CALIFORNIA HIGH-SPEED TRAIN

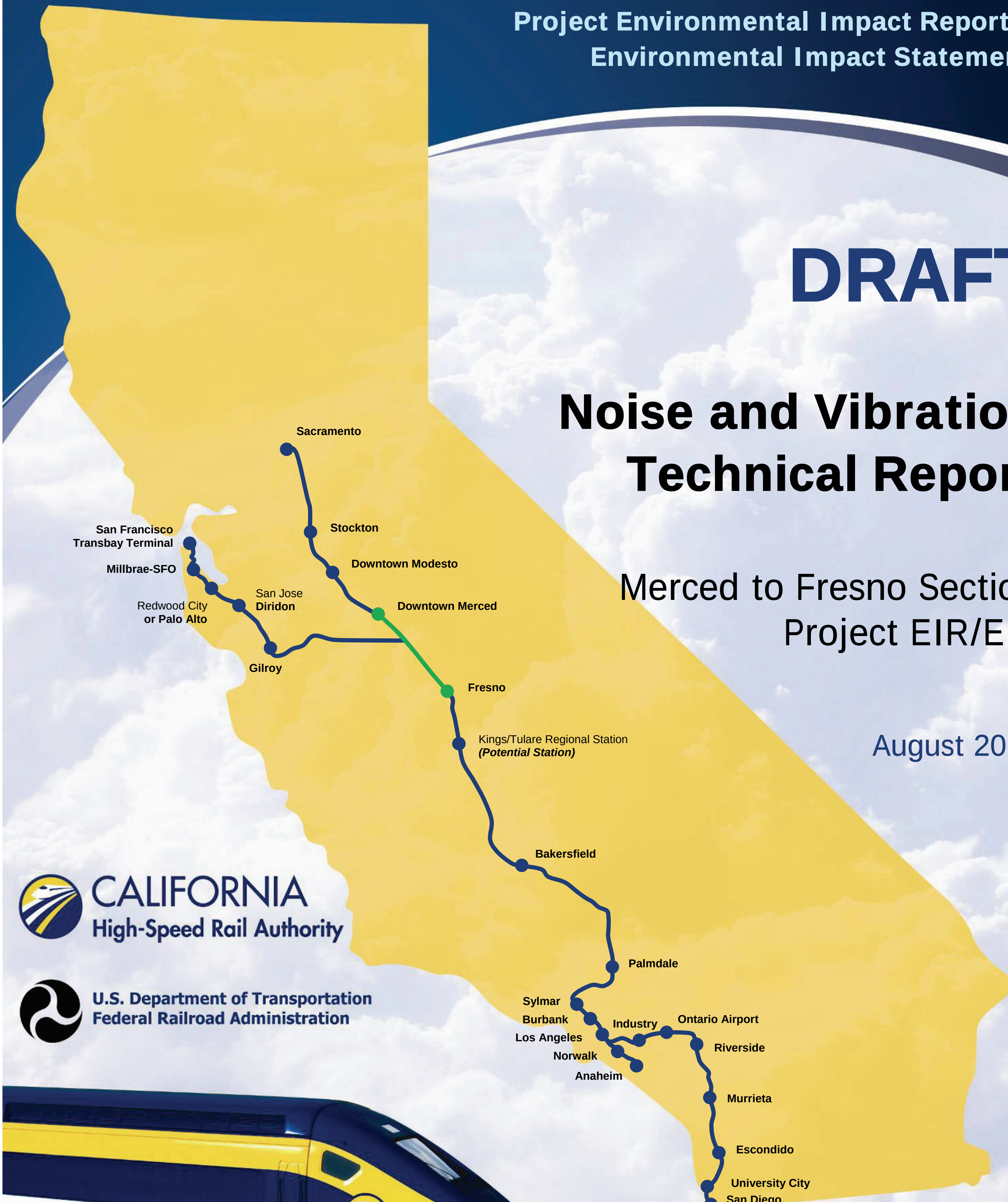
Project Environmental Impact Report / Environmental Impact Statement

DRAFT

Noise and Vibration Technical Report

Merced to Fresno Section Project EIR/EIS

August 2011



CALIFORNIA High-Speed Rail Authority

U.S. Department of Transportation
Federal Railroad Administration

CALIFORNIA HIGH-SPEED TRAIN PROJECT EIR/EIS

DRAFT
TECHNICAL REPORT

Merced to Fresno Section

Noise and Vibration Technical Report

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August 2011

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List of Abbreviated Terms

Authority	California High-Speed Rail Authority
Caltrans	California State Department of Transportation
CFR	Code of Federal Regulations
CNEL	community noise equivalent level, dBA
dB	decibel(s)
dBA	A-weighted decibel(s)
EIR	environmental impact report
EIS	environmental impact statement
EMU	electric multiple unit(s)
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMMH	Harris Miller Miller & Hanson Inc.
HST	high-speed train
ID	identifier
L_{dn}	day-night sound level, dBA
L_{eq}	equivalent sound level, dBA
L_{max}	maximum sound level
L_v	vibration velocity, dB
LT	long-term measurement
mips	micro-inch per second
mph	miles per hour
NSA	noise-sensitive area
PPV	peak particle velocity
RMS	root mean square
SEL	sound exposure level
SR	State Route
ST	short-term measurement
TDA	tire-derived aggregate
U.S.C.	United States Code

VdB	vibration decibel(s)
VSA	vibration-sensitive area

1.0 Introduction

The California High-Speed Train (HST) System, as shown in Figure 1-1, is planned to provide intercity, high-speed service on more than 800 miles of tracks throughout California, connecting the major population centers of Sacramento, the San Francisco Bay Area, the Central Valley, Los Angeles, the Inland Empire, Orange County, and San Diego. The HST System is envisioned as a state-of-the-art, electrically powered, high-speed, steel-wheel-on-steel-rail technology, which will include contemporary safety, signaling, and automated train-control systems. The trains will be capable of operating at speeds of up to 220 miles per hour (mph) over a fully grade-separated, dedicated track alignment.

Two phases of the California HST System are planned. Phase 1 will connect San Francisco to Los Angeles via the Pacheco Pass and the Central Valley. An expected express trip time between San Francisco and Los Angeles is mandated to be 2 hours and 40 minutes or less. Phase 2 will connect the Central Valley to the state's capital, Sacramento, and will extend the system from Los Angeles to San Diego.

The California HST System will be planned, designed, constructed, and operated under the direction of the California High-Speed Rail Authority (Authority), a state governing board formed in 1996. The Authority's statutory mandate is to develop a high-speed rail system that is coordinated with the state's existing transportation network, which includes intercity rail and bus lines, regional commuter rail lines, urban rail and bus transit lines, highways, and airports.

Definition of HST System

The system that includes the HST tracks, structures, stations, traction powered substations, and maintenance facilities and train vehicles able to travel 220 mph.

The Merced to Fresno HST Section is a critical Phase 1 link connecting the Bay Area HST sections to the Fresno to Bakersfield, Bakersfield to Palmdale, and Palmdale to Los Angeles HST sections. The Merced to Fresno Section alternatives originated in two program environmental impact report/environmental impact statement (EIR/EIS) documents. The Authority and the Federal Railroad Administration (FRA) prepared the 2005 *Final Program EIR/EIS for the Proposed California High-Speed Train System EIR/EIS* (Statewide Program EIR/EIS) and the 2008 *Bay Area to Central Valley HST Final Program EIR/EIS* (Bay Area to Central Valley Program EIR/EIS) to evaluate the ability of an HST system to meet the existing and future capacity demands on California's intercity transportation system and to identify a preferred alignment for the San Francisco Bay Area (Bay Area) to Central Valley sections of the HST System, respectively.

For each of the environmental resources evaluated for this project, analysts defined the study areas to be surveyed for existing conditions and to be analyzed for impacts**.** These study areas are defined with the following basic parameters:

- The potential area of disturbance or construction footprint, encompassing required right-of-way and areas required for construction including staging areas and temporary construction easements. The construction footprint is common to all resource areas.
- A resource-specific buffer for evaluation of indirect impacts. The buffer varies by resource area.

This technical report has been prepared in support of the Project EIR/EIS prepared for the Merced to Fresno Section of the proposed California HST System. It provides support and detailed analysis of noise resource related to the No Project Alternative and HST alternatives. This report describes the existing conditions, the range of possible impacts of for alternative, and the measures to avoid, minimize, or, if necessary, mitigate impacts of the HST alternatives on noise resource. The analysis is based upon an approximate 15% design of the HST alternatives and has been conservatively estimated to quantify and qualify impacts; however, further design may reduce or change impacts.

Noise and vibration are key elements of the environmental impact assessment for a high-speed rail project. Increases in noise and vibration are frequently cited as among the potential impacts of most

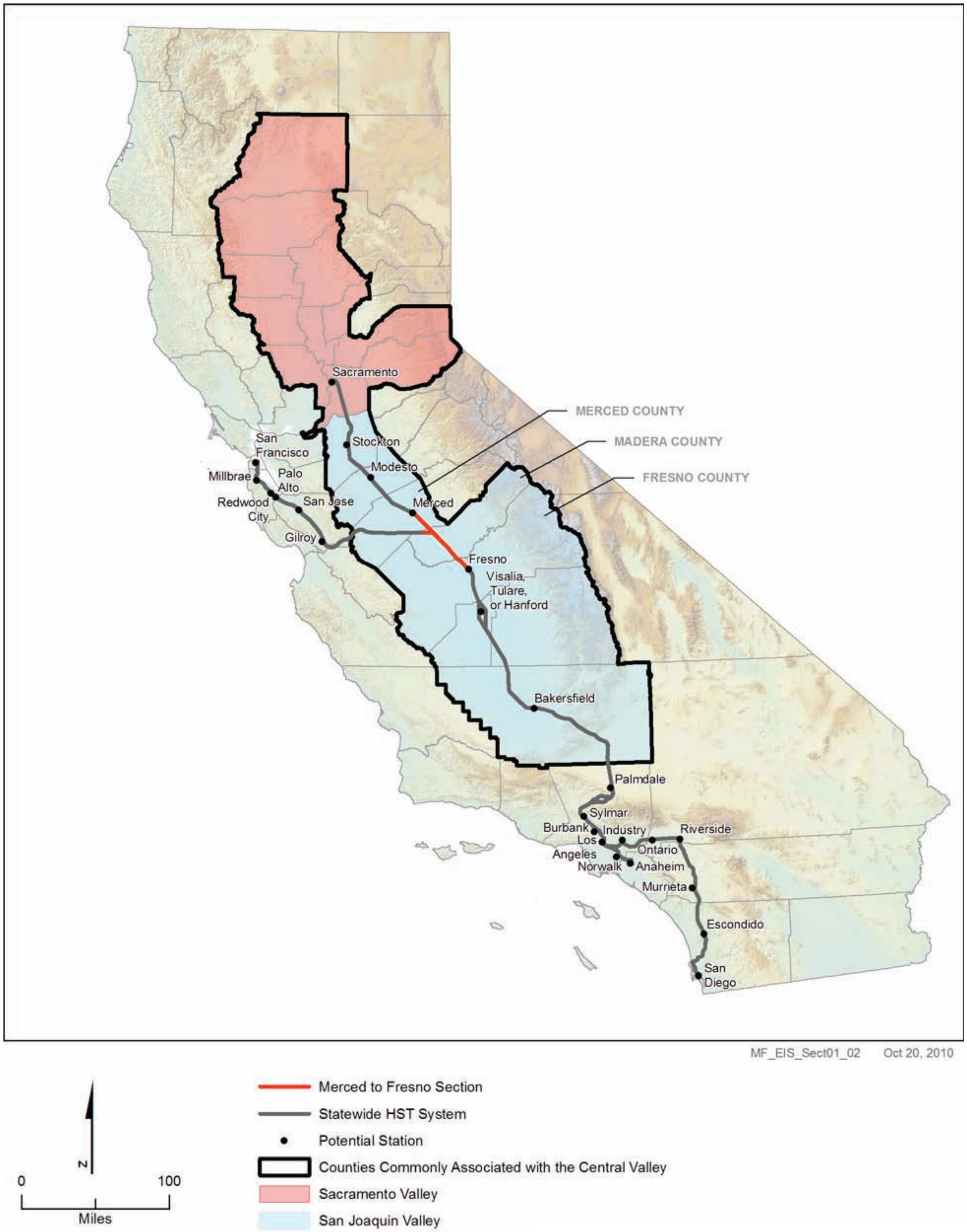


Figure 1-1
California High-Speed Train System

concern to residences in the vicinity of an HST project. To address these concerns, the U.S. Department of Transportation has published impact assessment procedures and criteria for ensuring an acceptable noise and vibration environment in the neighborhoods surrounding such facilities. Department of Transportation agencies, such as the FRA and the Federal Transit Administration (FTA), developed guidelines to comply with federal laws related to the assessment of ground transportation noise and vibration impacts. In addition, the National Environmental Policy Act of 1969 (42 United States Code [U.S.C.] 4321, et. seq.) (Public Law 91-190) (40 Code of Federal Regulations [CFR] 1506.5) requires evaluation of potential environmental impacts for federal or federally supported projects that could affect environmental quality, including noise impacts. Furthermore, the Noise Control Act of 1972 (42 U.S.C. 4910) declared "it is the policy of the U.S. to promote an environment for all Americans free from noise that jeopardizes their health or welfare."

In addition to the federal-level concern with the noise and vibration environment, a number of state and local polices and ordinances in California apply to noise and vibration from other transportation sources. Noise elements often incorporate specific allowable noise levels. Many general plans prepared by cities and counties contain noise elements that stipulate limits on construction noise, especially with respect to permitted hours. Where airports are present, especially larger ones, there may be a section on airport land use compatibility plans with respect to noise.

For this report, two documents were used to develop the methodology for evaluating impacts. The FRA developed the *High-Speed Ground Transportation Noise and Vibration Impact Assessment* (2005) for evaluation of noise and vibration impacts associated with HSTs. The FTA published guidelines titled *Transit Noise and Vibration Impact Assessment* (2006). Although originally developed for use on public mass transit projects, the FTA guidance manual includes a methodology that is applicable to HST station activities, yard activities, and construction. Noise and vibration impact criteria and calculation procedures have been developed to provide an estimate of the long-term impacts and annoyance from HSTs, as well as short-term impacts during construction. The assessment methodology has three steps: screening, general assessment, and detailed analysis. Each step becomes increasingly detailed. This methodology provides a means for identification of impacts and development of mitigation measures.

The FRA methodology was first used on the Statewide Program EIR/EISs (Authority and FRA 2005), which identified the following mitigation measures to address potential noise and vibration impacts:

- Select an HST system to meet state-of-the-art technology specifications for noise and vibration.
- Provide a high level of maintenance of trains and tracks.
- Install noise mitigation for sensitive receptors.
- Install track features to mitigate vibration such as resilient fasteners, tie pads, ballast mats, resiliently supported ties, or floating slabs.

This noise and vibration technical report describes the applicable regulatory requirements, affected environment, potential impacts, and recommended mitigation measures associated with noise and vibration generated from the proposed HST System for the section between Merced and Fresno.

Section 2 of this report provides a project description and resource study area. Section 3 provides an overview of noise and vibration descriptors. Section 4 describes the applicable noise and vibration impact criteria. Section 5 describes existing noise and vibration conditions within the project vicinity. Section 6 describes the noise and vibration prediction methodology used in the assessment. Section 7 summarizes the noise and vibration impacts. Section 8 describes the mitigation analysis, including recommended noise and vibration mitigation measures. Section 9 provides a list of sources referenced throughout the report, and Section 10 presents the qualifications of the document's preparers.

2.0 Project Description

The purpose of the Merced to Fresno Section of the HST project is to implement the California HST System between Merced and Fresno, providing the public with electric-powered high-speed rail service that provides predictable and consistent travel times between major urban centers and connectivity to airports, mass transit systems, and the highway network in the south San Joaquin Valley, and to connect the northern and southern portions of the HST System. The approximately 65-mile-long corridor between Merced and Fresno is an essential part of the statewide HST System. The Merced to Fresno Section is the location where the HST would intersect and connect with the Bay Area and Sacramento branches of the HST System; it would provide a potential location for the heavy maintenance facility (HMF) where the HSTs would be assembled and maintained, as well as a test track for the trains; it would also provide Merced and Fresno access to a new transportation mode and would contribute to increased mobility throughout California.

2.1 No Project Alternative

The No Project Alternative refers to the projected growth planned for the region through the 2035 time horizon without the HST project and serves as a basis of comparison for environmental analysis of the HST build alternatives. The No Project Alternative includes planned improvements to the highway, aviation, conventional passenger rail, and freight rail systems in the Merced to Fresno project area. There are many environmental impacts that would result under the No Project Alternative.

2.2 High-Speed Train Alternatives

As shown in Figure 2-1, there are three HST alignment alternatives proposed for the Merced to Fresno Section of the HST System: the UPRR/SR 99 Alternative, which would primarily parallel the UPRR railway; the BNSF Alternative, which would parallel the BNSF railway for a portion of the distance between Merced and Fresno; and the Hybrid Alternative, which combines features of the UPRR/SR 99 and BNSF alternatives. In addition, there is an HST station proposed for both the City of Merced and the City of Fresno, there is a wye connection (see text box on page 2-3) west to the Bay Area, and there are five potential sites for a proposed HMF.

2.2.1 UPRR/SR 99 Alternative

This section describes the UPRR/SR 99 Alternative, including the Chowchilla design options, wyes, and HST stations.

2.2.1.1 North-South Alignment

The north-south alignment of the UPRR/SR 99 Alternative would begin at the HST station in Downtown Merced, located on the west side of the UPRR right-of-way. South of the station and leaving Downtown Merced, the alternative would be at-grade and cross under SR 99. Approaching the City of Chowchilla, the UPRR/SR 99 Alternative has two design options: the East Chowchilla design option, which would pass Chowchilla on the east side of town, and the West Chowchilla design option, which would pass Chowchilla 3 to 4 miles west of the city before turning back to rejoin the UPRR/SR 99 transportation corridor. These design options would take the following routes:

- **East Chowchilla design option:** This design option would transition from the west side of the UPRR/SR 99 corridor to an elevated structure as it crosses the UPRR railway and N Chowchilla Boulevard just north of Avenue 27, continuing on an elevated structure away from the UPRR corridor along the west side of and parallel to SR 99 to cross Berenda Slough. Toward the south side of Chowchilla, this design option would cross over SR 99 north of the SR 99/SR 152 interchange near Avenue 23½ south of Chowchilla. Continuing south on the east side of SR 99 and the UPRR corridor, this design option would remain elevated for 7.1 miles through the communities of

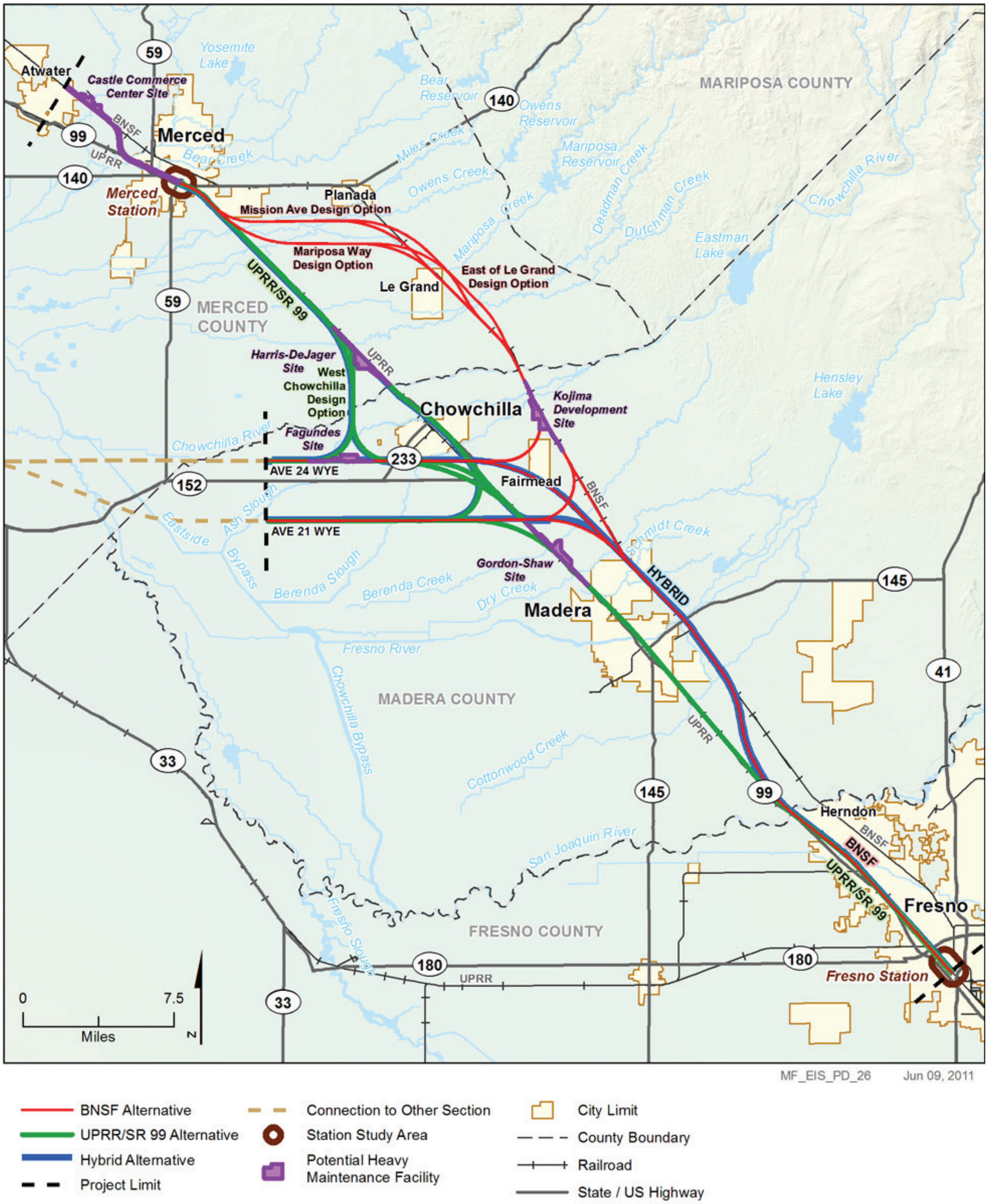


Figure 2-1
Merced to Fresno Section
HST Alternatives

Fairmead and Berenda until reaching the Dry Creek Crossing. The East Chowchilla design option connects to the HST sections to the west via either the Ave 24 or Ave 21 wyes (described below).

- **West Chowchilla design option:** This design option would travel due south from Sandy Mush Road north of Chowchilla, following the west side of Road 11¾. The alignment would turn southeast toward the UPRR/SR 99 corridor south of Chowchilla. The West Chowchilla design option would cross over the UPRR and SR 99 east of the Fairmead city limits to again parallel the UPRR/SR 99 corridor. The West Chowchilla design option would result in a net decrease of approximately 13 miles of track for the HST System compared to the East Chowchilla design option and would remain outside the limits of the City of Chowchilla. The West Chowchilla design option connects to the HST sections to the west via the Ave 24 Wye, but not the Ave 21 Wye.

The UPRR/SR 99 Alternative would continue toward Madera along the east side of the UPRR south of Dry Creek and remain on an elevated profile for 8.9 miles through Madera. After crossing over Cottonwood Creek and Avenue 12, the HST alignment would transition to an at-grade profile and continue to be at-grade until north of the San Joaquin River. After the alternative crosses the San Joaquin River, it would rise over the UPRR railway on an elevated guideway, supported by straddle bents, before crossing over the existing Herndon Avenue and again descending into an at-grade profile and continuing west of and parallel to the UPRR right-of-way. After elevating to cross the UPRR railway on the southern bank of the San Joaquin River, south of Herndon Avenue, the alternative would transition from an elevated to an at-grade profile. Traveling south from Golden State Boulevard at-grade, the alternative would cross under the reconstructed Ashlan Avenue and Clinton Avenue overhead structures. Advancing south from Clinton Avenue between Clinton Avenue and Belmont Avenue, the HST guideway would run at-grade adjacent to the western boundary of the UPRR right-of-way and then enter the HST station in Downtown Fresno. The HST guideway would descend in a retained-cut to pass under the San Joaquin Valley Railroad spur line and SR 180, transition back to at-grade before Stanislaus Street, and continue to be at-grade into the station. As part of a station design option, Tulare Street would become either an overpass or undercrossing at the station.

2.2.1.2 Wye Design Options

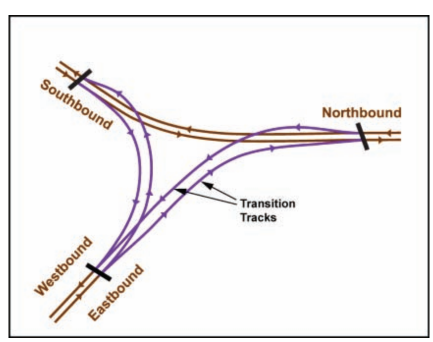
The following text describes the wye connection from the San Jose to Merced Section to the Merced to Fresno Section. There are two variations of the Ave 24 Wye for the UPRR/SR 99 Alternative because of the West Chowchilla design option. The Ave 21 Wye does not connect to the West Chowchilla design option and therefore does not have a variation.

<u>Ave 24 Wye</u>

The Ave 24 Wye design option would travel along the south side of eastbound Avenue 24 toward the UPRR/SR 99 Alternative and would begin diverging onto two sets of tracks west of Road 11 and west of the City of Chowchilla. Under the East Chowchilla design option, the northbound set of tracks would travel northeast across Road 12, joining the UPRR/SR 99 north-south alignment on the west side of the UPRR right-of-way just north of Sandy Mush Road. Under the West Chowchilla design option, the northbound set of tracks would travel northeast across Road 12 and would join the UPRR/SR 99 north-south alignment just south of Avenue 26. The southbound HST guideway would continue east along Avenue 24, turning south near SR 233 southeast of Chowchilla, crossing SR 99 and the UPRR railway to connect to the UPRR/SR 99 Alternative north-south alignment on the east side of the UPRR near Avenue 21½. Under the West Chowchilla design option, the southbound tracks would turn south near Road

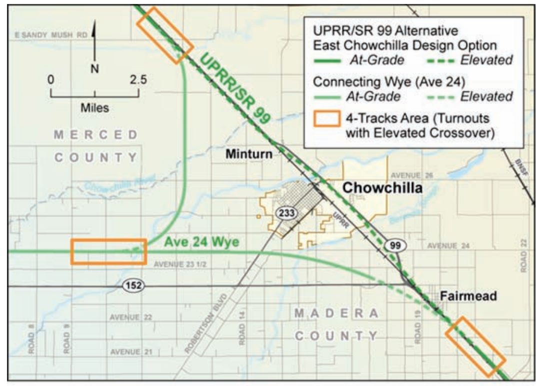
What is a "Wye"?

The word "wye" refers to the "Y"-like formation that is created where train tracks branch off the mainline to continue in different directions. The transition to a wye requires splitting two tracks into four tracks that cross over one another before the wye "legs" can diverge in opposite directions to allow bidirectional travel. For the Merced to Fresno Section of the HST System, the two tracks traveling east-west from the San Jose to Merced Section must become four tracks—a set of two tracks branching to the north and a set of two tracks branching to the south.

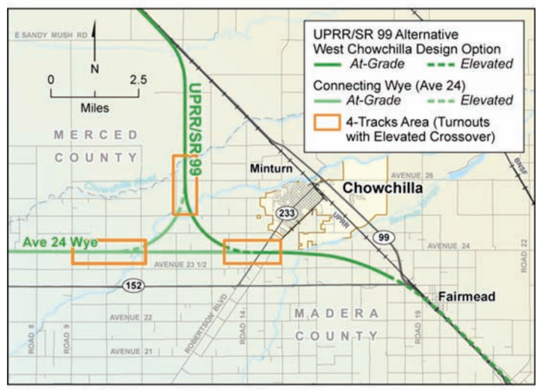


16 south of Chowchilla, crossing SR 99 and the UPRR to connect to the UPRR/SR 99 north-south alignment on the east side of the UPRR adjacent to the city limits of Fairmead.

Figure 2-2a shows the wye alignment for the East Chowchilla design option and Figure 2-2b shows the alignment for the West Chowchilla design option. Together, the figures illustrate the difference in the wye triangle formation for each design option connection. The north-south alignment of the West Chowchilla design option between Merced and Fresno diverges along Avenue 24 onto Road 12, on the north branch of the wye, allowing the HST alternative to avoid traveling through Chowchilla and to avoid constraining the city within the wye triangle.



(a) Ave 24 Wye with the East Chowchilla Design Option



(b) Ave 24 Wye with the West Chowchilla Design Option

Figure 2-2a and b
Ave 24 Wye and Chowchilla Design Options

<u>Ave 21 Wye</u>

The Ave 21 Wye would travel along the north side of Avenue 21. Just west of Road 16, the HST tracks would diverge north and south to connect to the UPRR/SR 99 Alternative, with the north leg of the wye joining the north-south alignment at Avenue 23½ and the south leg at Avenue 19½.

2.2.1.3 HST Stations

The Downtown Merced and Downtown Fresno station areas would each occupy several blocks, to include station plazas, drop-offs, a multimodal transit center, and parking structures. The areas would include the station platform and associated building and access structure, as well as lengths of platform tracks to accommodate local and express service at the stations. As currently proposed, both the Downtown Merced and Downtown Fresno stations would be at-grade, including all trackway and platforms, passenger services and concessions, and back-of-house functions.

<u>Downtown Merced Station</u>

The Downtown Merced Station would be between Martin Luther King Jr. Way to the northwest and G Street to the southeast. The station would be accessible from both sides of the UPRR, but the primary station house would front 16th Street. The major access points from SR 99 include V Street, R Street, Martin Luther King Jr. Way, and G Street. Primary access to the parking facility would be from West 15th Street and West 14th Street, just one block east of SR 99. The closest access to the parking facility from the SR 99 freeway would be R Street, which has a full interchange with the freeway. The site proposal includes a parking structure that would have the potential for up to 6 levels with a capacity of approximately 2,250 cars and an approximate height of 50 feet.

<u>Downtown Fresno Station Alternatives</u>

There are two station alternatives under consideration in Fresno: the Mariposa Street Station Alternative and the Kern Street Station Alternative.

<u>Mariposa Street Station Alternative</u>

The Mariposa Street Station Alternative is located in Downtown Fresno, less than 0.5 mile east of SR 99. The station would be centered on Mariposa Street and bordered by Fresno Street on the north, Tulare

Street on the south, H Street on the east, and G Street on the west. The station building would be approximately 75,000 square feet, with a maximum height of approximately 60 feet. The two-level station would be at-grade, with passenger access provided both east and west of the HST guideway and the UPRR tracks, which would run parallel with one another adjacent to the station. Entrances would be located at both G and H Streets. The eastern entrance would be at the intersection of H Street and Mariposa Street, with platform access provided via the pedestrian overcrossing. The main western entrance would be located at G Street and Mariposa Street.

The majority of station facilities would be located east of the UPRR tracks. The station and associated facilities would occupy approximately 18.5 acres, including 13 acres dedicated to the station, bus transit center, surface parking lots, and kiss-and-ride accommodations. A new intermodal facility would be included in the station footprint on the parcel bordered by Fresno Street to the north, Mariposa Street to the south, Broadway Street to the east, and H Street to the west. The site proposal includes the potential for up to 3 parking structures occupying a total of 5.5 acres. Two of the three potential parking structures would each sit on 2 acres, and each would have a capacity of approximately 1,500 cars. The third parking structure would have a slightly smaller footprint (1.5 acres), with 5 levels and a capacity of approximately 1,100 cars. Surface parking lots would provide approximately 300 additional parking spaces.

Kern Street Station Alternative

The Kern Street Station Alternative for the HST station would also be in Downtown Fresno and would be centered on Kern Street between Tulare Street and Inyo Street. This station would include the same components and acreage as the Mariposa Street Station Alternative, but the station would not encroach on the historic Southern Pacific Railroad depot just north of Tulare Street and would not require relocation of existing Greyhound facilities. Two of the 3 potential parking structures would each sit on 2 acres and each would have a capacity of approximately 1,500 cars. The third structure would have a slightly smaller footprint (1.5 acres) and a capacity of approximately 1,100 cars. Like the Mariposa Street Station Alternative, the majority of station facilities under the Kern Street Station Alternative would be east of the HST tracks.

2.2.2 BNSF Alternative

This section describes the BNSF Alternative, including the Le Grand design options and wyes. It does not include a discussion of the HST stations, because the station descriptions are identical for each of the three HST alignment alternatives.

2.2.2.1 North-South Alignment

The north-south alignment of the BNSF Alternative would begin at the proposed Downtown Merced Station. This alternative would remain at-grade through Merced and would cross under SR 99 at the south end of the city. Just south of the interchange at SR 99 and E Childs Avenue, the BNSF Alternative would cross over SR 99 and UPRR as it begins to curve to the east, crossing over the E Mission Avenue interchange. It would then travel east to the vicinity of Le Grand, where it would turn south and travel adjacent to the BNSF tracks.

To minimize impacts on the natural environment and the community of Le Grand, the project design includes four design options:

- **Mission Ave design option:** This design option would turn east to travel along the north side of Mission Avenue at Le Grand and then would elevate through Le Grand adjacent to and along the west side of the BNSF corridor.
- **Mission Ave East of Le Grand design option:** This design option would vary from the Mission Ave design option by traveling approximately 1 mile farther east before turning southeast to cross Santa Fe Avenue and the BNSF tracks south of Mission Avenue. The HST alignment would parallel the BNSF for a half-mile to the east, avoiding the urban limits of Le Grand. This design option would

cross Santa Fe Avenue and the BNSF railroad again approximately one-half mile north of Marguerite Road and would continue adjacent to the west side of the BNSF corridor.

- **Mariposa Way design option:** This design option would travel 1 mile farther than the Mission Ave design option before crossing SR 99 near Vassar Road and turning east toward Le Grand along the south side of Mariposa Way. East of Simonson Road, the HST alignment would turn to the southeast. Just prior to Savana Road in Le Grand, the HST alignment would transition from at-grade to elevated to pass through Le Grand on a 1.7-mile-long guideway adjacent to and along the west side of the BNSF corridor.
- **Mariposa Way East of Le Grand design option:** This design option would vary from the Mariposa Way design option by traveling approximately 1 mile farther east before turning southeast to cross Santa Fe Avenue and the BNSF tracks less than one-half mile south of Mariposa Way. The HST alignment would parallel the BNSF to the east of the railway for a half-mile, avoiding the urban limits of Le Grand. This design option would cross Santa Fe Avenue and the BNSF again approximately a half-mile north of Marguerite Road and would continue adjacent to the west side of the BNSF corridor.

