Noise and Vibration Technical Memorandum

Coachella Valley-San Gorgonio Pass Rail Corridor Service Program

May 2021

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Contents

Tables

Figures

Appendices

Abbreviations/Acronyms

Caltrans	California Department of Transportation
CEQA	California Environmental Quality Act
dB	decibels
dBA	A-weighted decibels
EIR	environmental impact report
EIS	environmental impact statement
EPA	Environmental Protection Agency
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
FTA Manual	FTA Transit Noise and Vibration Impact Assessment
LAUS	Los Angeles Union Station
L_{dn}	day-night average sound level
L_{eq}	equivalent sound level
L_{eq}(h)	1-hour A weighted equivalent sound level
NEPA	National Environmental Policy Act
PPV	peak particle velocity
Program	Coachella Valley-San Gorgonio Pass Rail Corridor Service Program
Program Corridor	Coachella Valley-San Gorgonio Pass Rail Corridor
RCTC	Riverside County Transportation Commission
ROW	right-of-way
SDP	Service Development Plan
SR	State Route
U.S.	United States
UP	Union Pacific Railroad
VdB	velocity in decibels

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1 Introduction

The Federal Railroad Administration (FRA), California Department of Transportation (Caltrans) Division of Rail and Mass Transportation, and Riverside County Transportation Commission (RCTC) are proposing the Coachella Valley-San Gorgonio Pass Rail Corridor Service Program (Program) to establish daily intercity passenger rail service between Los Angeles Union Station (LAUS) in Los Angeles County, California and the City of Coachella in Riverside County, California. This noise and vibration technical memorandum evaluates potential noise and vibration effects along the 144-mile Coachella Valley-San Gorgonio Pass Rail Corridor (Program Corridor) in support of a programmatic Tier 1 Environmental Impact Statement (EIS)/Environmental Impact Report (EIR). The evaluation of potential noise and vibration effects resulting from the Program includes:

- Changes to noise compared with the No Build Alternative as a result of construction and operation of the Build Alternative Options
- Changes to vibration compared with the No Build Alternative as a result of construction and operation of the Build Alternative Options

1.1 Study Approach

This evaluation was prepared pursuant to the requirements of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) and will be incorporated into the Tier 1/Program EIS/EIR evaluation.

FRA, Caltrans, and RCTC are using a tiered NEPA/CEQA process (e.g., Tier 1/Program EIS/EIR) to complete the environmental review of the Program, under 40 Code of Federal Regulations 1508.28 (titled “Tiering”), CEQA Guidelines Section 15168 (titled “Program EIR”), and Section 15170 (titled “Joint EIS/EIR”). “Tiering” is a staged environmental review process often applied to environmental review for complex transportation projects.

The Tier 1/Program EIS/EIR, along with the concurrent preparation of the Service Development Plan (SDP), are the first steps in the tiered environmental review process. Based on the decisions made in the Tier 1/Program EIS/EIR and SDP, future site-specific proposals of infrastructure improvements will be evaluated through one or more Tier 2/Project-level environmental clearance processes. A description of the Tier 1/Program EIS/EIR, SDP, and Tier 2/Project-level analysis processes are further discussed below:

- *Tier 1/Program EIS/EIR*: The Tier 1/Program EIS/EIR evaluates potential environmental impacts of the No Build Alternative and three Build Alternative Options broadly within the Program Corridor. The Program Corridor provides a flexible regional context for the best location of an enhanced passenger rail system while providing opportunities for the Build Alternative Options to account for engineering and environmental constraints. The Tier 1/Program EIS/EIR evaluation addresses broad questions and likely environmental effects within the Tier 1/Program EIS/EIR Study Area for specific environmental resources. The resource-specific study areas generally represent the potential area where rail infrastructure improvements and station facilities could be implemented and constructed but does not represent the precise location or footprint of the improvement or facility.
- *SDP*: The SDP defines the Program's service mode, estimated ridership to include demand and revenue forecasts, operational strategy, station and access analysis, operating and maintenance costs, required infrastructure improvements and capital programming, and public benefits analysis necessary to implement the proposed intercity passenger rail service. As part of the SDP process, the site-specific infrastructure improvement requirements are being identified, including the number of stations and the general areas/communities in which stations might be located. The SDP infrastructure analysis is being informed by rail operations simulation modeling and would occur parallel to the Tier 1/Program EIS/EIR evaluation process.
- *Tier 2 Project-Level Analysis*: Based on the environmental evaluation conducted in the Tier 1/Program EIS/EIR and the site-specific infrastructure improvements identified in the SDP, a Tier 2/Project-level analysis would be required. The Tier 2/Project-level analysis would be a separate environmental review potentially led and funded by an agency other than FRA. In addition, the Tier 2/Project-level analysis process would not automatically follow the Tier 1 process, rather the potential Tier 2 projects would need to be defined based on the Tier 1/Program EIS/EIR's broad scope and funding. The Tier 2/Project-level analysis would closely align with the future preliminary engineering process and would analyze site-specific direct and indirect Project-level effects, in addition to any required permits, consultations, or approvals needed for construction.

2 Program Location and Description

2.1 Program Location

The Tier 1/Program EIS/EIR analyzes the No Build Alternative and three Build Alternative Options in two geographic sections—a Western Section and an Eastern Section—occurring within existing railroad rights-of-way (ROW), as shown on Figure 2-1 through Figure 2-3. The Program Corridor runs west-to-east, extending up to 144 linear miles from a western terminus at LAUS to an eastern terminus in either the City of Indio or City of Coachella (depending on the Build Alternative Option).

From west to east, the cities traversed by the Build Alternative Options include Los Angeles, Vernon, Bell, Commerce, Montebello, Pico Rivera, Santa Fe Springs, Norwalk, La Mirada, Buena Park, Fullerton, Anaheim, Placentia, Yorba Linda, Chino Hills, Corona, Riverside, Grand Terrace, Colton, San Bernardino, Loma Linda, Redlands, Calimesa, Beaumont, Banning, Cabazon, Palm Springs, Cathedral City, Thousand Palms, Rancho Mirage, Palm Desert, Indio (under all Build Alternative Options), and/or Coachella (under Build Alternative Option 1 only). The boundary between Western and Eastern Sections is in the City of Colton, at the intersection of existing railroad lines owned by Union Pacific Railroad (UP) and BNSF.

2.2 Program Description

2.2.1 Build Alternative Option 1 (Coachella Terminus)

Build Alternative Option 1 includes a total Program Corridor distance of 144 miles and consists of a Western Section, terminating at LAUS, and an Eastern Section, terminating in the City of Coachella.

Western Section. Under Build Alternative Option 1, existing rail infrastructure would be used in the Western Section of the Program Corridor, and no additional railroad infrastructure improvements would be required. LAUS would serve as the western terminus, while existing stations in the Cities of Fullerton and Riverside would be utilized to support the proposed passenger rail service. No new stations or improvements to existing stations would be required to accommodate the proposed service within the Western Section of the Program Corridor.

Eastern Section. Under Build Alternative Option 1, potential new infrastructure improvements on the Eastern Section of the Program Corridor could include sidings, additional main line track, wayside signals, drainage, grade separation structures, and up to five new stations constructed in the following areas: 1) Loma Linda/Redlands Area (serving the Cities of Loma Linda and Redlands), 2) the Pass Area (serving the communities of Beaumont, Banning, and Cabazon), 3) the Mid Valley (serving the communities of Cathedral City, Thousand Palms, the Agua Caliente Casino area, Rancho Mirage, and Palm Desert), 4) the City of Indio, and 5) the City of Coachella as the eastern terminus of the Program Corridor.

2.2.2 Build Alternative Option 2 (Indio Terminus)

Build Alternative Option 2 includes a total Program Corridor distance of 140.25 miles and consists of a Western Section, terminating at LAUS, and an Eastern Section, terminating at the City of Indio.

Western Section. The Western Section under Build Alternative Option 2 would be the same as that described above under Build Alternative Option 1.

Eastern Section. Under Build Alternative Option 2, potential new infrastructure improvements on the Eastern Section of the Program Corridor could include sidings, additional main line track, wayside signals, drainage, grade separation structures, and up to four new potential stations could be constructed in the following areas: 1) Loma Linda/Redlands Area (serving the Cities of Loma Linda and Redlands), 2) the Pass Area (serving the communities of Beaumont, Banning, and Cabazon), 3) the Mid Valley (serving the communities of Cathedral City, Thousand Palms, the Agua Caliente Casino area, Rancho Mirage, and Palm Desert), and 4) the City of Indio as the eastern terminus of the Program Corridor.

2.2.3 Build Alternative Option 3 (Indio Terminus with Limited Third Track)

Build Alternative Option 3 includes a total Program Corridor distance of 140.25 miles and consists of a Western Section, terminating at LAUS, and an Eastern Section, terminating at the City of Indio.

Western Section. The Western Section under Build Alternative Option 3 would be the same as that described above under Build Alternative Options 1 and 2.

Eastern Section. The Eastern Section under Build Alternative Option 3 would be the same as that described above under Build Alternative Option 2, except for the following changes:

As part of Build Alternative Option 3, additional infrastructure improvements for the Eastern Section of the Program Corridor have been considered. These potential infrastructure improvements include the addition of station tracks and a third main line track. The addition of station tracks would be the same as described under Build Alternative Options 1 and 2; however, the addition of the third main track would be limited under Build Alternative Option 3 when compared with Build Alternative Options 1 and 2. The limited third track under Build Alternative Option 3 would augment the existing two main tracks along the Eastern Section of the Program Corridor to the proposed Mid Valley Station Area.

2.3 Construction

2.3.1 Western Section

In the Western Section, existing rail infrastructure would be used to accommodate the proposed service, and no additional track improvements would be required to accommodate the proposed service under all Build Alternative Options. LAUS would serve as the western terminus, and existing stations in the Cities of Fullerton and Riverside would be used, as depicted on Figure 2-1. No new stations or additions to existing stations would be required to accommodate the proposed service under all Build Alternative Options. The Tier 1/Program EIS/EIR Study Area for potential construction-related impacts on noise and vibration within the Western Section is up to 600 feet from either side of the existing railroad centerline.

2.3.2 Eastern Section

In the Eastern Section, proposed new infrastructure improvements under all Build Alternative Options could include sidings, additional main line track, wayside signals, drainage, grade-separation structures, and stations to accommodate the proposed service. The Eastern Section would use the existing station in the City of Palm Springs, which is the only existing station in the Eastern Section. Additionally, as depicted on Figure 2-2 and Figure 2-3, up to five new potential stations could be constructed in the following areas: 1) Loma Linda/Redlands Area (serving the Cities of Loma Linda and Redlands), 2) the Pass Area (serving the communities of Beaumont, Banning, and Cabazon), 3) the Mid-Valley (serving the communities of Cathedral City, Thousand Palms, the Agua Caliente Casino area, Rancho Mirage, and Palm Desert), 4) the City of Indio (under all Build Alternative Options), and/or 5) the City of Coachella (under Build Alternative Option 1 only).

The Tier 1/Program EIS/EIR Study Area for potential construction-related impacts on noise and vibration within the Eastern Section is up to 1,000 feet from either side of the centerline, plus a 500-foot buffer for the assessment of indirect impacts, for a total Tier 1/Program EIS/EIR Study Area of 1,500 feet from either side of the centerline at each of the individual station location areas. The remaining portion of the Eastern Section Tier 1/Program EIS/EIR Study Area encompasses up to 300 feet from the railroad centerline to include non-station-related infrastructure improvements, plus a 500-foot buffer for the assessment of indirect impacts, for a total Tier 1/Program EIS/EIR Study Area of 800 feet from the railroad centerline.

2.4 Operation

Passenger train frequencies proposed as part of the Program would consist of the addition of two daily round-trip intercity diesel-powered passenger trains operating the entire length of the Program Corridor between Los Angeles and Indio and/or Coachella, with one morning departure and one afternoon departure from each end of the Program Corridor.

Figure 2-1. Western Section of the Program Corridor (Build Alternative Options 1, 2, and 3)

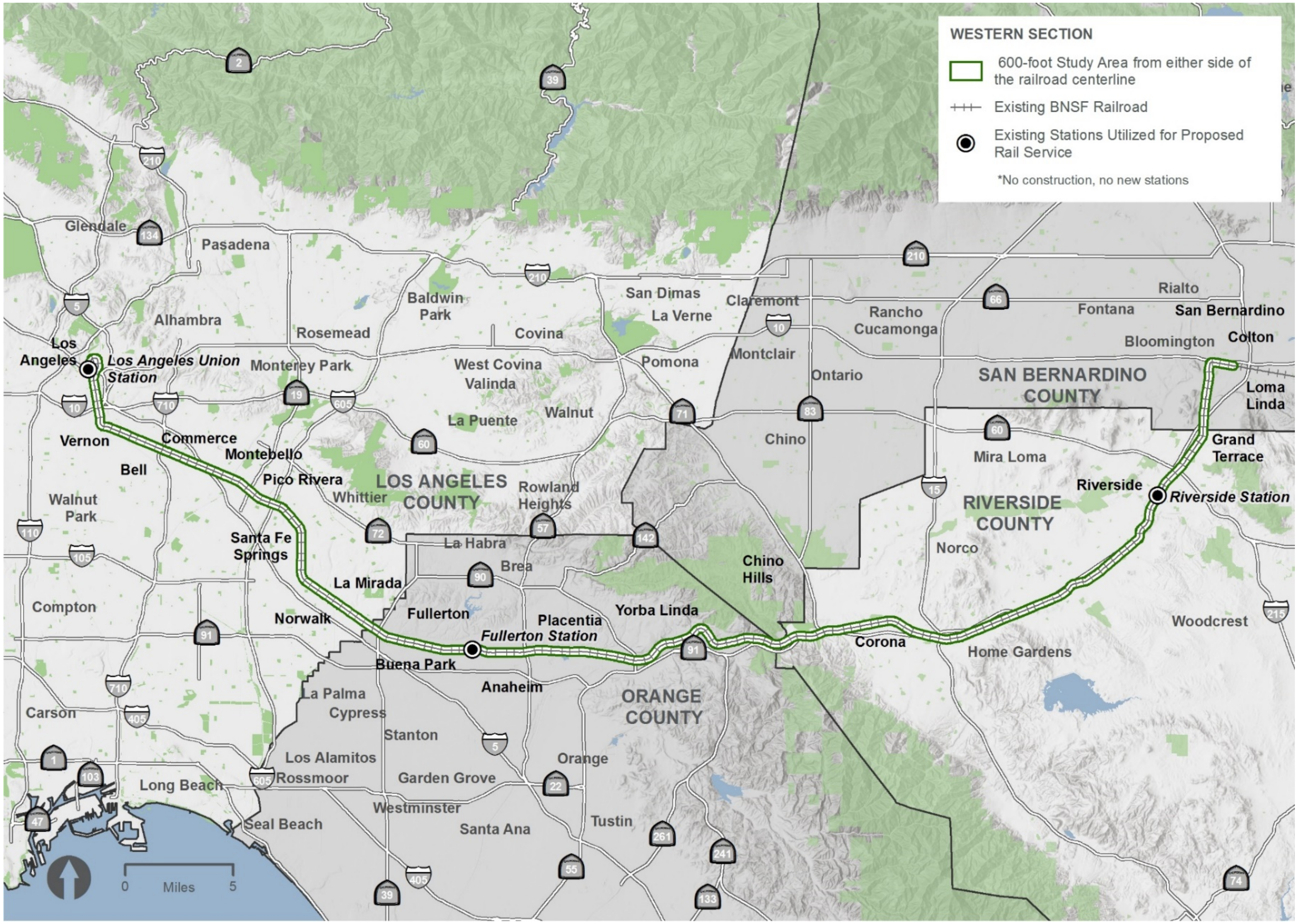

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Figure 2-2. Eastern Section of the Program Corridor (Build Alternative Option 1)

