature near the ground is higher than the air temperature at higher elevations, but when the sun sets, the earth cools quickly by infrared radiation into space and so does the air mass at lower elevations, so that the temperature of air at high elevations soon becomes warmer than that of the air near the ground. The speed of sound is higher in warmer air, and this inverted temperature profile causes the sound waves in the warmer air to overtake those travelling in cooler air, thus the sound "bends" back toward the ground (see **Figure 2.6-5**).

Figure 2.6-5: Effects of Temperature Gradients on Noise



Source: Caltrans TeNS, 2009.

Other factors such as air temperature, humidity, and turbulence can also have significant effects on sound propagation. For instance, air temperature and humidity have a significant effect on the rate of molecular absorption as sound travels large distances. A sound consisting primarily of middle frequencies such as speech or animal vocalization attenuates approximately five additional decibels for every 1,000 feet of travel with an air temperature of 70 degrees Fahrenheit and a humidity of 30 to 40 percent. This atmospheric effect is in addition to the other effects discussed above.

VIBRATION

Generally speaking, vibration is energy transmitted in waves through the ground. These energy waves dissipate with distance from the vibration source. Because energy is lost during the transfer of energy from one particle to another, the vibratory energy is reduced with increasing distance from the source. Vibration attenuates at a rate of approximately 50 percent for each doubling of distance from the source. This approach only takes into consideration the attenuation from geometric spreading. Since there are additional factors that reduce vibration over distance (e.g., damping from soil condition), this approach tends to provide for a conservative assessment of vibration level at the receiver.

Vibration is an oscillatory motion that can be described in terms of the displacement, velocity, or acceleration. Vibration is typically described by its peak amplitude and its root-mean-square (RMS) amplitude. The RMS value can be considered an average value over a given time interval. The peak vibration velocity is the same as the "peak particle velocity" (PPV), generally presented in units of inches/second (in/sec). Peak particle velocity is defined as the maximum instantaneous positive or negative peak of the vibration signal, and PPV is generally used to assess the potential for damage to buildings and structures. The RMS amplitude is typically used for assessing human annoyance to vibration.

PHYSICAL SETTING

The existing noise environment in the Bay Area is comprised of two primary categories of noise sources: transportation and non-transportation. Transportation sources include surface vehicle traffic; railroad train operations, including light rail and commuter trains; and aircraft operations. Non-transportation, or stationary/fixed sources include commercial/industrial equipment, construction equipment, and any other sources not associated with the transportation of people or goods. Existing noise exposure in the Bay Area associated with these primary noise sources is presented below.

Traffic Noise Sources

The ambient noise environment in the Bay Area is defined by a wide variety of noise sources, none more pervasive than traffic. Traffic noise exposure is primarily a function of the volume of vehicles per day, the speed of those vehicles, the number of those vehicles represented by medium and heavy trucks, the distribution of those vehicles during daytime and nighttime hours, and the proximity of noise-sensitive receivers to the roadway. Existing traffic noise exposure is expected to be as low as 50 dB L_{dn} in the most isolated and less frequented locations of the Bay Area, while receivers neighboring area interstates are likely to experience levels as high as 75 dB L_{dn} (FTA Guidance Manual, 2006). Bus transit can also make a meaningful contribution to roadway noise levels. In San Francisco, a large portion of the transit bus fleet is electrified and, consequently, the contribution of bus transit to localized roadway noise levels is decreased. Traffic noise assessment in this analysis is inclusive of bus transit, as buses are an assumed percentage of overall roadway volumes used in the calculation of roadside noise levels.

Rail Noise Sources

The Bay Area is also presently affected by noise from freight and passenger rail operations. While these operations generate significant noise levels in the immediate vicinity of the railways, train operations are intermittent and area railways are widely dispersed. Commuter rail such as SF MUNI and VTA operate with more frequency than standard gauge rail operations but lower speeds resulting in lower noise levels. BART operations, on the other hand, can attain higher speeds and have the potential for greater noise levels along extended stretches. The contribution of rail noise to the overall ambient noise environment in the Bay Area is relatively minor compared to other sources such as traffic. Train operations may be a source of significant groundborne vibration near the tracks. Vibration sensitive receivers within 100 feet of rail operations may be adversely affected by vibration exposure during train events.

Aircraft Noise Sources

The Bay Area is home to many airports—including public use, private use, and military facilities. Major airports include San Francisco International, Oakland International and Norman Y. Mineta San José International. In addition to the numerous daily aircraft operations originating and terminating at these facilities, aircraft not utilizing these airports frequently fly over the Bay Area. All of these operations contribute to the overall ambient noise environment. In general, like rail noise, the proximity of the receiver to the airport and aircraft flight path determines the noise exposure. Other contributing factors include the type of aircraft operated, altitude of the aircraft, and atmospheric conditions. Atmospheric conditions may contribute to the direction of aircraft operations (flow) and affect aircraft noise propagation.

Construction Noise Sources

New development and implementation of transportation improvements will necessarily include construction activities that create relatively short-term noise exposure. Noise production from construction equipment varies greatly depending on factors such as operation being performed and equipment type, model, age, and condition. Noise associated with heavy equipment diesel engine operations often dominates the noise environment in the vicinity of construction sites. Stationary sources such as generators, pumps, and compressors may also produce a significant contribution. However, if present, operations from impact equipment (e.g., pile driving, pavement breaking) will generally produce the highest noise levels, and may also produce significant vibration in the vicinity. Maximum noise exposure from typical construction equipment operations is approximately 75-100 dB (L_{max} at 50 feet) with noise from heavy demolition and pile driving operations having the highest noise production. Please refer to **Table 2.6-2** for typical construction noise levels.

TABLE 2.6-2: TYPICAL NOISE LEVELS FROM DEMOLITION/ CONSTRUCTION EQUIPMENT OPERATIONS

Construction Equipment	*Noise Exposure Level, dB L_{max} at 50 Feet*
Air Compressor	78-81
Backhoe	78-80
Ballast Equalizer	82
Ballast Tamper	83
Compactor	82-83
Concrete Mixer (Truck)	79-85
Concrete Pump (Truck)	81-82
Concrete Vibrator	76-80
Crane	81-88
Dozer	82-85
Generator	81
Grader	85
Impact Wrench	85
Jack Hammer	88-89
Loader	79-85
Paver	77-89
Pile Driver (Impact)	101
Pneumatic Tool	85
Pump	76-81
Rail Saw	90
Rock Drill	81-98
Roller	74-80
Saw	76
Scarifier	83-90
Scraper	84-89
Shovel	82
Spike Driver	77
Tie Cutter	84
Tie Handler	80
Tie Inserter	85
Heavy Diesel Truck	88

Sources: FTA Guidance Manual (Chapter 12), FHWA RCNM V.1.00.

Industry and Other Non-Transportation Noise Sources

A wide variety of industrial and other non-transportation noise sources are located within the Bay Area. These include manufacturing plants, landfills, treatment plants (e.g., water), power generation facilities, food packaging plants, lumber mills, and aggregate mining facilities, just to name a few. Noise generated by these sources varies widely, but in many cases may be a significant if not dominant contributor to the noise environment.

REGULATORY SETTING

Federal Regulations

United State Department of Transportation (USDOT)

The USDOT is composed of several agencies that have the primary responsibilities of keeping the traveling public safe, increasing their mobility, and having our transportation systems contribute to the economic growth of the nation. The USDOT agencies with established acoustical criteria appropriate for this study include the FHWA, the Federal Transit Administration (FTA), the Federal Aviation Administration (FAA), and the Federal Rail Administration (FRA).

Title 23, Part 772 of the Code of Federal Regulation (23 CFR 772) (FHWA)

Title 23, Part 772 of the Code of Federal Regulation (23 CFR 772) is the federal regulation governing traffic noise impact. A federal or federally-funded project would have a traffic noise impact if it involves the construction of a new highway, or includes substantial modification of an existing highway, where the project would result in a substantial operational noise increase, or where the predicted operational noise level approaches or exceeds the FHWA Noise Abatement Criteria (NAC). In this case, a "substantial increase" is not defined by the FHWA, but is generally defined by the state and/or local governing agencies. The noise level is defined as "approaching" the NAC if it is within 1 dB of the applicable criterion. **Table 2.6-3** summarizes the FHWA NAC as presented in the USDOT/FHWA Highway Traffic Noise Analysis and Abatement Policy and Guidance document.

Title 14, Part 36 of the Code of Federal Regulation (14 CFR 36) (FAA)

Aircraft operated in the United States are subject to federal requirements for noise emissions levels. The requirements are set forth in Title 14, Part 36 of the Code of Federal Regulation (14 CFR 36), which establishes maximum acceptable noise levels for specific aircraft types, considering model year, aircraft weight, and number of engines.