Continuing southeast along the west side of BNSF, the BNSF Alternative would begin to curve just before Plainsburg Road through a predominantly rural and agricultural area. One mile south of Le Grand, the HST alignment would cross Deadman and Dutchman creeks. The alignment would deviate from the BNSF corridor just southeast of S White Rock Road, where it would remain at-grade for another 7 miles, except at the bridge crossings, and would continue on the west side of the BNSF corridor through the community of Sharon. The HST alignment would continue at-grade through the community of Kismet until crossing at Dry Creek. The BNSF Alternative would then continue at-grade through agricultural areas along the west side of the BNSF corridor through the community of Madera Acres north of the City of Madera. South of Avenue 15 east of Madera, the alignment would transition toward the UPRR corridor, following the east side of the UPRR corridor near Avenue 9 south of Madera, then continuing along nearly the same route as the UPRR/SR 99 Alternative over the San Joaquin River to enter the community of Herndon. After crossing the San Joaquin River, the alignment would be the same as for the UPRR/SR 99 Alternative

2.2.2.2 Wye Design Options

The Ave 24 Wye and the Ave 21 Wye would be the same as described for the UPRR/SR 99 Alternative (East Chowchilla design option), except as noted below.

Ave 24 Wye

As with the UPRR/SR 99 Alternative, the Ave 24 Wye would follow along the south side of Avenue 24 and would begin diverging into two sets of tracks (i.e., four tracks) beginning west of Road 17. Two tracks would travel north near Road 20½, where they would join the north-south alignment of the BNSF Alternative on the west side of the BNSF corridor near Avenue 26½. The two southbound tracks would join the BNSF Alternative on the west side of the BNSF corridor south of Avenue 21.

Ave 21 Wye

As with the UPRR/SR 99 Alternative, the Ave 21 Wye would travel along the north side of Avenue 21. Two tracks would diverge, turning north and south to connect to the north-south alignment of the BNSF Alternative just west of Road 21. The north leg of the wye would join the north-south alignment just south of Avenue 24 and the south leg would join the north-south alignment just east of Frontage Road/Road 26 north of the community of Madera Acres.

2.2.3 Hybrid Alternative

This section describes the Hybrid Alternative, which generally follows the alignment of the UPRR/SR 99 Alternative in the north and the BNSF Alternative in the south. It does not include a discussion of the HST stations because the station descriptions are identical for each of the three HST alternatives.

2.2.3.1 North-South Alignment

From north to south, generally, the Hybrid Alternative would follow the UPRR/SR 99 alignment with either the West Chowchilla design option with the Ave 24 Wye or the East Chowchilla design option with the Ave 21 Wye. Approaching the Chowchilla city limits, the Hybrid Alternative would follow one of two options:

- In conjunction with the Ave 24 Wye, the HST alignment would veer due south from Sandy Mush Road along a curve and would continue at-grade for 4 miles parallel to and on the west side of Road 11¾. The Hybrid Alternative would then curve to a corridor on the south side of Avenue 24 and would travel parallel for the next 4.3 miles. Along this curve, the southbound HST track would become an elevated structure for approximately 9,000 feet to cross over the Ave 24 Wye connection tracks and Ash Slough, while the northbound HST track would remain at-grade. Continuing east on the south side of Avenue 24, the HST alignment would become identical to the Ave 24 Wye connection for the BNSF Alternative and would follow the alignment of the BNSF Alternative until Madera.
- In conjunction with the Ave 21 Wye connection, the HST alignment would transition from the west side of UPRR and SR 99 to an elevated structure as it crosses the UPRR and N Chowchilla Boulevard just north of Avenue 27, continuing on an elevated structure along the west side of and parallel to SR 99 away from the UPRR corridor while it crosses Berenda Slough. Toward the south side of Chowchilla, the alignment (with the Ave 21 Wye) would cross over SR 99 north of the SR 99/SR 152 interchange near Avenue 23½ south of Chowchilla. It would continue to follow along the east side of SR 99 until reaching Avenue 21, where it would curve east and run parallel to Avenue 21, briefly. The alignment would then follow a path similar to the Ave 21 Wye connection for the BNSF Alternative, but with a tighter 220 mph curve. The alternative would then follow the BNSF Alternative alignment until Madera.

Through Madera and until reaching the San Joaquin River, the Hybrid Alternative is the same as the BNSF Alternative. Once crossing the San Joaquin River, the alignment of the Hybrid Alternative becomes the same as for the UPRR/SR 99 Alternative.

2.2.3.2 Wye Design Options

The wye connections for the Hybrid Alternative follow Avenue 24 and Avenue 21, similar to those of the UPRR/SR 99 and BNSF alternatives.

Ave 24 Wye

The Ave 24 Wye is the same as the combination of the UPRR/SR 99 Alternative with the West Chowchilla design option, and the Ave 24 Wye for the BNSF Alternative.

Ave 21 Wye

The Ave 21 Wye is similar to the combination of the UPRR/SR 99 Alternative with the Ave 21 Wye on the northbound leg and the BNSF Alternative with the Ave 21 Wye on the southbound leg. However, the south leg under the Hybrid Alternative would follow a tighter, 220 mph curve than the BNSF Alternative, which follows a 250 mph curve.

2.2.4 Heavy Maintenance Facility Alternatives

The Authority is studying five HMF sites (see Figure 2-1) within the Merced to Fresno Section, one of which may be selected.

- **Castle Commerce Center HMF site** – A 370-acre site located 6 miles northwest of Merced, at the former Castle Air Force Base in northern unincorporated Merced County. It is adjacent to and on the east side of the BNSF mainline, 1.75 miles south of the UPRR mainline, off of Santa Fe Drive and Shuttle Road, 2.75 miles from the existing SR 99 interchange. The Castle Commerce Center HMF would be accessible by all HST alternatives.

- **Harris-DeJager HMF site** – A 401-acre site located north of Chowchilla adjacent to and on the west side of the UPRR corridor, along S Vista Road and near the SR 99 interchange under construction. The Harris-DeJager HMF would be accessible by the UPRR/SR 99 and Hybrid alternatives if coming from the Ave 21 Wye and the UPRR/SR 99 Alternative with the East Chowchilla design option and the Ave 24 Wye.

- **Fagundes HMF site** – A 231-acre site, located 3 miles southwest of Chowchilla on the north side of SR 152, between Road 11 and Road 12. This HMF would be accessible by all HST alternatives with the Ave 24 Wye.

- **Gordon-Shaw HMF site** – A 364-acre site adjacent to and on the east side of the UPRR corridor, extending from north of Berenda Boulevard to Avenue 19. The Gordon-Shaw HMF would be accessible from the UPRR/SR 99 Alternative.

- **Kojima Development HMF site** – A 392-acre site on the west side of the BNSF corridor east of Chowchilla, located along Santa Fe Drive and Robertson Boulevard (Avenue 26). The Kojima Development HMF would be accessible by the BNSF Alternative with the Ave 21 Wye.

3.0 Noise and Vibration Descriptors

This section introduces the basic descriptors, metrics, and criteria used to quantify noise and vibration and to assess potential impacts for the construction and operation of the Merced to Fresno Section. The main reference documents for the material in this section are the guidance manuals *High-Speed Ground Transportation Noise and Vibration Impact Assessment* (FRA 2005) and *Transit Noise and Vibration Impact Assessment* (FTA 2006).

3.1 Noise

Noise from an HST system is expressed in terms of a “source-path-receiver” framework. The “source” generates noise levels, which depend on the type of source (e.g., HST) and its operating characteristics (e.g., speed). The “receiver” is the noise-sensitive land use (e.g., residence, hospital, or school) exposed to noise from the source. In between the source and the receiver is the “path” where the noise is reduced by distance, intervening buildings, and topography. Environmental noise impacts are assessed at the receiver. Not all receivers have the same noise-sensitivity. Consequently, there are noise criteria for the various types of receivers.

The descriptor generally used for environmental noise is the A-weighted sound pressure level. It describes the level of noise measured at a receiver at any moment in time and can be read directly from noise monitoring equipment with the weighting set on "A." The letter "A" indicates that the sound has been filtered to reduce the strength of very low- and very high-frequency sounds, much as the human ear does. Without this A-weighting, noise monitoring equipment would respond to sounds people cannot hear, such as high-frequency dog whistles and low-frequency seismic disturbances. On the average, each A-weighted sound pressure level increase of 10 decibels (dB) corresponds to an approximate doubling of subjective loudness. Figure 3-1 shows typical A-weighted decibels (dBA), for HSTs and other sources.

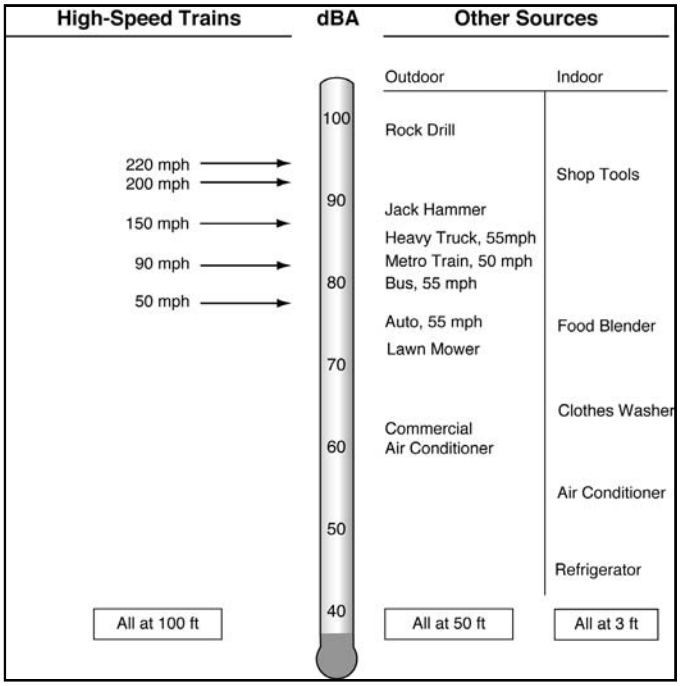


Figure 3-1
Typical A-Weighted Sound Pressure Levels

This report uses the following single-number descriptors, all based on the A-weighted sound pressure level as the fundamental unit for environmental noise measurements, computations, and the impact assessment:

- **Maximum sound level (L_{max})** during a single noise event or measurement period: The L_{max} is the maximum A-weighted sound level reached during a single noise event.
- **Equivalent sound level (L_{eq})** of many events over a defined measurement period: The L_{eq} represents a receiver's averaged noise exposure of all noise events that occur during a specified period, such as 1 minute, 1 hour, 24 hours, etc. L_{eq} can be used to report results of short-term noise measurements, usually ranging between 15 minutes and 1 hour, to supplement longer-term measurements. FRA noise impact criteria for daytime-only nonresidential land uses are based on the L_{eq} in 1 hour of HST operations occurring when noise could interfere with a sensitive activity, such as an hour when school is in session. The Federal Highway Administration (FHWA) criteria use the L_{eq} as the descriptor for highway noise impacts.
- **Day-night sound level (L_{dn})** from all events over a 24-hour period: The L_{dn} represents a receiver's averaged noise exposure of all noise events that occur in a 24-hour period with a penalty added for nighttime noise periods. The basic unit used in calculating L_{dn} is the hourly L_{eq} (L_{eq}[h]) for each 1-hour period during day and night, which is then totaled after increasing all nighttime A-weighted levels (between 10 p.m. and 7 a.m.) by 10 dB. In this report, L_{dn} is used to assess noise for residential land uses. Typical community L_{dn} values in the United States range from about 50 dBA to 70 dBA.
- **Sound exposure level (SEL)** during a single noise event: SEL is the primary descriptor of high-speed rail vehicle noise emissions and an intermediate value in the calculation of both L_{eq} and L_{dn}. It represents a receiver's cumulative noise exposure from an event and represents the total A-weighted sound during the event normalized to a 1-second interval.
- **Community noise equivalent level (CNEL)** from all events over a 24-hour period: CNEL is a community noise descriptor frequently used in California. CNEL is calculated in a manner similar to L_{dn} except with an additional 5 dBA penalty added for evening hours (between 7 p.m. and 10 p.m.) to take into account residential evening activities. CNEL values are generally within about 1 dBA of L_{dn} values measured for the same noise environments.

3.2 Ground-Borne Noise and Vibration

People seldom experience outdoor ground-borne vibration in everyday life. Typical outdoor vibration levels in the ground are usually well below the threshold of perception for humans. However, there are situations where vibrations can be noticeable near operations of construction equipment or train pass-bys. Indoors, however, it is common for people to feel the response of buildings to “ground-borne vibrations” generated by outdoor sources, such as construction or trains. In addition, vibrations of walls, floors, and ceilings inside a room can cause a faint rumbling sound throughout the room. This is referred to as “ground-borne noise” because it is a result of ground-borne vibrations transmitted into the building. This section describes the way vibrations are quantified and evaluated.

3.2.1 Vibration

Vibration is an oscillatory motion that can be described in terms of displacement, velocity, or acceleration. Because the motion is oscillatory, there is no net movement of the vibrating element, and the average of any of the motion descriptors is zero. For example, for a vibrating floor, the displacement is the distance that a point on the floor moves away from its static position. Velocity represents the instantaneous speed of the floor movement, and acceleration is the rate of change of the speed.

Displacement is rarely used to describe ground-borne vibration because most transducers for measuring ground-borne vibration use either velocity or acceleration, and the response of humans, buildings, and equipment to vibration is more accurately described by using velocity or acceleration.

Vibration from an HST is expressed in terms of a “source-path-receiver” framework. The “source” is the train rolling on the tracks, which generates vibration energy transmitted through the supporting structure under the tracks and into the ground. When the vibration transmits into the ground, it propagates through the various soil and rock strata, the “path,” to the foundations of nearby buildings, the “receivers.” Ground-borne vibrations generally reduce with distance depending on the local geological conditions. A “receiver” is a vibration-sensitive building (e.g., residence, hospital, or school) where the vibrations may cause perceptible shaking of the floors, walls, and ceilings and a rumbling sound inside rooms. Not all receivers have the same vibration-sensitivity. Consequently, there are vibration criteria for the various types of receivers.

3.2.2 Amplitude Descriptors

The various methods used to quantify vibration amplitude are shown in Figure 3-2. The raw signal is the instantaneous vibration velocity, which fluctuates around the zero point. The peak particle velocity (PPV) is defined as the maximum instantaneous positive or negative peak of the vibration signal. PPV often is used in monitoring blasting vibration because it is related to the stresses that are experienced by buildings.

Although PPV is appropriate for evaluating the potential of building damage, it is not suitable for evaluating human response. It takes time for the human body to respond to vibration signals. In a sense, the human body responds to an average vibration amplitude. Because the net average of a vibration signal is zero, the root mean square (RMS) amplitude is used to describe the "smoothed" vibration amplitude. The RMS of a signal is the average of the squared amplitude of the signal. The average is typically calculated over a 1-second period. Figures 3-2 shows the RMS amplitude superimposed on the vibration signal.

The PPV and RMS velocities are normally described in inches per second. Decibel notation, which is commonly used for vibration, serves to compress the range of numbers required to describe vibration. The bottom graph in Figure 3-2 shows the RMS curve of the top graph expressed in decibels.

A reference must always be specified when a quantity is expressed in terms of decibels. The accepted reference quantity for vibration velocity level in the United States is 1 micro-inch per second (mips). The abbreviation VdB is used in this technical report for “vibration decibels” to reduce the potential for confusion with sound decibels.

Figure 3-3 shows the vibration levels commonly experienced in the environment. Background vibration levels in residential areas are usually 50 VdB or lower, well below the threshold of perception of humans, which is around 65 VdB. The range of commonly experienced vibrations is between 50 VdB and 100 VdB. Very low vibration levels below the human perception threshold can still be of concern to sensitive manufacturing or research facilities and hospitals with medical operations.

3.2.3 Ground-Borne Noise

The annoyance potential of ground-borne noise is usually characterized by using the A-weighted sound level. Low-frequency components in rumbling sounds can be more annoying than broadband sounds that have the same A-weighted level. For example, a ground-borne noise level of 40 dBA sounds louder than 40 dBA broadband airborne noise. Because of this, ground-borne noise criteria are set at lower levels than airborne noise criteria, and the limits for ground-borne noise are lower than for airborne noise.

Ground-borne noise is not generally a problem for buildings near at-grade railroad tracks because the airborne noise from trains dominates the environment for distances far exceeding those where ground-borne vibrations are substantial. Ground-borne noise becomes an issue in cases where airborne noise cannot be heard, such as in buildings near tunnels.

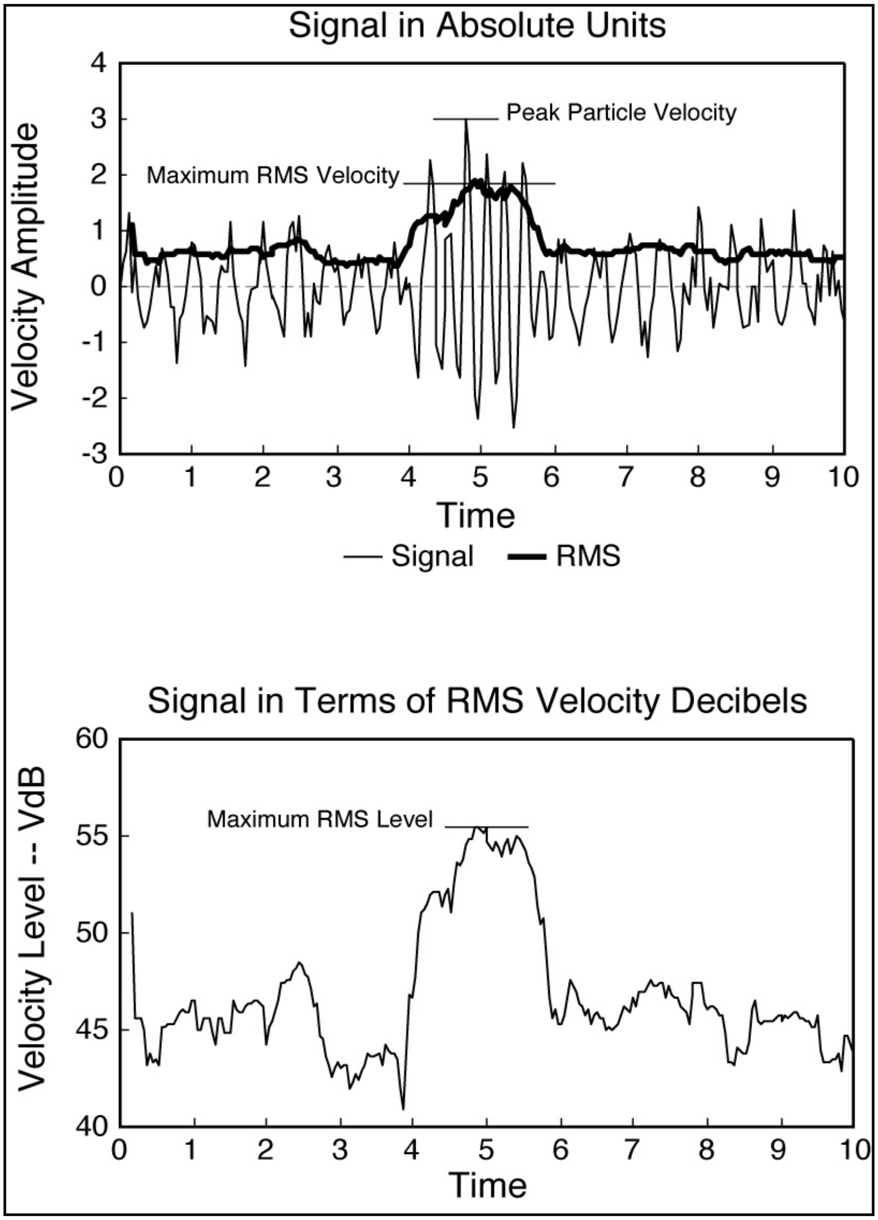


Figure 3-2
Different Methods of Describing
a Vibration Signal

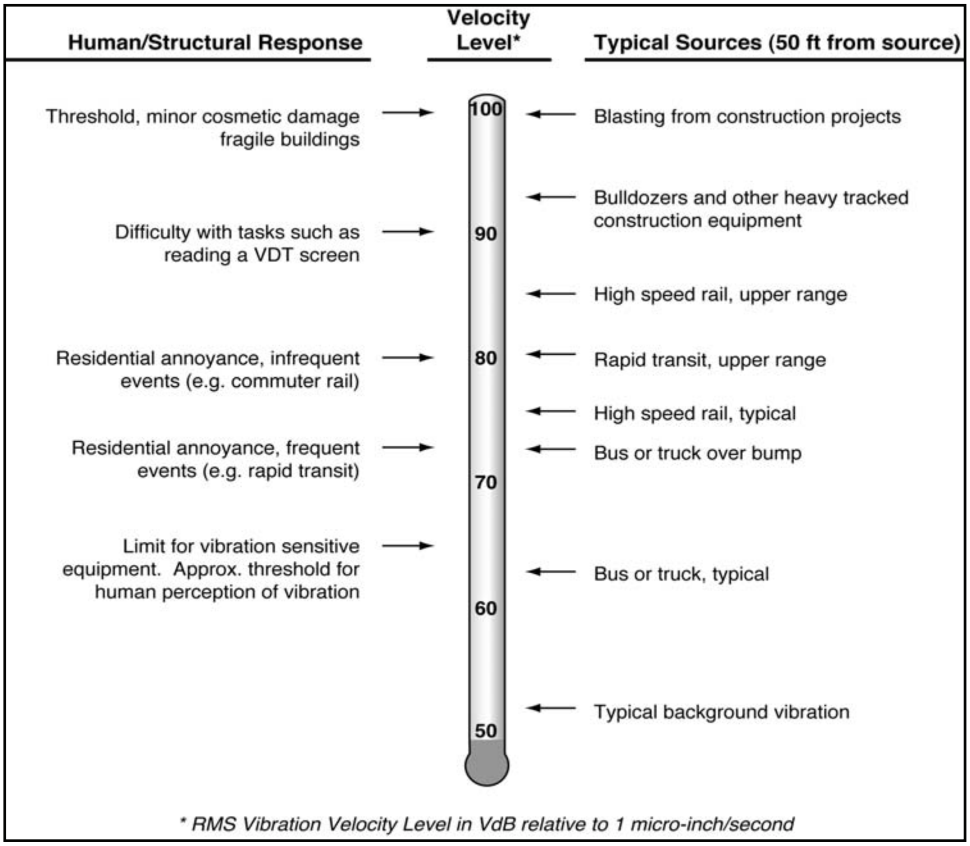


Figure 3-3
Typical Levels of Ground-Borne Vibration

4.0 Noise and Vibration Impact Criteria

4.1 Noise Impact Criteria

4.1.1 Operational Noise

The HST Project uses noise impact criteria adopted by the FRA to assess the contribution of the noise from HST to the existing environment and by the FTA to assess the contribution of the noise from conventional rail operations, construction, and facilities. These guidelines establish methods for analyzing and assessing noise and vibration impacts. The impact criteria are used to evaluate whether a noise environment may be considered acceptable for different land uses. Table 4-1 lists descriptions of the three land use categories.

Table 4-1
Federal Railroad Administration Land Use Categories

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

[a] Onset-rate adjusted sound levels (L_{eq} and L_{dn}) are to be used where applicable.
[b] L_{eq} for the noisiest hour of transit-related activity during hours of noise sensitivity.

Depending on how close a receiver is to an alignment, single-event HST pass-bys may result in a “startle effect.” However, additional research is needed in this area to determine if any real noise impacts are associated with the startle effect (FRA 2005). Therefore, for the purpose of the impact assessment, it is typically used only as additional information and is not part of the defined noise impact.

This technical report uses three noise descriptors to evaluate noise impacts: $L_{dn,}$ L_{eq}, and SEL:

- The L_{dn} depends on the number of events during day and night separately, as well as the duration of each event, which is affected by vehicle speed. The FRA and FTA have adopted L_{dn} as the measure of cumulative noise impact for residential land uses (those involving sleep) because it:
  - Correlates well with the results of attitudinal surveys of residential noise impact.
  - Increases with the number of noise events over 24 hours and the events’ durations.
  - Takes into account the increased sensitivity to noise at night when most people are asleep.

  - Allows composite measurements to capture all sources of community noise combined.
  - Allows quantitative comparison of HST noise with all other community noises.
  - Is the designated metric used by other federal agencies such as FTA, Department of Housing and Urban Development, Federal Aviation Administration, and the U.S. Environmental Protection Agency.

- The FRA and FTA have adopted the hourly L_{eq} as the measure of cumulative noise impact for nonresidential land uses (those not involving sleep) because it:
  - Correlates well with speech interference in conversation and on the telephone, as well as interruption of television, radio, and music enjoyment.
  - Increases with the number of noise events over the hour and their durations.
  - Is used by the FHWA in assessing highway-traffic noise impacts.

  L_{eq} can be used to compare and contrast modal alternatives such as highways and HSTs. L_{eq} is computed for the loudest HST facility or operational hour during noise-sensitive activity at each particular non-residential land use. For example, if schools are in session from 9 a.m. to 4 p.m., the maximum hourly L_{eq} for one of those hours is assessed against the FRA noise criterion.

- The SEL represents the noise exposure of a single event. The SEL is primarily used when calculating overall noise exposure from trains, but criteria for noise impacts on wildlife and domestic animals are based on the SEL alone.

FRA noise impact criteria for human annoyance, presented in Figure 4-1, are based on comparison of the existing outdoor noise levels and the future outdoor noise levels from a proposed HST project. The FRA noise impact criteria specify a comparison of future with existing noise levels, not with projections of future no-build noise exposure. This is because comparison of a projection with an existing condition is more accurate than a comparison of two projections. Noise-level increases are categorized as no impact, moderate impact, or severe impact. Severely affected areas experience a clearly unacceptable community noise level, whereas persons in a moderately affected area notice the increase in noise but without strong, adverse reactions.

The areas of significant impact for the project will correspond to those defined by FRA as “severe impact,” as presented in Figure 4-1. It is FRA policy to develop noise abatement measures for areas where severe noise impacts are expected. Mitigation for areas within the “moderate impact” portion of the figure could be provided if benefits outweigh costs.

4.1.2 Noise Effects on Wildlife and Domestic Animals

Impacts on wildlife (mammals and birds) and domestic animals (livestock and poultry) are also addressed by FRA. Noise exposure limits for each are an SEL of 100 dB from HST pass-bys, as shown in Table 4-2.

Table 4-2
Interim Criteria for High-Speed Train Noise Effects on Animals

Animal Category	Class	Noise Metric	Noise Level (dBA)
Domestic	Mammals (livestock)	SEL	100
	Birds (poultry)	SEL	100
Wild	Mammals	SEL	100
	Birds	SEL	100

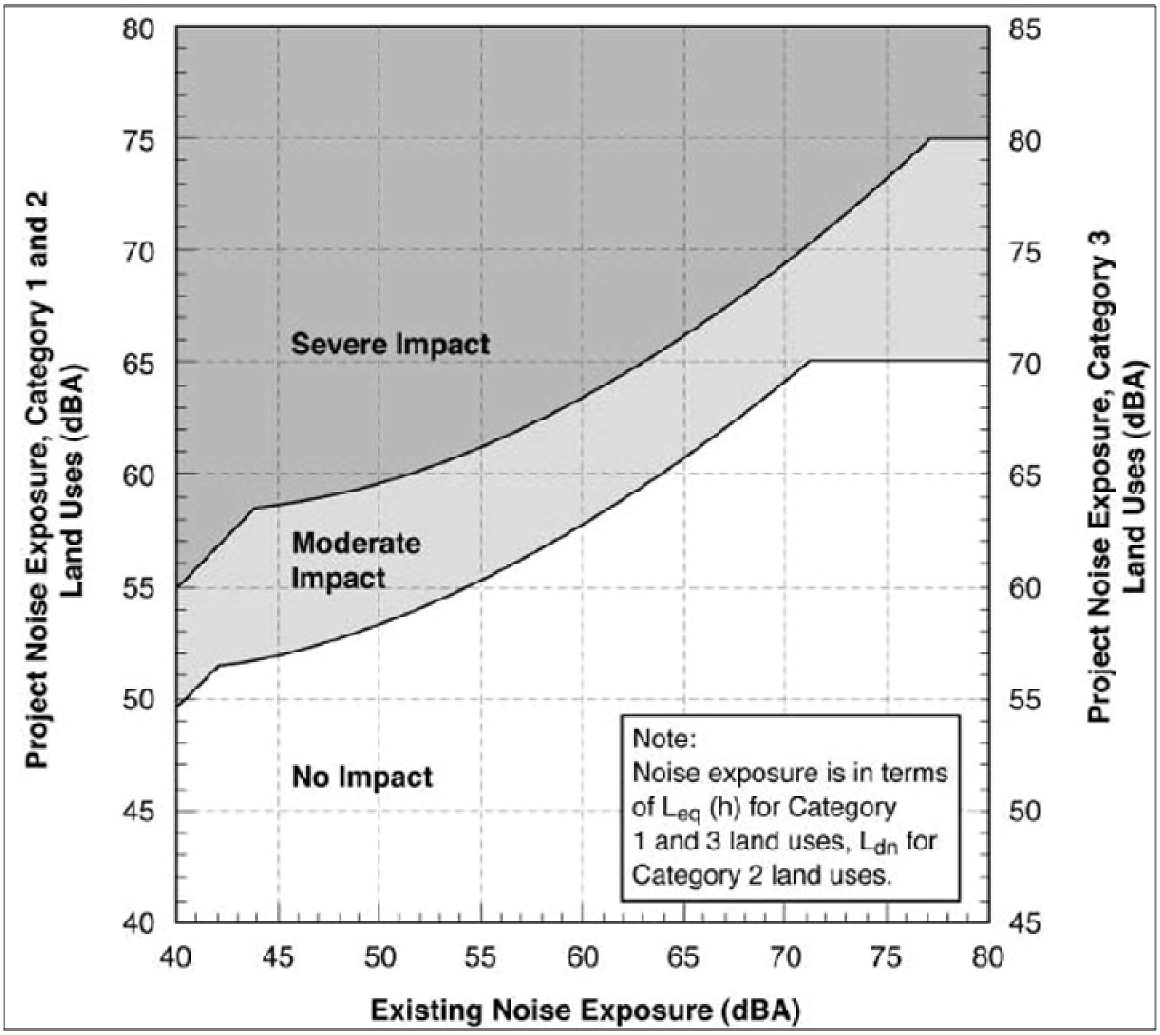


Figure 4-1
Noise Impact Criteria for Transit and High-Speed Train Projects

4.1.3 Startle Effects of High-Speed Train Noise

An additional concern for HSTs is the rapid onset rate of sound, which can startle humans. Although no penalties (in decibels) are applied to the noise exposure, the potential for startle effect is included in the impact assessment. The potential for startle effect is dependent on proximity to the tracks, as shown in Figure 4-2.

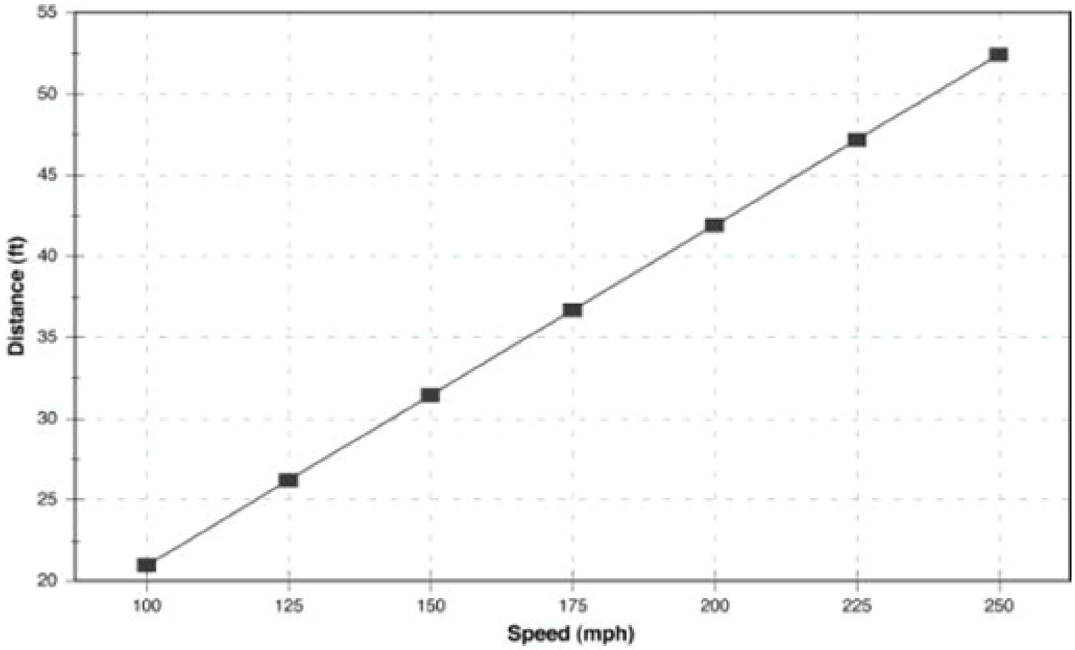


Figure 4-2
Distance from Tracks within Which Human Surprise Can Occur from High-Speed Trains

4.1.4 Noise Study Areas

FRA provides information regarding screening distances to define the study area for noise assessments for the land uses listed in Table 4-1. Screening distances indicate whether any noise-sensitive receivers are close enough to the proposed alignment for a noise impact to be possible. If receivers are located beyond these screening distances, FRA has determined that impacts would be unlikely; therefore, additional assessment would not be required. The FRA includes three ranges of speeds in the screening methodology; the highest speed regime category (Regime III, 180 mph) was used to define the Merced to Fresno HST alignment screening distances within the study areas. Table 4-3 lists the screening distances for noise assessments. Consistent with FRA methodology, screening distances were adjusted to match project conditions, such as speeds up to 220 mph and project schedules.

Table 4-3
Screening Distances for Noise Assessments for Proposed Alignments under Speed Regime III[a]

Corridor Type	Existing Noise Environment	Screening Distance for Train Type and Speed Regime[b] (feet)
Railroad	Urban/noisy suburban – unobstructed	700
	Urban/noisy suburban – intervening buildings[c]	300
	Quiet suburban/rural	1,200

Corridor Type	Existing Noise Environment	Screening Distance for Train Type and Speed Regime[b] (feet)
Highway	Urban/noisy suburban – unobstructed	600
	Urban/noisy suburban – intervening buildings[c]	350
	Quiet suburban/rural	1,100
New	Urban/noisy suburban – unobstructed	700
	Urban/noisy suburban – intervening buildings[c]	350
	Quiet suburban/rural	1,300

[a] 170 mph or greater

[b] Measured from centerline of guideway or rail corridor. Minimum distance is assumed to be 50 feet.

[c] Rows of buildings assumed to be at 200 feet, 400 feet, 600 feet, 800 feet, and 1,000 feet parallel to guideway.

4.1.5 Construction Noise

The construction noise assessment is based on guidelines included in the FTA guidance manual (FTA 2006); the FTA methodology is an updated version of the FRA approach and is used for this project. Table 4-4 shows FRA noise assessment criteria for construction noise. An 8-hour L_{eq} and a 30-day average noise exposure are used to assess impacts. A 30-day average L_{dn} is used to assess impacts in residential areas, and a 30-day average 24-hour L_{eq} is used to assess impacts in commercial and industrial areas. The noise emission levels of the construction equipment, utilization factor, hours of operation, and location of equipment are used to calculate 8-hour and 30-day average noise exposures. FTA assessment criteria are used in those areas where local municipalities have not addressed construction noise limits.