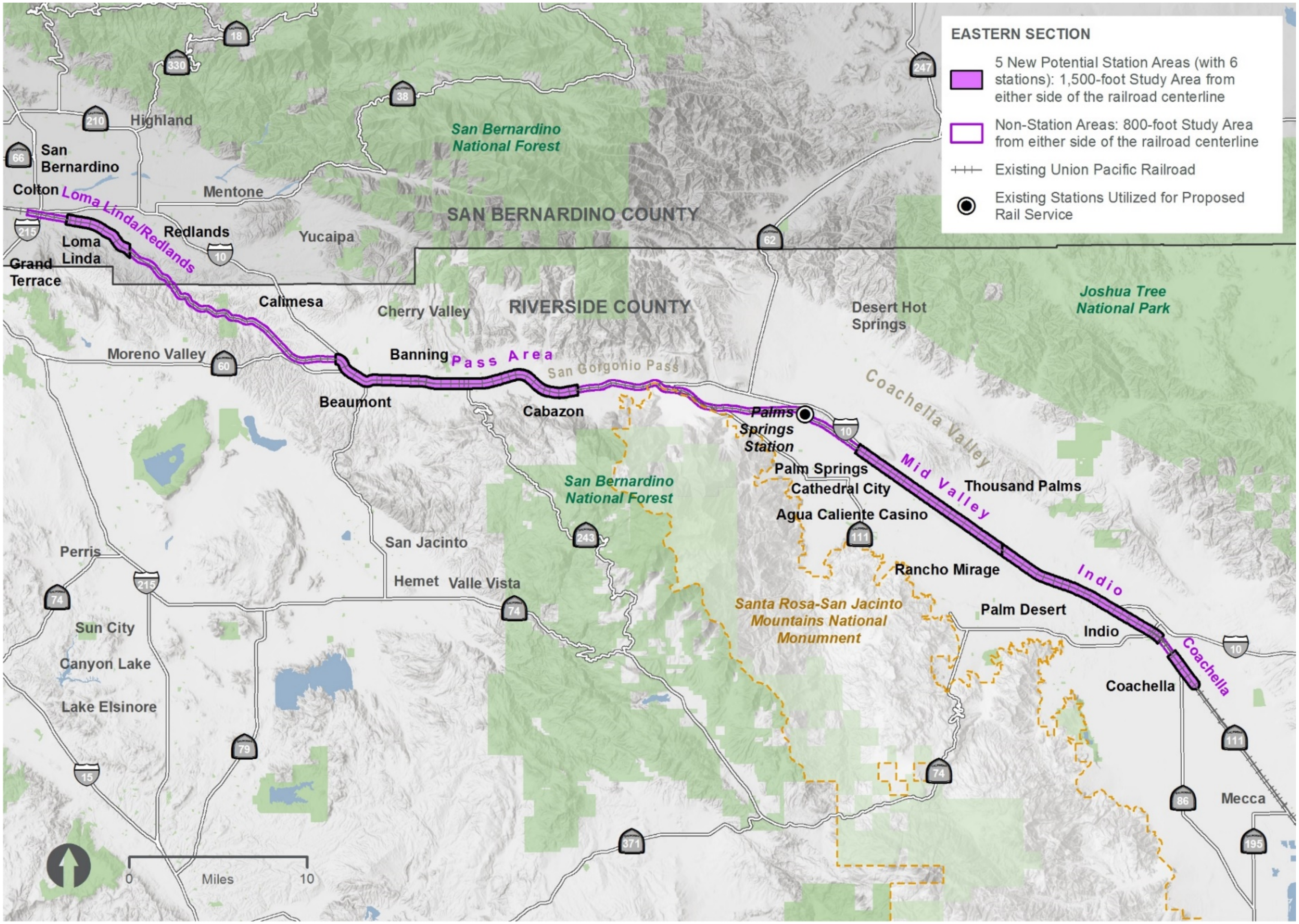

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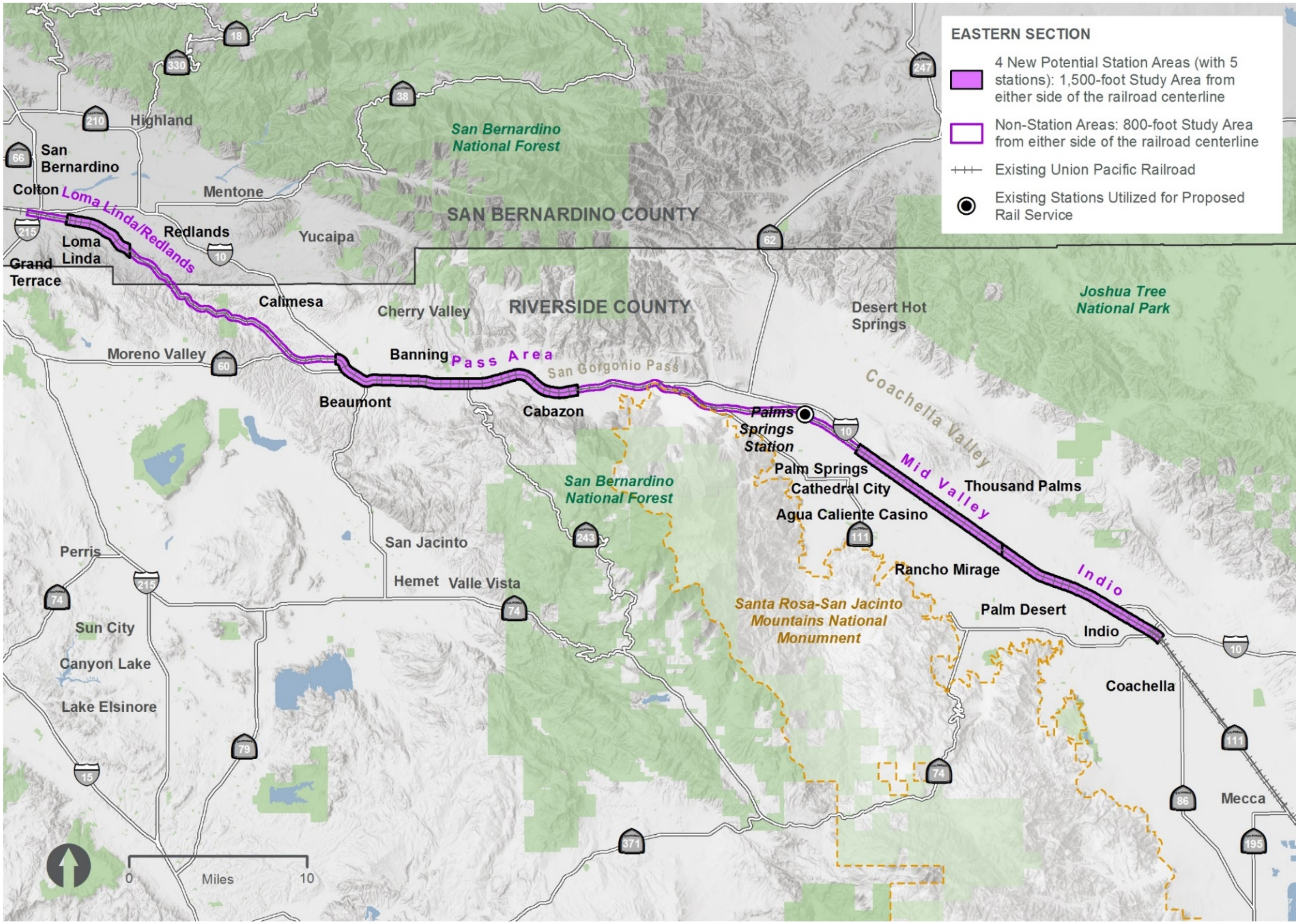
Figure 2-3. Eastern Section of the Program Corridor (Build Alternative Options 2 and 3)



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3 Regulatory Framework

In accordance with NEPA (42 United States [U.S.] Code Section 4321 et seq.), CEQ regulations implementing NEPA (40 Code of Federal Regulations Parts 1501 1508), FRA's Procedures for Considering Environmental Impacts (64 *Federal Register* 28545, May 26, 1999) and CEQA, FRA identified potential noise-sensitive land uses within the Tier 1/Program EIS/EIR Study Area and evaluated the potential impacts that could occur from implementation of the Build Alternative Options. Federal and local guidelines for environmental noise and vibration relevant to the Tier 1/Program-level analysis are described in this section. The thresholds of significance used for assessment of noise and vibration effects are discussed in Section 6, Environmental Consequences.

3.1 Federal

3.1.1 Environmental Protection Agency

In 1974, the U.S. Environmental Protection Agency (EPA) published *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, a comprehensive document that identifies noise levels to protect public health and welfare against hearing loss, annoyance, and activity interference (U.S. EPA 1974).

In response to the requirements of the Noise Control Act, U.S. EPA identified indoor and outdoor noise limits to protect public health and welfare. U.S. EPA identified outdoor day-night average sound level (L_{dn}) limits of 55 decibels (dB) and indoor L_{dn} limits of 45 dB as desirable for protecting against speech interference and sleep disturbance in residential areas and at educational and health care facilities. The sound-level criterion for protecting against hearing damage in commercial and industrial areas is identified as the 24-hour equivalent sound level (L_{eq}) value of 70 dB (both outdoors and indoors). Based on attitudinal surveys, U.S. EPA determined that a 5 dB increase in L_{dn} or L_{eq} could result in a change in community reaction (U.S. EPA 1974). L_{dn} and L_{eq} are described in further detail in Appendix A, *Fundamental Concepts of Environmental Noise.*

The Noise Control Act also directed federal agencies to comply with applicable federal, state, interstate, and local noise control regulations. Although U.S. EPA was given a major role in disseminating information to the public and coordinating with federal agencies, each federal agency retained authority to adopt noise regulations pertaining to its programs. U.S. EPA can require federal agencies to justify their noise regulations in terms of Noise Control Act policy requirements.

The following key federal agencies have adopted noise regulations and standards:

- Housing and Urban Development: Noise standards for federally funded housing projects

- Federal Aviation Administration: Noise standards for aircraft
- Federal Highway Administration: Noise standards for federally funded highway projects
- Federal Transit Administration (FTA): Noise standards for federally funded transit projects
- FRA: Noise standards for federally funded rail projects

3.1.2 Federal Railroad Administration/Federal Transit Administration Noise Impact Criteria

According to the FRA's *Procedures for Considering Environmental Impacts* (64 *Federal Register* 28545, May 26, 1999) Section 14(n)(13) (FRA 1999a), an "EIS should assess the impacts on both passenger and freight transportation, by all modes, from local, regional, national, and international perspectives. The EIS should include a discussion of both construction period and long-term impacts on vehicular traffic congestion."

The FRA and the FTA have published impact assessment procedures and criteria pertaining to noise. Consistent with a Tier 1/Program EIS/EIR assessment, guidance by these agencies will be considered in the evaluation of noise and vibration associated with the Build Alternative Options. Assessment of noise and vibration impacts associated with the Program is based on guidance in the *FTA Transit Noise and Vibration Impact Assessment Manual* (FTA Manual) (FTA 2018). The FTA Manual is used for rail projects where conventional train speeds are below 90 miles per hour (FRA 2012). Therefore, FRA conventional rail projects generally use noise and vibration assessment guidance from the FTA Manual. The FTA Manual also includes assessment methods for noise and vibration from construction.

Construction

FTA has developed methods for evaluating construction noise levels, which are discussed in the FTA Manual. The FTA Manual does not contain standardized criteria for assessing construction noise impacts. Instead, it includes guidelines for suggested noise limits for residential uses exposed to construction noise to describe levels that may result in an adverse community reaction. These guidelines are summarized in Table 3-1.

Table 3-1. Federal Transit Administration Construction Noise Impact Guidelines

Land Use	8-hour L_{eq} (dBA), Day	8-hour L_{eq} (dBA), Night
Residential	80	70
Commercial	85	85
Industrial	90	90

Source: FTA 2018

Notes:

dBA=A-weighted decibel; L_{eq}=equivalent sound level

Thresholds for construction noise may be set at the local level, as described in Section 3.3, according to the expected hours of equipment operation and the noise limits specified in the noise ordinances of the applicable jurisdictions.

Rail Operations

FRA published and implemented impact assessment procedures and criteria pertaining to noise. According to the *High-Speed Ground Transportation Noise and Vibration Impact* Assessment (FRA 2012), the FTA Manual is used for rail projects where conventional train speeds are below 90 miles per hour; as such, FRA generally uses noise and vibration guidance from the FTA Manual. Therefore, noise and vibration impacts associated with operation of the Build Alternative Options are based on guidance in the FTA Manual.

The FTA Manual describes the noise impact criteria that have been adopted to assess noise contributions and potential impacts on the existing environment from rapid transit sources. The noise impact criteria defined in the FTA Manual are based on an objective that calls for maintaining a noise environment that is considered acceptable for noise-sensitive land uses.

For assessing noise from transit operations, FTA defines three land use categories.

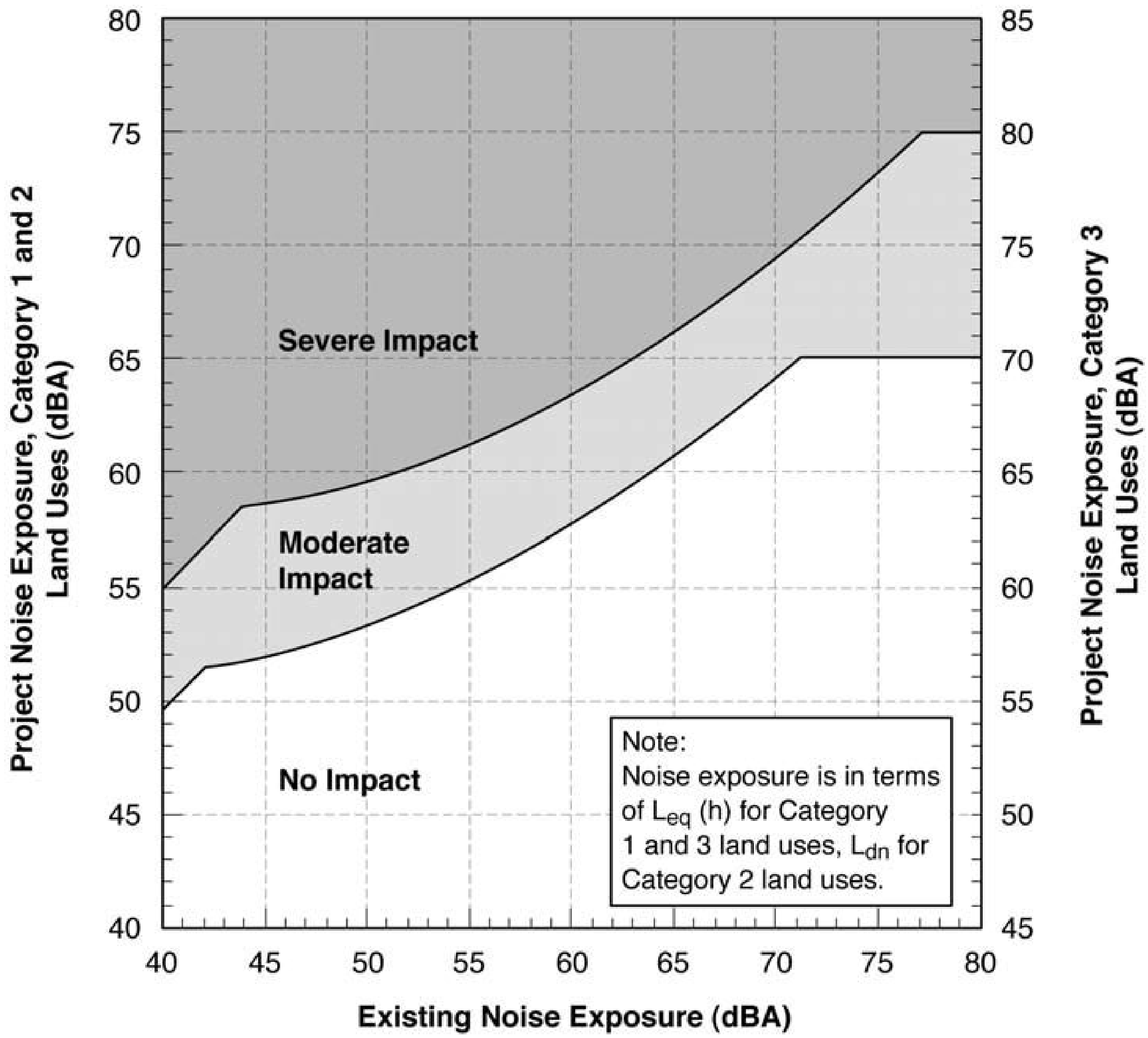
- **Category 1**: Tracts of land where quiet is an essential element of their intended purpose, such as outdoor amphitheaters, concert pavilions, and national historic landmarks with significant outdoor use.
- **Category 2**: Residences and buildings where people normally sleep, including homes, hospitals, and hotels.
- **Category 3**: Institutional land uses (e.g., schools, places of worship, libraries) that are typically available during daytime and evening hours. Other uses in this category can include medical offices, conference rooms, recording studios, concert halls, cemeteries, monuments, museums, historical sites, parks, and recreational facilities.