The FAA Part 150 program encourages airports to prepare noise exposure maps that show land uses that are incompatible with high noise levels (FICON, 1992). The program proposes measures to reduce any incompatibility. With an FAA Part 150 program approved, airport projects such as land acquisition, residential/school sound insulation, etc. become eligible for federal Airport Improvement Program (AIP) funding.

TABLE 2.6-3: SUMMARY OF FHWA NOISE ABATEMENT CRITERIA

Activity Category	*NAC, Hourly-Average Noise Level (L_{eq}[h], dBA)*	*Description of Activities*
A	57 Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose
B	67 Exterior	Picnic areas, recreation areas, playgrounds, active sport areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals
C	72 Exterior	Developed lands, properties, or activities not included in categories A or B above
D	--	Undeveloped lands
E	52 Interior	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums

Source: USDOT/FHWA, 1995.

FTA

Transit Operations Noise

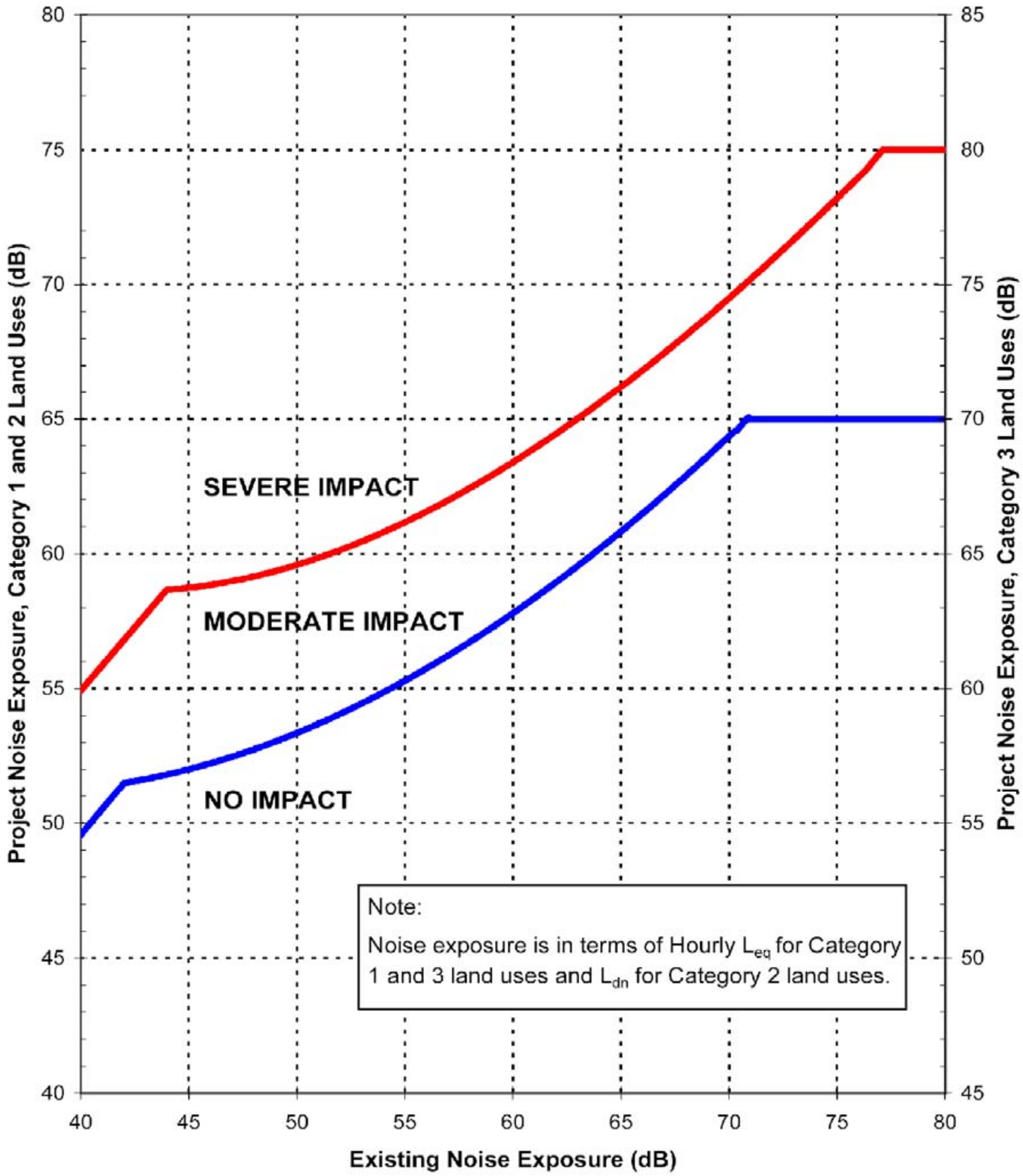
The FTA offers regulations regarding noise exposure associated with federally funded transit projects. "Moderate impact" and "severe impact" criteria are established based on the existing ambient noise environment and the noise sensitivity of the receiving land use. Three categories of land use are established for the impact analysis.

- Category 1: Includes lands set aside for serenity and quiet or for outdoors performing arts entertainment (e.g., national historic landmarks, outdoor amphitheaters).
- Category 2: Residences and buildings where people normally sleep (e.g., homes, hospitals, hotels).
- Category 3: Institutional land with primary daytime and/or evening use (e.g., schools, libraries, churches, medical offices, theaters, parks).

Figure 2.6-6 is a graphical representation of the FTA noise impact criteria. Please note that Categories 1 and 3 apply the L_{eq} for the noisiest hour of transit-related activity during hours of noise sensitivity. Category 2 applies the L_{dn} since these receivers may be impacted by nighttime (10 p.m.-7 a.m.) transit-related events.

Subjectively, a "moderate impact" is generally noticeable to most people but may not be sufficient to cause strong, adverse reactions from the community. A "severe impact" would likely produce a high percentage of highly annoyed people in the community.

Figure 2.6-6: FTA Noise Impact Criteria



Transit Operations Vibration

The FTA offers regulations regarding vibration exposure associated with federally funded transit projects. Three categories of land use are established for the impact analysis.

- Category 1: Buildings where vibration would interfere with interior operations.
- Category 2: Residences and buildings where people normally sleep (e.g., homes, hospitals, hotels).
- Category 3: Institutional land with primary daytime and/or evening use (e.g., schools, libraries, churches, medical offices, theaters, parks).

Table 2.6-4 summarizes the FTA vibration impact criteria.

TABLE 2.6-4: FTA GROUND-BORNE VIBRATION (GVB) IMPACT CRITERIA FOR GENERAL ASSESSMENT

	GBV Impact Levels (VdB re 1 micro-inch /sec)		
Land Use Category	*Frequent Event[1]*	*Occasional Events[2]*	*Infrequent Events[3]*
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB	65 VdB	65 VdB
Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB

Notes:

1. "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2. "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3. "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.
4. 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.

Source: FTA Guidance Manual, May 2006.

Construction Noise

In addition to transit operations noise, the FTA offers guidance with respect to the evaluation of transit construction noise exposure. Like the operational noise criteria, construction noise criteria should consider the existing (ambient) noise environment. Additionally, construction noise exposure should consider the duration of construction activities and the receiving land use (i.e., sensitivity of receiver). The FTA construction noise guidelines are summarized in **Table 2.6-5.**

TABLE 2.6-5: SUMMARY OF FTA CONSTRUCTION NOISE CRITERIA (GUIDELINES)

Impacted Land Use Type	*Hourly L_{eq}, dBA*		*8-Hour L_{eq}, dBA*	
	Daytime (7 a.m.-10 p.m.)	*Nighttime (10 p.m.-7 a.m.)*	*Daytime (7 a.m.-10 p.m.)*	*Nighttime (10 p.m.-7 a.m.)*
Residential	90	80	80	70
Commercial	100	100	85	85
Industrial	100	100	90	90

Note: In urban areas with very high ambient noise levels, construction noise should not exceed ambient plus 10 dB.

Source: FTA, 2006.

Construction Vibration

The FTA has published guidance relative to impacts from vibration exposure. The FTA has established a general impact criterion of 0.5 in/sec peak particle velocity (PPV). Structural damage to buildings would not be expected below this value. It is expected that regularly experienced vibration levels of 80 VdB (0.01 in/sec PPV) or higher may create an annoyance response from human receivers, and may be considered a nuisance.

State Regulations

California Department of Transportation (Caltrans)

Traffic Operations Noise

The California Department of Transportation Traffic Noise Analysis Protocol (Protocol) establishes the policies and procedures to be used in the assessment of traffic noise exposure and impact for new construction and reconstruction projects. The NAC in the Protocol are the same as those presented in 23 CFR 772 (see USDOT/FHWA information above). The Protocol defines a substantial project-related traffic noise level increase when the project's worst-case hour exceeds the ambient worst-case hour by 12 dB or more.