Table 4-4
Federal Railroad Administration Construction Noise Assessment Criteria

Land Use	8-Hour L_{eq}, dBA		Noise Exposure, dBA
	Day	Night	30-Day Average
Residential	80	70	75[a]
Commercial	85	85	80[b]
Industrial	90	90	85[b]

[a] In urban areas with very high ambient noise levels (L_{dn} exceeds 65 dB), L_{dn} from construction operations should not exceed existing ambient + 10 dB.

[b] Twenty-four-hour L_{eq}, not L_{dn}.

4.1.6 Traffic Noise

The FHWA *Procedures for Abatement of Highway Traffic Noise and Construction Noise*, Title 23 CFR 772, Subchapter H (1982) provides the criteria for highway noise impacts. Table 4-5 lists the traffic noise abatement criteria. A noise impact occurs if predicted noise levels approach the levels for specific land use categories listed in Table 4-5 or substantially exceed existing noise levels, as defined by the California State Department of Transportation (Caltrans). According to these regulations, only projects that include construction of new highway, reconstruction of existing highways with a substantial change in the horizontal alignment or vertical profile, or an increase in the number of through traffic lanes require a traffic noise analysis. If impacts are identified, noise abatement must be considered. In addition, FHWA guidance regarding the physical alteration of an existing highway states "changes in the horizontal alignment that reduce the distance between the source and the receiver by half or more result in a Type I project" (FHWA 2010). A Type I project is defined in 23 CFR 772 as a proposed federal or federal-aid highway project for the construction of a highway on a new location or the physical alteration of an existing highway that significantly changes either the horizontal or vertical alignment or increases the number of through-traffic lanes. FHWA requires the identification of highway traffic noise impacts and examination of potential abatement measures for all Type I projects receiving federal-aid funds.

Table 4-5
Federal Highway Administration Traffic Noise Abatement Criteria

Type	Land Use Category	Hourly Leq1
A	Lands on which serenity and quiet are of extraordinary significance and serve an important public need, and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.	57 (Exterior)
B[2]	Residential.	67 (Exterior)
C[2]	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.	67 (Exterior)
D	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.	52 (Interior)
E[2]	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in Types A through D or F	72 (Exterior)
F	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.	NA
G	Undeveloped lands that are not permitted (without building permits).	NA

[1] Hourly equivalent dBA.
[2] Includes undeveloped lands permitted for this activity category.
NA = not applicable
Source: FHWA Procedures for Abatement of Highway Traffic Noise and Construction Noise (23 CFR 772).

Caltrans is responsible for implementing the FHWA regulations in California. Under Caltrans policy, a traffic-noise impact occurs if predicted noise levels are within 1 dB of the FHWA criteria shown in Table 4-5; therefore, a residential impact occurs at 66 dBA L_{eq}, and a commercial impact occurs at 71 dBA L_{eq}. Caltrans also considers a 12-dB increase in noise a substantial impact, regardless of the original noise level.

4.2 Vibration Impact Criteria

4.2.1 Operational Vibration

Vibration impact levels are affected by the receptor's land use category and the number of vibration events, and are stated in terms of the maximum RMS vibration level. The impact level also depends on the type of analysis being conducted (i.e., ground-borne vibration or ground-borne noise). FRA provides guidelines to assess the human response to different levels of ground-borne noise and vibration. Table 4-6 shows the guidelines; these levels represent the maximum permissible RMS level of an event for different land use categories. In addition, the guidelines provide criteria for special buildings, such as concert halls, recording studios, and theaters that are especially sensitive to ground-borne noise and vibration. Table 4-7 shows the impact criteria for these special buildings.

Table 4-6
Ground-Borne Vibration and Noise Impact Criteria

Land Use Category	Ground-Borne Vibration Impact Levels (VdB re 1 mips)		Ground-Borne Noise Impact Levels (dB re 20 micro Pascals)	
	Frequent Events[a]	Infrequent Events[b]	Frequent Events[a]	Infrequent Events[b]
Category 1: Buildings where vibration would interfere with interior operations	65 VdB[c]	65 VdB[c]	NA[d]	NA[d]
Category 2: Residences and buildings where people normally sleep	72 VdB	80 VdB	35 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use	75 VdB	83 VdB	40 dBA	48 dBA

[a] Defined as more than 70 vibration events per day.

[b] Defined as fewer than 70 vibration events per day.

[c] This criterion limit is based on levels that are acceptable for most moderately sensitive equipment, such as optical microscopes. Vibration-sensitive manufacturing or research would 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.

[d] Vibration-sensitive equipment is not sensitive to ground-borne noise.

Note:

NA = not applicable

Table 4-7
Ground-Borne Vibration and Noise Impact Criteria for Special Buildings

Type of Building or Room	Ground-Borne Vibration Impact Levels (VdB re 1 mips)		Ground-Borne Noise Impact Levels (dB re 20 micro-Pascals)	
	Frequent[a] Events	Infrequent[b] Events	Frequent[a] Events	Infrequent[b] Events
Concert Halls	65 VdB	65 VdB	25 dBA	25 dBA
Television Studios	65 VdB	65 VdB	25 dBA	25 dBA
Recording Studios	65 VdB	65 VdB	25 dBA	25 dBA
Auditoriums	72 VdB	80 VdB	30 dBA	38 dBA
Theaters	72 VdB	80 VdB	35 dBA	43 dBA

Type of Building or Room	Ground-Borne Vibration Impact Levels (VdB re 1 mips)		Ground-Borne Noise Impact Levels (dB re 20 micro-Pascals)	
	Frequent[a] Events	Infrequent[b] Events	Frequent[a] Events	Infrequent[b] Events

[a] Defined as more than 70 vibration events per day.
[b] Defined as fewer than 70 vibration events per day.

A vibration event would occur when a train passes the location. Frequent events are defined as more than 70 vibration events per day. Infrequent events would be fewer than 70 vibration events per day. Table 4-6 and Table 4-7 include separate FRA criteria for ground-borne noise; the "rumble" that can be radiated from the motion of room surfaces in buildings due to ground-borne vibration. Although expressed in dBA, which emphasizes the more audible middle and high frequencies, the criteria are set significantly lower than for airborne noise to account for the annoying low-frequency character of ground-borne noise. Because airborne noise often masks ground-borne noise for above ground (i.e., at-grade or elevated) HSTs, ground-borne noise criteria are primarily applied to operations in a tunnel where airborne noise is not a factor. The Merced to Fresno Section is planned to be above ground. As a result, for the Merced to Fresno Section, ground-borne noise criteria are applied only to buildings with sensitive interior spaces that are well insulated from exterior noise.

Specification of mitigation measures requires more detailed information and more refined impact criteria using the frequency distribution, or spectrum of the vibration energy. A detailed vibration analysis method provides impact criteria in terms of the 1/3-octave band frequency spectrum. A detailed vibration analysis was conducted for the Merced to Fresno HST assessment. Figure 4-3 shows the FTA detailed ground-borne vibration impact criteria used in assessing project impacts. The criteria in Figure 4-3 are based on exceedances of the 1/3-octave band vibration levels over the frequency range of 8 Hz to 80 Hz.

For example, if the vibration levels in any frequency band from an HST exceed the Residential (Night) line in Figure 4-3 at a residential location, vibration impact would be assessed. In addition, the detailed criteria were used to assess vibration impacts at highly sensitive locations using the VC-A through VC-E thresholds shown in Figure 4-3.

4.2.2 Accounting for Existing Vibration Levels

An important factor not incorporated in the vibration impact criteria is how to account for existing vibration. The impact criteria in Tables 4-6 and 4-7 do not indicate how to account for existing ground-borne vibration from freight and passenger trains. FRA and FTA guidance manuals provide supplementary information for those cases where a rail project shares a “heavily-used rail corridor (more than 12 trains per day).” According to FRA, if the existing train vibration exceeds the impact criteria in Tables 4-6 and 4-7, the project would cause an additional vibration impact if the project substantially increases the number of vibration events. A doubling of the number of events is considered a substantial increase (FRA 2005).

The project would more than double the number of vibration events in the existing rail corridors. Because the HST would share a “heavily-used rail corridor” in parts of the UPRR/SR 99, BNSF, and Hybrid Alternatives, special conditions were attached to the vibration impact assessment procedures of FRA. Consequently, existing railroad vibration levels must be compared with the criteria in Tables 4-6 and 4-7 to determine the extent of potential vibration impact from HST in areas where the alignment shares a rail corridor between Atwater and Fresno. In other parts of the corridor where the alignment is in rural areas or highway corridors, the criteria in Tables 4-6 and 4-7 apply directly to the HST alone.

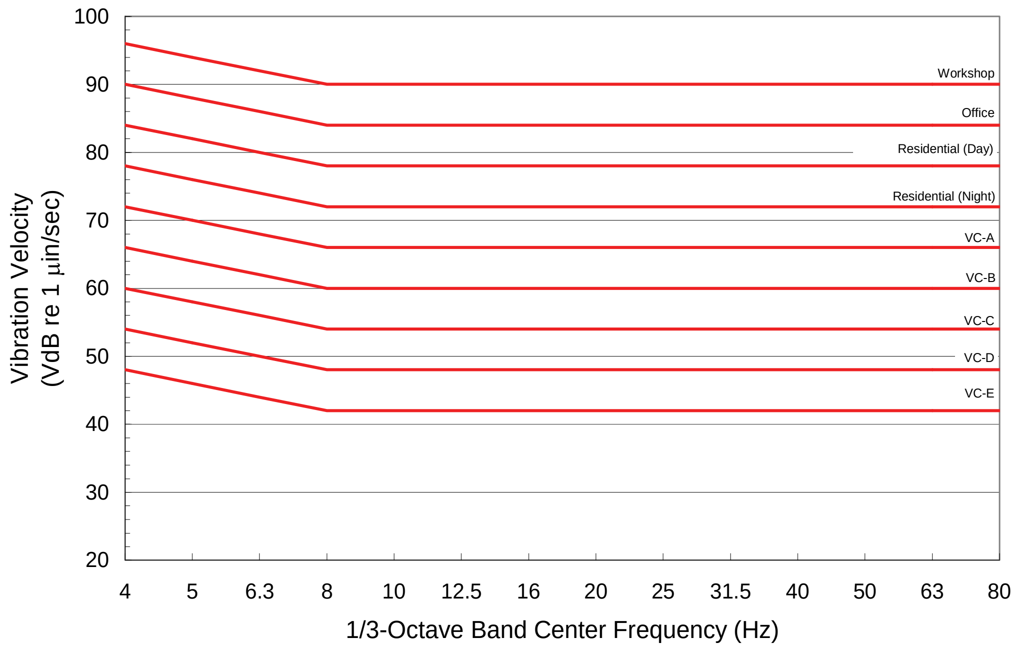


Figure 4-3
Federal Transit Authority Detailed Ground-Borne Vibration Impact Criteria

4.2.3 Definition of Vibration Study Areas

For the proposed project, study areas for vibration were defined as follows:

- Passenger station study area: 150 feet from station boundary.
- HST study areas, including existing rail: up to 275 feet.
- Highway study areas: 50 feet.

FRA also provides estimates of screening distances for vibration assessment for listed land use categories. The distances applicable to the Merced to Fresno Section presented in Table 4-8 were used to define the study areas where vibration may be a concern. To include all potentially affected areas along the Merced to Fresno Section, the highest speed and frequent event categories were used to establish screening distances. Consequently, vibration-sensitive residential properties within 275 feet and institutional properties within 220 feet were evaluated in this report. For conservative purposes, these distances were used for screening in all areas along the corridor.

Table 4-8
Screening Distances for Vibration Assessment

Land Use	Train Frequency[a]	Screening Distance	
		Train Speed of 100 to 200 mph (feet)	Train Speed of 200 to 300 mph (feet)
Residential	Frequent	220	275
	Infrequent	100	140
Institutional	Frequent	160	220
	Infrequent	70	100

[a] Frequent = greater than 70 pass-bys per day; infrequent = less than 70 pass-bys per day.

4.2.4 Construction Vibration

The construction vibration assessment is based on guidelines in the FTA guidance manual (FTA 2006) and local ordinances presented in Appendix A. None of the communities along the Merced to Fresno corridor address construction vibration limits.

To avoid temporary annoyances to the building occupants during construction or to avoid construction interference with vibration-sensitive equipment inside special-use buildings, FTA recommends using the long-term operational vibration criteria provided in Table 4-6 and Table 4-7. The FTA criteria were used to assess impacts from construction vibration.

Table 4-9 shows the FTA building damage criteria for construction activity; the table provides PPV limits for four building categories. These limits were used to identify areas that should be addressed during engineering design of the HST System.

Table 4-9
Construction Vibration Damage Criteria

Building Category	PPV (inch/second)	Approximate L_v[a]
I. Reinforced-concrete, steel, or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	98
III. Non-engineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

[a] RMS velocity in VdB re 1 mips.
L_v = vibration velocity, dB

5.0 Existing Noise and Vibration Conditions

5.1 Study Area

The proposed Merced to Fresno Section includes areas and communities within the incorporated boundaries of the cities of Atwater, Merced, Le Grand, Chowchilla, Madera, and Fresno, as well as unincorporated areas of Merced, Madera, and Fresno counties. Land use varies from noisy urban/suburban areas in the cities to quiet suburban and rural areas in the unincorporated areas. The study areas for the noise and vibration impact assessment analysis generally follow the proposed linear corridor between Merced (and Atwater) and Fresno. The study areas encompass three HST alternatives (UPRR/SR 99, BNSF, and Hybrid Alternatives) and two wyes (the Ave 24 Wye and the Ave 21 Wye). Most of the study areas along the north-south alignment of the UPRR/SR 99, BNSF, and Hybrid Alternatives are located along active railway or highway corridors. The study areas on the UPRR/SR 99 Alternative vary from urban to rural environments, with the largest urban environments being the cities of Merced, Madera, and Fresno. The study areas along the unique portion of the BNSF Alternative are rural, except for the communities of Le Grand and Madera Acres, which are suburban. The study areas for the wyes also are rural.

The noise and vibration study areas along the proposed alignments are bounded by the FRA *noise* screening distances, ranging from 300 feet from the proposed centerline in urban/suburban areas to 1,300 feet from the centerline in rural areas (see Table 4-3), and bounded by the FRA *vibration* screening distances ranging from 220 feet for institutional land uses to 275 feet for residential land uses (see Table 4-8). For screening purposes, the areas within the Central Valley (including the communities and areas of Atwater, Merced, Le Grand, Chowchilla, Madera, and Fresno) were considered urban/suburban (potentially obstructed or unobstructed), and most of the unincorporated areas were considered quiet suburban and rural. The proposed HST stations in Merced and Fresno are within urban and obstructed screening distances. Figures 5-1 through 5-4 show all noise and vibration measurement locations for the project.

5.2 Existing Noise Environment

Noise is one of the defining factors of the environment in which people live. Generally people rate the quality of their neighborhoods in terms of noise level, valuing quiet areas over noisy areas. Noise from external sources can result in community annoyance, especially in residential areas. In many community attitude surveys, transportation noise ranks among the most substantial causes of community dissatisfaction. Consequently, the introduction of a new transportation noise source, such as the HST, must be assessed according to the increase in existing noise levels in the community, levels to which residents have mostly become accustomed.

The existing environment for the proposed corridor of the project between Merced and Fresno consists of the incorporated and unincorporated areas of Merced, Madera, and Fresno counties. The proposed UPRR/SR 99 Alternative bisects the major cities of Atwater, Merced, Chowchilla, Madera, and Fresno, where existing noise levels are associated with local traffic, commercial activities, and industry. In general, the UPRR/SR 99 Alternative follows a busy transportation corridor with existing noise sources including State Route (SR) 99, UPRR and BNSF railways, and local arterial roads and streets. The proposed BNSF Alternative follows much of the UPRR/SR 99 Alternative but avoids the cities of Madera and Chowchilla by passing through suburban Le Grand and Madera Acres. Existing noise sources along the BNSF Alternative alignment include the BNSF railway, local traffic, and commercial/industrial noise near Le Grand.

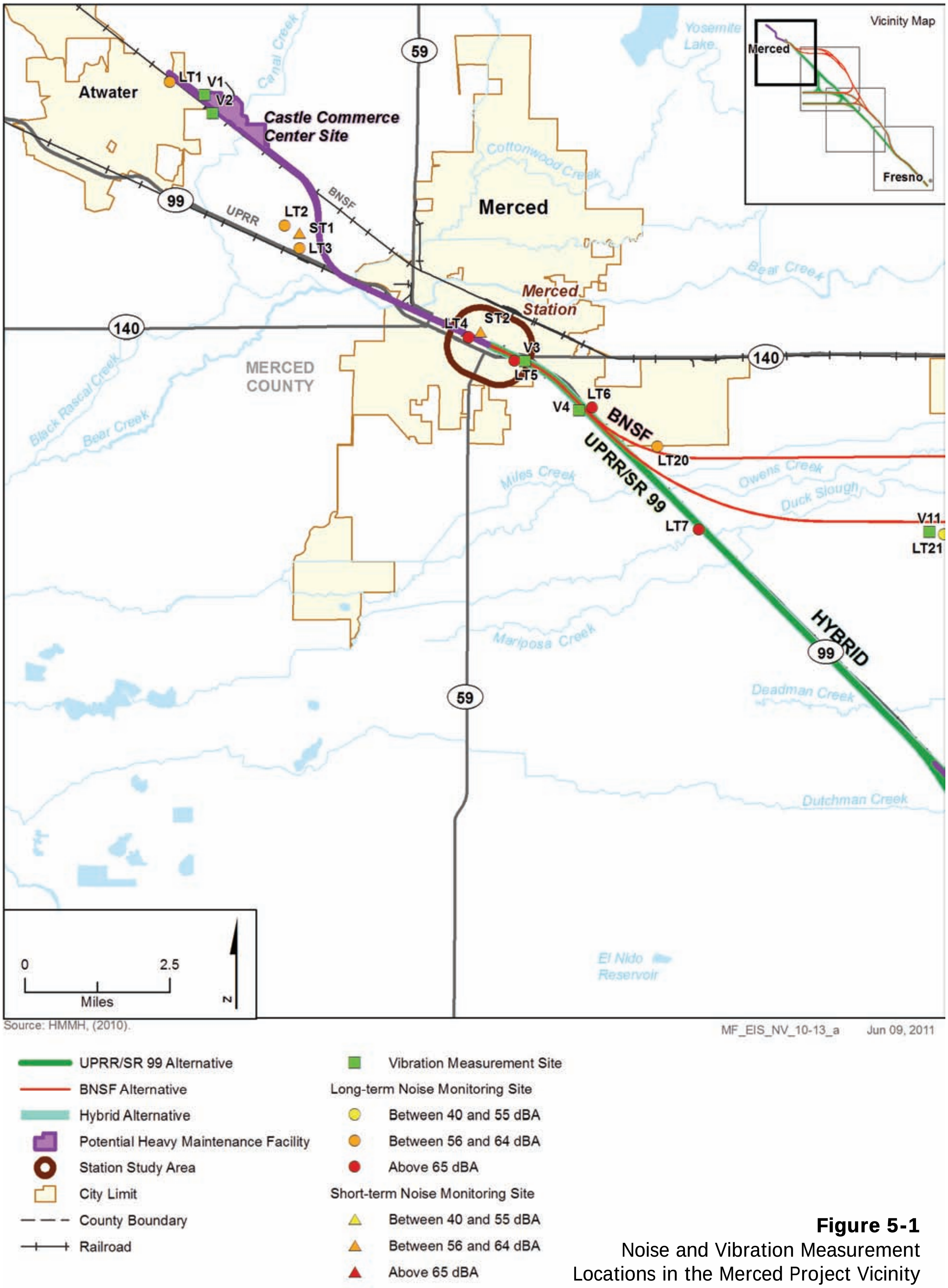


Figure 5-1
Noise and Vibration Measurement
Locations in the Merced Project Vicinity

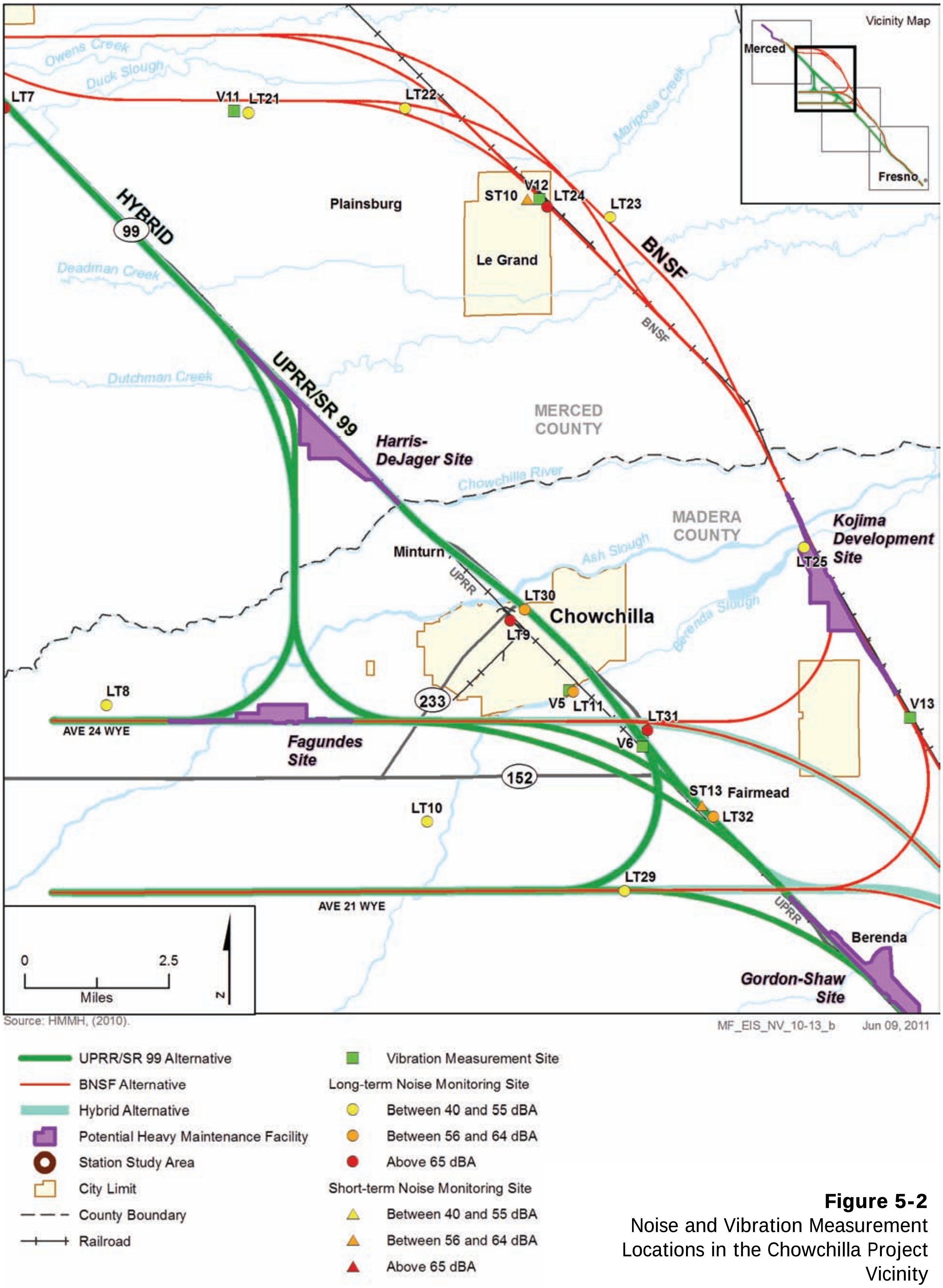


Figure 5-2
Noise and Vibration Measurement Locations in the Chowchilla Project Vicinity

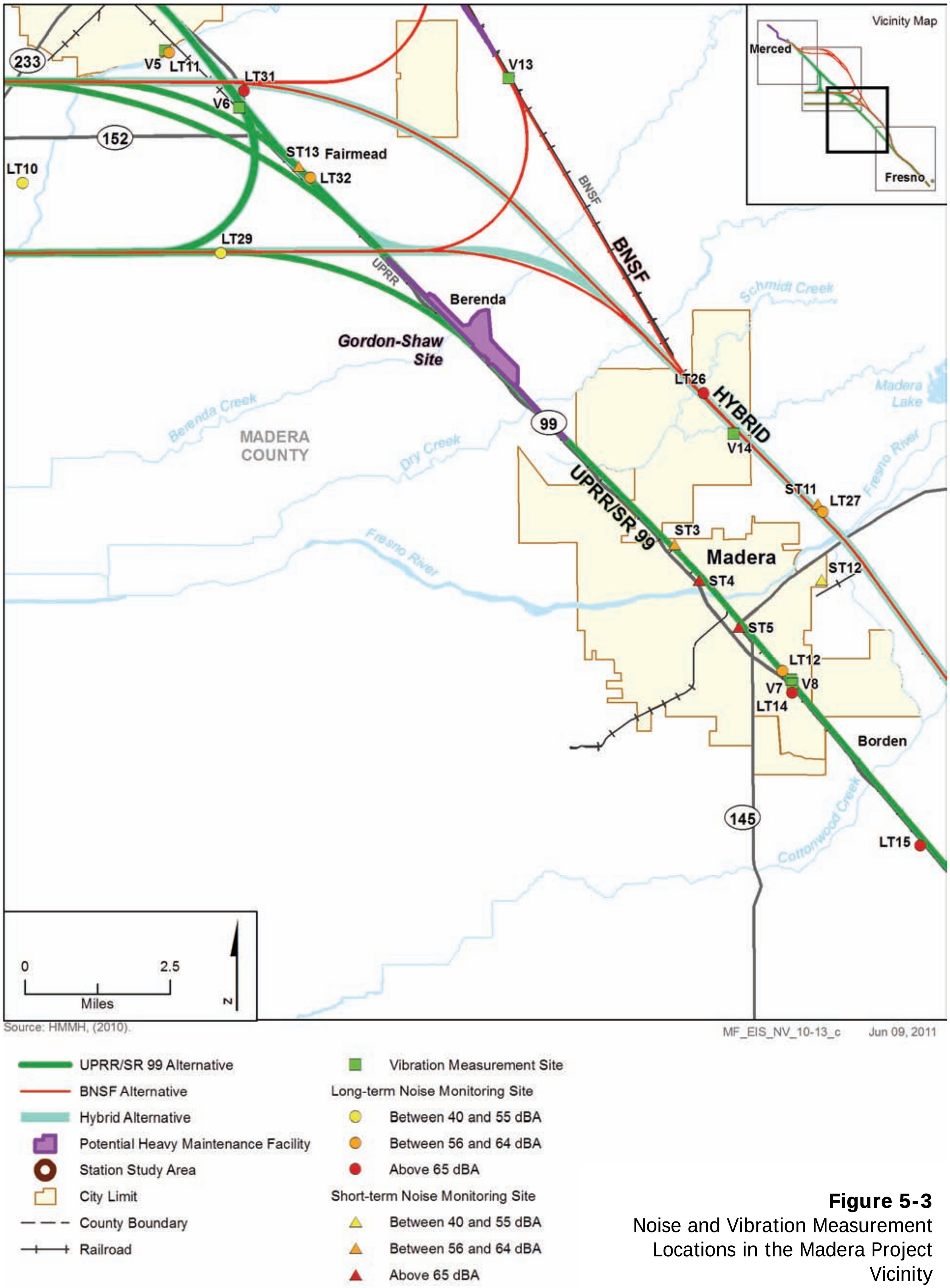


Figure 5-3
Noise and Vibration Measurement Locations in the Madera Project Vicinity

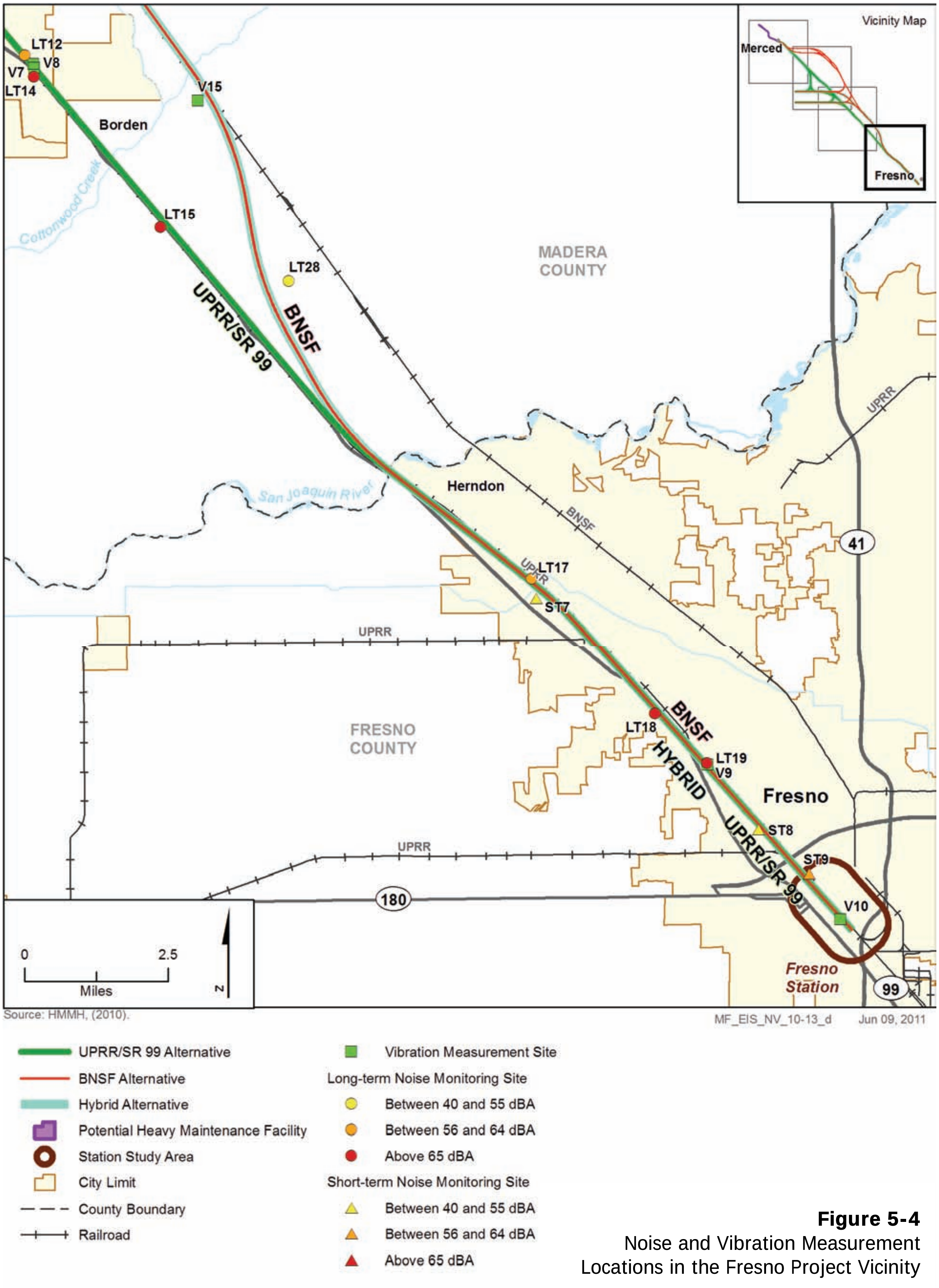


Figure 5-4
Noise and Vibration Measurement Locations in the Fresno Project Vicinity

The BNSF Alternative also passes through rural areas where the noise environment is determined by agriculture activities, crop-dusting aircraft, and local road traffic.

The Hybrid Alternative is a combination of the UPRR/SR 99 and BNSF Alternatives. The Hybrid Alternative follows two different corridors, depending on wye design option. The Hybrid Alternative with Ave 24 Wye follows the UPRR/SR 99 Alternative alignment with West Chowchilla design option from Merced to Chowchilla; from Chowchilla to Fresno, the alignment follows the BNSF Alternative alignment with Ave 24 Wye. The Hybrid Alternative with Ave 21 Wye follows the UPRR/SR 99 Alternative alignment with East Chowchilla design option from Merced to Chowchilla; from Chowchilla to Fresno, the alignment follows the BNSF Alternative alignment with Ave 21 Wye. The noise environments for these locations are identical to those for the UPRR/SR 99 and BNSF Alternatives.

5.2.1 Noise Measurement Methodology

Areas that could be affected by noise from the proposed project are identified by using the FRA screening methodology. Noise-sensitive areas (NSAs) were identified within the study area by locating noise-sensitive land uses listed in Table 4-1 (e.g., residential and institutional) within an appropriate screening distance for the HST alternatives. The screening distances used to identify NSAs were based on FRA guidance shown in Table 4-2. There are 62 NSAs within the noise study areas along the alternative alignments.

FRA makes it clear that it is not necessary, nor is it recommended, that existing noise conditions be measured at every noise-sensitive location in the study area. The recommended approach is to characterize the noise environment for clusters of sites bases on measurements or estimates at representative locations (FRA 2005, Sec. 3.2.2). To establish a base of existing environmental noise levels for project noise impact assessment, a series of noise measurements was conducted at selected sites along the proposed corridor between December 7, 2009, and April 30, 2010. The measurements consisted of long-term (24 hours in duration) and short-term (generally 15 to 60 minutes in duration) monitoring of the A-weighted sound level at representative noise-sensitive locations. A total of 32 long-term and 13 short-term noise measurements were made at locations selected to be representative of the noise environment throughout the study area, and especially at those locations most likely to be affected by HST noise. Long-term measurements were recorded on residential properties including single-family homes, multifamily buildings, and hospitals. Short-term measurements were recorded at noise-sensitive facilities and residences. At each site, the measurement microphone was positioned to characterize the exposure of the site to the dominant noise sources in the area. Larson Davis noise monitors (Models 820, 870, and 824) were used for gathering noise data. Figures 5-1 through 5-4 show the locations of the measurement sites. All of the measurement sites were located in NSAs and were selected to represent a range of existing noise conditions in all of the NSAs along the corridor.

5.2.1.1 UPRR/SR 99 Alternative

Tables 5-1 through 5-5 list the NSAs for the UPRR/SR 99 Alternative and the Ave 24 and Ave 21 wyes. The tables provide descriptions, locations, and representative noise measurement sites associated with each NSA. NSAs include specific noise-sensitive receivers where these receptors could be identified. The NSA tables are organized from north to south by alternatives and cities. Duplication of a defined NSA may occur throughout the tables where alternatives overlap.