Noise exposure values are reported as the L_{dn} average sound level for residential land uses (Category 2) or, the equivalent sound level over a 1-hour A weighted equivalent sound level (L_{eq}(h)) for other land uses (Categories 1 and 3). Commercial and industrial uses are not included in the vast majority of cases because they are generally compatible with higher noise levels. Exceptions include commercial land uses with a feature that receives significant outdoor use, such as a playground, or uses that require quiet as an important part of their function, such as recording studios.

In the FTA Manual, noise impact criteria for operation of rapid transit facilities consider a project's contribution to existing noise levels, using a sliding scale, according to the land uses affected. The criteria correspond to heightened community annoyance because of the introduction of a new transit facility relative to existing ambient noise conditions.

Noise impacts are assessed by comparing existing outdoor exposures with future project-related outdoor noise levels, as depicted on Figure 3-1. The criterion for each degree of impact is based on a sliding scale that is dependent on the existing noise exposure and the increase in noise exposure because of a project.

Figure 3-1. Federal Transit Administration Noise Impact Criteria



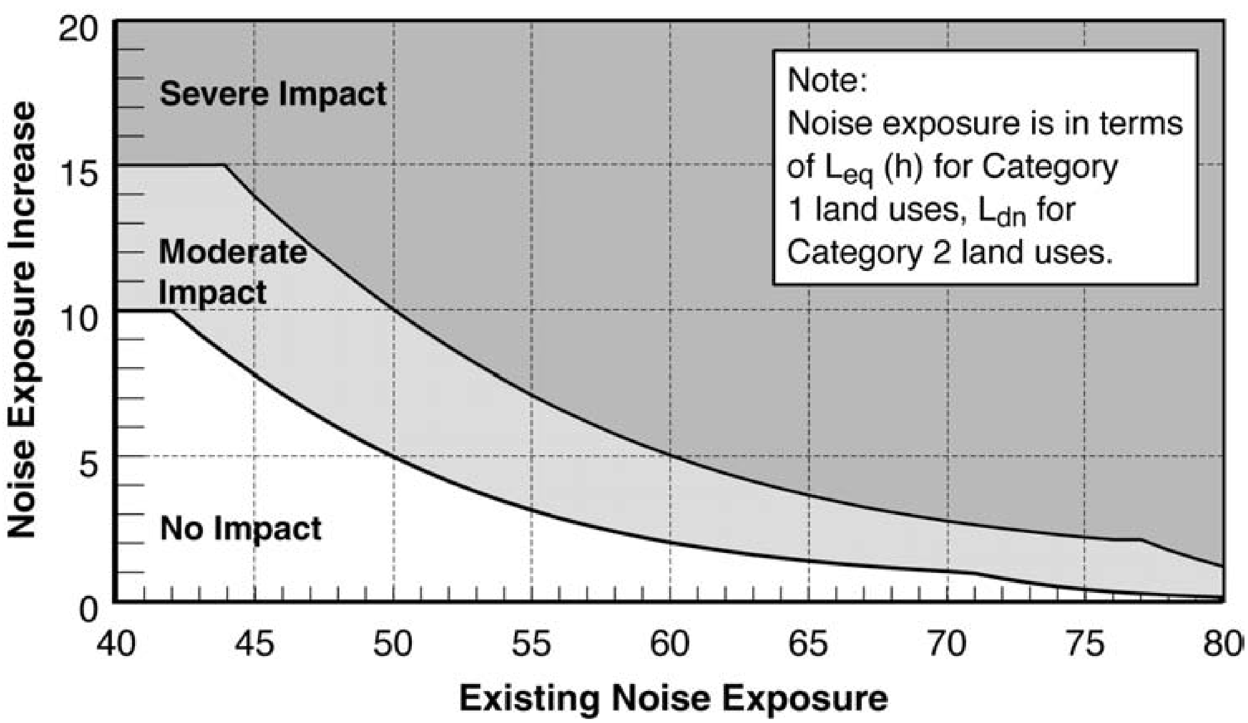
Source: FTA 2018.

The noise impact categories are as follows:

- **No Impact:** A project, on average, would result in an insignificant increase in the number of instances where people are "highly annoyed" by new noise.
- **Moderate Impact:** The change in cumulative noise is noticeable to most people but may not be enough to cause strong adverse community reactions.
- **Severe Impact:** A significant percentage of people would be highly annoyed by the noise, perhaps resulting in vigorous community reaction.

A project's noise contribution relative to the existing noise levels, as depicted on Figure 3-1, differs according to the level of existing noise exposure. For example, a project contribution of 59 A-weighted decibels (dBA) L_{dn} would be considered a severe impact at a Category 2 receptor with an existing noise exposure of up to 50 dBA L_{dn} (a difference of 9 dB), whereas a project contribution of 69 dBA L_{dn} would result in a severe impact at a Category 2 receptor with an existing noise exposure of up to 70 dBA L_{dn} (a difference of 1 dB). The impact curves on Figure 3-1 are based on community increases in cumulative noise exposure relative to existing conditions, as depicted on Figure 3-2. The justification for the sliding scale depicted in these figures recognizes that people who are already exposed to high levels of noise in the ambient environment are expected to tolerate small increases in noise in their community according to the level of their existing noise exposure.

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



Note: Noise exposure increase impact curves are adjusted by +5 dB for Category 3 land uses.

3.1.3 Federal Transit Administration Vibration Impact Criteria

General Vibration Effects

The FTA vibration impact criteria for the land use categories described above are depicted in Table 3-2. The criteria are based on the frequency of events and related to ground-borne vibration that can cause human annoyance or interfere with the use of vibration-sensitive equipment. The criteria for acceptable ground-borne vibration are based on the maximum vibration level (Vdb) for a single event and expressed in terms of root-mean-square velocity level.

Table 3-2. Ground-borne Vibration Impact Criteria for General Assessment

Land Use Category	Vibration Impact Levels for Frequent Events[a] (VdB re 1 micro-inch/second)	Vibration Impact Levels for Occasional Events[b] (VdB re 1 micro-inch/second)	Vibration Impact Levels for Infrequent Events[c] (VdB re 1 micro-inch/second)
Category 1: Buildings where vibration would interfere with interior operations	65 VdB[d]	65 VdB[d]	65 VdB[d]
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

Source: FTA 2018

Notes:

[a] The term *frequent events* is defined as more than 70 vibration events from the same source each day. Most rapid transit projects fall into this category.

[b] The term *occasional events* is defined as between 30 and 70 vibration events from the same source each day. Most commuter trunk lines have operations in this range.

[c] The term *infrequent events* is defined as fewer than 30 vibration events of the same kind each day. This category includes most commuter rail branch lines.

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

VdB=velocity in decibels

Potential for Damage to Fragile Structures

FTA analysis guidelines call for an investigation of the potential for vibration-induced damage to “fragile” or “extremely fragile” buildings (FTA 2018). Damage to a building is possible (but not necessarily probable) if ground-borne vibration levels exceed the following criteria:

- A 0.20-inch-per-second peak particle velocity (PPV) (approximately 100 velocity in decibels [VdB]) for non-engineered timber and masonry buildings
- A 0.12-inch-per-second PPV (approximately 95 VdB) for buildings that are extremely susceptible to vibration damage

Ground-borne Noise

At higher frequencies, ground-borne vibration can be perceived as a noise source. At sufficiently high amplitudes, the propagation of vibration waves through the ground can couple with building elements and cause them to vibrate at a frequency that is audible to the human ear.

Ground-borne noise could rattle windows, walls, or other items that are coupled to building surfaces. Ground-borne vibration levels that result in ground-borne noise are often experienced as a combination of perceptible vibration and low-frequency noise.

Ground-borne noise is normally not a consideration when rail transit sources are at-grade. Ground-borne noise generally becomes an important consideration for subterranean rail transit or other projects in which part of the alignment includes a tunnel. Ground-borne noise impacts are not anticipated for the Build Alternative Options.

3.1.4 Noise Control Act of 1972

The Noise Control Act of 1972 (Public Law 92 574) established a requirement for all federal agencies to administer their programs in a manner that promotes an environment that is free of noise that jeopardizes public health or welfare. U.S. EPA was assigned the following responsibilities:

- Providing information to the public regarding the identifiable effects of noise on public health and welfare
- Publishing information on the levels of environmental noise to protect the public health and welfare with an adequate margin of safety
- Coordinating federal research and activities related to noise control
- Establishing federal noise emission standards for selected products distributed in interstate commerce

3.2 State

3.2.1 California Noise Control Act

The California Noise Control Act was enacted in 1973. In preparing its general plan noise element, a city or county must identify local noise sources and analyze and quantify to the extent practicable current and projected noise levels from various sources, including highways and freeways; passenger and freight railroad operations; ground rapid transit systems; commercial, general, and military aviation and airport operations; and other stationary ground noise sources.

The State of California General Plan Guidelines (Governor's Office of Planning and Research 2003) provide noise compatibility guidelines for land use planning, according to the existing community noise level; however, these guidelines offer no information regarding construction noise. The state has also published its *Model Community Noise Ordinance* (California Office of Noise Control 1977), which provides guidance to cities and counties on how to develop a community noise ordinance. These guidelines include recommended limits on construction noise levels; however, these are only guidelines and are not enforceable.

California Department of Transportation Vibration Standards

For continuous/frequent intermittent sources, such as pile driving, Caltrans recommends a 0.25-inch-per-second PPV threshold for "historic and some old buildings" and a PPV of 0.3 inch per second for "older residential structures" (Caltrans 2004). These criteria are directed primarily toward, but not limited to, all construction related to pile driving, demolition, and pavement-breaking activities.

3.3 Local/Regional

The Program Corridor passes through many local jurisdictions. The Program Corridor extends through the counties of Los Angeles, Orange, San Bernardino, and Riverside and the cities of Los Angeles, Vernon, Bell, Commerce, Montebello, Pico Rivera, Santa Fe Springs, Norwalk, La Mirada, Buena Park, Fullerton, Anaheim, Placentia, Yorba Linda, Chino Hills, Corona, Riverside, Grand Terrace, Colton, San Bernardino, Loma Linda, Redlands, Calimesa, Beaumont, Banning, Cabazon, Palm Springs, Cathedral City, Thousand Palms, Rancho Mirage, Palm Desert, Indio, and Coachella. Many of these jurisdictions have noise standards that relate to land use compatibility with transportation noise sources (e.g., traffic, rail, aircraft); however, noise from transit sources is controlled at the federal level, not at the local level.

Noise ordinances applicable to the jurisdictions within the Tier 1/Program EIS/EIR Study Area do not apply noise limits to transportation sources but, rather, to non-transportation sources, such as construction equipment. In many cases, jurisdictions provide exemptions from noise ordinance standards for temporary construction work or necessary infrastructure repairs or improvements. In many cases, construction work during daytime hours is exempt from local regulations.

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4 Methodology

This section describes methods and approaches for the evaluation of noise and vibration from construction and operation of the Build Alternative Options. Because this analysis was conducted at a Tier 1/Program EIS/EIR service evaluation level, a screening-level noise and vibration impact assessment was completed rather than a detailed quantitative evaluation of noise and vibration levels. Detailed quantitative analysis would occur during Tier 2/Project-level analysis.

4.1 Noise

4.1.1 Construction Noise

The thresholds used in the evaluation were based on guidance from the FTA Manual (FTA 2018). Although construction noise may be exempt from daytime noise standards in local jurisdictions, FTA guidance should be used to minimize the potential for noise complaints. These thresholds are standard criteria for assessment of transit projects under FTA and are appropriate, given federal involvement in the Program. Thresholds for construction in local jurisdictions, if more stringent, would be addressed in a Tier 2/Project-level analysis. In many cases, local jurisdictions do not regulate daytime construction noise, and thus, FTA daytime standards are often used to determine potential for community annoyance during construction. As such, local ordinances were not evaluated for potential noise effects under the Tier 1/Program EIS/EIR evaluation. FTA guidelines for temporary construction, described below, provide a reasonable set of indicators that can be used as impact thresholds for the Tier 1/Program EIS/EIR evaluation.

Noise levels produced by commonly used construction equipment are summarized in Table 4-1. Individual types of heavy construction equipment are expected to generate noise levels ranging from 74 to 89 dBA at a distance of 50 feet. Given construction requirements, pile drivers could be used. Pile drivers typically generate a maximum noise level of up to 101 dBA at a distance of 50 feet. The construction noise level at a given receptor would depend on the type of construction activity, the noise level generated by that activity, and the distance and shielding between the activity and the noise-sensitive receptor.

Utilization factors for construction noise are used in the evaluation to describe source noise levels in terms of L_{eq} noise exposure, as outlined in the FTA guidelines for construction noise. The L_{eq} noise standard accounts for the energy average of noise over a specified interval (e.g., 1 hour or 8 hours); therefore, a utilization factor represents the amount of time a specific type of equipment is used during the interval.

Table 4-1. Construction Equipment Noise Emission Levels

Equipment	Typical Noise Level (dBA) 50 feet from Source	Typical Utilization Factors (minutes)
Grader	85	40
Bulldozer	85	40
Truck	88	40
Loader	85	40
Compactor	82	20
Backhoe	80	40
Crane	83	20
Roller	74	50
Paver	89	50
Excavator	85	40
Pile Driver (Impact)	101	20
Pile Driver (Sonic)	96	20

Sources: FTA 2018; Thalheimer 2000

Notes:

dBA=A-weighted decibel

Based on FTA guidance, a construction noise impact may occur if construction equipment exceeds 80 dBA L_{eq} (8 hours) at a residential location between the hours of 7:00 a.m. and 10:00 p.m. or 70 dBA L_{eq} (8 hours) between the hours of 10:00 p.m. and 7:00 a.m.