Rail Operations Noise

Caltrans endorses the use of the FTA noise criteria and methodologies for assessing project-related rail noise and vibration impacts.

Construction Noise

As presented in the Protocol, Section 14-8.2, Noise Control, Caltrans standard specifications establishes a construction noise exposure/production limit of 86 dB (L_{max}) at a distance of 50 feet. Additionally, this specification establishes that all internal combustion engines should be equipped with manufacturer-recommended mufflers, and that no internal combustion engines may be operated without mufflers.

California Code of Regulations (CCR)

Aircraft Operations

The California Airport Noise Standards, Title 21, Section 5000 et seq. of the California Code of Regulations (CCR) apply to any airport that is deemed to have a "noise problem" as established by the local County Board of Supervisors in accordance with the provisions in the regulation. Currently, within the Bay Area, Norman Y. Mineta-San José International Airport and San Francisco International Airport have been given this designation. The Standards establish a noise exposure limit "acceptable to a reasonable person residing in the vicinity of an airport" of 65 dB CNEL.

Noise Insulation Standard

The California Noise Insulation Standards found in CCR, Title 24 establish requirements for new multi-family residential units, hotels, and motels that may be subject to relatively high levels of transportation noise. In this case, the noise insulation criterion is 45 dB L_{dn}/CNEL inside noise-sensitive spaces. For developments with exterior transportation noise exposure exceeding 60 dB L_{dn}/CNEL, an acoustical analysis and mitigation (if required) must be provided showing compliance with the 45 dB L_{dn}/CNEL interior noise exposure limit.

Local Plans and Policies

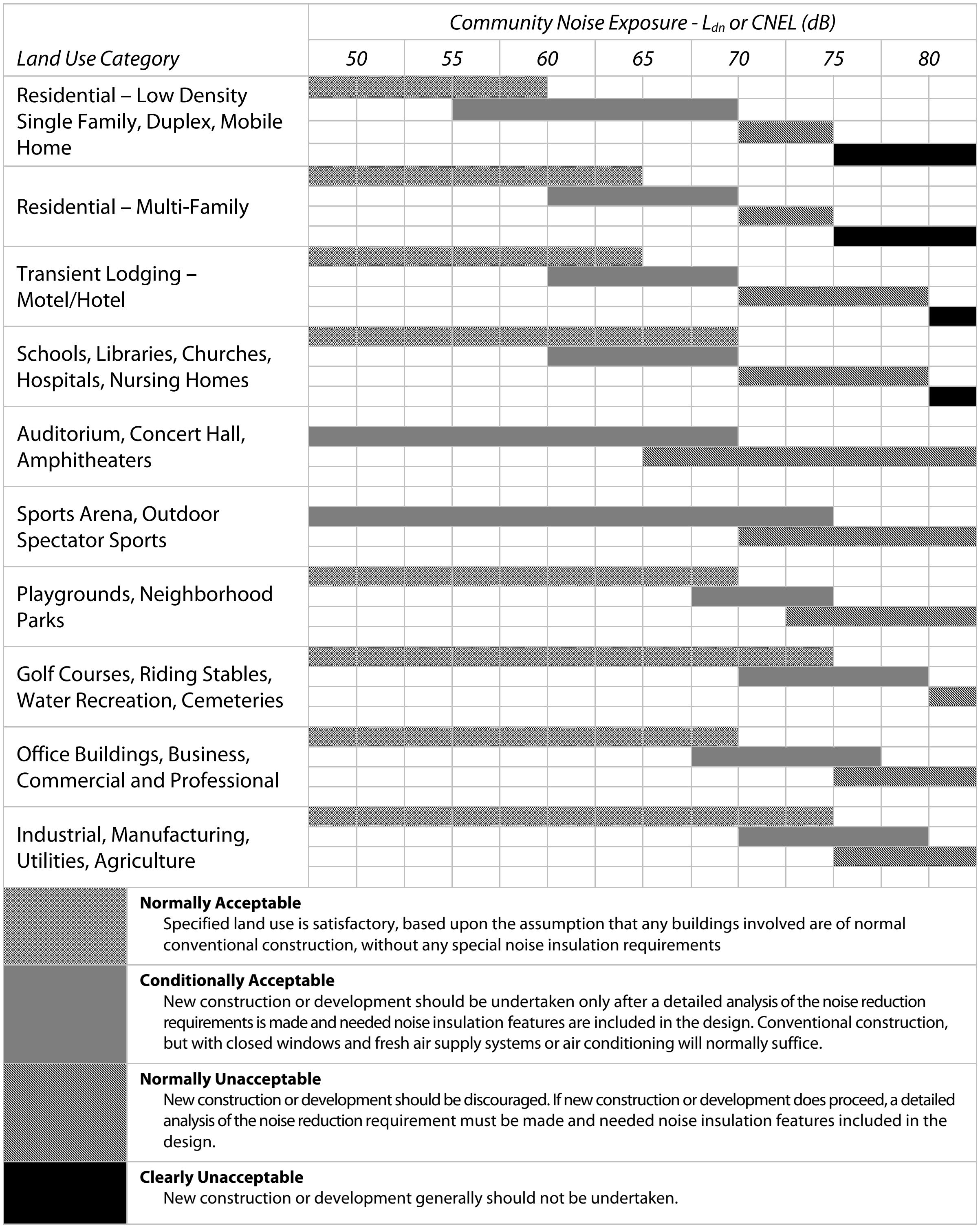
General Plan Noise Elements

Cities and counties within the Bay Area adopt a noise element as part of their general plans to identify, assess, and provide mitigation for noise problems within their communities. The noise element typically assesses current and projected future noise levels associated with local noise sources, including, but not limited to, traffic, trains, aircraft, and industrial operations. Local jurisdictions may adopt their own noise exposure goals and policies, which may or may not be the same or similar to those recommended by the State.

Typical noise/land use compatibility guidelines are presented in **Figure 2.6-7**. In general, noise-sensitive land uses are compatible with exterior transportation-related noise exposure not exceeding 65 dB L_{dn}/CNEL. Additionally, interior noise exposure (from transportation sources) should not exceed 45 dB L_{dn}/CNEL within noise-sensitive spaces. As implied by the name, the standards within the noise element of locally adopted general plans are for planning purposes, and are not generally intended to address noise complaints or other code compliance issues.

Cities and counties often provide noise level performance standards for non-transportation noise sources (e.g., commercial/industrial facilities, mechanical equipment). These standards are used to address intermittent noise exposure, and are often in terms of the hourly average noise level (L_{eq}) or maximum noise level (L_{max}). These criteria are generally tied directly to the standards presented in the city/county municipal code (i.e., noise ordinance).

Figure 2.6-7: Typical Noise/Land Use Compatibility Criteria



Source: State of California, Governor's Office of Planning and Research, 2003. *General Plan Guidelines.*

Municipal Codes

In addition to general plan noise element goals and policies, local jurisdictions often regulate noise exposure through enforcement of a noise ordinance. The noise code is generally applied to address noise complaints associated with non-transportation sources (e.g., public address systems, mechanical equipment), and may also address construction noise exposure/production limits. Noise exposure criteria presented within municipal codes should match performance criteria presented in the noise element of the general plan for the given jurisdiction.

Impact Analysis

SPECIFIC IMPACT SIGNIFICANCE CRITERIA

Implementation of the proposed Plan would have a potentially significant adverse impact if it would:

Criterion 1: Result in exposure of persons to or generation of temporary construction noise levels and/or groundborne vibration levels in excess of standards established in the applicable local general plan or noise ordinance standards. Where local jurisdiction standards are not presented, it is assumed that the proposed construction noise and vibration limits established by the FTA would apply (see Regulatory section above).

Criterion 2: Result in highway noise levels that approach or exceed the FHWA Noise Abatement Criteria.

Criterion 3: Result in transit noise level increases at existing noise-sensitive uses in excess of the FTA noise impact criteria. Please refer to **Figure 2.6-6**.

Criterion 4: Result in transit vibration in excess of the FTA guidance criteria. See **Table 2.6-4** for the applicable criteria. For vibration levels already exceeding the FTA thresholds (without the proposed Plan), a Plan-related increase in vibration level of 3 VdB would be considered significant.

Criterion 5: Where an airport land use plan is adopted or, where such a plan has not been adopted, within two miles of a public airport or public use airport, result in exposure of people residing or working in the planning area to excessive noise levels**.**

METHOD OF ANALYSIS

The method for the program-level analysis of noise impacts is described below. For all components of the analysis, it is expected that some project-specific noise and/or acoustical analyses may be required as part of the environmental review prior to project approval by the appropriate lead agency.

Regional Growth/Land Use Changes

Development projects implemented under the proposed Plan would generate noise during construction and operation. Additionally, residential and mixed-use development would potentially be constructed adjacent to high volume transportation corridors or other uses that might be incompatible with respect to noise (e.g., industrial/commercial facilities). The following analysis addresses these potential noise impacts qualitatively at a program level.