Table 5-1
Noise-Sensitive Areas for the UPRR/SR 99 Alternative North-South Alignment

NSA ID[a]	Alternative	City	Description	Measurement Locations[b]
NSA-1W	UPRR/SR 99	Atwater	This area is bounded by Crest Road and the Livingston Canal. The noise-sensitive land uses include residential neighborhoods consisting of single-family homes, both existing and under development, as well as recreational areas, including Veterans Park and Castle Youth Center. The existing noise in this area is dominated by BNSF traffic and local roadway traffic. The park (the nearest sensitive receptor) is located approximately 170 feet from the existing tracks.	LT1
NSA-2	UPRR/SR 99	Atwater	This area is bounded by the Livingston Canal and Belcher Avenue. The noise-sensitive land uses include scattered residential single-family homes and farms. BNSF tracks and Santa Fe Avenue are located between the proposed alternative alignment and residences to the east. The existing noise in this area is dominated by BNSF traffic. The closest residence to the alignment is located on Santa Fe Avenue approximately 60 feet from the existing railway line.	(LT1)
NSA-12	UPRR/SR 99	Merced County	This area is bounded by Sandy Mush Road and Harvey Petitt Road. The noise-sensitive land uses include scattered residential single-family homes and farms. UPRR tracks and SR 99 are located between the proposed alternative alignment and the homes to the east. The existing noise in this area is dominated by SR 99 traffic. The closest residence is approximately 100 feet from SR 99.	(LT7)
NSA-13	UPRR/SR 99	Chowchilla	This area is bounded by SR 233 and Avenue 24½. The noise-sensitive land use includes residential neighborhoods consisting of single-family homes and hotels. Some open land exists between homes and the proposed alternative alignment. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 400 feet from the existing railway line.	LT9, LT30
NSA-14	UPRR/SR 99	Chowchilla	This area is bounded by Avenue 24½ and Avenue 24. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 100 feet from the existing railway line.	LT11
NSA-15	UPRR/SR 99	Chowchilla	This area is bounded by Avenue 24 and Avenue 22¾. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise in this area is dominated by UPRR traffic and SR 99 traffic, with an overpass through the NSA. The closest residence is located approximately 150 feet from the existing tracks and 100 feet from the highway overpass.	LT31 (LT7, LT11)

NSA ID[a]	Alternative	City	Description	Measurement Locations[b]
NSA-16E	UPRR/SR 99	Chowchilla	This area is bounded by Avenue 22¾ and Avenue 22¼. The noise-sensitive land uses include residential neighborhoods consisting of single-family homes and a church. Galilee Missionary Baptist Church is located at 22491 Fairmead Boulevard. The existing noise in this area is dominated by noise from UPRR traffic. The closest residence is located approximately 150 feet from the existing railway line.	LT32, ST13 (LT9)
NSA-17	UPRR/SR 99	Chowchilla	This area is bounded by Avenue 22 and Avenue 20½. The noise-sensitive land uses include scattered residential single-family homes and farms. Open land exists between nearly all homes and the proposed alternative. The existing noise in this area is dominated by SR 99 traffic. The closest residence is located approximately 200 feet from SR 99.	(LT7, LT9)
NSA-18	UPRR/SR 99	Madera	This area is bounded by Avenue 20½ and Avenue 18¾. The noise-sensitive land uses include scattered residential single-family homes and farms. UPRR tracks and SR 99 exist between homes and the proposed alternative alignment. The existing noise in this area is dominated by SR 99 traffic. The closest residence is located approximately 250 feet from SR 99.	(LT7, LT9)
NSA-19	UPRR/SR 99	Madera	This area is bounded by Road 24 and Avenue 17. The noise-sensitive land use includes scattered residential neighborhoods consisting of single-family homes. Golden State Boulevard, SR 99, and UPRR tracks exist between the proposed alternative alignment and homes to the west. The existing noise in this area is dominated by SR 99 traffic. The closest residence is located approximately 150 feet from SR 99.	(LT12, LT14)
NSA-20	UPRR/SR 99	Madera	This area is bounded by Avenue 17 and Country Club Drive. The noise-sensitive land uses include hotels, a church, and scattered residential neighborhoods consisting of single-family homes. The Progressive Church of God in Christ is located at 15879 Cardwell Street. Commercial/industrial areas exist throughout the NSA. The existing noise in this area is dominated by SR 99 traffic and UPRR traffic. The closest residence is located approximately 100 feet from the existing railway line and 200 feet from SR 99.	ST3
NSA-21W	UPRR/SR 99	Madera	This area is Rotary Park on N Gateway Drive. The existing noise in this area is dominated by SR 99 traffic and UPRR traffic. The park is located adjacent to SR 99 and is approximately 140 feet from the existing railway line.	ST4

NSA ID[a]	Alternative	City	Description	Measurement Locations[b]
NSA-22E	UPRR/SR 99	Madera	This area is bounded by W Cleveland Avenue and Olive Avenue. The noise-sensitive land uses include churches and residential neighborhoods consisting of single-family homes. The Believer's Church of Madera is located at 117 North E Street. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 100 feet from the existing railway line.	(LT12, ST4, ST5)
NSA-23W	UPRR/SR 99	Madera	This area consists of Courthouse Park on W Yosemite Avenue. The existing noise in this area is dominated by noise from UPRR traffic. The park is located approximately 300 feet from the existing railway line.	ST5
NSA-24E	UPRR/SR 99	Madera	This area is bounded by E Olive Avenue and Road 28. The noise-sensitive land uses include residential neighborhoods consisting of single-family homes and single-family homes under development. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 50 feet from the existing railway line.	LT12
NSA-25W	UPRR/SR 99	Madera	This area is bounded by E Almond Avenue and Avenue 12. The noise-sensitive land uses include hotels, a hospital, a church, and scattered residential single-family homes. Madera Community Hospital is located at 1250 E Almond Avenue. The UPRR tracks and SR 99 intervene between the sensitive land use areas and the proposed alternative alignment. The existing noise in this area is dominated by SR 99 traffic. The closest residence is located approximately 200 feet from SR 99, and the hospital is located approximately 250 feet from SR 99.	LT14
NSA-26W	UPRR/SR 99	Madera	This area is bounded by Road 29 and Avenue 10. The noise-sensitive land uses include scattered residential single-family homes and farms. The UPRR tracks and SR 99 intervene between the homes and the proposed alternative alignment. The existing noise in this area is dominated by SR 99 traffic. The closest residence is located approximately 170 feet from SR 99.	LT15
NSA-27E	UPRR/SR 99	Madera	This area is bounded by Road 29 and Avenue 10. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise in this area is dominated by SR 99 traffic and UPRR traffic. The closest residence is located approximately 400 feet from the existing railway line and 450 feet from SR 99.	(LT12, LT14)
NSA-28W	UPRR/SR 99	Madera	This area is bounded by Avenue 10 and Road 31 along Golden State Boulevard. The noise-sensitive land use includes residential single-family homes dominated by noise from SR 99 traffic. UPRR tracks and SR 99 are located between homes and the proposed alternative alignment. The closest residence is approximately 150 feet from SR 99.	(LT15)

NSA ID[a]	Alternative	City	Description	Measurement Locations[b]
NSA-29W	UPRR/SR 99	Madera	This area is bounded by Road 32 and Avenue 8. The noise-sensitive land use includes residential single-family homes dominated by noise from SR 99 traffic. UPRR tracks and SR 99 are located between the residences and the proposed alternative alignment. The closest residence is located approximately 70 feet from SR 99.	(LT15)
NSA-30	UPRR/SR 99	Madera	This area is bounded by Avenue 8 and the San Joaquin River. The noise-sensitive land uses include scattered residential single-family homes and farms. The UPRR tracks, SR 99, and some open land are located between the residences and the proposed alternative alignment. The existing noise in this area is dominated by SR 99 traffic. The closest residence is located approximately 300 feet from SR 99.	(LT15)

[a] If listed, a “W” or “E” in the NSA ID indicates the west or east side of the corridor.

[b] Measurement locations in parentheses indicate that a comparable measurement site from a similar NSA was used to represent the NSA.

ID = identifier

LT = long-term measurement

ST = short-term measurement

Table 5-2
Noise-Sensitive Areas in the City of Merced

NSA ID[a]	Alternative	City	Description	Measurement Locations[b]
NSA-3E	UPRR/SR 99	Merced	This area is bounded by Belcher Avenue and Lucich Court along Franklin Avenue. The noise-sensitive land use includes residential neighborhoods consisting of single-family homes. The existing noise in this area is dominated by traffic on SR 99. The closest residence is located approximately 1,800 feet from SR 99.	LT2
NSA-4E	UPRR/SR 99	Merced	This area is bounded by Lucich Court and SR 99 along Franklin Road. The noise-sensitive land use includes residential neighborhoods and scattered single-family homes. Franklin Elementary School, located at 2736 Franklin Road, is approximately 1,950 feet from the highway. The Islamic Center of Merced is located at 2322 N Ashby Road. The existing noise in this area is dominated by SR 99 traffic. The closest residence is approximately 150 feet from SR 99.	LT3, ST1

NSA ID[a]	Alternative	City	Description	Measurement Locations[b]
NSA-5E	UPRR/SR 99	Merced	This area is located east of Ashby Road and is bounded by Wolf Street and Drake Avenue. The noise-sensitive land use includes residential neighborhoods consisting of single-family homes. Ashby Road, SR 99, and UPRR tracks intervene between the homes and the proposed alternative alignment. The existing noise in this area is dominated by SR 99 traffic. The closest residence is approximately 100 feet from SR 99.	(LT3)
NSA-6	UPRR/SR 99	Merced	This area is bounded by Massacio Street and V Street. The noise-sensitive land use includes residential neighborhoods consisting of single-family homes. SR 99 and commercial/industrial areas intervene between the homes and the proposed alternative alignment. The existing noise in this area is dominated by SR 99 traffic. The closest residence is approximately 150 feet from the highway.	(LT3, LT4)
NSA-7W	UPRR/SR 99	Merced	This area is bounded by V Street and G Street. The noise-sensitive land uses include residential single-family homes and multifamily residential buildings. Sierra Meadows Senior Apartments is located at 720 W 15th Street. Residential land use is adjacent to commercial areas in this NSA. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 300 feet from the existing railway line.	LT4
NSA-8E	UPRR/SR 99	Merced	This area includes Bob Hart Park on W Main Street. Commercial land uses intervene between the park and the proposed alternative alignment. The existing noise in this area is dominated by UPRR traffic. The park is located approximately 450 feet from the existing railway line.	ST2
NSA-9W	UPRR/SR 99	Merced	This area is bounded by G Street and Delong Street. The noise-sensitive land uses include residential single-family homes and hospitals. Mercy Medical Center Merced is located at 301 E 13th Street. A homeless shelter is located at 317 E 15th Street. The existing noise in this area is dominated by SR 99 traffic. The closest residential land use is the homeless shelter at approximately 250 feet from the highway overpass.	LT5
NSA-10	UPRR/SR 99	Merced	This area is bounded by E Childs Avenue and E Mission Avenue. The noise-sensitive land uses include residential single-family homes and multifamily buildings. Grove Apartments is at 340 S Parsons Avenue. Parsons Avenue, UPRR tracks, and SR 99 exist between residences to the east and the proposed alternative alignment. The existing noise in this area is dominated by SR 99 traffic. The closest residence is located approximately 350 feet from SR 99.	LT6

NSA ID[a]	Alternative	City	Description	Measurement Locations[b]
NSA-11	UPRR/SR 99	Merced	This area is bounded by E Mission Avenue and S Arboleda Drive. The noise-sensitive land uses include scattered residential single-family homes and farms. UPRR tracks and SR 99 exist between the proposed alternative alignment and homes to the east. Open land exists between nearly all homes and the proposed corridor. The existing noise in this area is dominated by SR 99 traffic. The closest residence is located approximately 70 feet from SR 99.	LT7

[a] If listed, a "W" or "E" in the NSA ID indicates the west or east side of the corridor.

[b] Measurement locations in parentheses indicate that a comparable measurement site from a similar NSA was used to represent the NSA.

Table 5-3
Noise-Sensitive Areas in the City of Fresno

NSA ID[a]	Alternative	City	Description	Measurement Locations[b]
NSA-31	UPRR/SR 99	Fresno	This area is bounded by the San Joaquin River and W Palo Alto Avenue. The noise-sensitive land uses include a hotel and residential neighborhoods consisting of single-family homes. The UPRR tracks, Golden State Boulevard, SR 99, and open land are located between the proposed alternative alignment and homes to the west. The existing noise in this area is dominated by noise from UPRR traffic. The closest residence is located approximately 100 feet from the existing railway line.	(LT17)
NSA-32E	UPRR/SR 99	Fresno	This area is bounded by N Bryan Avenue and N Barcus. The land use includes residential neighborhoods consisting of single-family homes. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 130 feet from the existing railway line.	LT17
NSA-33W	UPRR/SR 99	Fresno	This area is bounded by N Market Avenue and W Shaw Avenue. The noise-sensitive land uses include a hotel, a church, and residential neighborhoods consisting of single-family homes mixed in a commercial/industrial area. Some commercial/industrial land use is located between the residences and the proposed alternative alignment. The First Spanish Baptist Church is located at 5365 W Mission Avenue. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 350 feet from the existing railway line.	ST7

NSA ID[a]	Alternative	City	Description	Measurement Locations[b]
NSA-34W	UPRR/SR 99	Fresno	This area is bounded by Dakota Avenue and Princeton Avenue. The noise-sensitive land uses include hotels and residential neighborhoods consisting of multifamily buildings and single-family homes. Sunset Mobile and RV Park is located at 3187 N Parkway Drive. SR 99 intervenes between the residences and the proposed alternative alignment. A UPRR freight rail yard exists on the east side of the proposed alternative. The existing noise in this area is dominated by SR 99 traffic and activity at the freight yard. The closest residence is located approximately 200 feet from SR 99.	LT18
NSA-35W	UPRR/SR 99	Fresno	This area is bounded by Princeton Avenue and McKinley Avenue. The noise-sensitive land uses include hotels and residential neighborhoods consisting of single-family homes and multifamily buildings. The Hacienda, a senior housing facility, is located at 2550 W Clinton Avenue. SR 99 intervenes between most NSAs and the proposed alternative alignment. The existing noise in this area is dominated by SR 99 traffic. The closest residence is located approximately 40 feet from SR 99.	(LT18)
NSA-36E	UPRR/SR 99	Fresno	This area is bounded by Clinton Avenue and Belmont Avenue. The noise-sensitive land uses include residential neighborhoods consisting of single-family homes and multifamily buildings. Bel Haven Care is located at 2020 N Weber Avenue. The UPRR tracks and Weber Avenue intervene between the sensitive land uses and the proposed alternative alignment. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 100 feet from the existing railway line.	LT19
NSA-37W	UPRR/SR 99	Fresno	This area consists of Roeding Park on W Belmont Avenue. Motel Drive is located between the park and the proposed alternative alignment. The existing noise in this area is dominated by UPRR traffic. The park is located approximately 100 feet from the existing railway line.	ST8
NSA-38E	UPRR/SR 99	Fresno	This area is bounded by Belmont Avenue and Fresno Street. The noise-sensitive land uses include residential single-family homes and multifamily buildings. The H Street Lofts are located at 1814 H Street. Commercial/industrial areas are located between the sensitive land uses and the proposed alternative alignment. The existing noise in this area is dominated by local traffic and UPRR traffic. The closest residence is located approximately 360 feet from the existing railway line.	ST9

[a] If listed, a “W” or “E” in the NSA ID indicates the west or east side of the corridor.

[b] Measurement locations in parentheses indicate that a comparable measurement site from a similar NSA was used to represent the NSA.

Table 5-4
Noise-Sensitive Areas for the UPRR/SR 99 Alternative with Ave 24 Wye

NSA ID	Alternative	City	Description	Measurement Locations
NSA-61	UPRR/SR 99 East and West Chowchilla design options with Ave 24 Wye	Chowchilla	This area is to the west of SR 99 and is bounded by SR 99 and SR 152. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT8

Table 5-5
Noise Sensitive Areas for the UPRR/SR 99 Alternative with Ave 21 Wye

NSA ID	Alternative	City	Description	Measurement Locations[a]
NSA-55	UPRR/SR 99 with Ave 21 Wye	Madera	This area is bounded by Road 8 and Road 19. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT29
NSA-59	UPRR/SR 99 with Ave 21 Wye	Madera	This area is bounded by Road 19 and Road 21. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT29)
NSA-60	UPRR/SR 99 with Ave 21 Wye	Madera	This area is bounded by Avenue 21 and SR 152. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT29)

[a] Measurement locations in parentheses indicate that a comparable measurement site from a similar NSA was used to represent the NSA.

5.2.1.2 BNSF Alternative

Tables 5-6 through 5-8 list NSAs unique to the BNSF Alternative. NSAs for the BNSF Alternative are the same as the UPRR/SR 99 Alternative for areas of the north-south alignment that are common to both alternatives and in the cities of Merced and Fresno.

Table 5-6
Noise-Sensitive Areas for the Unique Portion of the BNSF Alternative North-South Alignment

NSA ID	Alternative	City	Description	Measurement Locations[a]
NSA-39	BNSF with Mission Ave design option	Merced	This area is bounded by S Coffee Street and Whealan Road. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT20

NSA ID	Alternative	City	Description	Measurement Locations[a]
NSA-40	BNSF with Mission Ave design option	Le Grand	This area is bounded by Whealan Road and Morley Avenue. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT21)
NSA-41	BNSF with Mission Ave design option	Le Grand	This area is bounded by Morley Avenue and Savana Road. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT22)
NSA-42	BNSF with Mariposa Way design option	Merced	This area is bounded by Pioneer Road and Whealan Road. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT20)
NSA-43	BNSF with Mariposa Way design option	Le Grand	This area is bounded by Whealan Road and Morley Avenue. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT21
NSA-44	BNSF with Mariposa Way design option	Le Grand	This area is bounded by Morley Avenue and Banks Road. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT22
NSA-45	BNSF with East of Le Grand design options	Le Grand	This area is bounded by Santa Fe Avenue and Fresno Road. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT23)
NSA-46	BNSF with East of Le Grand design options	Le Grand	This area is bounded by Fresno Road and Buchanan Hollow Road. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT23
NSA-47	BNSF	Le Grand	This area is bounded by Savana Road and Fresno Road. The noise-sensitive land uses include residential neighborhoods consisting of multifamily and single-family homes.	LT24, ST10
NSA-48	BNSF	Le Grand	This area is bounded by Fresno Road and White Rock Road. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT24)
NSA-49	BNSF	Le Grand	This area is bounded by White Rock Road and Avenue 24. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT25
NSA-50	BNSF	Madera	This area is bounded by Avenue 24 and Avenue 19. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT25)
NSA-51	BNSF	Madera Acres	This area is bounded by Avenue 19 and Road 27. The noise-sensitive land uses include residential neighborhoods consisting of single-family homes.	LT26
NSA-52	BNSF	Madera Acres	This area is bounded by Road 27 and Raymond Road. The noise-sensitive land uses include residential neighborhoods consisting of single-family homes.	LT27, ST11

NSA ID	Alternative	City	Description	Measurement Locations[a]
NSA-53	BNSF	Madera	This area is bounded by SR 145 and Avenue 15. The noise-sensitive land uses include residential neighborhoods consisting of single-family homes.	ST12
NSA-54	BNSF	Madera	This area is bounded by Avenue 15 and Avenue 9. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT28

[a] Measurement locations in parentheses indicate that a comparable measurement site from a similar NSA was used to represent the NSA.

Table 5-7
Noise-Sensitive Areas for the BNSF Alternative with Ave 24 Wye

NSA ID	Alternative	City	Description	Measurement Locations[a]
NSA-62	BNSF with Ave 24 Wye	Chowchilla	This area is bounded by Avenue 26 and Avenue 20½ east of SR 99. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT31 (LT25)

[a] Measurement locations in parentheses indicate that a comparable measurement site from a similar NSA was used to represent the NSA.

Table 5-8
Noise-Sensitive Areas for the BNSF Alternative with Ave 21 Wye

NSA ID	Alternative	City	Description	Measurement Locations[a]
NSA-56	BNSF with Ave 21 Wye	Madera	This area is bounded by Road 19 and Road 22. This NSA contains SR 99. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic and highway traffic near SR 99.	(LT32)
NSA-57	BNSF with Ave 21 Wye	Madera	This area is bounded by Road 22 and Avenue 19. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT25)
NSA-58	BNSF with Ave 21 Wye	Madera	This area is bounded by Road 22 and Avenue 23. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT32, LT25)

[a] Measurement locations in parentheses indicate that a comparable measurement site from a similar NSA was used to represent the NSA.

5.2.1.3 Hybrid Alternative

The Hybrid Alternative is a combination of the northern portion of the UPRR/SR 99 alignment and the southern portion of the BNSF Alternative. NSAs for the Hybrid Alternative are the same as the UPRR/SR 99 and BNSF Alternatives for areas of the north-south alignment that are common to both alternatives and in the cities of Merced and Fresno. Tables 5-9 through 5-11 list NSAs for the Hybrid Alternative that exist outside the cities of Merced and Fresno.

Table 5-9
Noise-Sensitive Areas for the Hybrid Alternative North-South Alignment

NSA ID	Alternative	City	Description	Measurement Locations
NSA-1W	Hybrid	Atwater	This area is bounded by Crest Road and the Livingston Canal. The noise-sensitive land uses include residential neighborhoods consisting of single-family homes, both existing and under development, as well as recreational areas, including Veterans Park and Castle Youth Center. The existing noise in this area is dominated by BNSF traffic and local roadway traffic. Veterans Park (the nearest sensitive receptor) is located approximately 170 feet from the existing tracks.	LT1
NSA-2	Hybrid	Atwater	This area is bounded by the Livingston Canal and Belcher Avenue. The noise-sensitive land uses include scattered residential single-family homes and farms. BNSF tracks and Santa Fe Avenue are located between the proposed alternative and residences to the east. The existing noise in this area is dominated by BNSF traffic. The closest residence to the alignment is located on Santa Fe Avenue, approximately 60 feet from the existing railway line.	(LT1)
NSA-12	Hybrid	Merced County	This area is bounded by Sandy Mush Road and Harvey Petitt Road. The noise-sensitive land uses include scattered residential single-family homes and farms. UPRR tracks and SR 99 are located between the proposed alternative alignment and residences to the east. The existing noise in this area is dominated by SR 99 traffic. The closest residence is approximately 100 feet from SR 99.	(LT7)
NSA-13	Hybrid	Chowchilla	This area is bounded by SR 233 and Avenue 24½. The noise-sensitive land use includes residential neighborhoods consisting of single-family homes and hotels. Some open land exists between homes and the proposed alternative alignment. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 400 feet from the existing railway line.	LT9, LT30
NSA-14	Hybrid	Chowchilla	This area is bounded by Avenue 24½ and Avenue 24. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 100 feet from the existing railway line.	LT11

NSA ID	Alternative	City	Description	Measurement Locations
NSA-15	Hybrid	Chowchilla	This area is bounded by Avenue 24 and Avenue 22¾. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise in this area is dominated by UPRR traffic and SR 99 traffic, with an overpass through the NSA. The closest residence is located approximately 150 feet from the existing tracks and 100 feet from the highway overpass.	LT31 (LT7, LT11)
NSA-50	Hybrid	Madera	This area is bounded by Avenue 24 and Avenue 19, east of SR 99. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT25)
NSA-51	Hybrid	Madera Acres	This area is bounded by Avenue 19 and Road 27. The noise-sensitive land uses include residential neighborhoods consisting of single-family homes.	LT26
NSA-52	Hybrid	Madera Acres	This area is bounded by Road 27 and Raymond Road. The noise-sensitive land uses include residential neighborhoods consisting of single-family homes.	LT27, ST11
NSA-53	Hybrid	Madera	This area is bounded by SR 145 and Avenue 15. The noise-sensitive land uses include residential neighborhoods consisting of single-family homes.	ST12
NSA-54	Hybrid	Madera	This area is bounded by Avenue 15 and Avenue 9. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT28

Table 5-10
Noise-Sensitive Areas for the Hybrid Alternative with Ave 24 Wye

NSA ID	Alternative	City	Description	Measurement Locations
NSA-61	Hybrid with Ave 24 Wye	Chowchilla	This area is to the west of SR 99 and is bounded by SR 99 and SR 152. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT8

Table 5-11
Noise-Sensitive Areas for the Hybrid Alternative with Ave 21 Wye

NSA ID	Alternative	City	Description	Measurement Locations
NSA-55	Hybrid with Ave 21 Wye	Madera	This area is bounded by Road 8 and Road 19. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	LT29
NSA-56	Hybrid with Ave 21 Wye	Madera	This area is bounded by Road 19 and Road 22. This NSA contains SR 99. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic and highway traffic near SR 99.	(LT32)
NSA-57	Hybrid with Ave 21 Wye	Madera	This area is bounded by Road 22 and Avenue 19. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT25)
NSA-60	Hybrid with Ave 21 Wye	Madera	This area is bounded by Avenue 21 and SR 152. The noise-sensitive land uses include scattered residential single-family homes and farms. The existing noise environment is dominated by rural traffic.	(LT29)

5.2.2 Noise Measurement Results

The following sections provide tables showing the long-term and short-term noise measurement results for the HST alternatives. The accompanying tables describe the existing noise environment in each portion of the study area, listing the measurement location ID, representative NSA, city, address, summary of contributing noise sources, and the resulting noise levels. Long-term measurement sites are listed for each portion of the HST project where the site measurement will be applied in the assessment. Short-term measurements are considered supplementary to long-term measurements. Each short-term measurement site is listed for the portion of the HST project where the site is located. Appendix B provides photographs of each measurement site, and Appendix C provides additional noise measurement data.

5.2.2.1 UPRR/SR 99 Alternative (Long-Term Sites)

Tables 5-12 through 5-16 list the long-term noise measurements for the UPRR/SR 99 Alternative. Measured L_{dn} levels ranged from 49 dBA to 75 dBA along the UPRR/SR 99 Alternative where measurement locations were either in urban/suburban areas or near SR 99. L_{dn} levels along this alternative vary because of proximity to SR 99.

Table 5-12
Long-Term Noise Measurement Locations for the UPRR/SR 99 Alternative North-South Alignment

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT1	1W	Atwater	3005 Lucky Debonair Street	BNSF, local traffic	56	51
LT9	13W	Chowchilla	240 Front Street	UPRR, local traffic	67	58

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT11	14	Chowchilla	17142 Avenue 24½	UPRR, rural traffic	62	53
LT12	24E	Madera	2046 Varbella Park	SR 99, UPRR, local traffic	64	57
LT14	25W	Madera	1250 E Almond Avenue	SR 99, UPRR, local traffic	71	65
LT15	26W	Madera	10696 SR 99	SR 99, UPRR, local traffic	66	61
LT30	13	Chowchilla	309 Prosperity Blvd	SR 99, UPRR, local traffic	63	63
LT31	15	Chowchilla	23711 Fairmead Blvd	SR 99, UPRR, local traffic	64	63
LT32	16E	Chowchilla	22327 Arnott Drive	SR 99, UPRR, local traffic	61	61

[a]L_{eq} values were averaged over two ranges of typical peak traffic hours: 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The lower of the two averages was used to accentuate the potential impacts.

Table 5-13
Long-Term Noise Measurement Locations for the City of Merced

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT2	3E	Merced	3227 W Culley Court	SR 99, local traffic	58	50
LT3	4E	Merced	2350 Franklin Road	SR 99, UPRR, local traffic	63	59
LT4	7W	Merced	720 W 15th Street	SR 99, UPRR, local traffic	73	64
LT5[b]	9W	Merced	301 E 13th Street	SR 99, UPRR, local traffic	72	62
LT6	10E	Merced	340 S Parsons Avenue	SR 99, UPRR, local traffic	75	71
LT7	11	Merced	4000 Mariposa Way	SR 99, UPRR	67	58

[a]L_{eq} values were averaged over two ranges of typical peak traffic hours: 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The lower of the two averages was used to accentuate the potential impacts.

[b]Correction for surface reflections (ASTM E966-02).

Table 5-14
Long-Term Noise Measurement Locations for the City of Fresno

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT17	32E	Fresno	5468 Delbert Avenue	UPRR, local traffic	63	57
LT18	34W	Fresno	3089 N Feland Avenue	SR 99, UPRR rail yard, local traffic	72	68
LT19	36E	Fresno	2020 N Weber Avenue	UPRR, local traffic	70	66

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)

[a]L_{eq} values were averaged over two ranges of typical peak traffic hours: 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The lower of the two averages was used to accentuate the potential impacts.

Table 5-15
Long-Term Noise Measurement Locations for the UPRR/SR 99 Alternative with Ave 24 Wye

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT8	39	Chowchilla	24290 Road 9	Rural traffic	51	45

[a]L_{eq} values were averaged over two ranges of typical peak traffic hours: 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The lower of the two averages was used to accentuate the potential impacts.

Table 5-16
Long-Term Noise Measurement Locations for the UPRR/SR 99 Alternative with Ave 21 Wye

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT10	41	Chowchilla	22283 Road 14½	Rural traffic	50	42
LT29	55	Madera	20978 Road 18	UPRR, local traffic	49	50

[a]L_{eq} values were averaged over two ranges of typical peak traffic hours: 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The lower of the two averages was used to accentuate the potential impacts.

5.2.2.2 BNSF Alternative (Long-Term Sites)

Tables 5-17 and 5-18 list the long-term noise measurements at locations that are unique to the BNSF Alternative. Measured L_{dn} values ranged from 46 dBA to 69 dBA in suburban and rural environments and vary based on community activity and traffic.

Table 5-17
Long-Term Noise Measurement Locations for the Unique Portion of the BNSF Alternative North-South Alignment

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT20	39	Merced	3269 E Mission Avenue	SR 99, UPRR, local traffic	56	59
LT21	43	Merced	823 Mariposa Way	Local traffic	48	46
LT22	44	Le Grand	2373 S Burchell Avenue	Local traffic, BNSF	49	50
LT23	46	Le Grand	4280 S Ipsen Avenue	BNSF, local traffic	47	48

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT24	47	Le Grand	4112 Marshall Street	BNSF, local traffic	67	64
LT25	49	Chowchilla	27112 Santa Fe Drive	BNSF, local traffic	54	50
LT26	51	Madera Acres	26226 Wayside Drive	BNSF, local traffic	69	66
LT27	52	Madera	16494 Harper Blvd	BNSF, local traffic	59	59
LT28	54	Madera	9691 Road 32	SR 99, BNSF, local traffic	46	44

[a]L_{eq} values were averaged over two ranges of typical peak traffic hours: 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The lower of the two averages was used to accentuate the potential impacts.

Table 5-18
Long-Term Noise Measurement Locations for the BNSF Alternative with Ave 21 Wye

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT10	55	Chowchilla	22283 Road 14½	Rural traffic	50	42
LT29	55	Madera	20978 Road 18	UPRR, local traffic	49	50

[a]L_{eq} values were averaged over two ranges of typical peak traffic hours: 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The lower of the two averages was used to accentuate the potential impacts.

5.2.2.3 Hybrid Alternative (Long-Term Sites)

The Hybrid Alternative is a combination of the northern portion of the UPRR/SR 99 Alternative and the southern portion of the BNSF Alternative. Long-term noise measurements for the Hybrid Alternative are the same as the UPRR/SR 99 and BNSF Alternatives for areas of the north-south alignment that are common to both alternatives and in the cities of Merced and Fresno. Tables 5-19 through 5-21 list long-term noise measurements for the Hybrid Alternative that exist outside the cities of Merced and Fresno.

Table 5-19
Long-Term Noise Measurement Locations for the Hybrid Alternative North-South Alignment

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT1	1W	Atwater	3005 Lucky Debonair Street	BNSF, local traffic	56	51
LT9	13W	Chowchilla	240 Front Street	UPRR, local traffic	67	58
LT11	14	Chowchilla	17142 Avenue 24½	UPRR, rural traffic	62	53
LT26	51	Madera Acres	26226 Wayside Drive	BNSF, local traffic	69	66

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT27	52	Madera	16494 Harper Blvd	BNSF, local traffic	59	59
LT28	54	Madera	9691 Road 32	SR 99, BNSF, local traffic	46	44
LT30	13	Chowchilla	309 Prosperity Blvd	SR 99, UPRR, local traffic	63	63
LT31	15	Chowchilla	23711 Fairmead Blvd	SR 99, UPRR, local traffic	64	63
LT32	16E	Chowchilla	22327 Arnott Drive	SR 99, UPRR, local traffic	61	61

[a]Leq values were averaged over two ranges of typical peak traffic hours: 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The lower of the two averages was used to accentuate the potential impacts.

Table 5-20
Long-Term Noise Measurement Locations for the Hybrid Alternative with Ave 24 Wye

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT8	39	Chowchilla	24290 Road 9	Rural traffic	51	45

[a]L_{eq} values were averaged over two ranges of typical peak traffic hours: 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The lower of the two averages was used to accentuate the potential impacts.

Table 5-21
Long-Term Noise Measurement Locations for the Hybrid Alternative with Ave 21 Wye

Site	NSA	City	Address	Contributing Noise Sources	Measured L_{dn} (dBA)	Peak-Hour[a] L_{eq} (dBA)
LT10	55	Chowchilla	22283 Road 14½	Rural traffic	50	42
LT29	55	Madera	20978 Road 18	UPRR, local traffic	49	50

[a]L_{eq} values were averaged over two ranges of typical peak traffic hours: 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The lower of the two averages was used to accentuate the potential impacts.

5.2.2.1 UPRR/SR 99 Alternative (Short-Term Sites)

Tables 5-22 through 5-24 list the short-term noise measurements for the UPRR/SR 99 Alternative. Measured L_{eq} levels ranged from 54 dBA to 69 dBA along the UPRR/SR 99 Alternative where measurement locations were either in urban or suburban areas or near SR 99.

Table 5-22
Short-Term Noise Measurement Locations for the UPRR/SR 99 Alternative North-South Alignment

Site	NSA	City	Location	Contributing Noise Sources	Duration	Measured L_{eq} (dBA)	Estimated L_{dn}[a] (dBA)
ST3	20	Madera	Progressive Church of God in Christ: 15879 Cardwell Street	UPRR, local traffic	1 hour	61	59
ST4	21W	Madera	Rotary Park: N Gateway Drive	SR 99, UPRR, local traffic	1 hour	69	67
ST5	23W	Madera	Courthouse Park: W Yosemite Avenue	UPRR, local traffic	1 hour	67	65
ST13	16E	Chowchilla	Galilee Missionary Baptist Church: 22491 Fairmead Blvd.	SR 99, local traffic	1 hour	60	58

[a]Based on Adjustment Option 4 (FTA 2006).

Table 5-23
Short-Term Noise Measurement Locations for the City of Merced

Site	NSA	City	Location	Contributing Noise Sources	Duration	Measured L_{eq} (dBA)	Estimated L_{dn}[a] (dBA)
ST1	4E	Merced	Franklin Elementary School: 2736 Franklin Road	SR 99, local traffic	15 minutes	56	54
ST2	8E	Merced	Bob Hart Park: W Main Street	UPRR, local traffic	15 minutes	61	59

[a]Based on Adjustment Option 4 (FTA 2006).