4.1.2 Operational Noise

Train Operations

The rail noise model focuses on land uses that could be subject to Program-related transit noise impacts. Although all developed land uses were evaluated in this analysis, the focus of the impact evaluation was on outdoor locations with frequent human use, institutional land uses, and residential buildings where people normally sleep.

The noise and vibration assessment was conducted in accordance with FTA Manual guidelines. The FTA Manual specifies that criteria are to be applied to compare future project noise with existing noise, rather than future project noise with projections of future “no-build” noise exposure.

Existing noise levels for receptor locations were derived from projected daily freight and intercity passenger, and commuter rail trips along the existing Program Corridor, described in Section 5. Given the high density of residential uses along much of the Program Corridor, existing noise levels from rail were calculated by adjusting for varying distances between noise-sensitive receptors and noise sources. The primary sources of noise along the Program Corridor were assumed to consist of either wayside noise from train passbys or grade crossings where trains are required to sound horns as they approach within 0.25 mile of the crossing. Geographic information system analysis was used to identify potentially affected parcels along the Program Corridor with the addition of two daily round-trip intercity diesel-powered passenger trains operating the entire length of the Program Corridor under Build Alternative Options 1, 2, and 3.

The noise model was based on FTA single-event source levels for train vehicles and horns, as defined in the FTA Manual. For the Tier 1/Program EIS/EIR, the FTA General Assessment method was used to determine projected future project-induced noise and vibration levels as a function of distance and to identify impacts on noise-sensitive receivers. Noise contributions from rail vehicles under the Build Alternative Options were calculated using the noise source levels for at-grade rail transit vehicles operating on welded rail, as outlined in the FTA Manual. Calculated noise levels associated with the Build Alternative Options were then compared with “moderate impact” and “severe impact” criteria according to existing ambient levels at a given receptor location, as described in Section 3.1.3.

A noise impact is considered to occur at a receptor location if the increased noise exposure for the receptor’s applicable land use category (Category 1, 2, or 3) is equal to or exceeds the FTA criterion for “moderate impact” or “severe impact,” as indicated on Figure 3-1, based on the existing noise exposure for the receptor. The Program assumes track configuration would be the same under both existing and future conditions as the Build Alternative Options’ route alternatives would use the existing railroad ROW; therefore, the focus of the evaluation was on the overall increase in daily train trips (two daily round-trips per day trips per day). The impact criteria are described in detail in Section 3.

Traffic

The Build Alternative Options were not estimated to result in any substantial capacity or operational improvements to existing traffic facilities. Changes in traffic noise, as a result of the Build Alternative Options, were based on anticipated changes in ridership because of the Program and subsequent potential effects on traffic noise levels.

A traffic noise impact is considered to occur where the increase in traffic volume on a given road segment would result in a 3 dBA increase relative to existing conditions. A traffic noise increase of 3 dBA is generally barely perceptible, while a 5 dBA increase is clearly noticeable (Caltrans 2009).

4.2 Vibration

4.2.1 Construction Vibration

Ground-borne vibration during construction of the Build Alternative Options was analyzed using the methodology discussed in Chapter 12 of the FTA Manual. The vibration source levels for typical construction equipment types, as depicted in Table 4-2, are expressed in terms of PPV in inches per second at a reference distance of 25 feet from the source and root-mean-square VdB at 25 feet. For this evaluation, a vibratory roller (source vibration level of 0.210 inch per second PPV) was identified as the piece of non-impact equipment that could produce the highest vibration levels. Impact-producing equipment types, such as pile drivers, are a substantial source of vibration, as depicted in Table 4-2.

Table 4-2. Typical Construction Equipment Vibration Levels

Equipment	Range	PPV at 25 Feet (inch/second)	Vibration Level at 25 Feet, VdB (approximate)
Pile driver (impact)	Upper range	1.518	112
Pile driver (impact)	Typical	0.644	104
Pile driver (sonic)	Upper range	0.734	105
Pile driver (sonic)	Typical	0.170	93
Clam shovel drop (slurry wall)	—	0.202	94
Vibratory roller	—	0.210	94
Large bulldozer	—	0.089	87
Loaded truck	—	0.076	86
Jackhammer	—	0.035	79
Small bulldozer	—	0.003	58

Source: FTA 2018

Notes:

PPV=peak particle velocity (inch per second); VdB=vibration velocity decibels

Vibration from construction equipment could cause damage to architectural resources adjacent to the Build Alternative Options' route alternatives. The potential for building damage was determined by using FTA methodology, including the damage potential vibration thresholds described under FTA Vibration Impact Criteria in Section 3.

A construction-related vibration impact is considered to occur if vibration levels from construction equipment are perceptible at a receiving residential land use (i.e., 75 VdB, described as the annoyance impact criterion for "occasional events" at Category 2 land uses, depicted in Table 3-2). A vibration impact resulting in building damage could occur at a PPV of 0.20 inch per second. This is based on the FTA criterion for fragile buildings.

4.2.2 Operational Vibration

The FTA procedure for a general vibration assessment was used for the evaluation of ground-borne vibration levels from trains within the Program Corridor. For the operational vibration evaluation, the number of daily events was classified under the FTA category of "frequent events" for the Western Section, which corresponds to more than 70 vibration events from freight, intercity passenger, and commuter trains per day, as defined in Table 3-2. For the Eastern Section, the number of daily events was classified under the FTA category of "occasional events," which corresponds to between 30 and 70 vibration events from freight and intercity passenger trains per day. Land use designations for Category 2 (residences and lodging facilities) and Category 3 (institutional use) were used in the evaluation.

Vibration source levels were derived from the FTA Manual using the generalized surface vibration curve for locomotive-powered passenger or freight vehicles. Soil propagation characteristics were assumed to be normal. For the generalized ground surface vibration curve, root-mean-square velocity-level data at the receptor were used, with the distance of interest adjusted according to vehicle speed (a maximum of 79 miles per hour was assumed throughout the Program Corridor), wheel condition (normal), track condition (normal), track treatments, and the number of floors above grade to receptor locations. Vibration-level adjustments for special track work were applied as applicable in areas adjacent to vibration-sensitive land uses.

Ground-borne vibration impact criteria for the FTA general assessment were used to assess vibration impacts from train operations. Impacts would be triggered at a vibration-sensitive location if future vibration levels were to exceed the FTA general assessment criteria under FTA Vibration Impact Criteria in Section 3, and predicted future vibration levels were to exceed existing vibration levels by 3 VdB or more.

4.3 Tier 1/Program EIS/EIR Study Area

The Tier 1/Program EIS/EIR Study Area for noise includes land uses that could be subject to Program-related transit noise impacts. Although all developed land uses were evaluated in this analysis, the focus of the impact evaluation was on outdoor locations with frequent human use, institutional land uses, and residential buildings where people normally sleep.

5 Existing Conditions

5.1 Physical Setting

5.1.1 Noise- and Vibration-Sensitive Land Uses

The Program Corridor crosses a large geographic area within Southern California, spanning approximately 144 miles from its western terminus in Los Angeles to its eastern terminus in Indio or Coachella. The Program Corridor occurs within an existing railroad corridor that traverses areas that have predominately been heavily modified for urban purposes, especially in the Western Section, although some areas occur in, or adjacent to, lands that are in a natural condition. Much of the Program Corridor from Los Angeles to Redlands is urbanized. The Eastern Section of the Program Corridor east of Colton is less urbanized with vacant land comprising of the largest land use category.

Build Alternative Option 1 (Coachella Terminus)

Almost the entire Western Section of the Program Corridor passes through highly developed urban and suburban areas, including many areas with adjacent sensitive land uses, such as residences (Category 2), schools (Category 3), and other institutional uses (Category 3). The Western Section also extends through many commercial and industrial areas, which are generally not noise sensitive unless they are associated with areas of frequent outdoor use.

The Eastern Section of the Program Corridor is highly developed in many locations, but also passes through sparsely populated rural areas and open space areas, including a large wind farm west of Palm Springs. There are several single- and multifamily residences (Category 2), lodging uses (Category 2), churches (Category 3), schools (Category 3), and other institutional uses (Category 3) within the Program Corridor. No Category 1 land uses were identified within the Program Corridor. Additional details related to land use within the Program Corridor, parks and schools located within the Program Corridor, and potentially historic buildings (which may be affected by vibration) are provided in Section 3.2, Land Use and Planning; Section 3.13, Cultural Resources; and Section 3.14, Parklands and Community Services, of the Tier 1/Program EIS/EIR.

Build Alternative Option 2 (Indio Terminus)

Distribution of existing land uses within the Western Section of the Program Corridor under Build Alternative Option 2 are the same as Build Alternative Option 1; however, there are fewer acres of land within the Program Corridor under Build Alternative Option 2 because of the shorter route alignment and reduced station options. Build Alternative Option 2 still contains several single- and multifamily residences (Category 2), lodging uses (Category 2), churches (Category 3), schools (Category 3), and other institutional uses (Category 3) within the Eastern Section.

Build Alternative Option 3 (Indio Terminus with Limited Third Track)

Potential sensitive land uses within the Program Corridor under Build Alternative Option 3 are the same as those identified for Build Alternative Option 2.

5.1.2 Existing Noise and Vibration Sources

The urban setting that constitutes most of the Western Section of the Program Corridor contains a mix of transportation and stationary noise sources associated with a highly developed area. Within the Eastern Section of the Program Corridor, there is a mix of urban, suburban, and rural areas that contain a similar mix of transportation and stationary noise sources. Noise from freeway and local traffic, transit, aircraft, heavy equipment, and industrial and commercial sources contribute to ambient noise along the Program Corridor. Train and traffic operations are assumed to be primary contributors to ambient noise in the Tier 1/Program EIS/EIR Study Area. The different types of train and traffic sources that contribute to ambient noise along the Program Corridor are discussed below.

Train Operations

Table 5-1 presents existing train operations from the three host railroads (host railroads have ownership and operating rights to the railroad sections) along the Program Corridor for all Build Alternative Options – Union Pacific Railroad, BNSF, and Southern California Regional Rail Authority (Metrolink). Operations vary considerably by segment; however, both the Western and Eastern Sections of the Program Corridor have high-density, multiple-track main lines that support freight and passenger rail operations, which contribute to existing noise and vibration levels in the Tier 1/Program EIS/EIR Study Area. The highest density segment in the Western Section is between Los Angeles and Fullerton and has an average of 86 daily trains, while the lowest density segment is between Fullerton and Atwood and has an average of 43 daily trains. The Eastern Section averages 43 daily trains along the Colton-Coachella segment, consisting of freight and passenger trains.

Table 5-1. Existing Year (2018) Daily Train Operations within Program Corridor (One-Way Trips)

Endpoints	Eastbound Commuter Trains (SCRRA)	Westbound Commuter Trains (SCRRA)	Eastbound Intercity Trains (Amtrak, Pacific Surfliner)	Westbound Intercity Trains (Amtrak, Pacific Surfliner)	Eastbound Long Distance Passenger Trains (Amtrak)	Westbound Long Distance Passenger Trains (Amtrak)	Eastbound Freight Trains (UP, BNSF)	Westbound Freight Trains (UP, BNSF)	Total Average Daily Volume of Trains
Western Section (SCRRA – Host Railroad; Additional Operators – Amtrak, BNSF)									
Los Angeles (Union Station-Soto)[a]	14	14	12	12	1	1	0.5	0.5	55
Western Section (BNSF – Host Railroad; Additional Operators – Amtrak, SCRRA, UP)									
Los Angeles (Soto)[a] – Fullerton	14	14	12	12	1	1	16	16	86
Fullerton-Atwood	5	4	0	0	1	1	16	16	43
Atwood-Riverside	13	12	0	0	1	1	17	17	61
Riverside-Highgrove	10	10	0	0	1	1	27	27	76
Highgrove-Colton	4	4	0	0	1	1	27	27	64
Eastern Section (UP – Host Railroad; Additional Operator – Amtrak)									
Colton-Coachella	0	0	0	0	0.5	0.5	21	21	43

Notes:

Daily train counts represent revenue train movements on a weekday (Monday-Friday). Freight train counts are based on Base Year (2013) daily freight train totals for the line segments shown above, as published in the 2018 California State Rail Plan, Appendix A.4, Table 20. Passenger and commuter train counts are based on the following public timetables in effect in September 2018: Metrolink “All Lines” timetable effective May 14, 2018, the 2018 LOSSAN Southern California Passenger Rail System Map and Timetables effective April 1, 2018, the Amtrak Southwest Chief timetable effective July 31, 2018, and the Amtrak Sunset Limited timetable effective March 11, 2018.

* Soto interlocking (Milepost 144.4) in Los Angeles

LOSSAN=Los Angeles-San Diego-San Luis Obispo; SCRRA=Southern California Regional Rail Authority; UP=Union Pacific Railroad

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Metrolink operates commuter trains in the Western Section and provides primarily peak-hour service to and from Los Angeles. Three different Metrolink commuter rail lines use some portion of the Western Section. Metrolink 91/Perris Valley Line trains operating between Los Angeles, Riverside, and Perris serve commuter rail stations in the Western Section between Los Angeles and Highgrove. Metrolink Orange County Line trains operating between Los Angeles and Oceanside serve commuter rail stations in the Western Section between Los Angeles and Fullerton. Metrolink Inland Empire-Orange County Line trains operating between Oceanside and San Bernardino serve commuter rail stations in the Western Section between Atwood (east of Fullerton) and Colton under Build Alternative Options 1, 2, and 3. These account for up to 50 one-way trips per day along some portion of the Western Section (a fourth Metrolink commuter line, the Riverside Line operating between Los Angeles and Riverside uses an alternate, parallel freight line between its two endpoints but shares common stations with 91 Line/Perris Valley Line trains at Los Angeles and Riverside-downtown).

Intercity passenger service is provided by Amtrak, which operates two types of trains in the Program Corridor, state-supported regional passenger trains and long-distance trains. The state-supported Pacific Surfliner trains operating between San Luis Obispo, Los Angeles, and San Diego serve Amtrak stations in the Western Section of the Program Corridor at Los Angeles and Fullerton. These account for 24 one-way trips per day in the Western Section. Amtrak's Southwest Chief long-distance train, operating between Los Angeles and Chicago, serves Amtrak stations in the Western Section at Los Angeles, Fullerton, and Riverside. This train accounts for two one-way trips per day along the Western Section of the Program Corridor.

Amtrak also operates one long-distance passenger train in the Eastern Section of the Program Corridor. The Sunset Limited train operating between Los Angeles and New Orleans serves the existing Amtrak station in the Eastern Section at Palm Springs. This train operates three days per week in each direction and accounts for 0.5 one-way trips per day along the Eastern Section.

Passenger trains, such as commuter and intercity trains, are operated on specific schedules and operate at higher maximum authorized speeds than freight trains using the Program Corridor. The number of freight trains per day, and their days and times of operation, can vary depending on customer requirements, including volumes at the ports of Los Angeles and Long Beach.[1]

[1] The evaluation in Table 5-1 assumes that freight trains would consist of an average of three locomotives and 75 cars each.

Freight and commuter trains are required to sound horns within 0.25 mile of grade crossings. This safety measure warns motor vehicle operators of an approaching train and is required under FRA regulations. Several grade crossings along the Western and Eastern sections are located near noise-sensitive uses.