Transportation Network

Traffic

For this noise analysis, the FHWA Highway Traffic Noise Prediction Model (FHWA-RD-77-108) combined with traffic volume and speed information provided by MTC were used to calculate traffic noise exposure in terms of the L_{dn} for identified roadway segments within the planning area. The assessed roadways do not include every roadway in the area; rather, they represent what are assumed to be the roadway segments most affected by the proposed Plan and consist of freeways, expressways and arterial roadways in the planning area. The initial traffic noise modeling for the proposed Plan does not account for the noise attenuation provided by existing noise barriers. Where such barriers exist, a 6 dB noise level reduction can be assumed at receivers along those roadway segments. To evaluate the proposed Plan, the base year (2010) condition was compared with the 2040 Plan scenario. The analysis reports the potential for absolute noise impacts. Following guidance published by Caltrans and the FHWA, a roadway noise impact is determined to occur if projected noise levels approach the NAC for noise sensitive land uses presented in **Table 2.6-3**. The NAC includes several categories of activities based on their sensitivity to increased noise and sets an hourly-average noise level for each group of activities that would be considered acceptable. Caltrans uses an approach criterion of 1 dBA, whereby a traffic noise impact is considered to occur if roadside noise approaches to within 1 dBA of the NAC. Therefore this analysis applies 66 dBA as the threshold for whether highway noise levels would result in a significant impact. This is 1 dBA below the FHWA threshold of 67 dBA for Activity Group B, which includes picnic areas, recreation areas, playgrounds, active sport areas, parks, residences, motels, hotels, schools, churches, libraries and hospitals, and thereby encompasses virtually all the relevant and sensitive land uses that are near roadways in the Bay Area. The analysis estimates the number of roadway miles under each scenario where noise levels would be equal to or greater than 66 dBA at a distance of 100 feet from the centerline of the roadway.

Rail Transit Operations

Where substantial rail operations increases are proposed in the proposed Plan, the FTA Transit Noise and Vibration Impact Assessment threshold was used to assess the potential for rail-related noise and vibration exposure at acoustically sensitive receivers. Generally there is insufficient data available (e.g., the increase in the number of additional hourly train pass-by events) to provide a quantitative analysis, therefore a qualitative analysis was undertaken, applying mitigation in the form of performance standards to maintain noise and vibration levels below FTA thresholds.

Construction

Development projects and transportation network improvement projects implemented under the proposed Plan would be expected to generate short term noise and vibration level increases during construction. These levels may be substantially higher than existing ambient noise levels or exceed the applicable local construction noise criteria or FTA criteria, adversely affecting acoustically sensitive receivers in the vicinity. Since detailed operations information on specific construction projects is not known at this time, the following analysis addresses these potential noise impacts in a qualitative fashion (program level analysis).

SUMMARY OF IMPACTS

Implementation of transportation improvements in the proposed Plan could result in both short- and long-term impacts on noise levels in the Planning Area. The analysis herein uses a horizon year of 2040 and includes region-wide vehicle miles travelled assumptions and therefore represents a cumulative analysis. Land use development under the proposed Plan would generate short-term noise during construction and long-term noise during operation. Region-wide vehicle miles travelled assumptions used in this analysis include trips generated by land use development projects. Additionally, residential and mixed-use development would potentially be constructed adjacent to high volume transportation corridors which could have adverse impacts to these uses.

Short Term Impacts

Many of the transportation improvements in the proposed Plan would entail construction, often using heavy equipment. Depending on the proximity of such activities to noise sensitive uses and the presence of intervening barriers, construction activities associated with individual projects could generate localized, short term noise impacts from excavation, grading, hauling, concrete pumping, and a variety of other activities requiring the operation of heavy equipment. Land use development projects implemented under the proposed Plan would also entail construction with heavy equipment which, depending on the proximity of such activities to noise sensitive uses, could generate localized, short term noise impacts. In these cases, construction of individual projects could cause exposure of persons to or generation of noise levels in excess of standards established in the applicable local general plan or noise ordinance standards.

Long Term Impacts

Numerous proposed Plan projects have been identified as having potentially significant operational local noise impacts on sensitive land uses, either from vehicle or rail travel. Direct impacts could result from new transit lines or increased frequency of service on existing lines (noise and groundborne vibration); widening of freeways, expressways, or arterials which brings noise closer to sensitive land uses; or addition of new lanes that result in higher traffic volumes and speeds. Land use development projects implemented under the proposed Plan would locate sensitive receptors in close proximity to transportation noise sources such as major arterial roadways and rail transit alignments.

IMPACTS AND MITIGATION MEASURES

Impact

2.6-1 Implementation of the proposed Plan could result in exposure of persons to or generation of temporary construction noise levels and/or groundborne vibration levels in excess of standards established by local jurisdictions or transportation agencies.

Impacts of Land Use Projects

Regional Effects

Although some development would occur outside Priority Development Areas (PDAs), the proposed Plan envisions future residential and job growth primarily within PDAs where transit infrastructure either exists or is planned. As such, implementation of the proposed Plan would result in a concentration of development within identified PDAs that are existing infill development areas. Resulting construction activities associated with development of new residences and commercial and retail land uses would have the potential to temporarily affect nearby sensitive receivers such as existing residences, schools and nursing homes.

From a regional perspective, temporary construction noise and vibration within these PDAs would occur in urban or suburban areas where ambient noise and vibration levels are already affected by roadway traffic and transit sources and would therefore be less noticeable to receivers than if these activities were to occur on the edges of existing development areas or near Priority Conservation Areas (PCAs). As such, separation of PDAs from PCAs represents one method of assessing the potential for regional construction noise and vibration impacts.

Review of the maps of PDAs and PCAs in Appendix C of the *Jobs-Housing Connection Strategy* reveals that, generally, buffers are maintained between PDAs and PCAs. San Francisco and Marin County are two places, however, where this is not the case. In San Francisco, two PCAs are identified within the "urban neighborhood" designation. However, the San Francisco PCAs are City parks that are located adjacent to U.S. Highway 101 or near the Caltrain tracks and therefore are located within an urban area where ambient noise and vibration levels are already affected by roadway traffic and transit sources; as a result, temporary construction noise would not be considered significant from a regional perspective. See Impact 2.6-2 for assessment of roadside noise levels from traffic increases.

The southernmost PDA in Marin County is designated as a *Transit Neighborhood* PDA and has two designated PCAs adjacent or proximate to it. However, both PCAs are proximate to U.S. 101 and subject to existing traffic noise. As a transit neighborhood near Highway 101 and its associated vehicle noise, the PDA is identified in the proposed Plan as appropriate for residential development (low-rise apartments, condominiums, and town homes). Development of this type would be unlikely to involve pile driving or other high impact noise and vibration generating equipment, since these construction activities are generally associated with high-rise development. Consequently, implementation of existing construction noise standards should be sufficient to reduce the potential impact of construction noise to a level that is less than significant (LS). In the absence of pile driving or other high impact equipment, construction-related vibration impacts would also be less than significant at the regional level (LS).

Localized Effects

Construction standards generally limit construction activities to times when construction noise would have the least effect on adjacent land uses, and would require such measures as properly muffling equipment noise, locating equipment as far from sensitive receptors as possible, and turning off equipment when not in use. Some jurisdictions may also have property line or other noise level limits that must be adhered to during construction. Development under the proposed Plan would range from high intensity regional center development of high and midrise offices and residences in San Francisco, Oakland and San José to low-rise development in rural towns such as Sebastopol and Graton. Consequently, depending on the extent of construction activities involved, localized construction-related noise effects may be significant or minor.

Construction activities with the potential for resulting in significant construction-related noise or vibration impacts would be those for which pile driving or other similar invasive foundation work would be required. Generally, these types of construction activities are associated with high-rise development, which the proposed Plan envisions to occur within the "Regional Center" areas of downtown San Francisco, Oakland and San José.

Two of these cities have robust noise ordinances that contain either property line performance standards on construction equipment relative to land use and time of day (Oakland Planning Code Section 17.130.050) or identify performance noise standards for construction equipment at a specific distance (Article 29 of the San Francisco Police Code). The City of San José restricts construction-related activities to certain hours of the day (City of San José Municipal Code Section 20.100.450).

The City of San Francisco's standards specifically exempt pile driving and other impact equipment. Pile driving, which has been documented to generate noise levels in excess of 100 decibels (dBA) at 50 feet could potentially result in significant noise impacts regardless of existing noise ordinance standards. Because the potential exists for development with Regional Center areas to require pile driving adjacent (within 200 feet) to other buildings that may be occupied by residents or other sensitive receptors, construction noise impacts in excess of 90 dBA within these areas are identified as potentially significant (PS) and mitigation is required. Mitigation Measures 2.6(a), 2.6(b), and 2.6(c) are described below.