Table 5-24
Short-Term Noise Measurement Locations for the City of Fresno

Site	NSA	City	Location	Contributing Noise Sources	Duration	Measured L_{eq} (dBA)	Estimated L_{dn}[a] (dBA)
ST7	33W	Fresno	First Spanish Baptist Church: 5365 W Mission Avenue	SR 99, UPRR, local traffic	1 hour	54	52
ST8	37W	Fresno	Roeding Park: W Belmont Avenue	UPRR tracks, local traffic	1 hour	55	53
ST9b	38E	Fresno	H Street Lofts: 1814 H Street	UPRR, local traffic	1 hour	61	59

[a]Based on Adjustment Option 4 (FTA 2006).
[b]Correction for surface reflections (ASTM E966–02).

5.2.2.2 BNSF Alternative (Short-Term Sites)

Table 5-25 lists the short-term noise measurements. Measured L_{eq} levels ranged from 54 dBA to 61 dBA in areas specific to the BNSF Alternative where measurement locations exist in suburban and rural environments. The levels vary based on community activity and traffic.

Table 5-25
Short-Term Noise Measurement Locations for the BNSF Alternative North-South Alignment

Site	NSA	City	Location	Contributing Noise Sources	Duration	Measured L_{eq} (dBA)	Estimated L_{dn}[a] (dBA)
ST10	47	Le Grand	Le Grand Elementary School: 13071 Le Grand Road	Local traffic	1 hour	57	55
ST11	52	Madera	Morning Star Baptist Church: 16587 Harper Blvd.	Local traffic	1 hour	56	54
ST12	53	Madera	Millview Park: Clinton Street	Local traffic	1 hour	51	49

[a]Based on Adjustment Option 4 (FTA 2006).

5.2.2.3 Hybrid Alternative (short-Term Sites)

The Hybrid Alternative is a combination of the northern portion of the UPRR/SR 99 alignment and the southern portion of the BNSF Alternative. Short-term noise measurements for the Hybrid Alternative are the same as the UPRR/SR 99 and BNSF Alternatives for areas of the north-south alignment common to both alternatives and in the cities of Merced and Fresno. Short-term noise measurements for the Hybrid Alternative that exist outside the cities of Merced and Fresno are listed in Table 5-26.

Table 5-26
Short-Term Noise Measurement Locations for the Hybrid Alternative North-South Alignment

Site	NSA	City	Location	Contributing Noise Sources	Duration	Measured L_{eq} (dBA)	Estimated L_{dn}[a] (dBA)
ST11	52	Madera	Morning Star Baptist Church: 16587 Harper Blvd.	Local traffic	1 hour	56	54
ST12	53	Madera	Millview Park: Clinton Street	Local traffic	1 hour	51	49
ST13	16E	Chowchilla	Galilee Missionary Baptist Church: 22491 Fairmead Blvd.	SR 99, local traffic	1 hour	60	58

[a]Based on Adjustment Option 4 (FTA 2006).

5.2.3 Noise Measurement Discussion

5.2.3.1 Existing Noise along UPRR/SR 99 Alternative Corridor

North-South Alignment

The noise environment along the proposed UPRR/SR 99 Alternative is influenced by SR 99, UPRR, and BNSF railroad traffic, and local community noise (e.g., local roadway traffic, pedestrian and resident noise, animals, and electronics). At the north end of the alignment in Atwater, passenger and freight trains dominate the noise exposure in areas close to the UPRR and BNSF tracks. In areas close to Santa Fe Avenue, local roadway traffic dominates the noise environment. Nearing Merced from the north, traffic on SR 99 and freight trains on the UPRR railroad dominate the noise exposure, with roadway traffic contributing more near the city center where SR 99, SR 59, and SR 140 converge. Merced Regional Airport is located approximately 2 miles southwest of Merced's city center and contributes aircraft noise to the environment.

South of Merced, noise from SR 99 and the UPRR railroad dominates the noise environment in unincorporated areas between Merced and Chowchilla. Because NSAs in Chowchilla are farther from SR 99 than the UPRR railroad, freight trains and local community noise dominate the noise environment for both Chowchilla design options. In addition, there is a general aviation airport in Chowchilla located 1 mile southeast of the city center.

South of Chowchilla, noise from SR 99 and the UPRR railroad dominates the existing noise environment at scattered residences. Entering Madera, the proposed alignment is farther from SR 99. Near Madera's city center the noise environment is dominated by UPRR railroad traffic and local community noise. Madera Municipal Airport is located approximately 3 miles northwest of the city center. This general aviation airport contributes aircraft noise to the environment.

In the unincorporated area between Madera and Fresno, SR 99 and UPRR traffic dominate the noise environment. Entering Fresno, the noise environment is dominated by freight trains and local roadway traffic. The UPRR runs through Fresno east of SR 99, and the UPRR rail yard is located between Ashlan Avenue and Clinton Avenue. In this area, the rail yard contributes to the noise environment along with SR 99 and local community noise. South of the rail yard, the noise environment is dominated by UPRR railroad traffic and local community noise. Fresno is the most densely populated city along the proposed corridor, with several highways, busy local roads, the UPRR, and aircraft noise contributing to the noise environment. SR 99, SR 180, and SR 41 are near the proposed HST station in Fresno.

Fresno has two airports, Fresno-Yosemite International and Fresno Chandler Downtown. Fresno-Yosemite International is located approximately 3 miles northeast of Fresno's city center and operates scheduled commercial flights. Fresno Chandler Downtown is located approximately 2.5 miles southwest of the city center and is a public airport used for general aviation. Sierra Sky Park Airport, located approximately 8 miles northwest of Fresno's city center, is a privately owned airport used for general aviation.

Ave 24 Wye and Ave 21 Wye

The Ave 24 Wye and the Ave 21 Wye design options are in a rural, unincorporated portion of Madera County. The existing noise environment is dominated by natural sounds, distant traffic, and agricultural activities.

5.2.3.2 Existing Noise along BNSF Alternative Corridor

North-South Alignment

The proposed BNSF Alternative alignment is the same as UPRR/SR 99 Alternative alignment to the south end of Merced. The BNSF Alternative alignment then moves east into rural unincorporated areas following four design options: Mariposa Way, Mariposa Way East of Le Grand, Mission Ave, and Mission Ave East of Le Grand. The City of Le Grand has a low population and is mainly residential; therefore, it is considered suburban. After Le Grand, the design options merge and the BNSF Alternative continues south toward Madera Acres. This portion of the alignment passes through farmland with a noise environment dominated by rural activities. Madera Acres is north of Madera and is also mainly residential, so it is also considered suburban. The BNSF Alternative continues through the suburban areas of Madera Acres and Madera until it turns west, back toward the UPRR/SR 99 Alternative alignment near the Madera County line. Traffic on local roadways is likely the greatest contributor of noise, added to by agricultural activity and aircraft noise. The HST alternatives continue to share the corridor to the proposed Fresno HST station.

Ave 24 Wye and Ave 21 Wye

The Ave 24 Wye and the Ave 21 Wye design options are in a rural, unincorporated portion of Madera County. The existing noise environment is dominated by natural sounds, distant traffic, and agricultural activities.

5.2.3.3 Heavy Maintenance Facility

Because an HMF would be located along one of the HST alternatives, the appropriate part of the discussion above would apply to the existing noise environment at each of the proposed HMF sites.

5.2.3.4 Existing Noise along Hybrid Alternative Corridor

The Hybrid Alternative alignment is a combination of the UPRR/SR 99 Alternative and BNSF Alternative alignments. The Hybrid Alternative follows two different corridors depending on wye design option. The Hybrid Alternative with Ave 24 Wye follows the UPRR/SR 99 Alternative alignment with West Chowchilla design option from Merced to Chowchilla; from Chowchilla to Fresno, the alignment follows the BNSF Alternative alignment with Ave 24 Wye. The Hybrid Alternative with Ave 21 Wye follows the UPRR/SR 99 Alternative alignment with East Chowchilla design option from Merced to Chowchilla; from Chowchilla to Fresno, the alignment follows the BNSF Alternative alignment with Ave 21 Wye. The noise environments for these areas were previously described for the UPRR/SR 99 and BNSF Alternatives.

5.3 Existing Vibration Conditions

Most of the time, people are unaware of vibrations in the environment. Vibration levels are generally below the threshold of perception in outdoor areas. As a result, characterization of the existing outdoor vibration environment is generally not important. However, vibration levels may be perceptible in buildings in the vicinity of railroad tracks, highways, rough roads carrying heavy trucks, and construction activities. People tend to be more aware of vibrations in the indoor environment, especially when vibrations from repetitive events are perceptible. When those repetitive events are train pass-bys that shake the building, people become especially annoyed. FRA recognizes that addition of a new vibration source like the HST to a corridor that already has a source of repetitive vibrations represents a potential impact. Consequently, characterization of the existing vibration environment is usually confined to areas near transportation corridors.

Sources of existing vibrations along the UPRR/SR 99 Alternative include UPRR and BNSF freight and Amtrak passenger trains, as well as truck traffic on SR 99. Sources of existing vibrations along the unique portion of the BNSF Alternative include BNSF freight and Amtrak passenger trains. Along both alternatives, existing vibration levels are generally low, except near existing railroad tracks. The Hybrid Alternative is a combination of the UPRR/SR 99 and BNSF Alternatives. The Hybrid Alternative follows two different corridors depending on wye design option. The Hybrid Alternative with Ave 24 Wye follows the UPRR/SR 99 Alternative alignment with West Chowchilla design option from Merced to Chowchilla; from Chowchilla to Fresno, the alignment follows the BNSF Alternative alignment with Ave 24 Wye. The Hybrid Alternative with Ave 21 Wye follows the UPRR/SR 99 Alternative alignment with East Chowchilla design option from Merced to Chowchilla; from Chowchilla to Fresno, the alignment follows the BNSF Alternative alignment with Ave 21 Wye. The vibration environments for these locations are identical to the vibration environments for the UPRR/SR 99 and BNSF Alternatives.

5.3.1 Vibration Measurement Methodology

To identify areas that could be affected by vibration from the project, vibration-sensitive areas (VSAs) were identified within the study areas. Table 4-6 lists vibration-sensitive land uses within the appropriate screening distance for the proposed HST alternatives. Table 4-8 lists the FRA screening distances used to identify VSAs. The VSA identifiers (IDs) correspond to the NSA IDs. Forty-six VSAs are within the vibration study areas along the HST alternatives. Fifteen vibration measurements were recorded at sites throughout the study area. Figures 5-1 through 5-4 show the locations of the vibration measurement sites. Most of the vibration measurement sites are located within a defined VSA. However, three vibration propagation sites are not located within the specific boundaries of any VSA. All vibration sites that are being used to represent a VSA, including these three vibration propagation sites, are listed as measurement locations in parenthesis for the VSA. Duplication of a defined VSA may occur throughout the tables where HST alternatives overlap.

5.3.1.1 UPRR/SR 99 Alternative

VSAs for the UPRR/SR 99 Alternative are listed in Tables 5-27 through 5-31 and include locations, descriptions, and vibration measurement sites associated with each VSA.

Table 5-27
Vibration-Sensitive Areas for the UPRR/SR 99 Alternative North-South Alignment

VSA ID[a]	Alternative	City	Description	Measurement Locations[b]
VSA-1W	UPRR/SR 99	Atwater	This area is bounded by Crest Road and the Livingston Canal. The land uses include residential neighborhoods consisting of single-family homes, and single-family homes under development, and recreational areas including Veterans Park and Castle Youth Center. The closest edge of the park is located approximately 170 feet from the existing railway line. There are homes in this VSA located within 50 feet of the proposed alignment.	V2 (V1)
VSA-2	UPRR/SR 99	Atwater	This area is bounded by the Livingston Canal and Belcher Avenue. The land uses include scattered residential single-family homes and farms. BNSF tracks and Santa Fe Avenue are located between the proposed alignment and homes to the east. Open land exists between nearly all homes and the proposed alternative. The closest residence is located on Santa Fe Avenue approximately 60 feet from the existing railway line. There are homes in this VSA located within 50 feet of the proposed alignment.	(V2, V1)
VSA-12	UPRR/SR 99	Merced County	This area is bounded by Sandy Mush Road and Harvey Petitt Road. The land uses include scattered residential single-family homes and farms. UPRR tracks and SR 99 are located between the proposed alignment and homes to the east. Open land exists between nearly all homes and the proposed corridor. The closest residence is located approximately 100 feet from SR 99. There are homes in this VSA located within 50 feet of the proposed alignment.	(V3, V4)

VSA ID[a]	Alternative	City	Description	Measurement Locations[b]
VSA-13	UPRR/SR 99	Chowchilla	This area is bounded by SR 233 and Avenue 24½. The noise-sensitive land uses includes residential neighborhoods consisting of single-family homes and hotels. Some open land exists between homes and the proposed alignment. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 400 feet from the existing railway line.	(V5, V6)
VSA-14	UPRR/SR 99	Chowchilla	This area is bounded by Avenue 24½ and Avenue 24. The land uses include scattered residential single-family homes and farms. The closest residence is located approximately 100 feet from the existing tracks. There are homes in this VSA located within 50 feet of the proposed alignment.	V5 (V6)
VSA-15	UPRR/SR 99	Chowchilla	This area is bounded by Avenue 24 and Avenue 22¾. The land uses include scattered residential single-family homes and farms. Open land exists between some homes and the proposed corridor. The closest residence is located approximately 150 feet from the existing tracks and 100 feet from the highway overpass. There are homes in this VSA located within 50 feet of the proposed alignment.	V6 (V5)
VSA-16E	UPRR/SR 99	Chowchilla	This area is bounded by Avenue 22¾ and Avenue 22¼. The land uses include residential neighborhoods consisting of single-family homes and a church. Galilee Missionary Baptist Church is at 22491 Fairmead Boulevard. The closest residence is located approximately 150 feet from the existing railway line. There are homes in this VSA located within 50 feet of the proposed alignment.	(V5, V6)
VSA-17	UPRR/SR 99	Chowchilla	This area is bounded by Avenue 22 and Avenue 20½. The land uses include scattered residential single-family homes and farms. Open land exists between nearly all homes and the proposed alignment. The closest residence is located approximately 200 feet from SR 99.	(V5, V6)
VSA-18	UPRR/SR 99	Madera	This area is bounded by Avenue 20½ and Avenue 18¾. The land uses include scattered residential single-family homes and farms. UPRR tracks and SR 99 are located between homes and the proposed alignment. The closest residence is located approximately 250 feet from SR 99.	(V7, V8)
VSA-20	UPRR/SR 99	Madera	This area is bounded by Avenue 17 and Country Club Drive. The land uses include hotels, a church, and scattered residential neighborhoods consisting of single-family homes. The Progressive Church of God in Christ is located at 15879 Cardwell Street. Commercial/industrial areas exist throughout the VSA. The closest residence is approximately 100 feet from the existing railway line and 200 feet from SR 99. There are homes in this VSA within 50 feet of the proposed alignment.	(V7, V8)

VSA ID[a]	Alternative	City	Description	Measurement Locations[b]
VSA-22E	UPRR/SR 99	Madera	This area is bounded by W Cleveland Avenue and Olive Avenue. The land uses include churches and residential neighborhoods consisting of single-family homes. The Believer's Church of Madera is at 117 North E Street. The closest residence is located approximately 100 feet from the existing railway line. There are homes in this VSA located within 50 feet of the proposed alignment.	(V7, V8)
VSA-24E	UPRR/SR 99	Madera	This area is bounded by E Olive Avenue and Road 28. The land uses includes residential neighborhoods consisting of single-family homes and single-family homes under development. The closest residence is located approximately 50 feet from the existing railway line. There are homes in this VSA located within 50 feet of the proposed alignment.	V7,V8

[a] If listed, a "W" or "E" in the VSA ID indicates the west or east side of the corridor.

[b] Measurement locations in parentheses indicate a measurement site not located within the specific boundaries of the VSA that is being used as a representative measurement for the VSA.

Table 5-28
Vibration-Sensitive Areas in the City of Merced

VSA ID[a]	Alternative	City	Description	Measurement Locations[b]
VSA-3E	UPRR/SR 99	Merced	This area is bounded by Belcher Avenue and Lucich Court along Franklin Avenue. The land use includes residential neighborhoods consisting of single-family homes. The closest residence is located approximately 1,800 feet from SR 99.	(V3, V4)
VSA-4E	UPRR/SR 99	Merced	This area is bounded by Lucich Court and SR 99 along Franklin Avenue. The land use includes residential neighborhoods and scattered single-family homes. Franklin Elementary School at 2736 Franklin Road is approximately 1,950 feet from the highway. The Islamic Center of Merced is at 2322 N Ashby Road. The closest residence is located approximately 150 feet from SR 99. There are homes in this VSA located within 50 feet of the proposed alignment.	(V3, V4)
VSA-7W	UPRR/SR 99	Merced	This area is bounded by V Street and G Street. The land uses include residential single-family homes and multifamily residential. Sierra Meadows Senior Apartments is at 720 W 15th Street. Residential land use is adjacent to commercial areas in this VSA. The closest residence is approximately 300 feet from the existing railway line.	(V3, V4)
VSA-9W	UPRR/SR 99	Merced	This area is bounded by G Street and Delong Street. The land uses include residential single-family homes and institutions. Mercy Medical Center Merced is located at 301 E 13th Street. A homeless shelter is located at 317 E 15th Street. The closest residential land use is the homeless shelter located approximately 250 feet	V3 (V4)

VSA ID[a]	Alternative	City	Description	Measurement Locations[b]
			from the highway overpass. There are homes in this VSA located within 50 feet of the proposed alignment.	
VSA-11	UPRR/SR 99	Merced	This area is bounded by Mariposa Way and S Arboleda Drive. The land uses include scattered residential single-family homes and farms. UPRR tracks and SR 99 are between the proposed alternative and homes to the east. Open land exists between nearly all homes and the proposed alignment. The closest residence is approximately 70 feet from SR 99.	(V3, V4)

[a] If listed, a "W" or "E" in the VSA ID indicates the west or east side of the corridor.

[b] Measurement locations in parentheses indicate a measurement site not located within the specific boundaries of the VSA that is being used as a representative measurement for the VSA.

Table 5-29
Vibration-Sensitive Areas in the City of Fresno

VSA ID[a]	Alternative	City	Description	Measurement Locations[b]
VSA-31	UPRR/SR 99	Fresno	This area is bounded by the San Joaquin River and W Palo Alto Avenue. The land uses include a hotel and residential neighborhoods consisting of single-family homes. UPRR tracks, Golden State Boulevard, SR 99, and open land exist between the proposed corridor and homes to the west. The closest residence is located approximately 100 feet from the existing railway line. There are homes in this VSA located within 50 feet of the proposed alignment.	(V9, V10)
VSA-32E	UPRR/SR 99	Fresno	This area is bounded by N Bryan Avenue and N Barcus. The land use includes residential neighborhoods consisting of single-family homes. The closest residence is located approximately 130 feet from the existing railway line.	(V9, V10)
VSA-33W	UPRR/SR 99	Fresno	This area is bounded by N Market Avenue and W Shaw Avenue. The land uses include a hotel, a church, and residential neighborhoods consisting of single-family homes mixed in a commercial/industrial area. Some commercial/industrial areas exist between homes and the proposed alignment. The First Spanish Baptist Church is at 5365 W Mission Avenue. The closest residence is located approximately 350 feet from the existing railway line.	(V9, V10)
VSA-34W	UPRR/SR 99	Fresno	This area is bounded by Dakota Avenue and Princeton Avenue. The land uses include hotels and residential neighborhoods consisting of multifamily buildings and single-family homes. Sunset Mobile and RV Park is located at 3187 N Parkway Drive. SR 99 is located between homes and the proposed alignment. A UPRR rail yard exists on the east side of the proposed alignment. The closest residence is approximately 200 feet from SR 99.	(V9, V10)

VSA ID[a]	Alternative	City	Description	Measurement Locations[b]
VSA-35W	UPRR/SR 99	Fresno	This area is bounded by Princeton Avenue and McKinley Avenue. The land uses include hotels and residential neighborhoods consisting of single-family homes and multifamily buildings. The Hacienda, a senior housing facility, is at 2550 W Clinton Avenue. SR 99 lies between the most sensitive areas and the proposed alignment. The closest residence is located approximately 40 feet from SR 99.	(V9, V10)
VSA-36E	UPRR/SR 99	Fresno	This area is bounded by Clinton Avenue and Belmont Avenue. The land uses include residential neighborhoods consisting of single-family homes and multifamily buildings. Bel Haven Care is located at 2020 N Weber Avenue. UPRR tracks and Weber Avenue are located between sensitive land uses and the proposed alignment. The closest residence is located approximately 100 feet from the existing railway line.	V9 (V10)

[a] If listed, a "W" or "E" in the VSA ID indicates the west or east side of the corridor.

[b] Measurement locations in parentheses indicate a measurement site not located within the specific boundaries of the VSA that is being used as a representative measurement for the VSA.

Table 5-30
Vibration-Sensitive Areas for the UPRR/SR 99 Alternative with Ave 24 Wye

VSA ID	Alternative	City	Description	Measurement Locations[a]
VSA-61	UPRR/SR 99 with East and West Chowchilla design options and Ave 24 Wye	Chowchilla	This area is to the west of SR 99 and is bounded by SR 99 and SR 152. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V5, V6)

[a] Measurement locations in parentheses indicate a measurement site not located within the specific boundaries of the VSA that is being used as a representative measurement for the VSA.

Table 5-31
Vibration-Sensitive Areas for the UPRR/SR 99 Alternative with Ave 21 Wye

VSA ID	Alternative	City	Description	Measurement Locations[a]
VSA-55	UPRR/SR 99 with Ave 21 Wye	Chowchilla	This area is bounded by Road 8 and Road 19. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic. There are homes in this VSA located within 50 feet of the proposed alternative.	(V5, V6)

VSA ID	Alternative	City	Description	Measurement Locations[a]
VSA-59	UPRR/SR 99 with Ave 21 Wye	Chowchilla	This area is bounded by Road 19 and Road 21. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V5, V6)
VSA-60	UPRR/SR 99 with Ave 21 Wye	Chowchilla	This area is bounded by Avenue 21 and SR-152. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V5, V6)

[a] Measurement locations in parentheses indicate a measurement site not located within the specific boundaries of the VSA that is being used as a representative measurement for the VSA.

5.3.1.2 BNSF Alternative

Tables 5-32 through 5-34 list VSAs that are unique to the BNSF Alternative. VSAs for the BNSF Alternative are the same as for the UPRR/SR 99 Alternative in common areas of the north-south alignment and in the cities of Merced and Fresno.

Table 5-32
Vibration-Sensitive Areas for the Unique Portion of the BNSF Alternative North-South Alignment

VSA ID	Alternative	City	Description	Measurement Locations[a]
VSA-39	BNSF with Mission Ave design option	Merced	This area is bounded by S Coffee Street and Whealan Road. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic. There are homes in this VSA located within 50 feet of the proposed alignment.	V11
VSA-40	BNSF with Mission Ave design option	Le Grand	This area is bounded by Whealan Road and Morley Avenue. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic. There are homes in this VSA located within 50 feet of the proposed alignment.	V11
VSA-41	BNSF with Mission Ave design option	Le Grand	This area is bounded by Morley Avenue and Savana Road. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic. There are homes in this VSA located within 50 feet of the proposed alignment.	(V11)
VSA-42	BNSF with Mission Ave design option	Merced	This area is bounded by Pioneer Road and Whealan Road. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic. There are homes in this VSA located within 50 feet of the proposed alignment.	V11

VSA ID	Alternative	City	Description	Measurement Locations[a]
VSA-43	BNSF with Mariposa Way design option	Le Grand	This area is bounded by Whealan Road and Morley Avenue. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic. There are homes in this VSA located within 50 feet of the proposed alignment.	V11
VSA-44	BNSF with both Mariposa Way design options	Le Grand	This area is bounded by Morley Avenue and Banks Road The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V11)
VSA-45	BNSF with both East of Le Grand design options	Le Grand	This area is bounded by Santa Fe Avenue and Fresno Road. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic. There are homes in this VSA located within 50 feet of the proposed alignment.	(V12)
VSA-46	BNSF with East of Le Grand design options	Le Grand	This area is bounded by Fresno Road and Buchanan Hollow Rd The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V12)
VSA-47	BNSF	Le Grand	This area is bounded by Savana Road and Fresno Road. The land uses include residential neighborhoods consisting of single-family and multifamily homes. There are homes in this VSA located within 50 feet of the proposed alignment.	V12
VSA-48	BNSF	Le Grand	This area is bounded by Fresno Road and White Rock Road. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic. There are homes in this VSA located within 50 feet of the proposed alignment.	(V12)
VSA-49	BNSF	Madera County	This area is bounded by White Rock Road and Avenue 24. The land uses include residential neighborhoods consisting of single-family and multifamily homes.	V13
VSA-51	BNSF	Madera Acres	This area is bounded by Avenue 19 and Road 27. The land use includes residential neighborhoods consisting of single-family homes. There are homes in this VSA located within 50 feet of the proposed alignment.	V14
VSA-52	BNSF	Madera Acres	This area is bounded by Road 27 and Raymond Road. The land use includes residential neighborhoods consisting of single-family homes. There are homes in this VSA located within 50 feet of the proposed alignment.	(V14)
VSA-53	BNSF	Madera	This area is bounded by SR 145 and Avenue 15. The land use includes residential neighborhoods consisting of single-family homes. There are homes in this VSA located within 50 feet of the proposed alignment.	(V14)

VSA ID	Alternative	City	Description	Measurement Locations[a]
VSA-54	BNSF	Madera	This area is bounded by Avenue 15 and Avenue 9. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	V15
[a] Measurement locations in parentheses indicate a measurement site not located within the specific boundaries of the VSA that is being used as a representative measurement for the VSA.				

Table 5-33
Vibration-Sensitive Areas for the BNSF Alternative with Ave 24 Wye

NSA ID	Alternative	City	Description	Measurement Locations[a]
NSA-62	BNSF with Ave 24 Wye	Chowchilla	This area is bounded by Avenue 26 and Avenue 20½ east of SR 99. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V5, V6)
[a] Measurement locations in parentheses indicate a measurement site not located within the specific boundaries of the VSA that is being used as a representative measurement for the VSA.				

Table 5-34
Vibration-Sensitive Areas for the BNSF Alternative with Ave 21 Wye

VSA ID	Alternative	City	Description	Measurement Locations[a]
VSA-56	BNSF with Ave 21 Wye	Chowchilla	This area is bounded by Road 19 and Road 22. This VSA contains SR 99. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic and highway traffic near SR 99. There are homes in this VSA located within 50 feet of the proposed alignment.	(V5, V6)
VSA-57	BNSF with Ave 21 Wye	Madera	This area is bounded by Road 22 and Avenue 19. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V5, V6)
VSA-58	BNSF with Ave 21 Wye	Madera	This area is bounded by Road 22 and Avenue 23. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V5, V6)
[a] Measurement locations in parentheses indicate a measurement site not located within the specific boundaries of the VSA that is being used as a representative measurement for the VSA.				

5.3.1.3 Hybrid Alternative

The Hybrid Alternative is a combination of the northern portion of the UPRR/SR 99 Alternative and the southern portion of the BNSF Alternative. VSAs for the Hybrid Alternative are the same as the UPRR/SR

99 and BNSF Alternatives for areas of the north-south alignment that are common to both alternatives and in the cities of Merced and Fresno. Tables 5-35 through 5-37 list VSAs for the Hybrid Alternative that exist outside the cities of Merced and Fresno.

Table 5-35
Vibration-Sensitive Areas for the Hybrid Alternative North-South Alignment

VSA ID[a]	Alternative	City	Description	Measurement Locations[b]
VSA-1W	Hybrid	Atwater	This area is bounded by Crest Road and the Livingston Canal. The land uses include residential neighborhoods consisting of single-family homes, single-family homes under development, and recreational areas consisting of Veterans Park and Castle Youth Center. The closest edge of the park is located approximately 170 feet from the existing railway line. There are homes in this VSA located within 50 feet of the proposed alignment.	V2 (V1)
VSA-2	Hybrid	Atwater	This area is bounded by the Livingston Canal and Belcher Avenue. The land uses include scattered residential single-family homes and farms. BNSF tracks and Santa Fe Avenue are located between the proposed alternative and homes to the east. Open land exists between nearly all homes and the proposed alternative. The closest residence is located on Santa Fe Avenue, approximately 60 feet from the existing railway line. There are homes in this VSA located within 50 feet of the proposed alignment.	(V2, V1)
VSA-12	UPRR/SR 99	Merced County	This area is bounded by Sandy Mush Road and Harvey Petitt Road. The land uses include scattered residential single-family homes and farms. UPRR tracks and SR 99 are located between the proposed alignment and homes to the east. Open land exists between nearly all homes and the proposed corridor. The closest residence is located approximately 100 feet from SR 99. There are homes in this VSA located within 50 feet of the proposed alignment.	(V3, V4)
VSA-13	UPRR/SR 99	Chowchilla	This area is bounded by SR 233 and Avenue 24½. The noise-sensitive land uses includes residential neighborhoods consisting of single-family homes and hotels. Some open land exists between homes and the proposed alignment. The existing noise in this area is dominated by UPRR traffic. The closest residence is located approximately 400 feet from the existing railway line.	(V5, V6)
VSA-14	UPRR/SR 99	Chowchilla	This area is bounded by Avenue 24½ and Avenue 24. The land uses include scattered residential single-family homes and farms. The closest residence is located approximately 100 feet from the existing tracks. There are homes in this VSA located within 50 feet of the proposed alignment.	V5 (V6)

VSA ID[a]	Alternative	City	Description	Measurement Locations[b]
VSA-15	UPRR/SR 99	Chowchilla	This area is bounded by Avenue 24 and Avenue 22¾. The land uses include scattered residential single-family homes and farms. Open land exists between some homes and the proposed corridor. The closest residence is located approximately 150 feet from the existing tracks and 100 feet from the highway overpass. There are homes in this VSA located within 50 feet of the proposed alignment.	V6 (V5)
VSA-50	Hybrid	Madera	This area is bounded by Avenue 24 and Avenue 19 east of SR 99. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V5, V6)
VSA-51	Hybrid	Madera Acres	This area is bounded by Avenue 19 and Road 27. The land use includes residential neighborhoods consisting of single-family homes. There are homes in this VSA located within 50 feet of the proposed alignment.	V14
VSA-52	Hybrid	Madera Acres	This area is bounded by Road 27 and Raymond Road. The land use includes residential neighborhoods consisting of single-family homes. There are homes in this VSA located within 50 feet of the proposed alignment.	(V14)
VSA-53	Hybrid	Madera	This area is bounded by SR 145 and Avenue 15. The land use includes residential neighborhoods consisting of single-family homes. There are homes in this VSA located within 50 feet of the proposed alignment.	(V14)
VSA-54	Hybrid	Madera	This area is bounded by Avenue 15 and Avenue 9. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	V15

[a] If listed, a "W" or "E" in the VSA ID indicates the west or east side of the corridor.

[b] Measurement locations in parentheses indicate a measurement site not located within the specific boundaries of the VSA that is being used as a representative measurement for the VSA.

Table 5-36
Vibration-Sensitive Areas for the Hybrid Alternative with Ave 24 Wye

VSA ID[a]	Alternative	City	Description	Measurement Locations[b]
VSA-61	Hybrid with Ave 24 Wye	Chowchilla	This area is to the west of SR 99 and is bounded by SR 99 and SR 152. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V5, V6)

[a] If listed, a "W" or "E" in the VSA ID indicates the west or east side of the corridor.

[a] Measurement locations in parentheses indicate a measurement site not located within the specific boundaries of the VSA that is being used as a representative measurement for the VSA.

Table 5-37
Vibration-Sensitive Areas for the Hybrid Alternative with Ave 21 Wye

VSA ID[a]	Alternative	City	Description	Measurement Locations[b]
VSA-55	UPRR/SR 99 with Ave 21 Wye	Chowchilla	This area is bounded by Road 8 and Road 19. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic. There are homes in this VSA located within 50 feet of the proposed alternative.	(V5, V6)
VSA-56	BNSF with Ave 21 Wye	Chowchilla	This area is bounded by Road 19 and Road 22. This VSA contains SR 99. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic and highway traffic near SR 99. There are homes in this VSA located within 50 feet of the proposed alignment.	(V5, V6)
VSA-57	BNSF with Ave 21 Wye	Madera	This area is bounded by Road 22 and Avenue 19. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V5, V6)
VSA-60	UPRR/SR 99 with Ave 21 Wye	Chowchilla	This area is bounded by Avenue 21 and SR 152. The land uses include scattered residential single-family homes and farms. The existing vibration environment is dominated by rural traffic.	(V5, V6)

[a] If listed, a “W” or “E” in the VSA ID indicates the west or east side of the corridor.

[b] Measurement locations in parentheses indicate a measurement site not located within the specific boundaries of the VSA that is being used as a representative measurement for the VSA.

5.3.2 Vibration Propagation Testing Methodology

A series of vibration measurements was recorded to determine the vibration propagation properties of the soil at representative locations along the HST alternatives. At each site, ground-borne vibration propagation tests were conducted in accordance with the approved FRA methodology. These tests involved impacting the ground and measuring the input force and corresponding ground vibration response at various distances. Future vibration levels at locations along the project corridor are predicted by combining the resulting force-response transfer function with the known input force characteristics of the California HST or an equivalent HST. Appendix D provides the resulting data from the vibration propagation measurements.

Figure 5-5 depicts the vibration propagation test procedure. As shown in the cross-section view at the top, the test consists of dropping a 60-pound weight from a height of 3 to 4 feet onto the ground. A load cell measures the force of the impact, and accelerometers measure the resulting vibration pulses at various distances. The relationship between the input force and the ground surface vibration, called the transfer mobility, characterizes vibration propagation at the location. It is possible to estimate the ground vibration that would be caused by a train by substituting the train force for the impact force. The bottom portion of Figure 5-5 shows how the dropped weight point source is used to simulate a line vibration source such as a train. Impact tests were performed at regular intervals in a line along the alignment.