Highways and Local Roads

Traffic noise from cars and trucks is a primary source of ambient noise in the Tier 1/Program EIS/EIR Study Area. Many highways and local roads serve commuter and heavy trucking demands in both the Western and Eastern Sections of the Program Corridor. Heavy trucks and buses are intermittent sources of vibration on local roads.

In the Western Section of the Tier 1/Program EIS/EIR Study Area, the three most important east to west regional highways include Interstate (I) 10, State Route (SR) 60, and SR 91.

In the Eastern Section, the Tier 1/Program EIS/EIR Study Area is served by I-10, SR 60, and SR 111. Within the Coachella Valley, the main roadways that carry vehicles to the San Gorgonio Pass are I-10 and SR 111. The I-10 runs along the northeastern rim of the Coachella Valley while SR 111 runs approximately 30 miles along the southwestern rim of the Coachella Valley and serves as the main arterial highway between almost all Coachella Valley cities.

5.2 Existing Noise Levels

Existing noise levels are calculated using methods in the FTA Manual, based on the existing frequency of train events. Day/night noise levels from total daily train operations were calculated for wayside and horn noise, based on the existing operations depicted in Table 5-1. Calculated ambient noise levels from existing train operation are depicted in Table 5-2.

In addition to rail operational noise, traffic noise from cars and trucks is a primary source of ambient noise within the Program Corridor. Many highways and local roads serve commuter and heavy trucking demands in both the Western and Eastern Section of the Program Corridor, including I-10, SR 60, and SR 91 in the Western Section and I-10, SR 60, and SR 111 in the Eastern Section.

Table 5-2. Ambient Noise Levels within Program Corridor from Existing Train Operations

Section	Train Noise Source	Ranges of Distance from Track (feet)	Range of Total Average Daily L_{dn} (dBA)	Range of Average L_{eq} (1 hour) (dBA)
Western Section				
Los Angeles (Union Station-Soto[a])	Wayside noise from train passbys	50 – 150	63.4 – 70.5	58.4 –65.5
Los Angeles (Union Station-Soto[a])	Horn noise levels within 0.25 mile of grade crossings	50 – 150	68.7 – 81.0	69.8 – 77.0
Los Angeles (Soto[a]-Fullerton)	Wayside noise from train passbys	50 - 150	70.6 – 77.8	64.6 –71.8
Los Angeles (Soto[a]-Fullerton)	Horn noise levels within 0.25 mile of grade crossings	50 – 150	74.1 – 83.4	71.4 – 78.6
Fullerton−Atwood	Wayside noise from train passbys	50 – 150	70.2 – 77.4	63.8 – 71.0
Fullerton‐Atwood	Horn noise levels within 0.25 mile of grade crossings	50 – 150	73.1 – 81.3	67.8 – 75.0
Atwood-Riverside	Wayside noise from train passbys	50 – 150	70.7 – 77.8	64.3 – 71.5
Atwood-Riverside	Horn noise levels within 0.25 mile of grade crossings	50 – 150	73.8 – 82.4	69.6 – 76.8
Riverside‐Highgrove	Wayside noise from train passbys	50 – 150	72.4 – 79.6	66.2 – 73.3
Riverside‐Highgrove	Horn noise levels within 0.25 mile of grade crossings	50 – 150	75.4 – 83.5	70.5 – 77.6
Highgrove‐Colton	Wayside noise from train passbys	50 – 150	72.4 – 79.5	66.0 – 73.2
Highgrove‐Colton	Horn noise levels within 0.25 mile of grade crossings	50 – 150	75.3 – 82.9	69.6 – 76.8

Section	Train Noise Source	Ranges of Distance from Track (feet)	Range of Total Average Daily L_{dn} (dBA)	Range of Average L_{eq} (1 hour) (dBA)
Eastern Section				
Colton-Coachella	Wayside noise from train passbys	50 – 150	71.0 – 78.2	64.8 – 71.9
Colton-Coachella	Horn noise levels within 0.25 mile of grade crossings	50 – 150	73.9 – 81.1	67.6 – 74.8

Notes:

[a] Soto interlocking (Milepost 144.4) in Los Angeles

dBA=A-weighted decibel; L_{dn}=day-night average noise level; L_{eq}=hourly equivalent A-weighted noise level

5.3 Existing Vibration Levels

Existing vibration sources in the Tier 1/Program EIS/EIR Study Area include train traffic in the Western and Eastern Sections of the existing Program Corridor and motor vehicle traffic on freeways and local arterial streets. Existing vibration levels were not quantified in this evaluation, because FTA classification of vibration events would not change under future conditions with implementation of any of the Build Alternative Options. The Program would add two daily round-trips to existing train traffic; however, this increase would not be to a level that would result in a change in the overall FTA category from a vibration perspective. For the purposes of this evaluation, existing vibration levels are considered the same under Build Alternative Options 1, 2, and 3.

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6 Environmental Consequences

6.1 Overview

Effects as a result of implementing the Build Alternative Options can be broadly classified into construction and operational effects. Both short-term or temporary effects and long-term or permanent noise and vibration effects would be anticipated as a result of constructing any of the Build Alternative Options.

Construction effects associated with noise and vibration are generally short term and are due to the use of construction equipment and vehicles, as well as operation of on-site materials processing and handling, such as concrete plants. The potential construction effects on noise and vibration are evaluated based on the intensity and duration of the construction activities. The longer the construction period and the more non-road construction equipment used (such as cranes, bulldozers, heavy duty trucks, and concrete batch plants), the greater the potential for construction noise and vibration effects.

Noise and vibration effects could also result from operation of any of the Build Alternative Options as the addition of two daily roundtrips would result in the increase of passenger rail trains traveling within the Program Corridor and the addition of new station facilities (e.g., new sources of mobile and stationary noise).

For both operation and construction, Build Alternative Option 1 is anticipated to result in the greatest noise and vibration impact due to a longer route alignment (i.e., addition of Indio to Coachella segment) and additional station option (Coachella Station option). When compared with Build Alternative Option 1, Build Alternative Option 2 may have slightly reduced effects due to a slightly smaller footprint associated with a shorter route alignment and fewer station options. When compared with Build Alternative Options 1 or 2, Build Alternative Option 3 may have slightly reduced effects due to a smaller footprint associated with a shorter route alignment, fewer station options, and reduced third track rail infrastructure. The magnitude of effects for all three Build Alternative Options would be similar when compared with the No Build Alternative, and, potential noise and vibration impacts as a result of the Program are conservatively evaluated largely in the context of the most intense alternative: Build Alternative Option 1. Site-specific sensitive land uses potentially affected by the Program would be further identified as part of the Tier 2/Project-level environmental review process. Specific types and degrees of noise and vibration impacts on sensitive receptors would not be known until further design and construction information is known.

6.2 No Build Alternative

Under the No Build Alternative, there would be no Program-related construction or increase in service. Ambient noise and vibration levels from existing train operations and local traffic would continue.

The No Build Alternative assumes completion of those reasonably foreseeable transportation, development, and infrastructure projects that are already in progress, are programmed, or are included in the fiscally constrained regional transportation plan, including several existing and committed transportation improvement projects in the Western Section. These projects would result in an increase in freight service, as well as an increase in passenger rail services in the Western Section, which may increase noise and vibration levels; however, the expected increase in rail service would occur within the existing rail ROW.

An increase in traffic and vehicle miles traveled is expected with the No Build Alternative because more cars would be on the roadways compared with what would occur with implementation of the Program. Therefore, traffic congestion is likely to worsen with the No Build Alternative. An increase in rail service and an increase in cars on the roadways would not result in new impacts because ambient noise and vibration levels from existing train operations and local traffic would continue.

6.3 Build Alternative Options 1, 2, and 3

6.3.1 Western Section

Construction

The Build Alternative Options would not require construction of additional rail or station infrastructure in the Western Section of the Program Corridor because the existing railroad and stations from LAUS to Colton would be used. When compared with the No Build Alternative, short-term/temporary effects associated with noise-level increases would be negligible because no additional construction activities are planned within the Western Section of the Program Corridor under Build Alternative Options 1, 2, and 3.

Operation

Current (2018) daily rail traffic volumes on the Western Section (as shown in Table 5-1) vary by segment. The highest density segment is between Los Angeles and Fullerton and has an average of 86 daily trains, while the lowest density segment is between Fullerton and Atwood and has an average of 43 daily trains. An additional two daily round-trip intercity passenger trains, even when compared with the lowest density segment, would represent a 9-percent increase in train activity compared with current (2018) traffic volume along the existing railroad ROW. In 2024 and 2044, the Build Alternative Options would add the same number of rail operations to higher baseline conditions. Therefore, the Program's effects in 2024 (6-percent increase) (RCTC and FRA 2021) and 2044 (3-percent increase) would be lower than those evaluated under existing conditions for the lowest density segment. The following evaluation considers the current (2018) traffic volumes.

Rail Noise

A noise analysis was conducted using FTA methodologies to calculate existing and projected noise levels in the Western Section of the Program Corridor under Build Alternative Options 1, 2, and 3. Industrial, commercial, and noise-sensitive residential receptors are adjacent to the Build Alternative Options' route alternatives throughout the Program Corridor; therefore, noise levels were computed at distances of 50, 100, and 150 feet from the Build Alternative Options' route alignments to be representative of the high-end range of rail noise levels.

Table 6-1 details the assumed equipment consist for intercity passenger rail service under all of the Build Alternative Options. This consist would use equipment identical to the state-supported Pacific Surfliner trains currently providing state-supported intercity passenger service on regional routes serving LAUS.

Table 6-1. Coachella Valley – San Gorgonio Pass Corridor Service Intercity Passenger Train Consist

Equipment Type	Units per Trainset
P42 diesel locomotive+	1
Pacific Surfliner Business Class (77 revenue seats)	1
Pacific Surfliner Coach Café (72 revenue seats)	1
Pacific Surfliner Coach (90 revenue seats)	1
Pacific Surfliner Cab Coach Baggage Car (82 revenue seats)	1
Revenue Seating Capacity of Trainset	321
Patrons/crew on Board	200*
Maximum Authorized Speed	79 mph
Train Weight	360 tons
Train Horsepower per Ton	10.69

Equipment Type	Units per Trainset
Train Length	410 feet
Train Length (without locomotive)	340 feet

Notes:

+ FRA selected a P42 passenger locomotive as the preferred motive power for the Coachella Valley project's operations simulation modeling of the proposed intercity passenger service, owing to a lack of real-world performance data for the Siemens Charger locomotive, which precluded the development of a Charger locomotive model for the Rail Traffic Controller operations simulation software.

* Patrons/crew on board projection based on 2044 ridership forecast presented in the Program's Alternatives Analysis report.

FRA=Federal Railroad Administration

Table 6-2 summarizes a conceptual train schedule for the proposed new intercity passenger service under Build Alternative Option 1, 2, and 3. The Build Alternative Options would result in the addition of four daytime (7:00 a.m. to 10:00 p.m.) one-way intercity train trips per day along the Western Section between Los Angeles and Colton.

Table 6-2. Proposed Coachella Valley – San Gorgonio Pass Rail Corridor Service Conceptual Train Schedule (Build Alternative Options 1, 2, and 3)

Eastbound: Read Down		Miles	Stations	Miles	Westbound: Read Up	
Los Angeles – Indio: Build Alternative Option 1, 2, and 3						
750	752	—	Train No.	—	751	753
10:20 AM	3:20 PM	0	Los Angeles	144	12:40 PM	6:40 PM
10:28 AM	3:28 PM	*5*	Soto (no stop)	*139*	*12:26 PM*	*6:26 PM*
10:55 AM	3:55 PM	26	Fullerton	118	12:06 PM	6:06 PM
11:39 AM	4:39 PM	62	Riverside	82	11:22 AM	5:22 PM
11:47 AM	4:47 PM	*68*	*Colton (no stop)*	*76*	*11:12 AM*	*5:12 PM*
11:59 AM	4:59 PM	72	Loma Linda	72	10:59 AM	4:59 PM
12:38 PM	5:38PM	103	Pass Area	41	10:20 AM	4:20 PM
1:02 PM	6:02 PM	118	Palm Springs	26	9:59 AM	3:59 PM
1:14 PM	6:14 PM	128	Mid Valley	16	9:45 AM	3:45 PM
1:30 PM	6:30 PM	141	Indio	3	9:32 AM	3:32 PM
Indio to Coachella – Build Alternative Option 1 only						
1:38 PM	6:38 PM	144	Coachella	0	9:25 AM	3:25 PM

Current average daily rail volumes in the Program Corridor range from 43 to 86 trains, consisting of freight, passenger, and commuter trains. The addition of four daily intercity trips would result in a cumulative total of up to 90 one-way trips per day on the Los Angeles-Fullerton segment, which carries the highest volume of trains. Loudest conditions occur on the Riverside-Highgrove segment, where a higher volume of daily freight trains contributes to ambient noise levels in this area. A summary of train volumes under existing and with-Program conditions is shown in Table 6-3.

Table 6-3. Summary of Train Volumes under Existing (2018) and with-Program Conditions (Build Alternative Options 1, 2, and 3)

Endpoints	Existing Freight One-way Train Trips (both directions)	Existing Passenger One-way Train Trips (both directions)	Total Existing Daily Volume of Trains (both directions)	Program Passenger One-way Train Trips (both directions)	Total With-Program Daily Volume of Trains (both directions)
Western Section (Metrolink – Host Railroad; Additional Operators – Amtrak, BNSF)					
Los Angeles Union Station-Soto*	1	54	55	4	59
Western Section (BNSF– Host Railroad; Additional Operators – Amtrak, Metrolink, Union Pacific)					
Los Angeles (Soto*) – Fullerton	32	54	86	4	90
Fullerton-Atwood	32	11	43	4	47
Atwood-Riverside	34	27	61	4	65
Riverside-Highgrove	54	22	76	4	80
Highgrove-Colton	54	10	64	4	68
Eastern Section (Union Pacific– Host Railroad; Additional Operator – Amtrak)					
Colton-Coachella	42	1	43	4	47

Notes:

Daily train counts represent revenue train movements on a weekday (Monday-Friday). Freight train counts are based on Base Year (2013) daily freight train totals for the line segments shown above, as published in the 2018 California State Rail Plan, Appendix A.4, Table 20. Passenger and commuter train counts are based on the following public timetables in effect in September 2018: Metrolink "All Lines" timetable effective May 14, 2018, the 2018 LOSSAN Southern California Passenger Rail System Map and Timetables effective April 1, 2018, the Amtrak Southwest Chief timetable effective July 31, 2018, and the Amtrak Sunset Limited timetable effective March 11, 2018.

* Soto interlocking (Milepost 144.4) in Los Angeles

Noise level calculations for train operations are depicted in Table 6-4 and Table 6-5. These trains would serve the Western Section of the Program Corridor from LAUS to the City of Colton. The results of the analysis are separated by wayside (engine and wheel/rail noise) and warning horn noise (at the at-grade grade crossings). Noise levels are shown in terms of L_{dn} for Category 2 uses and L_{eq} for Category 3 uses, consistent with FTA methodology described in Section 3.1.3. As depicted in Table 6-4, no impacts are predicted to occur at Category 2 (residential/lodging) land uses at 50 feet from grade crossings. No impacts are predicted to occur at Category 3 (institutional) uses, as depicted in Table 6-5.