Neither San Francisco, Oakland nor San José has developed any quantitative standards with regard to vibration. Construction-related vibration impacts from pile driving are generally assessed in environmental review documents by applying the methodology of the Federal Transit Administration which includes standards for structural damage as well as for human annoyance.

Pile driving can result in peak particle velocities (PPV) of up to 1.5 inches per second (in/sec) at a distance of 25 feet (FTA, 2006), but typically average about 0.644 PPV. The Caltrans measure of the threshold of architectural damage for conventional sensitive structures is 0.5 in/sec PPV for new residential structures and modern commercial buildings and 0.25 in/sec PPV for historic and older buildings. Therefore, the potential exists for pile driving to occur within 50 feet of a historic building, resulting in a potential significant vibration impact related to structural damage and mitigation measures are recommended.

Vibration levels can also result in interference or annoyance impacts for residences or other land uses where people sleep, such as hotels and hospitals. FTA vibration annoyance potential criteria depend on the frequency of the events. When vibration events occur more than 70 times per day, as would be the case with pile driving, they are considered "frequent events." Frequent events in excess of 72 VdB are considered to result in a significant vibration impact. Consequently, there would be a potentially significant (PS) vibration annoyance impact if pile driving were to occur within 300 feet of a sensitive receptor and mitigation measures are required. Mitigation Measures 2.6(a), 2.6(b), and 2.6(c) are described below.

Impacts of Transportation Projects

Regional Effects

Construction related noise and vibration impacts of transportation projects, similar to development projects, would depend on the extent of construction being undertaken. Construction activities with the potential for resulting in significant construction-related noise or vibration impacts would be those for which pile driving or other similar invasive foundation work would be required. Generally speaking these types of construction activities are associated with construction of elevated freeways, flyovers, overpasses or other structures requiring substantial structural support.

There are over 200 regional transportation projects identified for the Bay Area region as a whole. Of these projects, several would require pile driving or other similar invasive foundation work such as:

- Golden Gate Bridge seismic retrofit;
- Construction of the Transbay Transit Center and Caltrain Extension;
- Implement Sonoma-Marin Area Rail Transit District (SMART) Commuter Rail;
- Improve ferry facilities/equipment including the Downtown San Francisco Ferry Terminal and procuring additional spare ferry vessel; and
- Implement Presidio Parkway Project.

Many of these regional projects have undergone individual CEQA and/or NEPA review for construction noise impacts and are already being implemented/constructed. Construction noise impacts for these projects are generally determined to be less than significant (LS) with the implementation of mitigation measures in recognition of the temporary nature of construction activities. Mitigation Measures 2.6(a), 2.6(b), and 2.6(c) are described below.

Construction-related vibration impacts are localized in nature and dependant on local soil conditions and the proximity to residential receptors. Consequently, construction-related vibration is not an impact readily assessed at the regional level and is considered herein as a localized effect below.

Localized Effects

Localized transportation projects are proposed throughout the Bay Area and, like the regional projects discussed above, would have the potential for localized noise and vibration impacts, particularly when pile driving or other similar invasive foundation work would be required. Construction noise mitigation normally required by Caltrans' Standard Specifications and Standard Special Provisions[1] as well as local city and county ordinances would be implemented for individual transportation projects that include physical construction activities. Standards generally limit construction activities to times when construction noise would have the least effect on adjacent land uses, and would require such measures as properly muffling equipment noise, locating equipment as far from sensitive receptors as possible, and turning off equipment when not in use. Some jurisdictions may also have property line or other noise level limits that must be adhered to during construction.

It is not expected that these standards would eliminate all construction-related noise, since complete mitigation may not be possible for certain projects, such as those that require pile driving and those in close proximity to sensitive receptors; nonetheless, implementation of existing construction noise standards and identified mitigation measures below should be sufficient to reduce the potential impact of construction noise to a level that is less than significant for standard construction techniques. However,

[1] California Department of Transportation (Caltrans), Technical Noise Supplement, 2009.

recognizing that projects requiring pile driving can generate noise levels above 100 dBA at 50 feet and that the best mitigation measures available can only result in relatively modest reductions, this impact is identified as potentially significant (PS). Mitigation Measures 2.6(a), 2.6(b), and 2.6(c) are described below.

Combined Effects

It is unlikely that both construction of a development project and construction of a transportation project under the proposed Plan would occur adjacent to one another and simultaneously. However, if this were to occur, nearby sensitive receptors would be exposed to an increased intensity of construction-related noise. In acoustical theory, a doubling of sound energy results in an increase of 3 dBA. Consequently, while two adjacent construction projects would combine to increase the resultant noise level, this combined increase would be no more than 3 dBA above the noise generated by a single project and hence would not be perceptible compared to the initial increase over ambient generated by a single construction project. However, since localized effects are identified as potentially significant for both land use projects and transportation project the combined affect is also identified as potentially significant (PS). Mitigation Measures 2.6(a), 2.6(b), and 2.6(c) are described below.

Mitigation Measures

Implementing agencies and/or project sponsors shall consider implementation of mitigations measures including but not limited to those identified below.

2.6(a) Mitigation measures that shall be considered by implementing agencies and/or project sponsors where feasible based on project-and site-specific considerations include, but are not limited to the following. Implementing agencies shall require one or more of the following set of noise attenuation measures under the supervision of a qualified acoustical consultant:

- Restricting construction activities to permitted hours as defined under local jurisdiction regulations (e.g.; Alameda County Code restricts construction noise to between 7:00 am and 7:00 pm on weekdays and between 8:00 am and 5:00 pm on weekend);
- Properly maintaining construction equipment and outfitting construction equipment with the best available noise suppression devices (e.g. mufflers, silencers, wraps);
- Prohibiting idling of construction equipment for extended periods of time in the vicinity of sensitive receptors;
- Locating stationary equipment such as generators, compressors, rock crushers, and cement mixers as far from sensitive receptors as possible;
- Erecting temporary plywood noise barriers around the construction site when adjacent occupied sensitive land uses are present within 75 feet;
- Implementing “quiet” pile-driving technology (such as pre-drilling of piles and the use of more than one pile driver to shorten the total pile driving duration), where feasible, in consideration of geotechnical and structural requirements and conditions;
- Using noise control blankets on building structures as buildings are erected to reduce noise emission from the site; and
- Using cushion blocks to dampen impact noise from pile driving.

2.6(b) Mitigation measures that shall be considered by implementing agencies and/or project sponsors where feasible based on project-and site-specific considerations include, but are not limited to the following vibration attenuation measures under the supervision of a qualified acoustical consultant if pile-driving and/or other potential vibration-generating construction activities are to occur within 60 feet of a historic structure.

- The project sponsors shall engage a qualified geotechnical engineer and qualified historic preservation professional and/or structural engineer to conduct a pre-construction assessment of existing subsurface conditions and the structural integrity of nearby (within 60 feet) historic structures subject to pile-driving activity. If recommended by the pre-construction assessment, for structures or facilities within 60 feet of pile-driving activities, the project sponsors shall require groundborne vibration monitoring of nearby historic structures. Such methods and technologies shall be based on the specific conditions at the construction site such as, but not limited to, the pre-construction surveying of potentially affected historic structures and underpinning of foundations of potentially affected structures, as necessary.
- The pre-construction assessment shall include a monitoring program to detect ground settlement or lateral movement of structures in the vicinity of pile-driving activities and identify corrective measures to be taken should monitored vibration levels indicate the potential for building damage. In the event of unacceptable ground movement with the potential to cause structural damage, all impact work shall cease and corrective measures shall be implemented to minimize the risk to the subject, or adjacent, historic structure.

2.6(c) To mitigate pile-driving vibration impacts related to human annoyance, the implementing agency shall require project sponsors to implement Mitigation Measure 2.6(a) above where feasible based on project- and site-specific considerations.

Significance after Mitigation

Projects taking advantage of CEQA Streamlining provisions of SB 375 (Public Resources sections 21155.1, 21155.2, and 21159.28) must apply the mitigation measures described above, as feasible, to address site-specific conditions. To the extent that an individual project adopts and implements all feasible mitigation measures described above, the impact would be less than significant with mitigation (LS-M).

MTC/ABAG cannot require local implementing agencies to adopt the above mitigation measures, and it is ultimately the responsibility of a lead agency to determine and adopt mitigation. Therefore it cannot be ensured that this mitigation measure would be implemented in all cases, and this impact remains significant and unavoidable (SU).

Impact

2.6-2 Implementation of the proposed Plan could result in increased traffic volumes that could result in roadside noise levels that approach or exceed the FHWA Noise Abatement Criteria.