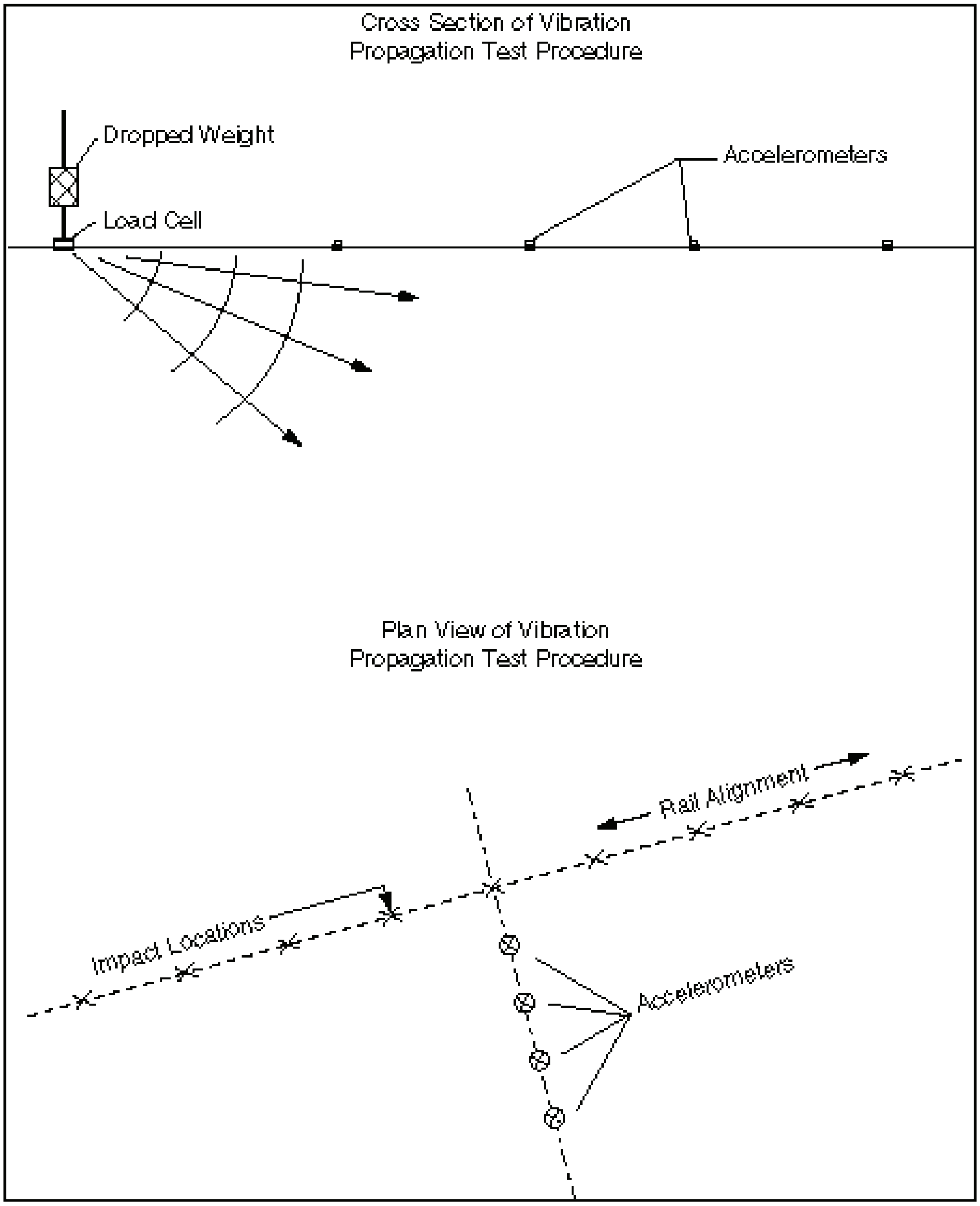


Figure 5-5
Vibration Propagation Test Procedure

5.3.3 Vibration Measurement Results

Vibrations from freight and Amtrak trains were measured in each community along the alternative alignments to compare the resulting data points with the FTA vibration curve for locomotives, as shown in Figure 5-6. This comparison shows whether the FTA curve can be used to determine the range of distances at which existing train vibrations exceed FRA/FTA vibration criteria. Measurements were made using PCB 393A and 393C accelerometers and a TEAC LX-110 digital recorder. Tables 5-38 through 5-40 show details of the measurement locations; Appendix B provides photographs of each site.

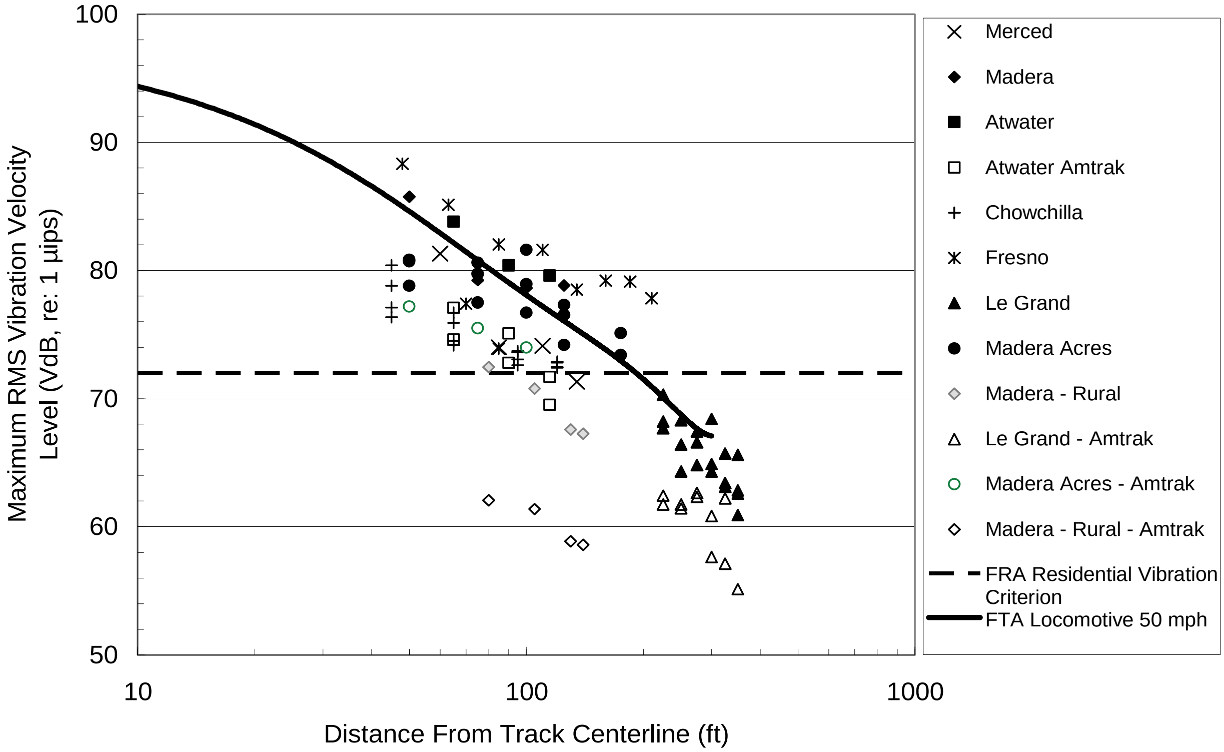


Figure 5-6
Existing Train Locomotive Vibration Levels

Table 5-38
Vibration Measurement Locations for the UPRR/SR 99 Alternative

Site	VSA	City	Measurement Type	Address
V1	None	Atwater	Propagation	Santa Fe Avenue near F Street
V2	1W	Atwater	Existing	Piro Drive near Nebela Driver
V3	9W	Merced	Existing	B Street and Crist Avenue
V4	None	Merced	Propagation	1605 E Gerard Avenue
V5	14	Chowchilla	Propagation	17142 Avenue 24½
V6	15	Chowchilla	Existing	23515 Chowchilla Boulevard
V7	24E	Madera	Propagation	Peach Street near Cherry Street
V8	24E	Madera	Existing	Peach Street near Nectarine Street
V9	36E	Fresno	Existing	2020 N Weber Avenue
V10	None	Fresno	Propagation	G Street near Inyo Street

Table 5-39
Vibration Measurement Locations for the Unique Portion of the BNSF Alternative

Site	VSA	City	Measurement Type	Address
V11	49	Le Grand	Propagation	Mariposa Way and Whealan Road
V12	54	Le Grand	Propagation/existing	Santa Fe Avenue and Le Grand Road
V13	56	Madera	Existing	Santa Fe Drive and Avenue 24
V14	58	Madera Acres	Propagation/existing	Avenue 18 and Tulip Road
V15	61	Madera	Propagation	Avenue 13 and Road 30½

Table 5-40
Vibration Measurement Locations for the Hybrid Alternative

Site	VSA	City	Measurement Type	Address
V1	None	Atwater	Propagation	Santa Fe Avenue near F Street
V2	1W	Atwater	Existing	Piro Drive near Nebela Drive
V3	9W	Merced	Existing	B Street and Crist Avenue
V4	None	Merced	Propagation	1605 E Gerard Avenue
V5	14	Chowchilla	Propagation	17142 Avenue 24½
V6	15	Chowchilla	Existing	23515 Chowchilla Blvd
V9	36E	Fresno	Existing	2020 N Weber Avenue
V10	None	Fresno	Propagation	G Street near Inyo Street
V14	58	Madera Acres	Propagation/existing	Avenue 18 and Tulip Road
V15	61	Madera	Propagation	Avenue 13 and Road 30½

Vibration measurements were also gathered from truck traffic on SR 99 at a distance of approximately 150 feet from the highway centerline. Figure 5-6 shows the resulting vibration measurements from freight and Amtrak trains; the ground vibrations from locomotives measured in each community are compared with the generalized vibration curve in Figure 10-1 of the FTA guidance manual (FTA 2006). Each data point identifies the vibration level measured at a specific distance from the track centerline. The measured data from existing locomotive vibrations along the corridor confirm the applicability of the generic FTA vibration curve. The results indicate that the FTA curve does represent an average of the data, thereby validating its use for estimating the existing impact conditions.

5.3.4 Vibration Measurement Discussion

The vibration data from locomotives measured in each community along the HST alternative alignments correspond to the general trend of the FTA vibration curve. Consequently, the FTA curve was used in the FRA assessment procedure for potential impacts in an existing railroad corridor discussed in Section 4.2.2. The curve intersects the vibration criteria for Categories 1, 2, and 3 at distances of 400 feet, 180 feet, and 140 feet from the tracks, respectively. Within these ranges, vibration impacts are likely to occur when HST vibrations are taken into account. Outside of these ranges, the usual FRA vibration criteria (Section 4.2.1) were applied to the conceptual HST operations.

Truck traffic did not affect the vibration analysis for the Merced to Fresno Section. The vibration levels measured from truck traffic range from about 35 to 55 VdB. These levels are below the 65 VdB threshold of perception.

5.3.4.1 Existing Vibration along UPRR/SR 99 Alternative Corridor

North-South Alignment

Sources of existing vibrations along the alignment include UPRR and BNSF freight and Amtrak passenger trains, as well as truck traffic on SR 99. Consequently, vibrations from freight and Amtrak trains were measured in each community along the alignment to estimate the range where existing train vibrations are substantial according to FRA/FTA thresholds. Overall ground-borne vibration levels measured in Chowchilla from UPRR trains ranged from 80 VdB at 45 feet to 72 VdB at 120 feet from the tracks. Measured levels in Madera from UPRR trains ranged from 84 VdB at 50 feet to 77 VdB at 125 feet from the tracks. Vibration measurements were also conducted for truck traffic on SR 99 at a distance of approximately 150 feet from the highway centerline. The overall vibration levels, ranging from about 35 VdB to 55 VdB, are below the 65 VdB threshold of perception. Therefore, truck traffic is not considered to affect the vibration analysis for the Merced to Fresno Section. Figure 5-6 shows the results of the measurements, where ground vibrations from locomotives measured in each community are compared with the generalized vibration curve in Figure 10-1 of the FTA guidance manual (FTA 2006). The measured vibration levels were adjusted to 50 mph for comparison. The vibration data for locomotives in each community along the alignment support the general trend of typical locomotives in the FTA guidance manual, which is shown as a bold line in Figure 5-6.

Downtown Merced Station

Overall vibration levels in the City of Merced measured for freight trains on the UPRR tracks ranged from 80 VdB at 60 feet to 70 VdB at 135 feet from the tracks.

Downtown Fresno Station

Overall vibration levels in the City of Fresno measured for freight and Amtrak trains ranged from 87 VdB at 48 feet to 77 VdB at 210 feet from the tracks.

Ave 24 Wye and Ave 21 Wye

There are no significant existing sources of ground-borne vibration along either the Ave 24 Wye or the Ave 21 Wye.

5.3.4.2 Existing Vibration along BNSF Alternative Corridor

North-South Alignment

Sources of existing vibrations along the unique portion of the BNSF Alternative include BNSF freight and Amtrak passenger trains. Vibrations from freight and Amtrak trains were measured along the alternative and vibration propagation testing was conducted as discussed in the UPRR/SR 99 corridor section. Measured overall ground-borne vibration levels for BNSF trains in Le Grand ranged from 72 VdB at 225 feet to 63 VdB at 350 feet from the tracks. The vibration levels from Amtrak trains in Le Grand were lower at 65 VdB at 225 feet to 58 VdB at 350 feet from the tracks. Existing overall ground-borne vibration levels for BNSF trains in Madera ranged from 80 VdB at 50 feet to 74 VdB at 175 feet from the tracks, and for Amtrak trains from 77 VdB at 50 feet to 62 VdB at 140 feet from the tracks.

Ave 24 Wye and Ave 21 Wye

There are no significant existing sources of ground-borne vibration along either the Ave 24 Wye or the Ave 21 Wye.

5.3.4.3 Existing Vibration along Hybrid Alternative Corridor

The Hybrid Alternative study area is a combination of the study areas for the UPRR/SR 99 Alternative and the BNSF Alternative. The alternative follows two different corridors depending on wye design option. The Hybrid Alternative with Ave 24 Wye follows the UPRR/SR 99 alignment with the West Chowchilla design option from Merced to Chowchilla; from Chowchilla to Fresno, the alignment follows the BNSF alignment with Ave 24 Wye. for the Hybrid Alternative with Ave 21 Wye follows the UPRR/SR 99 alignment with the East Chowchilla design option from Merced to Chowchilla; from Chowchilla to Fresno, the alignment follows the BNSF alignment with Ave 21 Wye. The vibration environments for these locations are identical to those discussed for the UPRR/SR 99 and BNSF Alternatives.

5.3.4.4 Heavy Maintenance Facility

Castle Commerce Center – UPRR/SR 99, BNSF, and Hybrid Alternatives

Existing vibration and vibration propagation measurements in Atwater are representative of the area near the Castle Commerce Center. The measured existing overall vibration levels for BNSF trains ranged from 81 VdB at 65 feet to 77 VdB at 115 feet from the tracks; Amtrak trains ranged from 74 VdB at 65 feet to 66 VdB at 115 feet from the tracks.

Harris-DeJager – UPRR/SR 99 Alternative with Ave 21 Wye

Vibration measurements along the UPRR in Chowchilla are representative of the existing vibration levels in the area of the Harris-DeJager HMF site.

Fagundes – UPRR/SR 99, BNSF with Ave 24 Wye, and Hybrid Alternatives

There are no significant existing sources of ground-borne vibration near the Fagundes HMF site.

Gordon-Shaw – UPRR/SR 99 Alternative

Vibration measurements along the UPRR in Madera are representative of the existing vibration levels in the area of the Gordon-Shaw HMF site.

Kojima Development – BNSF Alternative

Vibration measurements along the BNSF in Madera and Le Grand are representative of the existing vibration levels in the area of the Kojima Development HMF site.

6.0 Noise and Vibration Prediction Methodology

Noise and vibration from HST construction and operation were analyzed quantitatively by using FTA- and FRA-approved methods. Project information on the proposed HST alternatives and the conceptual HST operations was used in noise and vibration models. Field noise and vibration measurements along with professional judgment supplemented the FTA and FRA model methodology.

- The FRA guidance manual (FRA 2005) was used as the primary source of guidance for analysis of HST noise and vibration impacts and mitigation; FTA guidance supplemented the FRA guidance. Chapter 5 (Detailed Noise Analysis) of the FRA guidance manual was followed for impact analyses of all alignments to be carried forward in the project EIR/EIS.

- For the vibration impact and mitigation analyses of the HST alternatives carried forward in the project EIR/EIS, the process presented in Chapter 9 (Detailed Vibration Assessment) of the FRA manual was used at selected residences, schools, hotels/motels, medical facilities, and other vibration-sensitive receptors. The detailed vibration impact analysis was prepared in 1/3-octave bands, as described in Chapter 11 (Detailed Vibration Analysis) of the FTA guidance manual.

- For non-HST noise sources, such as stations, maintenance facilities, and construction, the methods described in the FTA manual were used.

For impact analysis, the following thresholds were used in assessing locations with impact:

- FRA Severe Noise Impact Criteria for HST Operations
- FTA Detailed Vibration Impact Criteria for HST Operations
- FHWA Noise Abatement Criteria for Traffic (on highways affected by the project)
- FTA Noise Impact Criteria for Ancillary and Non-HST Noise Sources

The following sections provide additional details of the methodology for the noise and vibration assessments.

6.1 Noise

6.1.1 Train Operation Noise

The noise impact from the conceptual HST train operations was assessed at each noise-sensitive receiver by using the FRA methodology for detailed noise analysis provided in the FRA guidance manual (FRA 2005). The detailed noise analysis included a measurement program at representative clusters of receivers to determine existing ambient noise conditions and a noise prediction method to determine future noise conditions. The noise predictions at these receivers were based on the following data and assumptions:

- All noise modeling projections were consistent with the methodology in the *High-Speed Ground Transportation Noise and Vibration Impact Assessment* (FRA 2005).

- The noise modeling projections assumed atmospheric absorption of sound based on the International Standard ISO 9613-2.

- The source reference levels used were for the VHS electric vehicle type in Table 5-2 of the FRA guidance manual (FRA 2005). Changes to the source reference values included modeling the propulsion source height at 2 feet above the rails and using a K factor of 1 for the propulsion source. These adjustments accounted for the assumed trainsets having distributed-power electric multiple unit (EMU) vehicles with a maximum speed of 220 mph. All trainsets were assumed to be 8-car consists.

- HST track was assumed to be ballast and tie with continuous welded rail, consistent with the assumptions in the FRA guidance manual (FRA 2005). Ballast and tie track is typically 2 to 4 dB quieter than slab track.

- The full system schedule of conceptual train operations was used for the noise modeling. For noise modeling, the hours between 10:00 p.m. and 7:00 a.m. define nighttime events. The six peak hours of operation include the three morning hours between 6:00 a.m. and 9:00 a.m., and the three afternoon/evening hours between 4:00 p.m. and 7:00 p.m. The 10 off-peak hours of operation occur from 5:00 a.m. to 6:00 a.m., 9:00 a.m. to 4:00 p.m., and 7:00 p.m. to 9:00 p.m. No operations were assumed to begin between 9:00 p.m. and 5:00 a.m. The detailed full system schedule is defined as follows:

  - Between San Francisco and Los Angeles, 52 daytime and 8 nighttime trains in each direction would pass through the Downtown Fresno Station without stopping; in addition, 42 daytime and 6 nighttime trains in each direction would stop at the station.

  - Between San Francisco and Sacramento, 5 daytime trains and 1 nighttime train in each direction would pass through the Downtown Merced Station without stopping; in addition, 14 daytime and 2 nighttime trains in each direction would stop at the station.

  - Between Sacramento and Los Angeles, 10 daytime and 2 nighttime trains in each direction would pass through the Downtown Merced Station without stopping; in addition, 14 daytime and 2 nighttime trains in each direction would stop at the station. All of these trains would stop at the Fresno station.

  - The maximum speed along the corridor would be 220 mph. For the BNSF Alternative, speed profiles were provided only for the Mariposa Way design option. For noise and vibration modeling, the speeds along the additional three BNSF Alternative design options (Mission Ave, Mariposa Way East of Le Grand, and Mission Ave East of Le Grand) were assumed to be similar. Speed profiles terminating in Merced were adjusted to end at Merced station.

- All top-of-rail elevations were provided by CH2M HILL and URS. Top-of-rail elevations are based on the 15% preliminary design available in April 2011. For at-grade sections on the Ave 21 Wye from Road 15 to Road 8, tracks were assumed to be on an embankment 5 feet above the existing grade.

- It was assumed that the track would be on aerial structures wherever top-of-rail elevations are more than 15 feet above existing grade.

- All aerial structure sections of the corridor were assumed to be as described in the *California High-Speed Train Project, Typical Cross Section 15% R0 090404 Technical Memorandum* (Authority and FRA 2010).

- Noise projections assumed that buildings within property acquisition footprint were not to be included in the impact assessment.

- No adjustments were made to predicted noise levels to account for increases in localized noise due to special trackwork, such as crossovers and turnouts.

- There would be no noise exposure effects associated with changes in freight rail or Amtrak operations due to the implementation of the HST project.

Noise impacts from conceptual HST operations was assessed by using the FRA noise impact criteria shown in Figure 4-1. The FRA criteria compare the projected noise exposure with the existing ambient noise exposure at each noise-sensitive receiver or clusters of receivers. Assessment results were tabulated at the identified receivers or clusters of receivers according to the three FRA categories of impact: No Impact, Moderate Impact, or Severe Impact.

6.1.2 Station Noise

Noise impacts associated with HST stations in Merced and Fresno were assessed at each noise-sensitive receiver by following the methodology for detailed noise analysis around stations provided in Section 6.7 of the FTA guidance manual (FTA 2006). The detailed noise analysis included the measurement program at representative clusters of receivers in the station area to determine existing ambient noise conditions and a noise prediction method to determine future noise conditions. The noise predictions at these receivers were based on the following data:

- Type of train equipment to be used (EMU trains assumed).
- Train schedules (number of stopping trains and number of through trains during daytime and nighttime hours).
- Train consists (number of cars).
- Speed profiles of stopping trains and through trains.
- Plan and profiles of elevated station structures.
- Landform topography such as buildings in the immediate vicinity of the station.

Because of the elevation of the station deck, ground effects were considered not to affect sound propagation. Projected noise and existing ambient noise exposures were tabulated at the identified receivers or clusters of receivers. Levels of impact (No Impact, Moderate Impact, or Severe Impact) were determined by comparing the existing and projected noise exposure based on the impact criteria in Figure 4-1.

6.1.3 Traffic and Grade-Separation Noise

In addition to noise from HST operations, noise from changes in traffic volume due to the project was considered, primarily near the HST stations. Although the proposed UPRR/SR 99 Alternative would relocate SR 99 frontage roads and other local roads in some areas, traffic on SR 99 currently dominates noise levels in areas close to the highway and is expected to continue to do so in the future. Traffic on local roads provides only a minor contribution to overall noise levels; relocation of these roads is not expected to cause significant changes in noise levels. A more detailed analysis of potential traffic noise impacts due to relocation of local roads should be conducted when additional design details are available.

In portions of the project vicinity where the SR 99 mainline would be realigned, the potential exists for noise impacts in locations where the relocated highway would be closer to receptors. FHWA guidance regarding the physical alteration of an existing highway states “changes in the horizontal alignment that reduce the distance between the source and the receiver by half or more result in a Type I project” (FHWA 2010). FHWA requires identification of highway traffic noise impacts and examination of potential abatement measures for all Type I projects receiving federal-aid funds. Currently, project plans have not been developed to the point where a detailed evaluation is possible. One example where a detailed analysis would be necessary is the proposed relocation of SR 99 between Clinton Avenue and Ashlan Avenue in Fresno. Preliminary plans indicate that travel lanes of the highway would move closer to residences.

For areas adjacent to the proposed HST stations, there is the potential for changes in traffic volume to affect the noise levels. The following methods were used to determine locations where there would be the potential for noise impact from traffic:

- Traffic growth factors for intersections near the HST stations were used to assess locations where the change in traffic volume could result in an increase in noise of 3 dB or greater, which represents a noticeable increase in noise level on an L_{dn} basis.

- At locations where the growth factors resulted in a 3 dB or more increase in noise, an analysis was conducted to determine what portion of the increase in traffic volume is related to the project.

Potential benefits in the noise environment associated with the project include grade separation of some streets and arterials that previously crossed the existing freight tracks. In these cases, two clear benefits would be realized: improved traffic flow and elimination of freight train horns and crossing bells. A simple traffic noise model based on the FHWA methodology was used to assess the change in noise level due to the improved traffic flow; the FTA and FRA methodologies were used to estimate the benefits of eliminating the crossing bells and horn blowing.

6.1.4 Non-High-Speed Train Noise Sources

Noise from non-HST sources included three types of maintenance facilities (heavy maintenance, maintenance of way, and overnight servicing) and electrical power substations. For maintenance facilities, FTA methodology was used for an analysis of noise from train movements in and out of maintenance facilities and activities associated with maintenance, repair, and storage of trains. Source noise included wheel squeal as the trains pass through the curved sections at the ends of the storage tracks, shop activities, car washes, warning horns, and traffic.

6.1.5 Construction Noise

Construction noise impacts were assessed according to the methodology described in Chapter 12 of the FTA guidance manual (FTA 2006). Construction noise estimates are always approximate because of the lack of specific information available at the time of the environmental assessment. Decisions about the procedures and equipment to be used will be made by the contractor. Project designers try to minimize constraints on how construction will be performed and the equipment that will be used so that contractors can perform construction in the most cost-effective manner. Nevertheless, estimated construction scenarios for typical railroad construction projects allow a quantitative construction noise assessment by comparing the predicted noise levels with impact criteria appropriate for the construction stage. The methodology included the following:

- Noise emissions from equipment expected be used by contractors
- Usage scenarios for how the equipment will be operated
- Estimated site layouts of equipment along the right-of-way
- Relationship of the construction operations to nearby noise-sensitive receivers

FTA provides criteria for maximum acceptable 8-hour noise levels (L_{eq}) for daytime and nighttime, as well as the 30-day average L_{dn} for long-term construction projects (see Table 4-4).

6.2 Ground-borne Noise and Vibration

6.2.1 Train Operation Vibration

Identification of vibration impacts from conceptual HST operations followed the FRA guidance manual approach. First, a general vibration assessment identified potential impacts at vibration-sensitive receivers. This general vibration assessment used the generalized vibration curve provided in the guidance manual, which assumes a generic soil condition. Adjustments were made for track type, train speed, and type of receiver building. Vibration criteria were applied to interior building use activities based on the predicted vibration levels.

The general vibration assessment was followed by a detailed vibration assessment, which identified vibration-sensitive receivers within 50 feet of the HST centerline and further identified receivers that require mitigation measures. The detailed vibration assessment was conducted according to the procedures in Chapter 9 of the FRA guidance manual (FRA 2005). The detailed assessment included a prediction model that required measurements of ground vibration propagation characteristics of the soil, vibration source characteristics of the train type expected to be used (an EMU train was assumed), speed, track type, and transfer characteristics into specific buildings. For vibration-sensitive receivers not near existing railroad tracks, the existing vibration conditions were not measured, in accordance with the vibration impact criteria shown in Table 4-6. However, much of the Merced to Fresno Section is adjacent to railroad rights-of-way where ground-borne vibrations were measured to be relatively high, as shown in Figure 5-6. For locations near an existing freight railroad track where existing vibrations are already at the impact level, FRA established special vibration impact criteria. These criteria were used in the vicinity of the BNSF and UPRR tracks.

The projection of ground-borne vibration from conceptual HST operations was based on the following data and assumptions:

- All vibration modeling projections were consistent with the methodology in the *High-Speed Ground Transportation Noise and Vibration Impact Assessment* (FRA 2005).
- The detailed vibration assessment and impact criteria used followed the *Transit Noise and Vibration Impact Assessment* (FTA 2006).
- The force density level of the HST was modeled by using data from the Pendolino train depicted in Figure 9-5 of the FRA guidance manual (FRA 2005).
- The track was assumed to be ballast and tie with continuous welded rail.
- It was assumed that the track would be on aerial structures wherever top-of-rail elevations are more than 15 feet above existing grade.
- All vibration modeling projections were assumed to be 10 dB lower wherever the track is on an aerial structure, in accordance with the FRA guidance manual (FRA 2005).
- The vibration projections were based on the same train speeds as the noise projections described in Section 6.1.1.
- Vibration projections assumed that any buildings within the property acquisition footprint were not to be included in the impact assessment.
- No adjustments were made to the predicted vibration levels to account for increases in localized vibration due to special trackwork, such as crossovers and turnouts.
- The difference in building and ground vibration is zero, assuming that the coupling loss for a typical building foundation would equal the amplification due to building resonances. This was based on FRA guidance manual (FRA 2005) recommendations.

Section 7 provides additional detailed assumptions made during the vibration impact analysis.

6.2.2 Construction Vibration

Construction vibration impact was assessed in accordance with the methodology described in Chapter 12 of the FTA guidance manual (FTA 2006) for quantitative construction vibration assessments. As in the construction noise assessment procedure, estimated construction scenarios have been developed for typical railroad construction projects, allowing a quantitative construction vibration assessment to be performed by comparing the predicted ground-borne vibration levels with impact criteria appropriate for the construction stage. Construction vibration was assessed quantitatively wherever there was a potential for blasting, pile driving, vibratory compaction, demolition, or excavation near vibration-sensitive structures. Criteria for annoyance (see Tables 4-6 and 4-7) and damage (see Table 4-9) were applied to determine impact from construction vibration. The methodology included the following:

- Vibration source levels from equipment expected to be used by contractors.
- Estimated site layouts of equipment along the right-of-way.
- Distance from the construction operations to nearby vibration-sensitive receivers.

7.0 Noise and Vibration Impacts

A noise and vibration impact assessment was performed based on the criteria discussed in Section 4 and the methodology, data, and assumptions described in Section 6. The impact area for the Merced to Fresno Section includes the project's proposed ground disturbance footprint (e.g., trackway, stations, substations, equipment storage areas, maintenance facility, and temporary construction staging areas). Commitments for surveys, analyses, and mitigation made in the programmatic EIR/EIS documents from 2005 and 2008 are addressed in this technical report. The results for the various project sources are described below.

7.1 Noise Impact Assessment

Noise impacts were assessed according to the methodology, data, and assumptions described in Section 6.1. The following sections describe the projected noise impacts related to HST activities for the HST alternatives, activities in the vicinity of the Fresno and Merced stations, and conceptual operations at maintenance facilities. Construction-related noise impacts are discussed in Section 7.3. Table 7-1 summarizes the noise impacts for all HST alternatives.

Figure 7-1 provides projected curves of 24-hour sound levels from high-speed rail operations versus distance for train speeds of 150 mph and 220 mph. Other variables used to calculate the projected curves are consistent with the project assumptions described in Section 6.1. These general results apply similarly to HST operations for any of the HST alternatives. The following sections provide detailed comparisons of the existing and future noise levels for the HST alternatives.

Table 7-1
Summary of Noise Impacts for All High-Speed Train Alternatives

HST Alternative	Total Number of Impacts	
	Moderate	Severe
UPRR/SR 99 Alternative – Range of Impacts	1,243 to 1,325 residential, 5 to 6 churches, 1 school, 1 hospital	787 to 884 residential, 1 to 2 churches, 1 park, 1 outdoor movie theater
BNSF Alternative – Range of Impacts	780 to 1,253 residential, 3 to 4 churches	420 to 468 residential, 1 park
Hybrid Alternative – Range of Impacts	796 to 915 residential, 3 to 4 churches	419 to 458 residential, 1 park
HMF Alternatives		
Castle Commerce Center	291	91
Harris-DeJager	0	0
Fagundes	0	0
Gordon-Shaw	0	0
Kojima Development	0	0

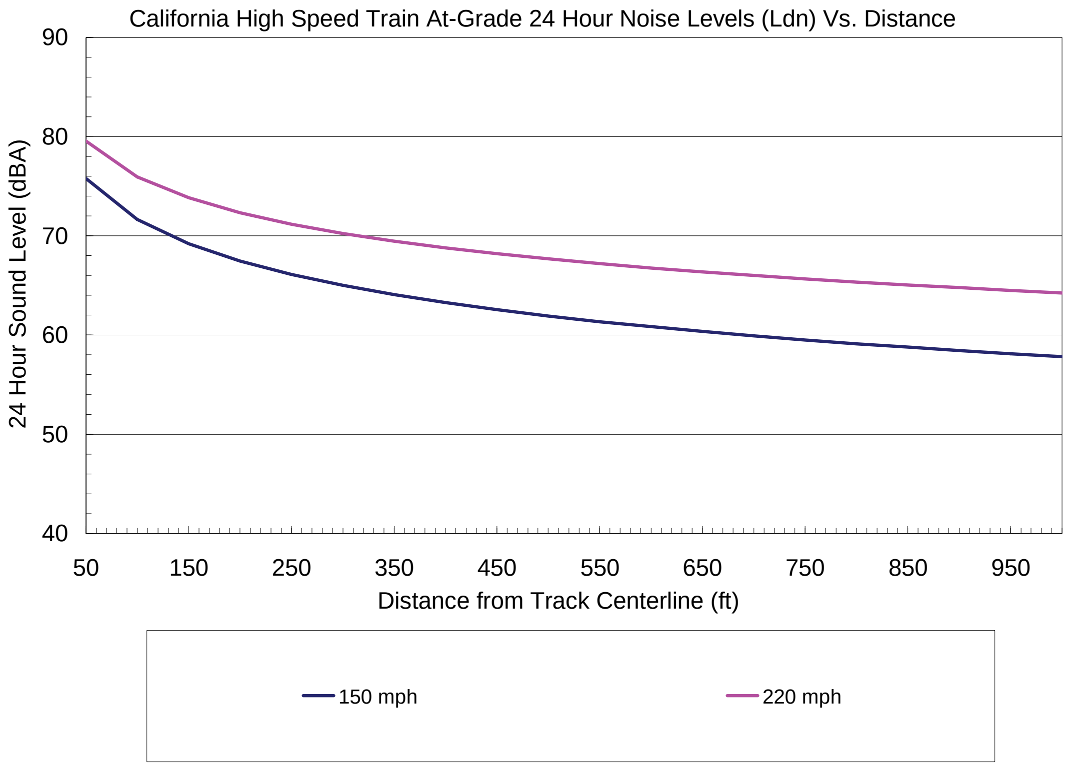


Figure 7-1
Projected High-Speed Train 24-Hour Noise Levels versus Distance

Figures 7-2 through 7-5 show the operational noise impact locations for the HST and HMF alternatives in the design year 2035.

7.1.1 UPRR/SR 99 Alternative Impacts during Operation

Table 7-2 summarizes all potential noise impacts related to operation of HSTs under the UPRR/SR 99 Alternative during the design year (2035). The table reports the total number of noise impacts projected to occur under each of three UPRR/SR 99 design options, including two design options with the Ave 24 Wye and one design option with the Ave 21 Wye. There is one design option for the Ave 21 Wye (East Chowchilla design option). There are two design options for the Ave 24 Wye (East Chowchilla and West Chowchilla design options).

The table indicates that for the Ave 24 Wye East Chowchilla design option, severe noise impacts would occur at 861 residences, 1 church, 1 park, and 1 outdoor movie theater. For the Ave 24 Wye West Chowchilla design option, severe noise impacts would occur at 884 residences, 2 churches, 1 park, and 1 outdoor movie theater. For the Ave 21 Wye, the number of severe noise impacts would be reduced to 787 residences, 1 church, 1 park, and 1 outdoor movie theater.

The number of moderate impacts would vary among each of the three design options. The greatest number of moderate impacts would occur with the Ave 21 Wye East Chowchilla design option, followed by the Ave 24 Wye East Chowchilla design option, and the least with the Ave 24 Wye West Chowchilla design option.