Table 6-4. Western Section Noise Levels from Existing-plus-Program Train Operations, Category 2 (Residential) Land Uses

Endpoints	Train Noise Source	Distance from Track (feet)	Existing Average Daily Ldn (dBA)	Program Ldn (dBA)	Combined Ldn (dBA)	Increase over Existing, dB	Moderate Impact Threshold (Program L_{dn})[a]	Severe Impact Threshold (Program L_{dn})[a]	Impact?
LAUS-Soto*	Wayside noise[b]	50	70.5	50.7	70.5	0.0	66 L_{dn}	70 L_{dn}	None
LAUS-Soto*	Wayside noise[b]	100	66.0	46.2	66.0	0.0	62 L_{dn}	67 L_{dn}	None
LAUS-Soto*	Wayside noise[b]	150	63.4	43.6	63.4	0.0	60 L_{dn}	65 L_{dn}	None
LAUS-Soto*	Horn noise[c]	50	81.0	64.6	81.1	+ 0.1	66 L_{dn}	75 L_{dn}	None
LAUS-Soto*	Horn noise[c]	100	71.3	60.1	71.6	+ 0.3	66 L_{dn}	70 L_{dn}	None
LAUS-Soto*	Horn noise[c]	150	68.7	57.5	69.0	+ 0.3	64 L_{dn}	69 L_{dn}	None
Los Angeles (Soto*)-Fullerton	Wayside noise[b]	50	77.8	50.7	77.8	0.0	66 L_{dn}	75 L_{dn}	None
Los Angeles (Soto*)-Fullerton	Wayside noise[b]	100	73.2	46.2	73.2	0.0	66 L_{dn}	71 L_{dn}	None
Los Angeles (Soto*)-Fullerton	Wayside noise[b]	150	70.6	43.6	70.6	0.0	66 L_{dn}	70 L_{dn}	None
Los Angeles (Soto*)-Fullerton	Horn noise[c]	50	83.4	64.6	83.5	+ 0.1	66 L_{dn}	75 L_{dn}	None
Los Angeles (Soto*)-Fullerton	Horn noise[c]	100	76.7	60.1	76.8	+ 0.1	66 L_{dn}	74 L_{dn}	None
Los Angeles (Soto*)-Fullerton	Horn noise[c]	150	74.1	57.5	74.2	+ 0.1	66 L_{dn}	72 L_{dn}	None
Fullerton-Atwood	Wayside noise[b]	50	77.4	50.7	77.4	0.0	66 L_{dn}	74 L_{dn}	None

Endpoints	Train Noise Source	Distance from Track (feet)	Existing Average Daily Ldn (dBA)	Program Ldn (dBA)	Combined Ldn (dBA)	Increase over Existing, dB	Moderate Impact Threshold (Program L_{dn})[a]	Severe Impact Threshold (Program L_{dn})[a]	Impact?
Fullerton-Atwood	Wayside noise[b]	100	72.9	46.2	72.9	0.0	66 L_{dn}	71 L_{dn}	None
Fullerton-Atwood	Wayside noise[b]	150	70.2	43.6	70.2	0.0	65 L_{dn}	69 L_{dn}	None
Fullerton-Atwood	Horn noise[c]	50	81.3	64.6	81.4	+ 0.1	66 L_{dn}	75 L_{dn}	None
Fullerton-Atwood	Horn noise[c]	100	75.8	60.1	75.9	+ 0.1	66 L_{dn}	74 L_{dn}	None
Fullerton-Atwood	Horn noise[c]	150	73.1	57.5	73.2	+ 0.1	66 L_{dn}	71 L_{dn}	None
Atwood-Riverside	Wayside noise[b]	50	77.8	50.7	77.8	0.0	66 L_{dn}	75 L_{dn}	None
Atwood-Riverside	Wayside noise[b]	100	73.3	46.2	73.3	0.0	66 L_{dn}	71 L_{dn}	None
Atwood-Riverside	Wayside noise[b]	150	70.7	43.6	70.7	0.0	66 L_{dn}	70 L_{dn}	None
Atwood-Riverside	Horn noise[c]	50	82.4	64.6	82.5	+ 0.1	66 L_{dn}	75 L_{dn}	None
Atwood-Riverside	Horn noise[c]	100	76.4	60.1	76.5	+ 0.1	66 L_{dn}	74 L_{dn}	None
Atwood-Riverside	Horn noise[c]	150	73.8	57.5	73.9	+ 0.1	66 L_{dn}	72 L_{dn}	None
Riverside-Highgrove	Wayside noise[b]	50	79.6	50.7	79.6	0.0	66 L_{dn}	75 L_{dn}	None
Riverside-Highgrove	Wayside noise[b]	100	75.1	46.2	75.1	0.0	66 L_{dn}	73 L_{dn}	None
Riverside-Highgrove	Wayside noise[b]	150	72.4	43.6	72.4	0.0	66 L_{dn}	71 L_{dn}	None
Riverside-Highgrove	Horn noise[c]	50	83.5	64.6	83.6	+ 0.1	66 L_{dn}	75 L_{dn}	None

Endpoints	Train Noise Source	Distance from Track (feet)	Existing Average Daily Ldn (dBA)	Program Ldn (dBA)	Combined Ldn (dBA)	Increase over Existing, dB	Moderate Impact Threshold (Program L_{dn})[a]	Severe Impact Threshold (Program L_{dn})[a]	Impact?
Riverside-Highgrove	Horn noise[c]	100	78.1	60.1	78.2	+ 0.1	66 L_{dn}	75 L_{dn}	None
Riverside-Highgrove	Horn noise[c]	150	75.4	57.5	75.5	+ 0.1	66 L_{dn}	73 L_{dn}	None
Highgrove-Colton	Wayside noise[b]	50	79.5	50.7	79.5	0.0	66 L_{dn}	75 L_{dn}	None
Highgrove-Colton	Wayside noise[b]	100	75.0	46.2	75.0	0.0	66 L_{dn}	73 L_{dn}	None
Highgrove-Colton	Wayside noise[b]	150	72.4	43.6	72.4	0.0	66 L_{dn}	71 L_{dn}	None
Highgrove-Colton	Horn noise[c]	50	82.9	64.6	83.0	+ 0.1	66 L_{dn}	75 L_{dn}	None
Highgrove-Colton	Horn noise[c]	100	77.9	60.1	78.0	+ 0.1	66 L_{dn}	75 L_{dn}	None
Highgrove-Colton	Horn noise[c]	150	75.3	57.5	75.4	+ 0.1	66 L_{dn}	73 L_{dn}	None

Notes:

[a] Moderate and severe impacts are compared with the Program's contribution to existing levels (i.e., the Program L_{dn}). These thresholds do not apply to the combined L_{dn}.

[b] Wayside noise from train passbys

[c] Horn noise levels within 0.25 mile of grade crossings

LAUS=Los Angeles Union Station; L_{dn}=Day-night average noise level; L_{eq}=Hourly equivalent A-weighted noise level; dBA=A-weighted decibel

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Table 6-5. Western Section Noise Levels from Existing-plus-Program Train Operations, Category 3 (Institutional) Land Uses within the Tier 1/Program EIS/EIR Study Area

Endpoints	Train Noise Source	Distance from Track (feet)	Existing Average Daily Leq (dBA)	Program Leq (dBA)	Combined Leq (dBA)	Increase over Existing	Moderate Impact Threshold (Program L_{eq})[a]	Severe Impact Threshold (Program L_{eq})[a]	Impact?
LAUS-Soto*	Wayside noise[b]	50	65.5	52.8	65.7	+ 0.2	67 L_{eq}	72 L_{eq}	None
LAUS-Soto*	Wayside noise[b]	100	61.0	48.3	61.2	+ 0.2	64 L_{eq}	69 L_{eq}	None
LAUS-Soto*	Wayside noise[b]	150	58.4	45.6	58.6	+ 0.2	62 L_{eq}	67 L_{eq}	None
LAUS-Soto*	Horn noise[c]	50	77.0	66.7	77.4	+ 0.4	71 L_{eq}	79 L_{eq}	None
LAUS-Soto*	Horn noise[c]	100	72.5	62.2	72.9	+ 0.4	71 L_{eq}	76 L_{eq}	None
LAUS-Soto*	Horn noise[c]	150	69.8	59.5	70.2	+ 0.4	70 L_{eq}	74 L_{eq}	None
Los Angeles (Soto*)-Fullerton	Wayside noise[b]	50	71.8	52.8	71.9	+ 0.1	71 L_{eq}	76 L_{eq}	None
Los Angeles (Soto*)-Fullerton	Wayside noise[b]	100	67.2	48.3	67.3	+ 0.1	68 L_{eq}	72 L_{eq}	None
Los Angeles (Soto*)-Fullerton	Wayside noise[b]	150	64.6	45.6	64.7	+ 0.1	66 L_{eq}	71 L_{eq}	None
Los Angeles (Soto*)-Fullerton	Horn noise[c]	50	78.6	66.7	78.9	+ 0.3	71 L_{eq}	80 L_{eq}	None
Los Angeles (Soto*)-Fullerton	Horn noise[c]	100	74.1	62.2	74.4	+ 0.3	71 L_{eq}	77 L_{eq}	None
Los Angeles (Soto*)-Fullerton	Horn noise[c]	150	71.4	59.5	71.7	+ 0.3	71 L_{eq}	75 L_{eq}	None

Endpoints	Train Noise Source	Distance from Track (feet)	Existing Average Daily Leq (dBA)	Program Leq (dBA)	Combined Leq (dBA)	Increase over Existing	Moderate Impact Threshold (Program L_{eq})[a]	Severe Impact Threshold (Program L_{eq})[a]	Impact?
Fullerton-Atwood	Wayside noise[b]	50	71.0	52.8	71.1	+ 0.1	71 L_{eq}	75 L_{eq}	None
Fullerton-Atwood	Wayside noise[b]	100	66.5	48.3	66.6	+ 0.1	68 L_{eq}	72 L_{eq}	None
Fullerton-Atwood	Wayside noise[b]	150	63.8	45.6	63.9	+ 0.1	66 L_{eq}	70 L_{eq}	None
Fullerton-Atwood	Horn noise[c]	50	75.0	66.7	75.6	+ 0.6	71 L_{eq}	78 L_{eq}	None
Fullerton-Atwood	Horn noise[c]	100	70.5	62.2	71.1	+ 0.6	71 L_{eq}	75 L_{eq}	None
Fullerton-Atwood	Horn noise[c]	150	67.8	59.5	68.4	+ 0.6	68 L_{eq}	73 L_{eq}	None
Atwood-Riverside	Wayside noise[b]	50	71.5	52.8	71.6	+ 0.1	71 L_{eq}	76 L_{eq}	None
Atwood-Riverside	Wayside noise[b]	100	67.0	48.3	67.1	+ 0.1	68 L_{eq}	72 L_{eq}	None
Atwood-Riverside	Wayside noise[b]	150	64.3	45.6	64.4	+ 0.1	66 L_{eq}	70 L_{eq}	None
Atwood-Riverside	Horn noise[c]	50	76.8	66.7	77.2	+ 0.4	71 L_{eq}	79 L_{eq}	None
Atwood-Riverside	Horn noise[c]	100	72.3	62.2	72.7	+ 0.4	71 L_{eq}	76 L_{eq}	None
Atwood-Riverside	Horn noise[c]	150	69.6	59.5	70.0	+ 0.4	70 L_{eq}	74 L_{eq}	None
Riverside-Highgrove	Wayside noise[b]	50	73.3	52.8	73.3	0.0	71 L_{eq}	76 L_{eq}	None
Riverside-Highgrove	Wayside noise[b]	100	68.8	48.3	68.8	0.0	69 L_{eq}	74 L_{eq}	None
Riverside-Highgrove	Wayside noise[b]	150	66.2	45.6	66.2	0.0	67 L_{eq}	72 L_{eq}	None

Endpoints	Train Noise Source	Distance from Track (feet)	Existing Average Daily Leq (dBA)	Program Leq (dBA)	Combined Leq (dBA)	Increase over Existing	Moderate Impact Threshold (Program L_{eq})[a]	Severe Impact Threshold (Program L_{eq})[a]	Impact?
Riverside-Highgrove	Horn noise[c]	50	77.6	66.7	77.9	+ 0.3	71 L_{eq}	80 L_{eq}	None
Riverside-Highgrove	Horn noise[c]	100	73.1	62.2	73.4	+ 0.3	71 L_{eq}	76 L_{eq}	None
Riverside-Highgrove	Horn noise[c]	150	70.5	59.5	70.8	+ 0.3	71 L_{eq}	75 L_{eq}	None
Highgrove-Colton	Wayside noise[b]	50	73.2	52.8	73.2	0.0	71 L_{eq}	76 L_{eq}	None
Highgrove-Colton	Wayside noise[b]	100	68.7	48.3	68.7	0.0	69 L_{eq}	74 L_{eq}	None
Highgrove-Colton	Wayside noise[b]	150	66.0	45.6	66.0	0.0	67 L_{eq}	72 L_{eq}	None
Highgrove-Colton	Horn noise[c]	50	76.8	66.7	77.2	+ 0.4	71 L_{eq}	79 L_{eq}	None
Highgrove-Colton	Horn noise[c]	100	72.3	62.2	72.7	+ 0.4	71 L_{eq}	76 L_{eq}	None
Highgrove-Colton	Horn noise[c]	150	69.6	59.5	70.0	+ 0.4	70 L_{eq}	74 L_{eq}	None

Notes:

[a] Moderate and severe impacts are compared with the Program's contribution to existing levels (i.e., the Program L_{dn}). These thresholds do not apply to the combined L_{dn}.