Impacts of Land Use and Transportation Projects

The proposed Plan envisions a mixture of development projects throughout the Bay Area region, primarily in PDAs. Land use development projects generate new vehicle trips and the proposed Plan has identified its PDAs near existing and planned transit corridors to reduce vehicle trip generation and reduce vehicle miles travelled throughout the region compared to development on the periphery of existing developed areas. As stated in *Chapter 2.1: Transportation*, the relative improvements under the proposed Plan are largely a result of proposed investments in transit operations and expansion, as well as a supportive land use pattern that better focuses growth in higher-density locations near transit services. Notwithstanding this reduction of vehicle trips compared to conventional development strategies, increased freeway volumes would result from implementation of development projects.

Transportation projects would also affect the distribution of vehicle travel throughout the region. Year 2040 project scenario traffic data includes both development projects and transportation projects. Consequently, with respect to the potential for an increase in regional freeways approaching or exceeding the 67 DNL Noise Abatement Criteria of the FHWA, this impact assessment includes implementation of both development and transportation projects envisioned under the proposed Plan.

Both development and transportation projects could also result in increases or redistribution of traffic on local expressways and arterial roadways that could change roadside noise levels.

Table 2.6-6 identifies the total roadway miles of potentially affected roadways (freeways, expressways, and arterials) that would result in noise levels exceeding 66 dBA for each county and the Bay Area as a whole at the 2040 plan horizon, compared to existing noise levels. The proposed Plan roadway miles are inclusive of both VMT increases due to development from implementation of the proposed Plan region-wide as well as distribution changes resulting from implementation of transportation projects. Additionally, these roadway miles are inclusive of on-road transit modes (buses).

The majority (94.3 percent) of all freeway miles on the modeled roadway network already exceed 66 dBA under existing conditions for the region as a whole. This percentage increases by 5.2 percent under 2040 conditions with implementation of the proposed Plan. Relative to existing conditions, roadway noise levels along arterials would be most affected by implementation of the proposed Plan. For the region as a whole, the proposed Plan would increase by 12.6 percent the arterial roadway miles that approach or exceed the FHWA Noise Abatement Criteria. The percentage of expressways that meet the 66 dBA criterion would also increase under the proposed Plan. For the region as a whole, the proposed Plan would increase by 1.7 percent the expressway miles that approach or exceed the FHWA Noise Abatement Criteria.

Increases in freeway and expressway miles approaching the FHWA Noise Abatement Criteria over the existing conditions will result from the proposed Plan, and this change would represent a potentially significant noise impact. Project sponsors are required to review and consider local land use policies (including noise ordinances and policies) in preparation of their project applications, and local governments are responsible for long-term land use planning related to noise issues and considering the appropriate location of sensitive receptors in relation to existing transportation corridors (the Noise Element described in the regulatory setting). Further, the State of California has Noise Insulation Standards in place to regulate new residential development. However, despite these sources of oversight and regulation, there is still the potential that the program of projects in the proposed Plan could create a significant change in the noise environment compared to existing conditions, particularly for uses that are already nearby roadways and not insulated sufficiently to address the new level of noise. As a result, this impact is considered potentially significant (PS). Mitigation Measure 2.6(d) is described below.

Mitigation Measures

Implementing agencies and/or project sponsors shall consider implementation of mitigations measures including but not limited to those identified below.

2.6(d) Mitigation measures that shall be considered by implementing agencies and/or project sponsors where feasible based on project-and site-specific considerations include, but are not limited to:

- Adjustments to proposed roadway or transit alignments to reduce noise levels in noise sensitive areas. For example, below-grade roadway alignments can effectively reduce noise levels in nearby areas.
- Techniques such as landscaped berms, dense plantings, reduced-noise paving materials, and traffic calming measures in the design of their transportation improvements.
- Contributing to the insulation of buildings or construction of noise barriers around sensitive receptor properties adjacent to the transportation improvement;
- Use land use planning measures, such as zoning, restrictions on development, site design, and buffers to ensure that future development is noise compatible with adjacent transportation facilities and land uses;
- Construct roadways so that they are depressed below-grade of the existing sensitive land uses to create an effective barrier between new roadway lanes, roadways, rail lines, transit centers, park-n-ride lots, and other new noise generating facilities; and
- Maximize the distance between noise-sensitive land uses and new noise-generating facilities and transportation systems.

Significance after Mitigation

Projects taking advantage of CEQA Streamlining provisions of SB 375 (Public Resources sections 21155.1, 21155.2, and 21159.28) must apply the mitigation measures described above, as feasible, to address site-specific conditions. To the extent that an individual project adopts and implements all feasible mitigation measures described above, the impact would be less than significant with mitigation (LS-M).

TABLE 2.6-6 NOISE LEVELS BY ROADWAY TYPE (ROADWAY MILES)

County	*Roadway Type*	*2010*			*Year 2040, Plan*			*Net Change From 2010*		
		# ≥ 66 dBA	*Total*	*% ≥ 66 dBA*	*# ≥ 66 dBA*	*Total*	*% ≥ 66 dBA*	*# ≥ 66 dBA*	*Total*	*% ≥ 66 dBA*
San Francisco	Freeway	43	43	99.7%	43	43	100.0%	0	0	0.0%
	Expressway	2	2	100.0%	2	2	100.0%	0	0	0.0%
	Arterial	140	315	44.3%	183	315	58.3%	43	0	14.0%
San Mateo	Freeway	158	165	95.8%	157	165	95.1%	1	0	-0.7%
	Expressway	31	33	95.8%	30	32	95.7%	-1	-1	-0.1%
	Arterial	125	441	28.3%	203	443	45.9%	78	2	17.6%
Santa Clara	Freeway	436	478	91.3%	574	575	99.8%	138	97	8.5%
	Expressway	224	277	80.7%	226	270	83.8%	2	-7	3.1%
	Arterial	402	1,160	34.7%	527	1,166	45.2%	125	6	10.5%
Alameda	Freeway	356	369	96.5%	440	441	99.9%	84	72	3.4%
	Expressway	37	40	92.5%	49	56	86.9%	12	16	-5.6%
	Arterial	364	904	40.3%	507	903	56.2%	143	-1	15.9%
Contra Costa	Freeway	250	264	94.7%	291	292	99.7%	41	28	5.0%
	Expressway	39	44	89.8%	58	64	90.5%	19	20	0.7%
	Arterial	219	805	27.2%	295	798	37.0%	76	-7	1.5%
Solano	Freeway	176	182	96.3%	282	282	100.0%	106	100	3.7%
	Expressway	55	65	85.5%	64	76	83.3%	9	11	-2.2%
	Arterial	64	457	14.0%	118	463	25.6%	54	6	11.6%
Napa	Freeway	24	24	100.0%	24	24	100.0%	0	0	0.0%
	Expressway	34	37	91.3%	37	37	100.0%	3	0	8.7%
	Arterial	38	114	33.6%	66	114	57.8%	28	0	24.2%
Sonoma	Freeway	114	159	90.4%	188	188	99.7%	74	29	9.3%
	Expressway	20	20	100.0%	20	20	100.0%	0	0	0.0%
	Arterial	146	591	24.8%	199	593	33.6%	53	2	8.8%

TABLE 2.6-6 NOISE LEVELS BY ROADWAY TYPE (ROADWAY MILES)

County	*Roadway Type*	*2010*			*Year 2040, Plan*			*Net Change From 2010*		
		# ≥ 66 dBA	*Total*	*% ≥ 66 dBA*	*# ≥ 66 dBA*	*Total*	*% ≥ 66 dBA*	*# ≥ 66 dBA*	*Total*	*% ≥ 66 dBA*
Marin	Freeway	101	105	96.2%	121	121	99.9%	20	16	3.7%
	Arterial	40	143	27.7%	67	146	45.5%	27	3	17.8%
Bay Area	Freeway	1,687	1,789	94.3%	2,119	2,131	99.5%	472	330	5.2%
	Expressway	442	517	85.5%	486	557	87.2%	44	40	1.7%
	Arterial	1,538	4,930	31.2%	2,165	4,939	43.8%	627	9	12.6%
	Combined	**3,667**	**7,236**	**50.7%**	**4,770**	**7,626**	**62.6%**	**1,103**	**390**	**11.9%**

MTC/ABAG cannot require local implementing agencies to adopt the above mitigation measures, and it is ultimately the responsibility of a lead agency to determine and adopt mitigation. Therefore it cannot be ensured that this mitigation measure would be implemented in all cases, and this impact remains significant and unavoidable (SU).

Impact

2.6-3 Implementation of the proposed Plan could result in increased noise exposure from transit sources that exceed FTA exposure thresholds.

Impacts of Land Use Projects

Many of the development areas in the proposed Plan are purposely located along existing and planned transit corridors to help facilitate a reduction in vehicle miles travelled in the region. Locating residential land uses in proximity to transit could result in exposure of future residents to noise levels in excess of land use compatibility standards established in the local general plan. For example, there are PDAs identified within San Francisco, San Mateo and Santa Clara counties adjacent to the Caltrain alignment, while some PDAs in Alameda, Contra Costa and Solano counties are adjacent to Amtrak alignments.