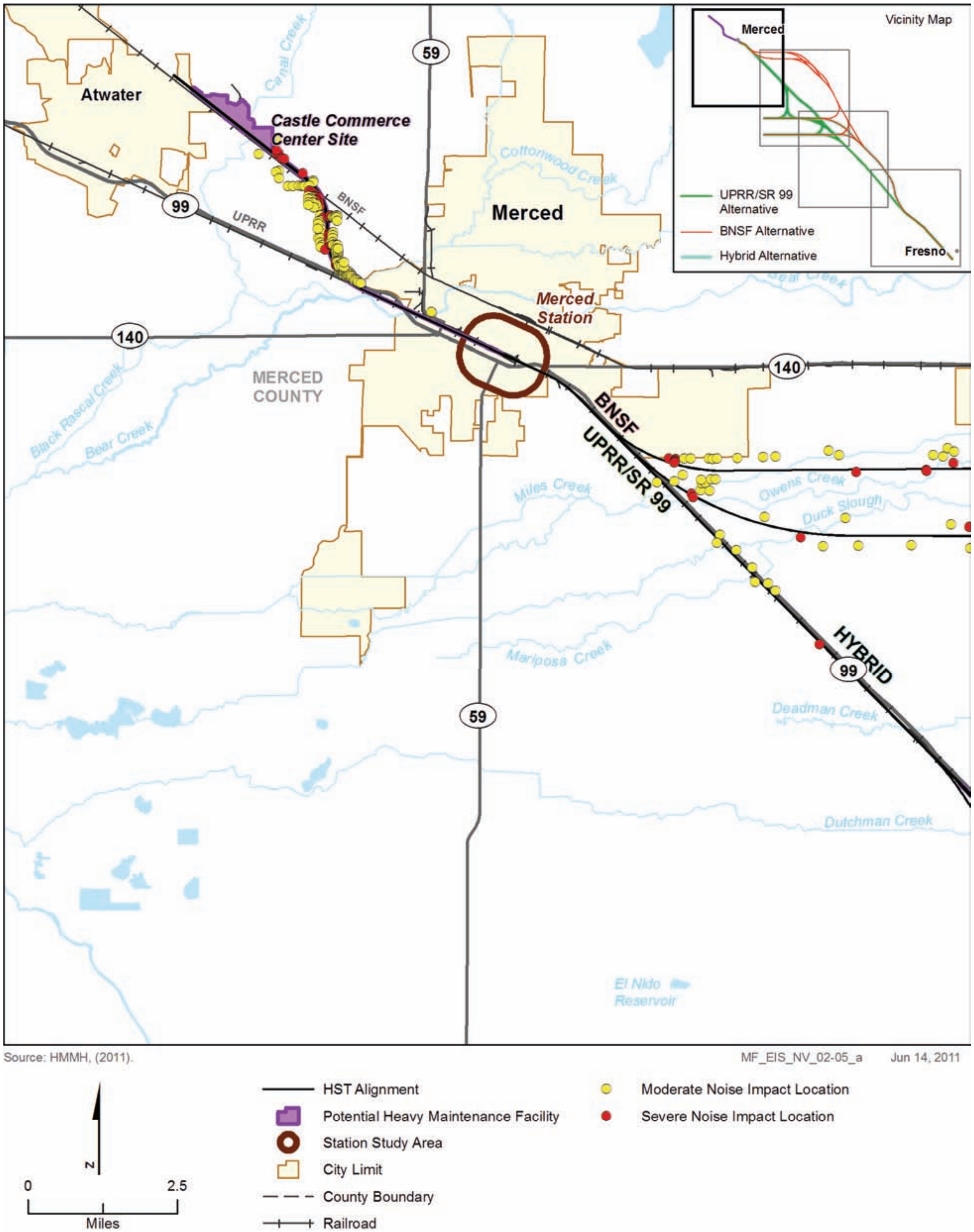


Figure 7-2
Noise Impact Locations in the Merced Project Vicinity

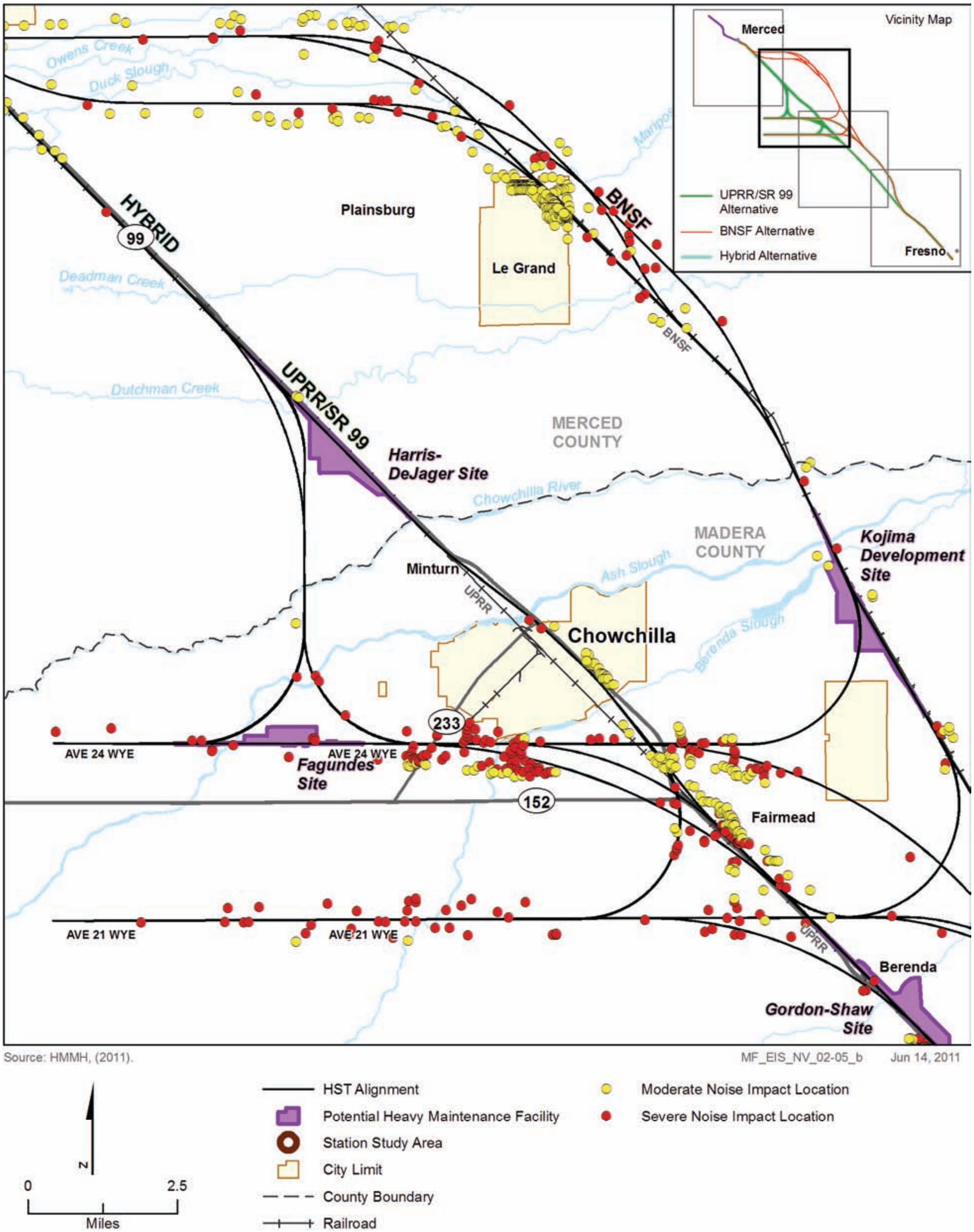


Figure 7-3
Noise Impact Locations in the Chowchilla Project Vicinity

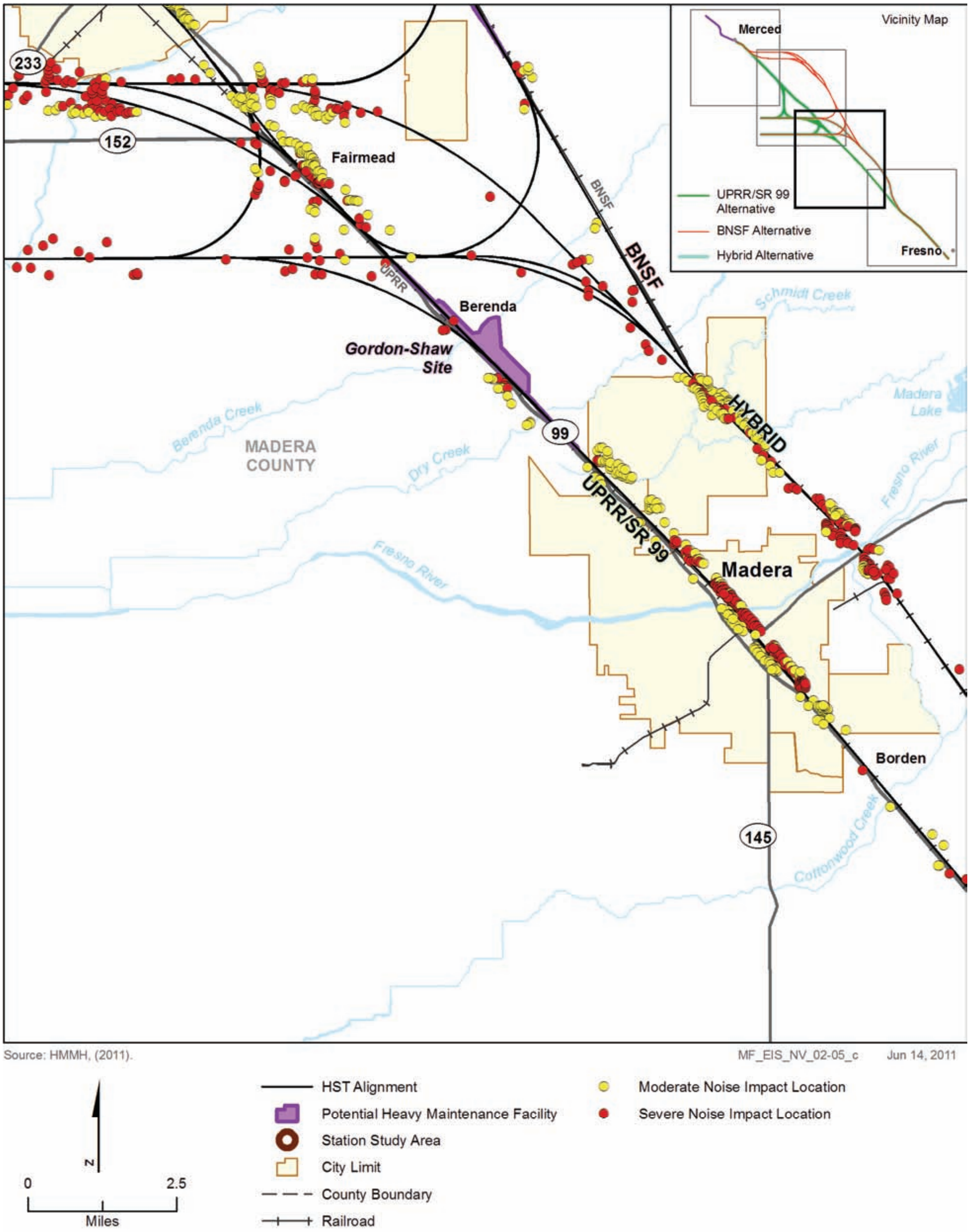


Figure 7-4
Noise Impact Locations in the Madera Project Vicinity

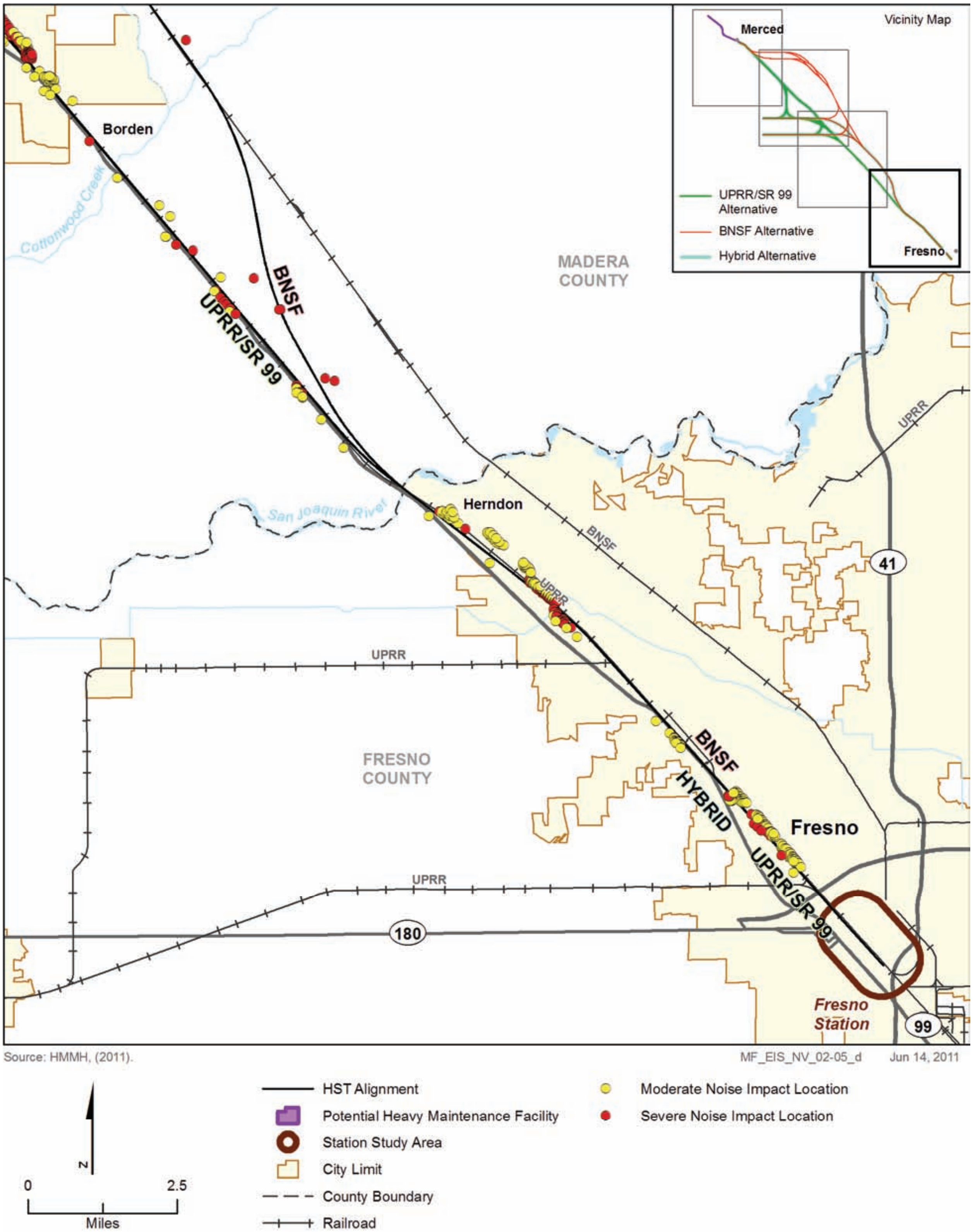


Figure 7-5
Noise Impact Locations in the Fresno Project Vicinity

Table 7-2
Total Noise Impacts for the UPRR/SR 99 Alternative without Mitigation during the Design Year (2035)

HST Alternative	Total Number of Impacts	
	Moderate	Severe
Impacts by Project Combination		
UPRR/SR 99 with West Chowchilla design option and Ave 24 Wye	1,243 residential, 5 churches, 1 school, 1 hospital	884 residential, 2 churches, 1 park, 1 outdoor movie theater
UPRR/SR 99 with East Chowchilla design option and Ave 24 Wye	1,302 residential, 6 churches, 1 school, 1 hospital	861 residential, 1 church, 1 park, 1 outdoor movie theater
UPRR/SR 99 with East Chowchilla design option and Ave 21 Wye	1,325 residential, 6 churches, 1 school, 1 hospital	787 residential, 1 church, 1 park, 1 outdoor movie theater
Total Range of Impacts for the UPRR/SR 99 Alternative	1,243 to 1,325 residential, 5 to 6 churches, 1 school, 1 hospital	787 to 884 residential, 1 to 2 churches, 1 park, 1 outdoor movie theater

7.1.1.1 North-South Alignment

Table 7-3 provides a further breakdown of noise impacts for each section of the north-south alignment of the UPRR/SR 99 Alternative. In the northern section (Merced Station to Deadman Creek, south of Le Grand), one severe noise impact is predicted to occur. Because of the relatively high existing noise levels in the urban area of Merced and the significantly fewer HST operations north of the wyes, the project would not result in noise increases sufficient to cause severe impacts. The one severe noise impact in the northern section occurs in a rural area at a single-family residence in close proximity to the alignment.

In the central section with the East Chowchilla design option (Deadman Creek to Dry Creek, north of Madera Acres), severe noise impacts are predicted to occur at 64 residences with the Ave 24 Wye and at 19 residences with the Ave 21 Wye. In the central section with the West Chowchilla design option (Deadman Creek to Dry Creek, north of Madera Acres), severe noise impacts are predicted to occur at 154 residences and 1 church with the Ave 24 Wye. In the southern section (Dry Creek to Fresno Station), severe noise impacts are predicted at 719 residences, 1 church, 1 park, and 1 outdoor movie theater.

7.1.1.2 Ave 24 Wye Design Option

Table 7-4 provides a further breakdown of noise impacts for the UPRR/SR 99 Alternative with the Ave 24 Wye. A total of 77 residences are predicted to experience severe impacts in this area with the East Chowchilla design option; 10 residences are predicted to experience severe impacts with the West Chowchilla design option.

7.1.1.3 Ave 21 Wye Design Option

Table 7-5 provides a further breakdown of noise impacts for the UPRR/SR 99 Alternative with the Ave 21 Wye. Severe noise impacts are expected at 48 residences in this area.

Table 7-3
Detailed Noise Impact Results for the UPRR/SR 99 Alternative North-South Alignment without Mitigation (2035)

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
				Predicted	Impact Criteria: Moderate	Impact Criteria: Severe			Moderate	Severe
Northern Section										
Merced Station to Mission Avenue (Merced city line)	374	195	67	62	62	68	68	1	0	0
Mission Avenue (Merced city line) to Deadman Creek	135 to 442	217	67	63 to 69	62	67	69 to 71	1 to 4	10	1
Northern Section Totals									10	1
Central Section										
Deadman Creek to Dry Creek (north of Madera Acres) (East Chowchilla design option with Ave 24 Wye)	64 to 1,956 82[d]	202 to 217 217[d]	61 to 67 60[d]	58 to 71 66[d]	58 to 62 62[d]	63 to 67 68[d]	63 to 72 67[d]	1 to 8 7[d]	131 residential, 1 church	64
Deadman Creek to Dry Creek (north of Madera Acres) (East Chowchilla design option with Ave 21 Wye)	64 to 1,679 82[d]	202 to 217 217[d]	61 to 67 60[d]	58 to 69 65[d]	58 to 62 62[d]	63 to 67 68[d]	63 to 70 66[d]	1 to 6 6[d]	188 residential, 1 church	19
Deadman Creek to Dry Creek (north of Madera Acres) (West Chowchilla design option with Ave 24 Wye)	61 to 2,336 82[d]	150 to 217 217[d]	50 to 64 60[d]	55 to 79 68[d]	53 to 60 62[d]	59–65 68[d]	56–79 69[d]	2 to 29 9[d]	114	154 residential, 1 church
Central Section, East Chowchilla Design Option with Ave 24 Wye Totals									131 residential, 1 church	64
Central Section, East Chowchilla Design Option with Ave 21 Wye Totals									136 residential, 1 church	19

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
					Impact Criteria					
				Predicted	Moderate	Severe			Moderate	Severe
Central Section, West Chowchilla with Ave 24 Wye Totals									114	154 residential, 1 church
Southern Section										
Dry Creek (north of Madera Acres) to San Joaquin River (Fresno city line)	70 to 1,762 71 to 973[d] 284[f]	217 217[d] 217[f]	64 to 71 54 to 67[d] 61[f]	61 to 69 63 to 68[d] 66[f]	60 to 64 60 to 66[d] 58[f]	65 to 69 65 to 72[d] 64[f]	65 to 73 63 to 70[d] 67[f]	1 to 7 3 to 11[d] 6[f]	575 residential[e], 4 churches, 1 school, 1 hospital	538 residential, 1 outdoor movie theater
San Joaquin River (Fresno city line) to Clinton Avenue	228 to 1,602 397 to 921[d]	215 to 217 217[d]	63 to 72 54[d]	60 to 71 63 to 66[d]	60 to 65 60[d]	65 to 70 66[d]	65 to 74 64 to 66[d]	1 to 9 9 to 12[d]	261 residential, 1 church	133 residential, 1 church
Clinton Avenue to Fresno HST Station	99 to 595 205[d]	195 to 217 205[d]	70 55[d]	64 to 75 69[d]	64 60[d]	69 66[d]	71 to 76 70[d]	1 to 6 14[d]	284	48 residential, 1 park
Southern Section Totals									1,120 residential[e], 5 churches, 1 school, 1 hospital	719 residential, 1 church, 1 park, 1 outdoor movie theater
UPRR/SR 99 North–South Alignment Totals										
Ave 24 Wye Option										
East Chowchilla Design Option									1,260 residential, 6 churches, 1 school, 1 hospital	784 residential, 1 church, 1 park, 1 outdoor movie theater

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
				Predicted	Impact Criteria				Moderate	Severe
					Moderate	Severe				
West Chowchilla Design Option									1,243 residential, 5 churches, 1 school, 1 hospital	874 residential, 2 churches, 1 park, 1 outdoor movie theater
Ave 21 Wye Option										
East Chowchilla Design Option									1,318 residential, 6 churches, 1 school, 1 hospital	739 residential, 1 church, 1 park, 1 outdoor movie theater

[a] The ranges shown for the distances and noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location.
[b] Noise levels are based on L_{dn} and measured in dBA, except for Land Use Category 3, which are based on peak-hour L_{eq}.
[c] All impacts are residential unless otherwise noted.
[d] Values are for Land Use Category 3 receptors. Noise levels are based on L_{eq} and measured in dBA.
[e] One less residential impact for the Ave 24 Wye.
[f] Values are for Land Use Category 1 receptors. Noise levels are based on L_{eq} and measured in dBA.

Table 7-4
Detailed Noise Impact Results for the UPRR/SR 99 Alternative with Ave 24 Wye without Mitigation (2035)

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
					Impact Criteria					
				Predicted	Moderate	Severe			Moderate	Severe
East Chowchilla Design Option with Ave 24 Wye	139 to 2,043	150 to 217	50 to 62	55 to 71	53 to 58	59 to 64	56 to 71	3 to 21	42	77
West Chowchilla Design Option with Ave 24 Wye	138 to 1,305	217	50 to 51	61 to 71	53 to 54	59 to 60	61 to 71	10 to 21	0	10

[a] The ranges shown for the distances and noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location.

[b] Noise levels are based on L_{dn} and measured in dBA, except for Land Use Category 3, which are based on peak-hour L_{eq}.

[c] All impacts are residential unless otherwise noted.

Table 7-5
Detailed Noise Impact Results for the UPRR/SR 99 Alternative with Ave 21 Wye without Mitigation (2035)

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
					Impact Criteria					
				Predicted	Moderate	Severe			Moderate	Severe
Ave 21 Wye	127 to 1,964	150 to 217	49 to 61	58 to 73	53 to 58	59 to 63	59 to 73	2 to 24	7	48

[a] The ranges shown for the distances and noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location.

[b] Noise levels are based on L_{dn} and measured in dBA, except for Land Use Category 3, which are based on peak-hour L_{eq}.

[c] All impacts are residential unless otherwise noted.

7.1.2 BNSF Alternative Impacts during Operation

Table 7-6 summarizes all potential noise impacts related to operation of HSTs under the BNSF Alternative during the design year (2035). The table reports the total number of noise impacts projected to occur under each of eight BNSF design options, including four design options with the Ave 24 Wye and four design options with the Ave 21 Wye. The BNSF Alternative includes four design options within the northern section of the north-south alignment between the Merced city line and the Chowchilla River.

Table 7-6 indicates that under any of the four Ave 24 Wye design options, severe noise impacts would occur at approximately the same number of residences, ranging from 457 with the Mariposa Way design option to 468 with the Mission Ave East of Le Grand design option. In each case, a severe impact also would occur at one park. Under the four Ave 21 Wye design options, the number of severe noise impacts at residences would range from 420 with the Mariposa Way design option to 431 with the Mission Ave East of Le Grand design option. In each case, a severe impact also would occur at one park. The number of moderate noise impacts would vary among each of the eight design options.

Table 7-6
Total Noise Impacts for the BNSF Alternative without Mitigation during the Design Year (2035)

BNSF Alternative	Total Number of Impacts	
	Moderate	Severe
Impacts by Project Combination		
BNSF North-South Alignment with Ave 24 Wye	789 residential, 3 churches	440 residential, 1 park
BNSF North-South Alignment with Ave 21 Wye	730 residential, 3 churches	403 residential, 1 park
Le Grand Design Options		
Mariposa Way	464 residential, 1 church	17
Mariposa Way East of Le Grand	50	25
Mission Ave	457	19
Mission Ave East of Le Grand	58	28
Impacts by Project Combination		
BNSF Alternative with Ave 24 Wye	839 to 1,253 residential, 3 to 4 churches	457 to 468 residential, 1 park
BNSF Alternative with Ave 21 Wye	780 to 1,194 residential, 3 to 4 churches	420 to 431 residential, 1 park
Total Range of Impacts for the BNSF Alternative	780 to 1,253 residential, 3 to 4 churches	420 to 468 residential, 1 park

7.1.2.1 North-South Alignment

Table 7-7 provides a further breakdown of noise impacts for each section of the north-south alignment under the BNSF Alternative. In the northern section (Merced Station to Mission Avenue/Merced city line), no severe noise impacts are predicted to occur within the City of Merced, because of the relatively high existing noise levels and the significantly fewer HST operations north of the wyes. South of Merced to the Chowchilla River, severe noise impacts are expected at 17 residences with the Mariposa Way design option, 25 residences with the East of Le Grand design option, 19 residences with the Mission Ave design option, and 28 residences with the Mission Ave East of Le Grand design option. In the central section (Chowchilla River to Lake Street, Madera), severe noise impacts are expected at 44 residences with the Ave 24 Wye and 42 residences with the Ave 21 Wye design option. In the southern section (Lake Street, Madera to Fresno Station), severe noise impacts are predicted at 302 residences and 1 park.

7.1.2.2 Ave 24 Wye Design Option

Table 7-8 provides a further breakdown of noise impacts under for the BNSF Alternative with the Ave 24 Wye. Severe noise impacts are expected at 94 residences in this area with this option.

7.1.2.3 Ave 21 Wye Design Option

Table 7-9 provides for a further breakdown of noise impacts under the BNSF Alternative with the Ave 21 Wye. Severe noise impacts are expected at 59 residences in this area under this option.

Table 7-7
Detailed Noise Impact Results for the BNSF Alternative North-South Alignment without Mitigation (2035)

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
				Predicted	Impact Criteria Moderate	Impact Criteria Severe			Moderate	Severe
Northern Section										
Merced HST Station (north) to Mission Avenue (Merced city line)	348	180	75	61	65	72	72	0	0	0
Mission Avenue (Merced city line) to Chowchilla River (county line) (Mariposa Way design option)	52 to 1,906 530[d]	214 to 217 217[d]	47 to 71 57[d]	53 to 70 62[d]	52 to 65 61[d]	59 to 70 67[d]	55 to 73 63[d]	1 to 18 6[d]	464 residential, 1 church	17
Mission Avenue (Merced city line) to Chowchilla River (county line) (Mariposa Way East of Le Grand design option)	52 to 1,856	214 to 217	47 to 67	53 to 72	52 to 62	59 to 67	55 to 72	2 to 25	50	25
Mission Avenue (Merced city line) to Chowchilla River (county line) (Mission Ave design option)	80 to 1,978	214 to 217	47 to 71	53 to 72	52 to 65	59 to 70	54 to 73	1 to 24	457	19
Mission Avenue (Merced city line) to Chowchilla River (county line) (Mission Ave East of Le Grand design option)	80 to 1,993	214 to 217	47 to 71	53 to 72	52 to 65	59 to 70	55 to 72	1 to 24	58	28
Northern Section, Mariposa Way Design Option Totals									464 residential, 1 church	17
Northern Section, Mariposa Way East of Le Grand Design Option Totals									50	25

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
				Predicted	Impact Criteria: Moderate	Impact Criteria: Severe			Moderate	Severe
Northern Section, Mission Ave Design Option Totals									457	19
Northern Section, Mission Ave East of Le Grand Design Option Totals									58	28
Central Section										
Chowchilla River (county line) to Lake Street, Madera (Ave 24 Wye)	133 to 1,675	149 to 217	54 to 69	55 to 71	54 to 64	60 to 69	57 to 73	1 to 11	140	44
Chowchilla River (county line) to Lake Street, Madera (Ave 21 Wye)	133 to 1,238	217	54 to 69	55 to 71	54 to 64	60 to 69	57 to 73	1 to 11	143	42
Central Section, Ave 24 Wye Totals									140	44
Central Section, Ave 21 Wye Totals									143	42
Southern Section										
Lake Street, Madera to San Joaquin River (Fresno city line)	69 to 1,349 552[d]	217 217[d]	46 to 69 56[d]	60 to 78 63[d]	52 to 64 60[d]	59 to 69 66[d]	61 to 78 64[d]	1 to 32 8[d]	44 residential, 1 church	123
San Joaquin River (Fresno city line) to Clinton Avenue	228 to 1,602 397 to 921[d]	217 217[d]	63 to 72 54[d]	60 to 71 63 to 66[d]	60 to 65 60[d]	65 to 70 66[d]	65 to 74 63 to 66[d]	1 to 8 9 to 12[d]	254 residential, 2 churches	131
Clinton Avenue to Fresno HST Station	99 to 595 205[d]	195 to 217 205[d]	70 55[d]	64 to 75 69[d]	64 60[d]	69 66[d]	71 to 76 70[d]	1 to 6 14[d]	284	48 residential, 1 park
Southern Section Totals									582 residential, 3 churches	302 residential, 1 park
BNSF North-South Alignment Totals										
Ave 24 Wye Options										
Mariposa Way Design Option									1,186 residential, 4 churches	363 residential, 1 park

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
				Predicted	Impact Criteria Moderate	Impact Criteria Severe			Moderate	Severe
Mariposa Way East of Le Grand Design Option									772 residential, 3 churches	371 residential, 1 park
Mission Ave Design Option									1,179 residential, 3 churches	365 residential, 1 park
Mission Ave East of Le Grand Design Option									780 residential, 3 churches	374 residential, 1 park
Ave 21 Wye Options										
Mariposa Way Design Option									1,189 residential, 4 churches	361 residential, 1 park
Mariposa Way East of Le Grand Design Option									775 residential, 3 churches	369 residential, 1 park
Mission Ave Design Option									1,182 residential, 3 churches	363 residential, 1 park
Mission Ave East of Le Grand Design Option									783 residential, 3 churches	372 residential, 1 park

[a] The ranges shown for the distances and noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location.
[b] Noise levels are based on L_{dn} and measured in dBA, except for Land Use Category 3, which are based on peak-hour L_{eq}.
[c] All impacts are residential unless otherwise noted.
[d] Values are for Land Use Category 3 receptors. Noise levels are based on L_{eq} and measured in dBA.

Table 7-8
Detailed Noise Impact Results for the BNSF Alternative with Ave 24 Wye without Mitigation (2035)

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
					Impact Criteria					
				Predicted	Moderate	Severe			Moderate	Severe
BNSF with Ave 24 Wye	61 to 2,054	216 to 217	50 to 64	55 to 78	53 to 60	59 to 65	56 to 78	2 to 28	67	94

[a] The ranges shown for the distances and noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location.
[b] Noise levels are based on L_{dn} and measured in dBA, except for Land Use Category 3, which are based on peak-hour L_{eq}.
[c] All impacts are residential unless otherwise noted.

Table 7-9
Detailed Noise Impact Results for the BNSF Alternative with Ave 21 Wye without Mitigation (2035)

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
					Impact Criteria					
				Predicted	Moderate	Severe			Moderate	Severe
BNSF with Ave 21 Wye	95 to 1,964	217	49 to 61	58 to 76	53 to 58	59 to 63	59 to 76	2 to 27	5	59

[a] The ranges shown for the distances and noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location.
[b] Noise levels are based on L_{dn} and measured in dBA, except for Land Use Category 3, which are based on peak-hour L_{eq}.
[c] All impacts are residential unless otherwise noted.

7.1.3 Hybrid Alternative Impacts during Operation

Table 7-10 summarizes all potential noise impacts related to operation of HSTs under the Hybrid Alternative during the design year (2035). The table reports the total number of noise impacts projected to occur for the Hybrid Alternative with the Ave 24 Wye and the Ave 21 Wye. Table 7-10 indicates that for the Ave 24 Wye, severe noise impacts would occur at 458 residences and 1 park. Moderate noise impacts would occur at 796 residences and 3 churches. For the Ave 21 Wye, severe noise impacts would occur at 419 residences and 1 park. Moderate noise impacts would occur at 915 residences and 4 churches.

Table 7-10
Total Noise Impacts for the Hybrid Alternative without Mitigation during the Design Year (2035)

HST Alternative	Total Number of Impacts	
	Moderate	Severe
Hybrid Alternative with Ave 24 Wye	796 residential, 3 churches	458 residential, 1 park
Hybrid Alternative with Ave 21 Wye	915 residential, 4 churches	419 residential, 1 park
Total Hybrid Alternative Range of Impact	796 to 915 residential, 3 to 4 churches	419 to 458 residential, 1 park

7.1.3.1 North-South Alignment

Table 7-11 provides a further breakdown of noise impacts for each section of the north-south alignment of the Hybrid Alternative. In the northern section (Merced Station to Deadman Creek, south of Le Grand), one severe noise impact is predicted to occur. Because of the relatively high existing noise levels in the urban area of Merced and the significantly fewer HST operations north of the wyes, project noise would not result in increases sufficient to cause severe impacts. The one severe noise impact in the northern sections occurs in a rural area at a single-family residence in close proximity to the alignment. In the central section with the Ave 24 Wye (Deadman Creek to Lake Street, Madera), severe noise impacts are predicted to occur at 144 residences. In the central section with the Ave 21 Wye, severe noise impacts are predicted to occur at 64 residences. In the southern section (Lake Street, Madera to Downtown Fresno Station), severe noise impacts are predicted at 302 residences and 1 park.

7.1.3.2 Ave 24 Wye Design Option

Table 7-12 provides for a further breakdown of noise impacts under the Hybrid Alternative with the Ave 24 Wye. A total of 11 residences are predicted to experience severe impacts in this area.

7.1.3.3 Ave 21 Wye Design Option

Table 7-13 provides for a further breakdown of noise impacts under the Hybrid Alternative with the Ave 21 Wye. A total of 52 residences are predicted to experience severe impacts in this area.