[b] Wayside noise from train passbys

[c] Horn noise levels within 0.25 mile of grade crossings

LAUS=Los Angeles Union Station; L_{dn}=Day-night average noise level; L_{eq}=Hourly equivalent A-weighted noise level; dBA=A-weighted decibel

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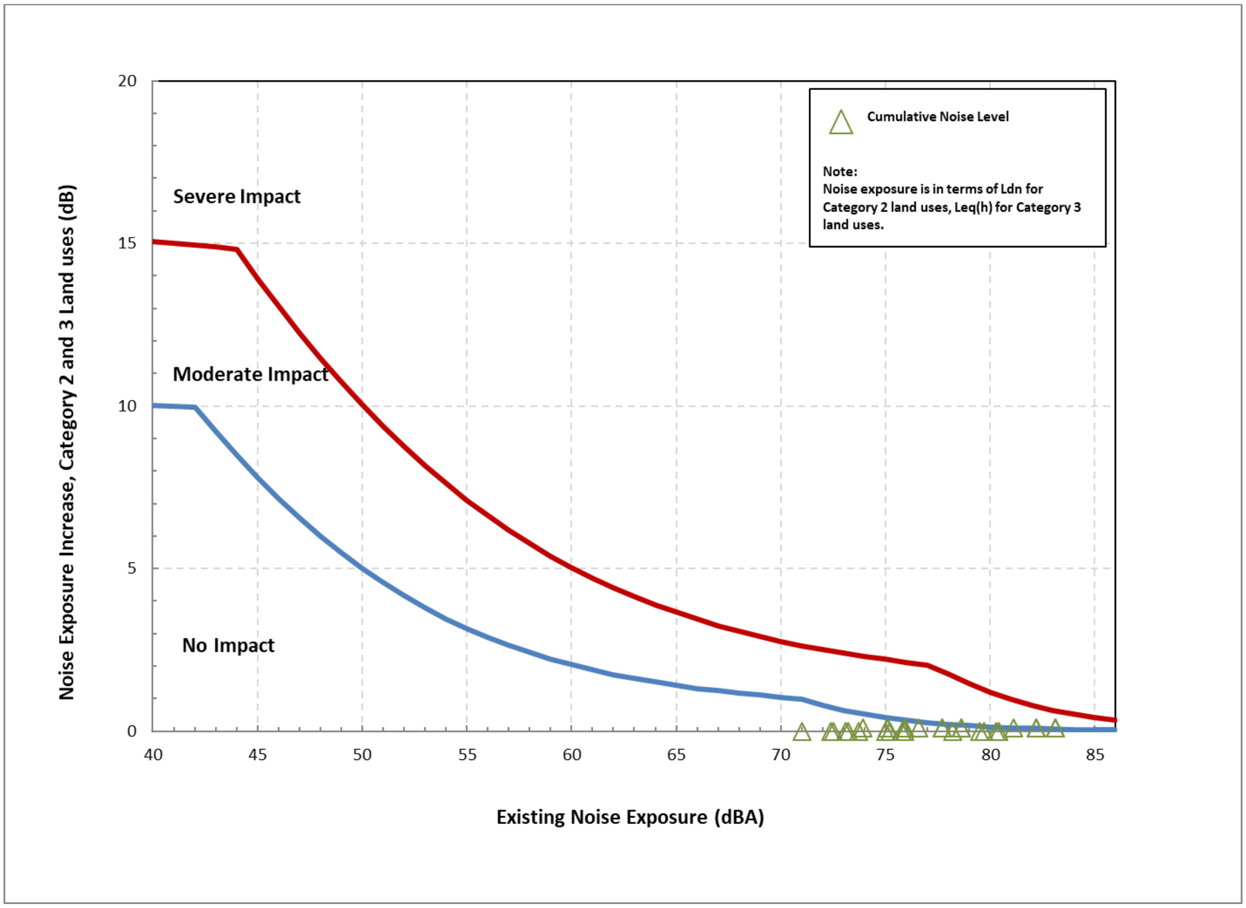
The cumulative increase in noise is the basis for the FTA noise impact criteria depicted on Figure 6-1 (FTA 2018). At a distance of 50 feet, the noise levels under each Build Alternative Option would be below the moderate impact threshold for both wayside and horn noise.

Figure 6-1. Program Noise Exposure Relative to Existing Conditions



Source: FTA 2018.

Vibration

The number of average daily trips in the Western Section of the Program Corridor would increase from a maximum of 86 per day to 90 per day, which would not result in a change in classification from “frequent events” (e.g., more than 70 events per day) under FTA. Train speeds are not projected to increase under future conditions.

Similar to the noise analysis, because the Build Alternative Options’ route alignments would not change relative to existing conditions, the evaluation focuses on the increase in commuter rail trips that would occur under the Build Alternative Options. As described in Section 3.1.3, the FTA classification of vibration events under existing conditions is “frequent events.” This classification would not change with implementation of the Build Alternative Options. If train traffic with the implementation of the Build Alternative Options would exceed the vibration criteria for “frequent events” and increase vibration levels by 3 VdB or more, this would result in an impact. However, train activity with implementation of the Program would involve commuter vehicles, which produce vibration levels that are more than 10 dB below freight trains in terms of VdB root-mean-square values. Therefore, no operational vibration impacts are expected.

6.3.2 Eastern Section

Construction

Noise

Specific infrastructure improvements may include sidings, additional main line track, wayside signals, drainage, grade-separation structures, and stations in the Eastern Section; however, specific improvements and locations have not yet been determined for the Tier 1/Program EIS/EIR evaluation. Potential worst-case equipment noise levels from construction of proposed infrastructure improvements were evaluated by combining the noise levels of up to three of the loudest pieces of equipment that would most likely operate at the same time during a given phase of construction. This worst-case analysis assumes a paving project, which would include a paver, a dump truck, and an excavator, with an overall noise level of 88 dBA L_{eq} (8 hours) at 50 feet. Estimated overall noise levels, based on attenuation over hard (i.e., acoustically reflective) ground, as a function of distance, are depicted in Table 6-6.

Although equipment may operate in many different areas as the Program is constructed, the highest noise levels are expected at those sites where the duration and intensity of construction activities would be greatest. Construction may extend through several residential areas and communities adjacent to the Build Alternative Options’ route alignments in the Eastern Section of the Program Corridor.

Table 6-6. Construction Equipment Noise Emission Levels by Distance

Distance Between Source and Receptor (feet)	Calculated L_{eq} Sound Level (dBA)
50	88
60	86
70	85
80	84
100	82

Distance Between Source and Receptor (feet)	Calculated L_{eq} Sound Level (dBA)
120	80
150	78
200	76
250	74
300	72
350	71
400	70
500	68
1,000	62

Notes:
Calculations based on FTA 2018; Thalheimer 2000.
This calculation does not include the effects, if any, of local shielding from walls, topography, or other barriers that may reduce sound levels further.
dBA=A-weighted decibel; L_{eq}=Hourly equivalent A-weighted noise level

Noise from construction activities is predicted to exceed the FTA daytime construction noise criterion at nearby residences, lodging facilities, and institutional uses within 120 feet of construction areas. The FTA nighttime noise criterion would be exceeded at residences and lodging facilities at a distance of up to 400 feet from construction areas. The need for construction during nighttime hours has not been specified and is, therefore, assumed to occur as a worst-case evaluation.

Impact pile drivers produce a maximum noise level of up to 101 dBA at a distance of 50 feet. If impact pile driving is used, the FTA daytime criterion may be exceeded at a distance of up to 275 feet, and the FTA nighttime criterion may be exceeded at a distance of up to 850 feet. The need for pile driving during construction has not been specified and is, therefore, assumed to occur as a worst-case evaluation.

Construction at a given location for each phase of the Program would be intermittent and short term for the noise-sensitive receptors adjacent to construction sites. Noise related to construction of the Build Alternative Options would cease once the Program is complete.

Noise impacts during construction would potentially occur at receivers located within 275 feet of construction activity during daytime hours and within 850 feet of construction activity during nighttime hours. Site-specific noise impacts and mitigation measures would be considered during Tier 2/Project-level analysis.

Vibration

Construction of the Build Alternative Options would result in temporary vibration along the Eastern Section of the Program Corridor from the use of heavy equipment and machinery. The vibration levels from construction activities were estimated using the equipment data in Table 4-2. The results are summarized in Table 6-7.

Table 6-7. Construction Equipment Vibration Levels by Distance

Distance Between Source and Receptor (feet)	Pile Driver (VdB)	Pile Driver (PPV)	Vibratory Roller (VdB)	Vibratory Roller (PPV)	Bulldozer (VdB)	Bulldozer (PPV)
25	104	0.644	94	0.210	87	0.089
40	98	0.384	88	0.125	81	0.053
50	95	0.300	85	0.098	78	0.042
60	93	0.246	83	0.080	76	0.034
63	92	0.233	82	0.076	75	0.032
70	91	0.207	81	0.068	74	0.029
75	90	0.192	80	0.063	73	0.027
100	86	0.140	76	0.046	69	0.019
110	85	0.126	75	0.041	68	0.017
160	80	0.084	70	0.027	63	0.012
200	77	0.065	67	0.021	60	0.009
230	75	0.056	65	0.018	58	0.008
250	74	0.051	64	0.017	57	0.007

Notes:

Calculations based on FTA 2018.

VdB=vibration velocity decibels; PPV=peak particle velocity (inch per second)

Ground-borne vibration from construction activities may periodically exceed the FTA vibration criterion at residences and lodging facilities within 110 feet of construction areas when using typical heavy equipment. If impact equipment, such as a pile driver, is used, the FTA vibration criterion would be exceeded at up to 230 feet. As depicted in Table 6-7, vibration levels from operation of a vibratory roller would exceed the FTA vibration criterion of 75 VdB at a distance of 110 feet, while operation of a bulldozer would exceed the criterion at a distance of 63 feet. Vibration levels from a vibratory roller would exceed the criterion for building damage at a distance of 25 feet. Pile drivers would exceed the building damage criterion at approximately 70 feet. Although vibration from construction equipment may be intermittently perceptible at sensitive receptor locations, the potential for substantial annoyance of occupants at nearby building structures is unlikely and would occur only during short intervals when equipment is operated near structures.

Vibration impacts during construction of the Build Alternative Options would potentially occur at receivers located within 230 feet of construction activity during daytime hours. Site-specific vibration impacts would be considered during Tier 2/Project-level analysis.

Operation

Current (2018) daily rail traffic volumes on the Eastern Section (as shown in Table 5-1) average 43 daily trains along the Colton-Coachella segment, consisting of freight and passenger trains. The addition of two daily round-trip intercity passenger trains would represent a 9-percent increase in train activity compared with current (2018) traffic volume along the existing railroad ROW. In 2024 and 2044, the Program would add the same number of rail operations to higher baseline conditions. Therefore, the Program's effects in 2024 (8-percent increase) (RCTC and FRA 2021) and 2044 (4.5-percent increase) would be lower than those evaluated under existing conditions. The following evaluation considers the current (2018) traffic volumes.

Rail Noise

Noise calculations for train operations along the Eastern Section are depicted in Table 6-8 and Table 6-9. Because the Program Corridor would not change relative to existing conditions, the evaluation focuses on the increase in intercity passenger rail trips that would occur along the Program Corridor. Noise levels are reported in terms of distance from the track.

The Build Alternative Options would add four daytime (7:00 a.m. to 10:00 p.m.) one-way intercity train trips per day along the Eastern Section. These trains would serve the area between the cities of Colton and Indio and/or Coachella within San Bernardino and Riverside counties.

Table 6-8 and Table 6-9 show the results of the evaluation, separated by wayside (engine and wheel/rail noise) and horn noise (at the at-grade grade crossings). As depicted in Table 6-8 no impacts are predicted to occur at Category 2 land uses 50 feet from grade crossings. No impacts are predicted to occur at institutional uses, as depicted in Table 6-9.

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Table 6-8. Eastern Section Noise Levels from Existing-plus-Program Train Operations, Category 2 (Residential) Land Uses (Colton-Coachella Section) within the Program Corridor

Train Noise Source	Distance from Track (feet)	Existing Average Daily Ldn (dBA)	Program Ldn (dBA)	Combined Ldn (dBA)	Increase over Existing, dB	Moderate Impact Threshold (Program L_{dn})[a]	Severe Impact Threshold (Program L_{dn})[a]	Impact?
Wayside noise from train passbys	50	78.4	50.7	78.4	0.0	66 L_{dn}	75 L_{dn}	None
Wayside noise from train passbys	100	73.9	46.2	73.9	0.0	66 L_{dn}	72 L_{dn}	None
Wayside noise from train passbys	150	71.3	43.6	71.3	0.0	66 L_{dn}	70 L_{dn}	None
Horn noise levels within 0.25 mile of grade crossings	50	81.3	64.6	81.4	+ 0.1	66 L_{dn}	75 L_{dn}	None
Horn noise levels within 0.25 mile of grade crossings	100	76.8	60.1	76.9	+ 0.1	66 L_{dn}	74 L_{dn}	None
Horn noise levels within 0.25 mile of grade crossings	150	74.2	57.5	74.3	+ 0.1	66 L_{dn}	72 L_{dn}	None

Notes:

[a] Moderate and severe impacts are compared with the Program's contribution to existing levels (i.e., the Programt L_{dn}). These thresholds do not apply to the combined L_{dn}.

L_{dn}=Day-night average noise level; L_{eq}=Hourly equivalent A-weighted noise level; dBA=A-weighted decibel

Table 6-9. Eastern Section Noise Levels from Existing-plus-Program Train Operations, Category 3 (Institutional) Land Uses (Colton-Coachella Section) within the Program Corridor

Train Noise Source	Distance from Track (feet)	Existing Average Daily Leq (dBA)	Program L_{eq} (dBA)	Combined Leq (dBA)	Increase over Existing, dB	Moderate Impact Threshold (Program L_{eq})[a]	Severe Impact Threshold (Program L_{eq})[a]	Impact?
Wayside noise from train passbys	50	72.0	52.8	72.1	+ 0.1	71 L_{eq}	76 L_{eq}	None
Wayside noise from train passbys	100	67.4	48.3	67.5	+ 0.1	68 L_{eq}	72 L_{eq}	None
Wayside noise from train passbys	150	64.8	45.6	64.9	+ 0.1	66 L_{eq}	71 L_{eq}	None
Horn noise levels within 0.25 mile of grade crossings	50	75.0	66.7	75.6	+ 0.6	71 L_{eq}	78 L_{eq}	None
Horn noise levels within 0.25 mile of grade crossings	100	70.5	62.2	71.1	+ 0.6	71 L_{eq}	75 L_{eq}	None
Horn noise levels within 0.25 mile of grade crossings	150	67.8	59.5	68.4	+ 0.6	68 L_{eq}	73 L_{eq}	None

Notes:

[a] Moderate and severe impacts are compared with the Program's contribution to existing levels, (i.e., the Program L_{dn}). These thresholds do not apply to the combined L_{dn}.

L_{dn}=Day-night average noise level; L_{eq}=Hourly equivalent A-weighted noise level; dBA=A-weighted decibel

The cumulative increase in noise is the basis for the FTA noise impact criteria depicted on Figure 6-1 (FTA 2018). At a distance of 50 feet, the noise level associated with operation of the Build Alternative Options would be below the moderate impact threshold for both wayside and horn noise.

Operation improvements may include grade-separation structures and stations in the Eastern Section; however, specific improvements and locations of stations and grade-separations have not yet been determined for the Tier 1/Program EIS/EIR evaluation.

In general, grade-separations would remove the requirement for trains to sound horns at crossings (as required for at-grade crossings), which would result in substantially lower noise levels near crossings where a conversion to a grade-separated structure is implemented.

Station platform noise sources generally include a public announcement system and chiming sounds from ticket vending machines. Announcement systems are typically designed to adjust volume levels automatically to a few decibels above ambient noise. Operation noise associated with these sources would occur for brief periods and would not be likely to result in an exceedance of FTA or local standards. Tier 2/Project-level analyses would quantitatively analyze potential operational noise.

Traffic Noise

New train ridership resulting from implementation of the Build Alternative Options is expected to affect the number of automobile trips east of Colton. The forecast for ridership in 2024 indicates a reduction in the number of automobile trips (between 263 to 358 per day), based on the number of train stops. This would result in a very small decrease in future traffic noise levels (less than 0.1 dB on a given road), which would not be a perceptible change relative to future No Build Alternative conditions in the same year.

Vibration

The number of one-way daily trips on the Eastern Section would increase from 43 per day to 47 per day, which would not result in a change in classification from “occasional events” (e.g., between 30 and 70 events per day) under FTA. Train speeds are not projected to increase under future conditions. Potential changes to vibration levels associated with operation of the Build Alternative Options in the Eastern Section would be similar to that described under the Western Section.

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7 Tier 2 Environmental Review Considerations

The Tier 1/Program EIS/EIR evaluation provides an overview of potential impacts resulting from development of the Build Alternative Options. Specific station locations, Tier 2/Project-level design, and construction methods have not been determined.

Tier 2/Project-level analyses would calculate the existing and future levels of ambient noise and vibration and would identify locations of sensitive receptors that may potentially be affected by noise and/or vibration under Tier 2 projects. The Tier 1/Program EIS/EIR indicated noise impacts during construction would potentially occur at receivers within 275 feet of construction activity during daytime hours and within 850 feet of construction activity during nighttime hours. Operation noise levels from additional train trips, new stations, and grade separations are not anticipated to exceed FTA impact criteria. The Tier 2/Project-level analysis would include numbers of residences and types of land uses affected. The Tier 2/Project-level analysis would also include a quantitative evaluation of potential noise and vibration effects on wildlife and natural parks.