The state General Plan Guidelines have established land use compatibility standards (presented in **Figure 2.6-7**) to address interior and exterior noise impacts on different land uses. For residential and commercial land uses, these are exterior noise standards that were developed to ensure that acceptable interior noise levels can be achieved with standard construction practices (normally acceptable) conditions). Other exposure categories would require additional insulating techniques beyond common code practices to achieve interior standards. In this way, exterior noise levels are also used as a tool to assess the acceptability of future interior noise levels for future land uses.

Noise monitoring conducted along the Caltrain alignment for proposed residential uses indicates exterior noise level of 71 DNL.[2] This degree of noise exposure is characterized as conditionally acceptable for residential land uses. Such development should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed noise insulation features are included in the design to achieve an interior noise level of 45 DNL, the standard established in the state General Plan Guidelines, as shown in **Figure 2.6-7**. Conventional construction, with the addition of closed windows and fresh air supply systems or air conditioning, will normally suffice for reducing impacts to acceptable levels in these locations. Further, development adjacent to transit lines would be most likely multi-family residential, and therefore, subject to noise insulation standards of Title 24 of the California Code or Regulations. These standards would ensure that multi-family residential land uses adjacent to transit would be constructed to maintain an acceptable interior noise level.

Construction methods and Title 24 requirements would address interior noise levels. However, exterior noise in common areas such as balconies would not be reduced by these methods. Consequently, mitigation measures are identified to reduce exterior noise exposure impacts in common areas.

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[2] Illingworth and Rodkin, *San Carlos Train Depot Site Noise and Vibration Assessment*, San Carlos CA, August 8, 2006.

Other existing (non-road) transit lines in the Bay Area (BART/VTA/MUNI) are electric-powered and therefore generate less noise than diesel locomotive operations along a heavy-rail alignment. Additionally, Caltrain is slated for an upgrade to electrically powered trains by 2019 which will reduce transit noise impacts along its corridor. However, California high speed rail will operate on a blended system with Caltrain by 2029 which could counteract any noise reduction benefits of electrification. Exterior noise exposure impacts from transit resulting from land use projects would be potentially significant (PS). Mitigation Measures 2.6(e), 2.6(f), and 2.6(g) are described below.

Impacts of Transportation Projects

Extension of rail transit service[3] to new areas of the Bay Area could result in exposure of existing sensitive land uses to noise levels in excess of standards developed by the FTA (see **Figure 2.6-6**). Such projects include:

- Third Street Light Rail line extension from north of King Street to Clay Street in Chinatown via a new Central Subway (San Francisco);
- Mission Bay Loop construction to connect the rail turnouts from the existing tracks on Third Street at 18th and 19th Streets with additional rail and overhead contact wire system on 18th, Illinois and 19th Street (San Francisco);
- MUNI T-Line extension from Bayshore/Sunnydale to Caltrain Bayshore Station (San Francisco);
- Light rail corridor extension into Parkmerced development project, add three new light rail stations and facilities, and add tail track and operator support facilities (San Francisco);
- Redwood City Street Car (Redwood City);
- Capitol Expressway light rail extension to Eastridge Transit Center - Phase II (San José);
- Light-rail transit extension from Winchester Station to Route 85 (Vasona Junction) (San José);
- Guadalupe Express light rail improvements (San José);
- Tasman Express Long T (includes double-tracking of a single-tracked light rail segment on the Mountain View line to facilitate the extra line of service) (San José);
- North First Street light rail speed Improvements (San José);
- Capitol Expressway Light Rail Extension - Phase I (includes sidewalk, landscape and street lights on both sides of the expressway from Capitol Avenue to Tully Road) (San José); and
- Sonoma-Marin Area Rail Transit District (SMART) Commuter Rail.

The degree of this potential impact would depend upon the type (diesel or electric powered) and frequency of rail pass-by events and the existing ambient noise level at the existing receptor. Some of the proposed transit extension projects have already undergone CEQA review for noise impacts. For example, the EIS/EIR for the extension of Third Street Light Rail in San Francisco (Central Subway)

[3] While there would also be projects that would increase or extend bus transit, buses are on-road travel and were included in the assessment of roadway noise in Impact 2.6-2.

determined that operational noise impacts of extending the light rail would be less than significant. The same is true for the Vasona Light Rail project in San José. These projects are located in urban areas that are relatively noise impacted by vehicle traffic. However, noise impacts of the Sonoma-Marin Area Rail Transit District (SMART) Commuter Rail transit project would be significant for train horn noise required at at-grade crossings.[4] Some of the above identified rail extension projects within the RTP would result in potentially significant (PS) impacts resulting from permanent increases in noise to existing sensitive receptors along the extended transit alignment that would require mitigation. Mitigation Measures 2.6(e), 2.6(f), and 2.6(g) are described below.

Heavy rail improvements could also include increasing the number of freight trains in the region. Because of the number of existing freight trains that use the existing heavy rail tracks, additional trains are not expected to increase daily noise along any given track by more than 3 dBA relative to baseline conditions and would be considered less than significant (LS).

Combined Effects

Both land use projects and transportation projects would have potentially significant impacts with regard to transit-related noise impacts on sensitive receptors. However, land use projects would be impacts to future sensitive receptors while transit projects would impact existing sensitive receptors. Consequently these two noise exposure impacts are not additive and the combined effects would be no different from the individual impacts addressed above. Mitigation Measures 2.6(e), 2.6(f), and 2.6(g) are described below.

Mitigation Measures

Implementing agencies and/or project sponsors shall consider implementation of mitigations measures including but not limited to those identified below.

2.6(e) Mitigation measures that shall be considered by implementing agencies and/or project sponsors where feasible based on project-and site-specific considerations include, but are not limited to the following. When finalizing a development project's site plan, the implementing agency shall require that project sponsors locate noise-sensitive outdoor use areas away from adjacent noise sources and shield noise-sensitive spaces with buildings or noise barriers whenever possible to reduce the potential significant impacts with regard to exterior noise exposure for new sensitive receptors.

2.6(f) Mitigation measures that shall be considered by implementing agencies and/or project sponsors where feasible based on project-and site-specific considerations include, but are not limited to the following. When finalizing a land use development's site plan or a transportation project's design, the implementing agency shall ensure that sufficient setback between occupied structures and the railroad tracks is provided.

2.6(g) Mitigation measures that shall be considered by implementing agencies and/or project sponsors where feasible based on project-and site-specific considerations include, but are not limited to the following. Prior to project approval, the implementing agency for a transportation project shall ensure

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4 Sonoma-Marin Area Rail Transit, Draft Environmental Impact Report, November 2005, http://www.sctainfo.org/pdf/smart/deir_ch3_7_noise.pdf

that the transportation project sponsor applies the following mitigation measures to achieve a site-specific exterior noise performance standard as indicated in **Figure 2.6-6** at sensitive land uses, as applicable for rail extension projects:

- Using sound reduction barriers such as landscaped berms and dense plantings;
- Locating rail extension below grade;
- Using methods to resilient damped wheels;
- Using vehicle skirts;
- Using under car acoustically absorptive material; and
- Installing sound insulation treatments for impacted structures.

Significance after Mitigation

Projects taking advantage of CEQA Streamlining provisions of SB 375 (Public Resources Code sections 21155.1, 21155.2, and 21159.28) must apply the mitigation measures described above, as feasible, to address site-specific conditions. To the extent that an individual project adopts and implements all feasible mitigation measures described above, the impact would normally be less than significant with mitigation (LS-M). However, there may be instances in which site-specific or project-specific conditions preclude the reduction of all project impacts to less than significant levels, such as where a new rail line or rail extension passes through a heavily developed residential neighborhood. For purposes of a conservative analysis, therefore, this impact remains significant and unavoidable (SU).

MTC/ABAG cannot require local implementing agencies to adopt the above mitigation measures, and it is ultimately the responsibility of a lead agency to determine and adopt mitigation. Therefore it cannot be ensured that this mitigation measure would be implemented in all cases. Further, there may be instances in which site-specific or project-specific conditions preclude the reduction of all project impacts to less-than-significant levels, such as where a new rail line or rail extension passes through a heavily developed residential neighborhood. For purposes of a conservative analysis, therefore, this impact remains significant and unavoidable (SU).

Impact

2.6-4 Implementation of the proposed Plan could result in increased vibration exposure from transit sources that exceed FTA exposure thresholds.

Impacts of Land Use Projects

Many of development areas in the proposed Plan are purposely located along existing and planned transit corridors to help facilitate a reduction in vehicle miles travelled in the region. Locating residential land uses in proximity to transit could also result in exposure of the future residents to vibration levels in excess of standards established by the FTA (see **Table 2.6-4**). Unlike noise impacts from transportation which are assessed in terms of a long-term (24-hour) noise descriptor, vibration impacts are assessed relative to peak vibration levels. Again, the PDAs along the Caltrain corridor may be used as a worst-case example as the weight of diesel locomotives result in greater vibration generation than light-rail vehicles.[5] Vibration monitoring conducted along the Caltrain alignment indicates peak vibration levels of 79 to 89 Vdb at a distance of 25 feet from track, and 63 to 72 VdB at a distance of 40 feet.[6] Comparing these values to the FTA standards presented in **Table 2.6-4** indicates that a significant vibration impact could occur if residential land uses are located within 40 feet from Caltrain tracks and potentially as far as 65 feet. Consequently, land use projects would have a potentially significant (PS) impact with regard to vibration exposure and mitigation measures are identified. Mitigation Measures 2.6(h) and 2.6(i) are described below.

Impacts of Transportation Projects

Extension of rail transit service[7] to new areas of the Bay Area could result in exposure of existing sensitive land uses to vibration levels in excess of standards developed by the FTA (see **Table 2.6-4**). Such projects include:

- Third Street Light Rail line extension from north of King Street to Clay Street in Chinatown via a new Central Subway (San Francisco);
- Mission Bay Loop construction to connect the rail turnouts from the existing tracks on Third Street at 18th and 19th Streets with additional rail and overhead contact wire system on 18th, Illinois and 19th Street (San Francisco);
- MUNI T-Line extension from Bayshore/Sunnydale to Caltrain Bayshore Station (San Francisco);
- Light rail corridor extension into Parkmerced development project, add three new light rail stations and facilities, and add tail track and operator support facilities (San Francisco);
- Redwood City Street Car (Redwood City);
- Capitol Expressway light rail extension to Eastridge Transit Center - Phase II (San José);
- Light-rail transit extension from Winchester Station to Route 85 (Vasona Junction) (San José);
- Guadalupe Express light rail improvements (San José);
- Tasman Express Long T (includes double-tracking of a single-tracked light rail segment on the Mountain View line to facilitate the extra line of service) (San José);
- North First Street light rail speed Improvements (San José);
- Capitol Expressway Light Rail Extension - Phase I (includes sidewalk, landscape and street lights on both sides of the expressway from Capitol Avenue to Tully Road) (San José); and
- Sonoma-Marin Area Rail Transit District (SMART) Commuter Rail.

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[5] Federal Transit Administration (FTA), *Transit Noise and Vibration Impact Assessment*, May 2006.

[6] Illingworth and Rodkin, *San Carlos Train Depot Site Noise and Vibration Assessment*, San Carlos CA, August 8, 2006.

[7] While there would also be projects that would increase or extend bus transit, buses are on-road travel and were included in the assessment of roadway noise in Impact 2.6-2.

The degree of this potential impact would depend upon the type (diesel or electric powered) and frequency of rail pass-by events and the existing soil conditions at the existing receptor. Some of the proposed transit extension projects have already undergone CEQA review for noise impacts. For example, the EIS/EIR for the extension of Third Street Light Rail in San Francisco (Central Subway) determined that the FTA vibration criteria of 72 VdB would be exceeded at one residential building and the FTA ground-borne noise criteria would be exceeded at two residential buildings on Third Street.[8] Mitigation measures were identified that included vibration propagation testing at these locations during final engineering to determine the predicted impacts and finalize the selection of mitigation measures of either: high resilience (soft) direct fixation fasteners for embedded track and in underground subway tunnels or ballast mats for ballast and tie track. Each of the above identified rail extension projects within the RTP could result in noise and vibration impacts requiring mitigation. Consequently, rail extension projects within the RTP would result in potentially significant (PS) impacts resulting from exposure of sensitive receptors to groundborne vibration along the extended transit alignments that would require mitigation.

Combined Effects

Both land use projects and transportation projects would have potential significant impacts with regard to transit-related vibration impacts on sensitive receptors. However, land use projects would be impacts to future sensitive receptors while transit projects would impact existing sensitive receptors. Consequently these two vibration exposure impacts are not additive and the combined effects would be no different from the individual impacts addressed above.

Mitigation Measures

Implementing agencies and/or project sponsors shall consider implementation of mitigations measures including but not limited to those identified below.

2.6(h) Mitigation measures that shall be considered by implementing agencies and/or project sponsors where feasible based on project-and site-specific considerations include, but are not limited to the following. When finalizing a development or transportation project's site plan, the implementing agency shall ensure that sufficient setback between occupied structures and the railroad tracks is provided. To meet the 72 VdB limit for the maximum measured train vibration level, residential buildings should be setback a minimum of 65 feet from the center of the nearest track. Alternatively, a reduced setback may be attainable if the project sponsor can demonstrate a project-specific vibration exposure meeting a performance standard of 72 VdB. Depending on specific project conditions, this standard may be attainable without additional mitigation measures or may require applied mitigation such as use of elastomeric pads in the building foundation.

2.6(i) Mitigation measures that shall be considered by implementing agencies and/or project sponsors where feasible based on project-and site-specific considerations include, but are not limited to the

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8 Federal Transit Administration, U.S. Department of Transportation, City and County of San Francisco, Planning Department, Final Supplemental Environmental Impact Statement/ Supplemental Environmental Impact Report, September 2008.

following. Prior to project approval the implementing shall ensure that project sponsors apply the following mitigation measures to achieve a vibration performance standard of 72 VdB at residential land uses, as feasible, for rail extension projects:

- Using high resilience (soft) direct fixation fasteners for embedded track; and
- Installing Ballast mat for ballast and tie track.

Significance after Mitigation

Projects taking advantage of CEQA Streamlining provisions of SB 375 (Public Resources Code sections 21155.1, 21155.2, and 21159.28) must apply the mitigation measures described above, as feasible, to address site-specific conditions. To the extent that an individual project adopts and implements all feasible mitigation measures described above, the impact would normally be less than significant with mitigation (LS-M). However, there may be instances in which site-specific or project-specific conditions preclude the reduction of all project impacts to less than significant levels, such as where a new rail line or rail extension passes through a heavily developed residential neighborhood. For purposes of a conservative analysis, therefore, this impact remains significant and unavoidable (SU).

MTC/ABAG cannot require local implementing agencies to adopt the above mitigation measures, and it is ultimately the responsibility of a lead agency to determine and adopt mitigation. Therefore it cannot be ensured that this mitigation measure would be implemented in all cases. Further, there may be instances in which site-specific or project-specific conditions preclude the reduction of all project impacts to less-than-significant levels, such as where a new rail line or rail extension passes through a heavily developed residential neighborhood. For purposes of a conservative analysis, therefore, this impact remains significant and unavoidable (SU).

Impact

2.6-5 Implementation of the proposed Plan could result in increased noise exposure from aircraft or airports.

Impacts of Land Use Projects

There are 21 public airports and two military/private airports throughout the Bay Area. Many of these airports are located in urbanized areas where the proposed Plan envisions new development in PDAs. Specifically, the following airports are located immediately adjacent to PDAs identified in the proposed Plan:

- Half Moon Bay Airport;
- San Francisco International Airport;
- San José International Airport;
- Reid-Hillview Municipal Airport (San José);
- Moffett Federal Airfield (Mountain View);
- Travis Air force Base (Fairfield);
- Livermore Municipal Airport; and

- Buchanan Field (Concord).

Most of these airports and airfields have an active airport land use Compatibility Plan (ALUCP) to encourage compatible land uses within the vicinity of the airport. The FAA Part 150 program encourages airports to prepare noise exposure maps that show land uses that are incompatible with high noise levels[9] and these are often included within the ALUCP. For example, San Francisco International Airport has prepared its ALUCP that indicates the number of housing opportunity sites within the 70 CNEL contour for airport operations. The potential exists for development pursuant to implementation of the proposed Plan to occur in areas of 70 CNEL. However, the land use compatibility standards contained in General Plans (see **Figure 2.6-7**) would discourage or require mitigation for construction of sensitive land uses in areas potentially impacted by aircraft noise. Recognizing both the local guidance of general plan noise elements and the guidance of ALUCPs as well as the sound insulation requirements of Title 24, potential noise impacts on sensitive land uses developed within PDAs pursuant to the proposed Plan are considered less than significant (LS), and no mitigation is required.

Impacts of Transportation Projects

There are no airport-related transportation investment projects identified in the Transportation Investment Strategy. Consequently there would be no impact with regard to airport or aircraft related noise as a result of implementation of the Transportation Investment Strategy. Because no impact is identified related to transportation projects, no combined effect is identified.

Combined Effects

As stated above, there are no airport-related transportation investment projects identified in the Transportation Investment Strategy. Consequently, there would be no combined airport exposure impacts from land use projects and transportation projects.

Mitigation Measures

None Required.

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[9] Federal Interagency Committee on Noise (FICON), *Federal Agency Review of Selected Airport Noise Analysis Issues*, August 1992.