Identified below are proposed programmatic mitigation strategies for further consideration in the Tier 2/Project-level analysis. Specific mitigation measures, to the extent required, would be identified and discussed during Tier 2/Project-level analysis after design details are known and specific impacts are identified. Potential mitigation measures and design features that would avoid or minimize noise and vibration effects would be developed in consultation with the appropriate agencies with jurisdiction. Proposed programmatic mitigation strategies include, but are not limited to the following:

- During Tier 2/Project-level analysis, a site-specific construction noise management plan shall be prepared for the specific rail infrastructure or station facility proposed. The construction noise management plan shall include, but not be limited to, the following:
  - A detailed construction schedule correlating to areas or zones of on-site Project construction activity(ies) and the anticipated equipment types and quantities involved. Information will include expected hours of actual operation per day for each type of equipment per phase and indication of anticipated concurrent construction activities on site.
  - Identification of construction noise reduction methods such as shutting off idling equipment, construction of a temporary noise barrier, maximizing the distance between construction equipment staging areas and adjacent sensitive land use receptors.

  - Identification of construction hours, allowable workdays, and the phone number of the job superintendent shall be clearly posted at all construction entrances to allow surrounding property owners to contact the job superintendent if necessary. In the event the municipality with jurisdiction receives a complaint, the construction noise management plan shall include guidance to ensure the appropriate corrective actions are implemented and a report of the action is provided to the reporting party. Appropriate corrective actions may include stricter enforcement of construction schedule, re-location of stationary equipment further from adjacent noise-sensitive receptors, reduction in the number of equipment working simultaneously in proximity to the sensitive receptor, erection of temporary noise barriers, or a combination of the above.

- During Tier 2/Project-level analysis, a site-specific noise and vibration assessment shall be prepared for the specific rail infrastructure or station facility proposed. The site-specific noise and vibration assessment shall include, but not be limited to, the following:
  - Identification of adjacent noise sensitive land uses that would be impacted by construction and operation activities associated with the specific rail infrastructure or station facility.
  - Identification of construction equipment required to be within 50 feet of existing structures. If construction equipment is required within 50 feet, the assessment will demonstrate that the human annoyance threshold of 78 VdB (0.032 inches per second PPV) and structural damage thresholds of 0.2 inches per second PPV for non-engineered timber and masonry buildings and 0.12 inches per second PPV for historic-age buildings that are extremely susceptible to vibration damage is achieved.
  - Identification of existing noise levels at the nearest noise sensitive land uses.
  - Identification of any on-site generated noise sources, including generators, mechanical equipment, and trucks and predicted noise levels at property lines from all identified equipment.
  - Recommended mitigation to be implemented (e.g., enclosures, barriers, site orientation), to ensure compliance with the local jurisdiction’s noise regulations or ordinances. Noise reduction measures shall include building noise-attenuating walls, reducing noise at the source by requiring quieter machinery or limiting the hours of operation, or other attenuation measures. Exact noise mitigation measures and their effectiveness shall be determined by the site-specific noise analyses.

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Appendix A. Fundamental Concepts of Environmental Noise

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Fundamental Concepts of Environmental Noise

Sound, Noise, and Acoustics

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) to a hearing organ, such as a human ear. Noise is defined as loud, unexpected, or annoying sound.

In the science of acoustics, the fundamental model consists of a sound (or noise) source, a receiver, and the propagation path between the two. The loudness of the noise source and the obstructions or atmospheric factors that affect the propagation path to the receiver determine the sound level and characteristics of the noise perceived by the receiver. The field of acoustics deals primarily with the propagation and control of sound.

Frequency

Continuous sound can be described by frequency (pitch) and amplitude (loudness). A low-frequency sound is perceived as low in pitch. Frequency is expressed in terms of cycles per second, or Hertz (Hz) (e.g., a frequency of 250 cycles per second is referred to as 250 Hz). High frequencies are sometimes more conveniently expressed in kilohertz (kHz), or thousands of Hz. The audible frequency range for humans is generally between 20 and 20,000 Hz.

Sound Pressure Levels and Decibels

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

Addition of Decibels

Because dBs are logarithmic units, SPL cannot be added or subtracted through ordinary arithmetic. Under the dB scale, a doubling of sound energy corresponds to a 3 dB increase. In other words, when two identical sources are each producing sound of the same loudness, the resulting sound level at a given distance would be 3 dB higher than one source 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 dB scale, three sources of equal loudness together produce a sound level 5 dB louder than one source.

A-Weighted Decibels

The dB scale alone does not adequately characterize how humans perceive sound. The dominant frequencies of a sound have a substantial effect on human response to that sound. Although the intensity (energy per unit area) of the sound is a purely physical quantity, the loudness or human response is determined by the characteristics of the human ear.

Human hearing is limited in its range of audible frequencies as well as the way in which it perceives the SPL in that range. In general, people are most sensitive to the frequency range of 1,000 to 8,000

Hz and perceive sounds within that range better than sounds of the same amplitude in higher or lower frequencies. To approximate the response of the human ear, sound levels of individual frequency bands are weighted, depending on human sensitivity to those frequencies. Then, an “A weighted” sound level (expressed in units of dBA) can be computed, based on this information.

The A-weighting network approximates the frequency response of the average young ear when listening to most ordinary sounds. When people judge the relative loudness or annoyance of a sound, their judgments correlate well with A-weighted sound levels of those sounds. Other weighting networks (e.g., B, C, and D scales) have been devised to address high noise levels or other special problems, but these scales are rarely used in conjunction with transit- or highway-related noise. Noise levels for technical reports related to transit or traffic noise are typically reported in terms of A-weighted decibels, or dBA. Table A-1 describes typical A-weighted noise levels for various noise sources.

Table A-1. Typical A-Weighted Noise Levels

Common Outdoor Activities or Conditions	Noise Level (dBA)	Common Indoor Activities or Locations
	— 110 —	Rock band
Jet flying at 1,000 feet		
	— 100 —	
Gas lawn mower at 3 feet		
	— 90 —	
Diesel truck at 50 feet at 50 mph		Food blender at 3 feet
	— 80 —	Garbage disposal at 3 feet
Noisy urban area, daytime		
Gas lawn mower, 100 feet	**— 70 —**	Vacuum cleaner at 10 feet
Commercial area		Normal speech at 3 feet
Heavy traffic at 300 feet	**— 60 —**	
		Large business office
Quiet urban daytime	**— 50 —**	Dishwasher next room
Quiet urban nighttime	**— 40 —**	Theater, large conference room (background)
Quiet suburban nighttime		
	— 30 —	Library
Quiet rural nighttime		Bedroom at night, concert
	— 20 —	
		Broadcast/recording studio
	— 10 —	
Lowest threshold of human hearing	**— 0 —**	Lowest threshold of human hearing

Source: California Department of Transportation, 2009.

Human Response to Changes in Noise Levels

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

Under controlled conditions in an acoustical laboratory, 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 (1,000 to 8,000 Hz) range. 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 (e.g., doubling the volume of traffic on a highway) that would result in a 3 dB increase in sound would generally be perceived as barely detectable.

Noise Descriptors

Noise in our daily environment fluctuates over time. Various noise descriptors have been developed to describe time-varying noise levels. The following are the noise descriptors most commonly used in transit noise analysis.

- Equivalent Sound Level (L_{eq}): L_{eq} represents an average of the sound energy occurring over a specified period. In effect, 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, or L_{eq}(h), is the energy average of A-weighted sound levels occurring during a 1-hour period.
- Percentile-Exceeded Sound Level (L_{xx}): L_{xx} represents the sound level exceeded for a given 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}): L_{max} is the highest instantaneous sound level measured during a specified period.
- Day/Night Level (L_{dn}): 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 between 10 p.m. and 7 a.m.
- 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 between 10 p.m. and 7 a.m. and a 5 dB penalty applied to the A-weighted sound levels occurring during evening hours between 7 p.m. and 10 p.m.

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 factors described below.

Geometric Spreading

Sound from a localized source (i.e., a point source) propagates uniformly outward in a spherical pattern. The sound level attenuates (or decreases) at a rate of 6 dB for each doubling of distance from a point source. Roadways consist of several localized noise sources on a defined path and, hence, can be treated as a line source, which approximates the effect of several point sources. Noise from a line source propagates outward in a cylindrical pattern, often referred to as cylindrical spreading. Sound levels attenuate at a rate of 3 dB for each doubling of distance from a line source.

Ground Absorption

The propagation path of noise from a roadway 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, excess attenuation has been expressed in terms of attenuation per doubling of distance. This approximation is usually sufficiently accurate for distances of less than 200 feet. For acoustically hard sites (i.e., sites with a reflective surface between the source and the receiver, such as a parking lot or body of water), no excess ground attenuation is assumed. For acoustically absorptive or soft sites (i.e., sites with an absorptive ground surface, such as soft dirt, grass, or scattered bushes and trees between the source and the receiver), an excess ground-attenuation value of 1.5 dB per doubling of distance is normally assumed. When added to the cylindrical spreading, the excess ground attenuation results in an overall drop-off rate of 4.5 dB per doubling of distance.

Atmospheric Effects

Receptors located downwind from a source can be exposed to increased noise levels relative to calm conditions, whereas locations upwind can have lower noise levels. Sound levels can increase at large distances (e.g., more than 500 feet) from a roadway because of atmospheric temperature inversion (i.e., increasing temperature with elevation). Other factors, such as air temperature, humidity, and turbulence, can also have significant effects.

Shielding by Natural or Human-Made Features

A large object or barrier in the path between a noise source and a receiver can substantially attenuate noise levels at the receiver. The amount of attenuation provided by shielding depends on the size of the object and the frequency content of the noise source. Natural terrain features (e.g., hills and dense woods) and human-made features (e.g., buildings and walls) can substantially reduce noise levels. Walls are often constructed between a source and a receiver for the specific purpose of reducing noise. A barrier that breaks the line of sight between a source and a receiver will typically result in at least 5 dB of noise reduction. Taller barriers provide increased noise reduction. Vegetation between a roadway and receiver is rarely effective in reducing noise because it does not create a solid barrier.

Fundamental Concepts of Ground-borne Vibration

This section describes basic concepts related to ground-borne vibration. In contrast to airborne sound, ground-borne vibration is not a phenomenon that most people experience every day. The background vibration velocity level in residential areas is usually much lower than the threshold of human perception. Most perceptible indoor vibration is caused by sources within buildings, such as mechanical equipment while in operation, people moving, or doors slamming. Typical outdoor sources of perceptible ground-borne vibration are construction equipment, steel-wheeled trains, and traffic on rough roads.

Construction activity can result in varying degrees of ground vibration, depending on the equipment and method used. Equipment such as air compressors, light trucks, and hydraulic loaders generate little or no ground vibration. Pile drivers, vibratory compactors, and demolition equipment have the potential to generate substantial vibration, which may present a concern if close to buildings (Federal Transit Administration 2006).

Dynamic construction equipment, such as pile drivers, can create vibrations that radiate along the surface and downward into the earth. These surface waves can be felt as ground-borne vibration. Vibration can result in effects that range from annoyance to structural damage. Variations in geology and distance result in different vibration levels with different frequencies and displacements. In all cases, vibration amplitudes decrease with increased distance from the vibration source.

As vibration waves travel outward from a source, they excite the particles of rock and soil through which they pass and cause them to oscillate. The actual distance that these particles move is usually only a few ten-thousandths to a few thousandths of an inch. The rate or velocity (in inches per second) at which these particles move is the commonly accepted definition of vibration amplitude, referred to as peak particle velocity (PPV).

Ground-borne vibration can also be expressed in terms of root-mean-square (RMS) vibration velocity to evaluate human response to vibration levels. RMS is defined as the average of the squared amplitude of the vibration signal. The vibration amplitude is expressed in terms of vibration decibels (VdB), which use a reference level of 1 micro-inch per second. Typical background vibration levels are between 50 and 60 VdB. The threshold of perception for most people is around 65 VdB. Vibration levels in the 70 to 80 VdB range are often noticeable but acceptable. Typically, vibration levels must exceed 100 VdB before building damage occurs. Historic structures, however, may have a damage threshold as low as 90 VdB.

The potential for annoyance and physical damage to buildings from vibration is the primary issue associated with ground-borne vibration. The human response to continuous ground-borne vibration is shown in Table A-2.

Table A-2. Human Response to Continuous Vibration

Peak Particle Velocity (inches/second)	Human Response
0.4–0.6	Unpleasant
0.2	Annoying
0.1	Begins to annoy
0.08	Readily perceptible
0.006–0.019	Threshold of perception

Source: Whiffen and Leonard, 1971.

The damage potential thresholds associated with vibration generated by construction activities are shown in Table A-3.

Table A-3. Maximum Vibration Levels for Preventing Damage

Building Category	Limiting Velocity (PPV in inches/ second)	Approximate Maximum Vibration Level (VdB)
Reinforced concrete, steel, or timber (no plaster)	0.5	102
Engineered concrete and masonry (no plaster)	0.3	98
Non-engineered timber and masonry buildings	0.2	94
Buildings that are extremely susceptible to vibration damage	0.12	90

PPV = peak particle velocity.
VdB = root-mean-square velocity in decibels (1 micro-inch/second).
Source: Federal Transit Administration, 2006.

At higher frequencies, ground-borne vibration can be perceived as a noise source. At sufficiently high amplitudes, the propagation of vibration waves through the ground can cause building elements to vibrate at a frequency that is audible to the human ear. Ground-borne noise can rattle windows, walls, or other items that are coupled to building surfaces. Ground-borne vibration levels that result in ground-borne noise are often experienced as a combination of perceptible vibration and low-frequency noise.

Land uses that are sensitive to ground-borne vibration include places where people reside, schools, libraries, and places of worship. Hospital operating rooms and certain types of industries that use vibration-sensitive equipment are considered highly sensitive to ground-borne noise and vibration. Outdoor park facilities, such as picnic areas or athletic fields, are not considered sensitive to ground-borne noise or vibration.

The human response to different levels of ground-borne noise and vibration is shown in Table A-4. Vibration levels with spectral components within the range of human hearing (30 and 60 Hz in the table) produce corresponding A-weighted noise levels. Thus, it is possible to experience vibrations as audible noise, even though physical vibrations may not be detected.

Table A-4. Maximum Vibration Levels for Preventing Damage

Vibration Velocity (VdB)	Low-Frequency Noise Level[a] (dBA)	Mid-Frequency Noise Level[b] (dBA)	Human Response
65	25	40	Approximate threshold of perception for many humans. Low-frequency sound usually inaudible; mid-frequency sound excessive for quiet sleeping areas.
75	35	50	Approximate dividing line between barely perceptible and distinctly perceptible. Many people find transit vibration at this level annoying. Low-frequency noise acceptable for sleeping areas; mid-frequency noise annoying in most quiet occupied areas.
85	45	60	Vibration acceptable only for an infrequent number of events per day. Low-frequency noise annoying for sleeping areas; mid-frequency noise annoying for institutional land uses such as schools and churches, even with infrequent events.

VdB = vibration decibel

dBA = A-weighted decibel

[a] Approximate noise level when vibration spectrum peak is near 30 Hz

[b] Approximate noise level when vibration spectrum peak is near 60 Hz

Source: Federal Transit Administration, 2006

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