Table 7-11
Detailed Noise Impact Results for Hybrid Alternative North-South Alignment without Mitigation (2035)

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
				Predicted	Impact Criteria Moderate	Impact Criteria Severe			Moderate	Severe
Northern Section										
Merced Station to Mission Avenue (Merced city line)	374	195	67	62	62	68	68	1	0	0
Mission Avenue (Merced city line) to Deadman Creek	135 to 442	217	67	63 to 69	62	67	69 to 71	1 to 4	10	1
Northern Section Totals									10	1
Central Section										
Deadman Creek to Lake Street, Madera (Ave 24 Wye)	61 to 2,035	150 to 217	50 to 69	55 to 78	53 to 64	59 to 69	56 to 78	1 to 28	204	144
Deadman Creek to Lake Street, Madera (Ave 21 Wye)	64 to 1,989 106[d]	217 217[d]	54 to 69 60[d]	58-78 65[d]	54 to 60 62[d]	60 to 69 68[d]	60 to 78 66[d]	1 to 24 6[d]	317 residential, 1 church	64
Central Section, Ave 24 Wye Totals									204	144
Central Section, Ave 21 Wye Totals									318 residential, 1 church	64
Southern Section										
Lake Street, Madera to San Joaquin River (Fresno city line)	69 to 1,349 552[d]	217 217[d]	46 to 69 56[d]	60 to 78 63[d]	52 to 64 60[d]	59 to 69 66[d]	61 to 78 64[d]	1 to 32 8[d]	44 residential, 1 church	123
San Joaquin River (Fresno city line) to Clinton Avenue	228 to 1,602 397 to 921[d]	217 217[d]	63 to 72 54[d]	60 to 71 63 to 66[d]	60 to 65 60[d]	65 to 70 66[d]	65 to 74 63 to 66[d]	1 to 8 9 to 12[d]	254 residential, 2 churches	131

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
				Predicted	Impact Criteria: Moderate	Impact Criteria: Severe			Moderate	Severe
Clinton Avenue to Fresno HST Station	99 to 595 205[d]	195 to 217 205[d]	70 55[d]	64 to 75 69[d]	64 60[d]	69 66[d]	71 to 76 70[d]	1 to 6 14[d]	284	48 residential, 1 park
Southern Section Totals									582 residential, 3 churches	302 residential, 1 park
Hybrid North-South Alignment Totals										
Ave 24 Wye Option										
Ave 24 Wye Total									796 residential, 3 churches	447 residential, 1 park
Ave 21 Wye Option										
Ave 21 Wye Total									909 residential, 4 churches	367 residential, 1 park

[a] The ranges shown for the distances and noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location.
[b] Noise levels are based on L_{dn} and measured in dBA, except for Land Use Category 3, which are based on peak-hour L_{eq}.
[c] All impacts are residential unless otherwise noted.
[d] Values are for Land Use Category 3 receptors. Noise levels are based on L_{eq} and measured in dBA.

Table 7-12
Detailed Noise Impact Results for the Hybrid Alternative with Ave 24 Wye without Mitigation (2035)

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
					Impact Criteria					
				Predicted	Moderate	Severe			Moderate	Severe
Hybrid with Ave 24 Wye	138 to 1,305	217	50 to 51	61 to 73	53 to 54	59 to 60	61 to 73	10 to 22	0	11

[a] The ranges shown for the distances and noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location.

[b] Noise levels are based on L_{dn} and measured in dBA, except for Land Use Category 3, which are based on peak-hour L_{eq}.

[c] All impacts are resi4ential unless otherwise noted.

Table 7-13
Detailed Noise Impact Results for the Hybrid Alternative with Ave 21 Wye without Mitigation (2035)

Receptor Location	Distance to Near Track (feet)[a]	Maximum Train Speed (mph)	Existing Noise Level[b]	Project Noise Level[b]			Total Noise Level[b]	Noise Level Increase[b]	Number of Impacts[c]	
					Impact Criteria					
				Predicted	Moderate	Severe			Moderate	Severe
Hybrid with Ave 21 Wye	127 to 1,964	150 to 217	49 to 61	58 to 73	53 to 58	59 to 63	59 to 73	2 to 24	6	52

[a] The ranges shown for the distances and noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location.

[b] Noise levels are based on L_{dn} and measured in dBA, except for Land Use Category 3, which are based on peak-hour L_{eq}.

[c] All impacts are residential unless otherwise noted.

7.1.4 Heavy Maintenance Facility Alternative Impacts during Operation

Table 7-14 summarizes noise impacts for the HMF alternatives.

Table 7-14
Summary of Noise Impact Assessment for the Heavy Maintenance Facilities without Mitigation during the Design Year (2035)

HMF Alternative	Total Number of Impacts	
	Moderate	Severe
Castle Commerce Center	291	91
Harris-DeJager	0	0
Fagundes	0	0
Gordon-Shaw	0	0
Kojima Development	0	0

7.1.4.1 Castle Commerce Center – UPRR/SR 99, BNSF, and Hybrid Alternatives

Noise impacts are projected at noise-sensitive receptors adjacent to the tracks leading to Castle Commerce Center north of Merced HST station. The noise modeling projections for the tracks leading to Castle Commerce Center assumed 24 train movements in and out of the facility during the nighttime and none during the daytime. All trains were assumed to travel at 150 mph along the maintenance facility lead tracks. The model used elevation data provided. Table 7-13 summarizes the projected noise impacts along the lead tracks to Castle Commerce Center. Figure 7-2 shows the predicted noise impacts for the Castle Commerce Center HMF.

7.1.4.2 Harris-DeJager – UPRR/SR 99 Alternative

No noise impacts are projected for Harris/DeJager HMF operations.

7.1.4.3 Fagundes – UPRR/SR 99, BNSF, and Hybrid Alternatives

No noise impacts are projected for Fagundes HMF operations.

7.1.4.4 Gordon-Shaw – UPRR/SR 99 Alternative

No noise impacts are projected for Gordon-Shaw HMF operations.

7.1.4.5 Kojima Development – BNSF Alternative

No noise impacts are projected for Kojima Development HMF operations.

7.1.5 Annoyance from Onset of High-Speed Train Pass-Bys

There is considerable evidence that increased annoyance is likely to occur for train noise events with rapid onset rates. Figure 4-2 shows the relationship of speed and distance to define locations where the onset rate for HST operations may cause a startle effect (FRA 2005). The potential for increased annoyance is primarily confined to an area very close to the tracks. In the Merced to Fresno Section, the maximum train speeds are 220 mph. At that speed, the distance from the tracks within which the startle effect can occur would be 45 feet, which is within the project right-of-way.

7.1.6 Noise Effects on Wildlife and Domestic Animals

FRA addresses impacts on wildlife (mammals and birds) and domestic animals (livestock and poultry). Noise exposure limits for each are an SEL of 100 dBA from train pass-bys. A screening assessment was conducted to determine typical and maximum distances from the HST tracks at which this limit may be exceeded. Train pass-by SELs were computed for two conditions: at-grade and on a 60-foot-high elevated structure. To provide a conservative estimate, in each case the HST maximum operating speed of 220 mph was used, and no shielding provided by intervening structures or terrain was assumed.

Table 7-15 indicates that in at-grade sections, the screening distance for a single train pass-by SEL of 100 dBA would be approximately 100 feet from the track centerline. In elevated track locations, a single-train pass-by SEL of 100 dBA would not occur beyond the edge of the structure, approximately 15 feet from the track centerline. This assumes the presence of a safety barrier on the edge of an aerial structure that is 3 feet above the top-of-rail height.

For reference, Table 7-15 also indicates the screening distances to potential wildlife/domestic animal impacts from freight trains that currently use the UPRR and BNSF railways. The distance to impact for a freight train is 75 feet where the warning horn is not sounded and 400 feet at a grade crossing where the horn is sounded. These screening distances assume a freight train consisting of two locomotives and 100 cars traveling at 50 mph, which is typical for trains on both the UPRR and BNSF tracks.

Table 7-15
Screening Distances for Effects on Wildlife and Domestic Animals

Track Location	Speed (mph)	SEL (dB[a])	Distance from Track Centerline (feet)
HST at-grade	220	100	100
HST 60-foot elevated structure	220	100	15[a]
Freight train, no horn noise	50	100	75
Freight train, sounding horn at grade crossing	50	100	400

[a] These projections assume a safety barrier on the edge of the aerial structure as shown in typical cross-sections. The safety barrier is assumed to be 3 feet above the top-of-rail height and located 15 feet from the track centerline.

7.2 Ground-Borne Vibration Impacts

Ground-borne vibration impacts were assessed according to the methodology, data, and assumptions described in Section 6.2. The following sections describe the projected vibration impacts related to HST activities for all HST alternatives. Section 7.3.3 addresses construction-related vibration impacts. Table 7-16 summarizes vibration impacts for all HST alternatives.

The approach used for assessing vibration impacts generally follows the approach used for noise impacts, except that existing vibration is not considered when evaluating impacts. The FTA impact threshold for frequent (i.e., more than 70) light-rail transit operations is 72 VdB for residential buildings (Category 2) and 75 VdB for institutional buildings; park lands are not considered vibration sensitive.

Figures 7-6 and 7-7 provide projections of maximum ground vibration levels from HST operations for each vibration propagation measurement site. The figures plot the FRA residential impact criterion against maximum vibration levels from HSTs at 150 mph and 220 mph, respectively.

There would be no vibration impacts for most locations along the Merced to Fresno Section under any of the HST alternatives. This is because the very inefficient propagation of vibration through the soils in the project vicinity, the low vehicle input force, and the presence of elevated structures, which provide significant attenuation of vibration levels in heavily populated areas where vibration-sensitive receptors are primarily located. In addition, no structures within the property acquisition footprint were included in the vibration analysis. Figure 7-8 shows the operational vibration impact locations for the HST and HMF alternatives in the design year 2035.

Table 7-16
Summary of Vibration Impacts for All High-Speed Train Alternatives during the Design Year (2035)

HST Alternative	Total Number of Impacts
UPRR/SR 99 Alternative – Range of Impacts	0
BNSF Alternative – Range of Impacts	0 to 1
Hybrid Alternative – Range of Impacts	0
HMF Alternatives	
Castle Commerce Center	0
Harris-DeJager	0
Fagundes	0
Gordon-Shaw	0
Kojima Development	0

7.2.1 UPRR/SR 99 Alternative Impacts during Operation

Table 7-17 summarizes all potential vibration impacts related to operation of HSTs for the UPRR/SR 99 Alternative during the design year (2035). The table reports the total number of vibration impacts projected to occur under each of three UPRR/SR 99 design options, including two design options with the Ave 24 Wye and one design option with the Ave 21 Wye. In most cases, vibration levels exceeding the impact criteria would be confined to the right-of-way. As a result, no vibration impacts are anticipated to occur under any of the design options.

Table 7-17
Total Vibration Impacts for the UPRR/SR 99 Alternative without Mitigation
during the Design Year (2035)

HST Alternative	Total Number of Impacts
Impacts by Project Combination	
UPRR/SR 99 Alternative with East Chowchilla design option and Ave 24 Wye	0
UPRR/SR 99 Alternative with West Chowchilla design option and Ave 24 Wye	0
UPRR/SR 99 Alternative with East Chowchilla design option and Ave 21 Wye	0
Total Range of Impacts for the UPRR/SR 99 Alternative	0

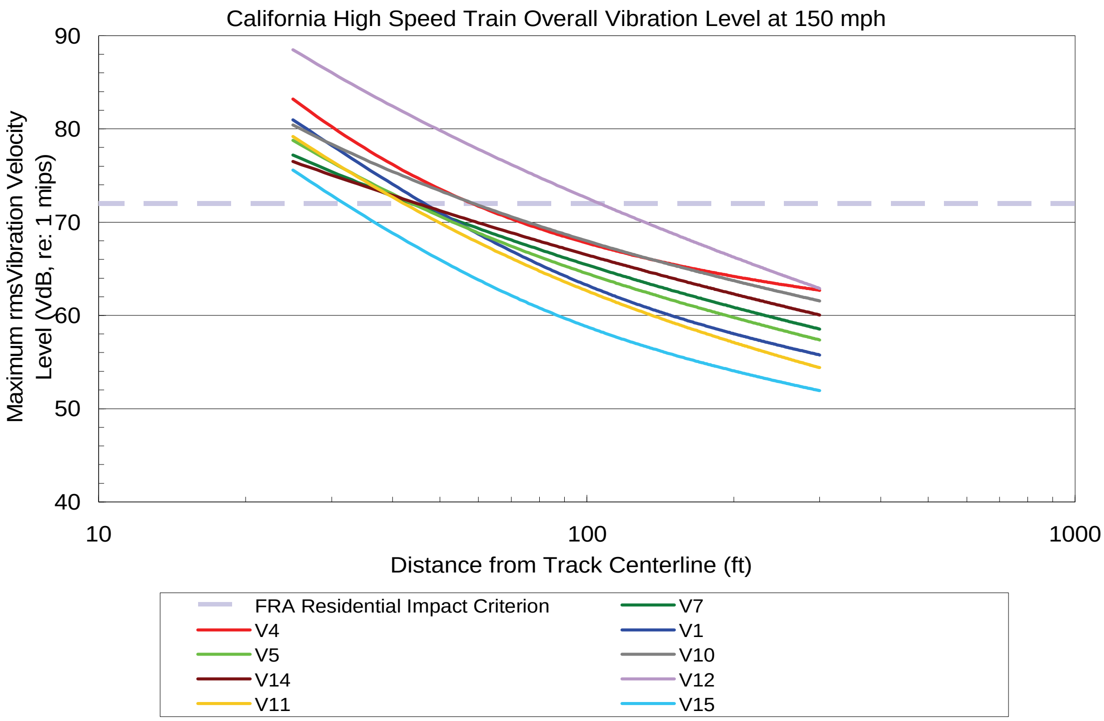


Figure 7-6
High-Speed Train Overall Vibration Levels
versus Distance at 150 mph

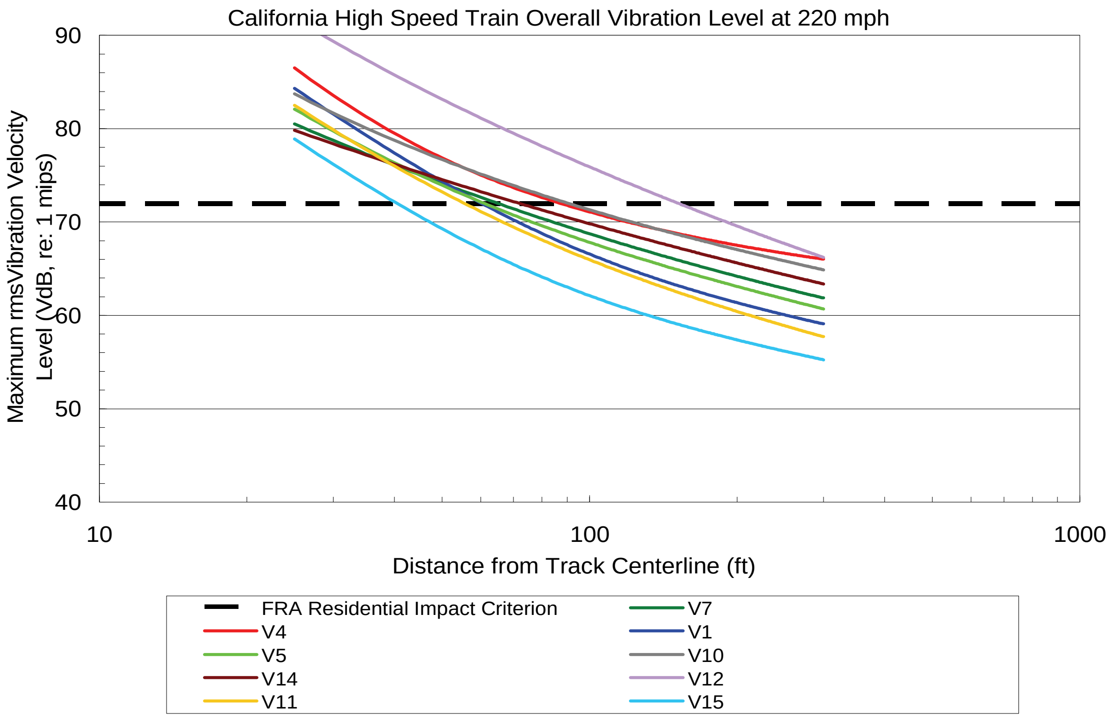


Figure 7-7
High-Speed Train Overall Vibration Levels
versus Distance at 220 mph

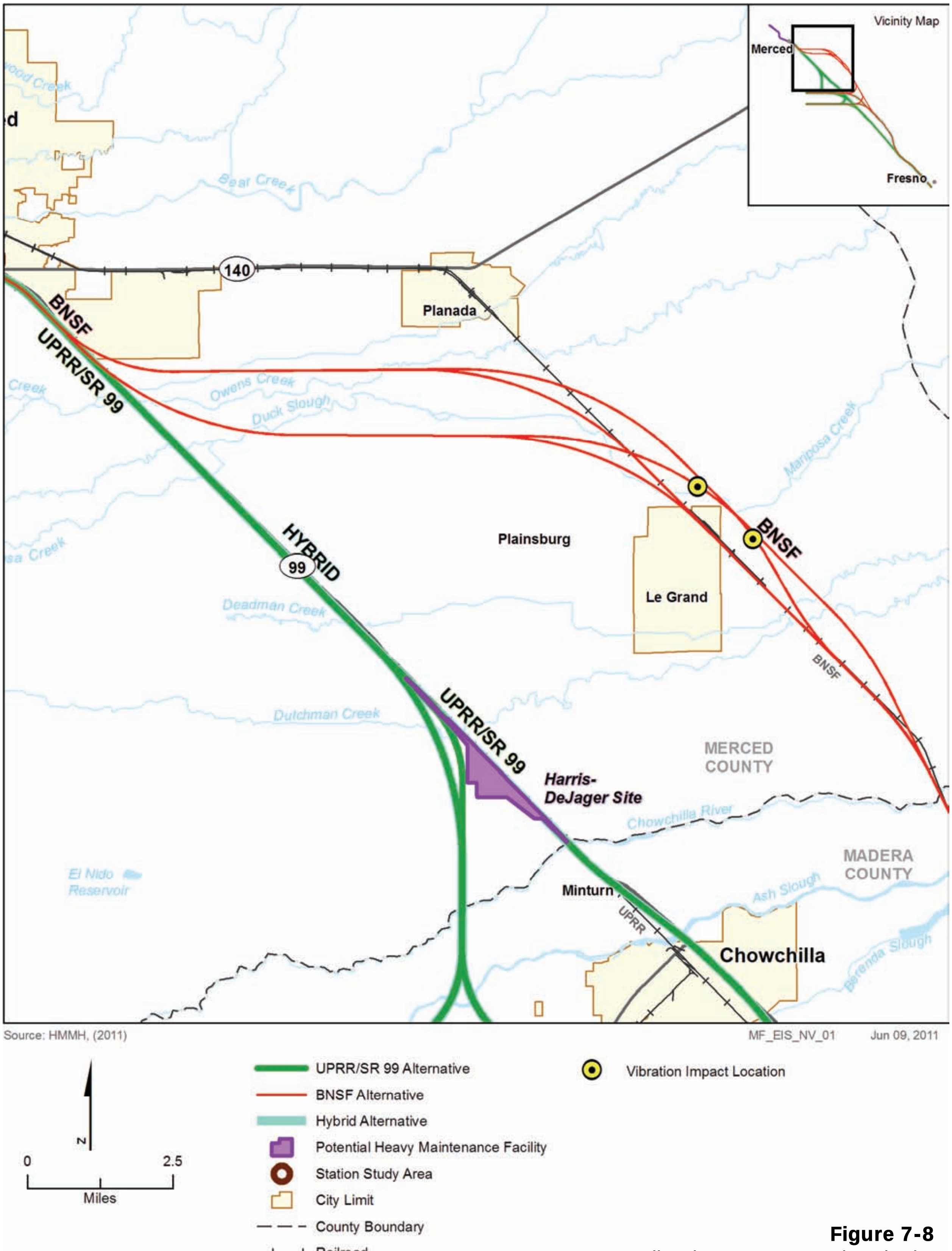


Figure 7-8
Vibration Impact Locations in the Chowchilla Project Vicinity

7.2.2 North-South Alignment

Table 7-18 provides a further breakdown of vibration impacts for each section of the north-south alignment of the UPRR/SR 99 Alternative. In addition to providing the number of impacts for each section, the table shows the distance from the track to the closest receptors (or cluster of receptors), the maximum operating speed within that section of the alignment, and the predicted maximum vibration velocity level occurring in any 1/3-octave band from 4 Hz to 80 Hz for the indicated receptor or receptors. For comparison to the predicted vibration levels, the table also provides the applicable vibration impact criterion for each receptor. Table 7-18 shows that within each section of the north-south alignment predicted vibration levels at the closest receptors are lower than the impact threshold. Therefore, no vibration impacts are projected.

7.2.2.1 Ave 24 Wye and Ave 21 Wye

Tables 7-19 and 7-20 provide a further breakdown of vibration impacts under the UPRR/SR 99 Alternative with the Ave 24 Wye and the Ave 21 Wye, respectively. The tables indicate that predicted vibration levels are lower than the impact threshold at the closest receptors. Therefore, no vibration impacts are projected.

Table 7-18
Detailed Vibration Impact Results for the UPRR/SR 99 Alternative North-South Alignment without Mitigation (2035)

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
Northern Section					
Merced HST Station (north) to Mission Avenue (Merced city line)	320	180	63	72	0
Mission Avenue (Merced city line) to Deadman Creek (south of Le Grand)	268	217	65	72	0
Northern Section Total					0
Central Section					
Deadman Creek to Dry Creek (north of Madera Acres) (East Chowchilla design option with Ave 24 Wye)	64	217	59	72	0
Deadman Creek to Dry Creek (north of Madera Acres) (East Chowchilla design option with Ave 21 Wye)	146	217	63	72	0
Deadman Creek to Dry Creek (north of Madera Acres) (West Chowchilla design option with Ave 24 Wye)	61	217	70	72	0
Central Section, East Chowchilla Design Option with Ave 24 Wye Total					0
Central Section, East Chowchilla Design Option with Ave 21 Wye Total					0
Central Section, West Chowchilla Design Option with Ave 24 Wye Total					0
Southern Section					
Dry Creek (north of Madera Acres) to San Joaquin River (Fresno city line)	74	217	59	72	0

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
San Joaquin River (Fresno city line) to Clinton Avenue	232	183	64	72	0
Clinton Avenue west to Fresno HST Station	75	217	70	72	0
Southern Section Total					0
UPRR/SR 99 North-South Alignment Totals					
Ave 24 Wye Options					
East Chowchilla Design Option					0
West Chowchilla Design Option					0
Ave 21 Wye Option					
East Chowchilla Design Option					0

[a] Vibration velocity level (VdB) re: 1 micro-inch per second.
[b] All impacts are residential unless otherwise noted.

Table 7-19
Detailed Vibration Impact Results for the UPRR/SR 99 Alternative with Ave 24 Wye without Mitigation (2035)

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
East Chowchilla Design Option with Ave 24 Wye	180	217	61	72	0
West Chowchilla Design Option with Ave 24 Wye	231	217	59	72	0

[a] Vibration velocity level (VdB) re: 1 micro-inch per second.
[b] All impacts are residential unless otherwise noted.

Table 7-20
Detailed Vibration Impact Results for the UPRR/SR 99 Alternative with Ave 21 Wye without Mitigation (2035)

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave band from 4 to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
Ave 21 Wye	156	217	62	72	0

[a] Vibration velocity level (VdB) re: 1 micro-inch per second.
[b] All impacts are residential unless otherwise noted.

7.2.3 BNSF Alternative Impacts during Operation

Table 7-21 summarizes all potential vibration impacts related to operation of HSTs under the BNSF Alternative during the design year (2035). The table reports the total number of vibration impacts projected to occur under each of eight BNSF design options, including four design options with the Ave 24 Wye and four design options with the Ave 21 Wye. The BNSF Alternative includes four design options within the northern section of the north-south alignment. This combination of four northern design options and two wye design options combines to produce eight distinct options.

As with the UPRR/SR 99 Alternative, in most cases vibration levels exceeding the impact criteria would be limited to the right-of-way. However, one vibration impact is projected for both the Mariposa Way East of Le Grand and Mission Ave East of Le Grand design options because of more efficient soil propagation in Le Grand.

Table 7-21
Total Vibration Impacts for the BNSF Alternative without Mitigation during the Design Year (2035)

HST Alternative	Total Number of Impacts
Impacts by Project Combination	
BNSF Alternative with Ave 24 Wye	0
BNSF Alternative with Ave 21 Wye	0
Le Grand Design Options	
Mariposa Way	0
Mariposa Way East of Le Grand	1
Mission Ave	0
Mission Ave East of Le Grand	1
Impact of Component Combined	
BNSF Alternative with Ave 24 Wye	0 to 1
BNSF Alternative with Ave 21 Wye	0 to 1
Total Range of Impacts for the BNSF Alternative	0 to 1

7.2.3.1 North-South Alignment

Table 7-22 provides a further breakdown of vibration impacts for each section of the north-south alignment of the BNSF Alternative. In addition to providing the number of impacts for each section, the table shows the distance from the track to the closest receptors (or cluster of receptors), the maximum operating speed within that section of the alignment, and the predicted maximum vibration velocity level occurring in any 1/3-octave band from 4 Hz to 80 Hz for the indicated receptor or receptors.
For comparison to the predicted vibration levels, the table also provides the applicable vibration impact criterion for each receptor.

Table 7-22 shows that there is one vibration impact for both the Mariposa Way East of Le Grand and Mission Ave East of Le Grand design options.

7.2.3.2 Ave 24 Wye and Ave 21 Wye

Tables 7-23 and 7-24 provide for a further breakdown of vibration impacts under the BNSF Alternative with the Ave 24 Wye and the Ave 21 Wye. The tables indicate that predicted vibration levels are lower than the impact threshold at the closest receptors. Therefore, no vibration impacts are projected.

7.2.4 Hybrid Alternative Impacts during Operation

Table 7-25 summarizes all potential vibration impacts related to operation of HSTs under the Hybrid Alternative during the design year (2035). The table reports the total number of vibration impacts projected to occur under the Hybrid Alternative with the Ave 24 Wye and the Ave 21 Wye.

In most cases, vibration levels exceeding the impact criteria would be confined to the right-of-way. As a result, no vibration impacts are anticipated to occur under any of the design options.

7.2.4.1 North-South Alignment

Table 7-26 provides a further breakdown of vibration impacts for each section of the north-south alignment of the Hybrid Alternative. In addition to providing the number of impacts for each section, the table shows the distance from the track to the closest receptors (or cluster of receptors), the maximum operating speed within that section of the alignment, and the predicted maximum vibration velocity level occurring in any 1/3-octave band from 4 Hz to 80 Hz for the indicated receptor or receptors. For comparison to the predicted vibration levels, the table also provides the applicable vibration impact criterion for each receptor.

Table 7-26 shows that within each section of the Hybrid Alternative north-south alignment predicted vibration levels at the closest receptors are lower than the impact threshold. Therefore, no vibration impacts are projected.

7.2.4.2 Ave 24 Wye

Table 7-27 provides with a further breakdown of vibration impacts under the Hybrid Alternative with the Ave 24 Wye. The table indicates that predicted vibration levels are lower than the impact threshold at the closest receptors. Therefore, no vibration impacts are projected.

7.2.4.3 Ave 21 Wye

Table 7-28 provides a further breakdown of vibration impacts under the Hybrid Alternative with the Ave 21 Wye. The table indicates that predicted vibration levels are lower than the impact threshold at the closest receptors. Therefore, no vibration impacts are projected.

7.2.5 Heavy Maintenance Facility Alternative Impacts during Operation

No vibration impacts are projected to result from HMF operations.

Table 7-22
Detailed Vibration Impact Results for the BNSF Alternative North-South Alignment without Mitigation (2035)

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
Northern Section					
Merced Station to Mission Avenue (Merced city line)	320	180	62	72	0
Mission Avenue (Merced city line) to Chowchilla River (county line) (Mariposa Way design option)	186	215	69	72	0
Mission Avenue (Merced city line) to Chowchilla River (county line) (Mariposa Way East of Le Grand design option)	91	216	76	72	1
Mission Avenue (Merced city line) to Chowchilla River (county line) (Mission Ave design option)	178	216	70	72	0
Mission Avenue (Merced city line) to Chowchilla River (county line) (Mission Ave East of Le Grand design option)	119	217	74	72	1
Northern Section, Mariposa Way Design Option Total					0
Northern Section, Mariposa Way East of Le Grand Design Option Total					1
Northern Section, Mission Ave Design Option Total					0
Northern Section, Mission Ave East of Le Grand Design Option Total					1

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
Central Section					
Chowchilla River (county line) to Lake Street, Madera (Ave 24 Wye)	120	208	63	72	0
Chowchilla River (county line) to Lake Street, Madera (Ave 21 Wye)	120	208	63	72	0
Central Section, Ave 24 Wye Total					0
Central Section, Ave 21 Wye Total					0
Southern Section					
Lake Street, Madera to San Joaquin River (Fresno city line)	79	217	66	72	0
San Joaquin River (Fresno city line) to Clinton Avenue	232	217	64	72	0
Clinton Avenue to West to Fresno Station	75	217	70	72	0
Southern Section Total					0
BNSF North-South Alignment Totals					
Mariposa Way Design Option Total					0
Mariposa Way East of Le Grand Design Option Total					1
Mission Ave Design Option Total					0
Mission Ave East of Le Grand Design Option Total					1
Ave 21 Wye Options					
Mariposa Way Design Option Total					0
Mariposa Way East of Le Grand Design Option Total					1
Mission Ave Design Option Total					0

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
Mission Ave East of Le Grand Design Option Total					1

[a] Vibration velocity level (VdB) re: 1 micro-inch per second.

[b] All impacts are residential unless otherwise noted. All location noted with levels above the impact criterion are with the right-of-way and will be relocated.

Table 7-23
Detailed Vibration Impact Results for the BNSF Alternative with Ave 24 Wye without Mitigation (2035)

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
Ave 24 Wye	61	217	70	72	0

[a] Vibration velocity level (VdB) re: 1 micro-inch per second.

[b] All impacts are residential unless otherwise noted.

Table 7-24
Detailed Vibration Impact Results for the BNSF Alternative with Ave 21 Wye without Mitigation (2035)

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
Ave 21 Wye	95	217	65	18	0

[a] Vibration velocity level (VdB) re: 1 micro-inch per second.
[b] All impacts are residential unless otherwise noted.

Table 7-25
Total Vibration Impacts for the Hybrid Alternative without Mitigation during the Design Year (2035)

HST Alternative	Total Number of Impacts
Hybrid Alternative with Ave 24 Wye	0
Hybrid Alternative with Ave 21 Wye	0
Total Hybrid Alternative Range of Impact	0

Table 7-26
Detailed Vibration Impact Results for the Hybrid Alternative North-South Alignment without Mitigation (2035)

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
Northern Section					
Merced Station to Mission Avenue (Merced city line)	320	180	63	72	0
Mission Avenue (Merced city line) to Deadman Creek (south of Le Grand)	268	217	65	72	0
Northern Section Total					0
Central Section					
Deadman Creek to Lake Street, Madera (Ave 24 Wye)	61	217	70	72	0
Deadman Creek to Lake Street, Madera (Ave 21 Wye)	64	217	69	72	0
Central Section, Ave 24 Wye Total					0
Central Section, Ave 21 Wye Total					
Southern Section					
Lake Street, Madera to San Joaquin River (Fresno city line)	79	217	66	72	0
San Joaquin River (Fresno city line) to Clinton Avenue	232	217	64	72	0
Clinton Avenue West to Fresno HST Station	75	217	70	72	0
Southern Section Total					0

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
Hybrid Alternative North-South Alignment Totals					
Ave 24 Wye Option					
Ave 24 Wye Total					0
Ave 21 Wye Option					
Ave 21 Wye Total					0

[a] Vibration velocity level (VdB) re: 1 micro-inch per second.
[b] All impacts are residential unless otherwise noted.

Table 7-27
Detailed Vibration Impact Results for the Hybrid Alternative with Ave 24 Wye without Mitigation (2035)

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
Ave 24 Wye	231	217	59	72	0

[a] Vibration velocity level (VdB) re: 1 micro-inch per second.
[b] All impacts are residential unless otherwise noted.

Table 7-28
Detailed Vibration Impact Results for the Hybrid Alternative with Ave 21 Wye without Mitigation (2035)

Receptor Location	Closest Receptor(s) Distance to Near Track (feet)	Maximum Train Speed (mph)	Maximum Vibration Velocity Level in any 1/3-Octave Band from 4 Hz to 80 Hz[a]		Number of Impacts[b]
			Predicted	Impact Criterion	
Ave 21 Wye	127	217	63	72	0

[a] Vibration velocity level (VdB) re: 1 micro-inch per second.
[b] All impacts are residential unless otherwise noted.

7.3 Traffic Noise Impacts

For the UPRR/SR 99, BNSF, and Hybrid Alternatives, the project would require relocating SR 99 between Ashlan Avenue and Clinton Avenue to accommodate the HST tracks. Because this is a Type 1 project, as defined in Section 4.1.6, noise mitigation must be evaluated for SR 99 in this area. In addition, because this shift in SR 99 is related to the project, the potential impacts associated with this shift have been evaluated as a part of the project. The proposed change in SR 99 would shift the roadway approximately 80 feet to the west, closer to several residences. The project also includes widening SR 99 from 3 lanes to 4 lanes.

At the draft EIR/EIS stage of the project, there is not sufficient engineering information available to conduct a detailed noise assessment for traffic impacts. However, the existing noise levels at the residences west of SR 99 currently exceed the Caltrans noise abatement criteria discussed in Section 4.1.6. The proposed changes in the project shift SR 99 closer to these residences and widen the roadway, which would further increase noise levels at residences west of SR 99 between Ashlan Avenue and Clinton Avenue in excess of the Caltrans noise abatement criteria. Because of this, mitigation would be required for all residences west of SR 99 between Ashlan Avenue and Clinton Avenue. Sound barriers, approximately 10 to 12 feet high and extending approximately 8,800 feet, would potentially be required to mitigate traffic noise impacts. When more detailed information regarding the SR 99 shift is available during the final EIR/EIS, a full analysis of the impact in this area will be conducted. However, this additional analysis would only refine the mitigation recommendations, because the mitigation is required because noise levels exceed the Caltrans noise abatement criteria.

7.4 Construction Noise and Vibration Analysis

7.4.1 Criteria/Local Noise Regulations

As described in Section 4.1.5, the construction noise assessment is based on guidelines included in the FTA guidance manual (FTA 2006). Table 4-4 in Section 4.1.5 summarizes FTA assessment criteria for construction noise. An 8-hour L_{eq} and a 30-day average noise exposure are used to assess impacts. A 30-day average L_{dn} is used to assess impacts in residential areas, and a 30-day average 24-hour L_{eq} is used to assess impacts in commercial and industrial areas. The noise emission levels of the construction equipment, utilization factor, hours of operation, and location of equipment are used to calculate 8-hour and 30-day average noise exposures.

7.4.2 Construction Noise Impacts

Construction noise varies greatly depending on the construction process, type and condition of equipment used, and layout of the construction site. Many of these factors are traditionally left to the contractor's discretion, which makes it difficult to accurately estimate levels of construction noise. Overall, construction noise levels are governed primarily by the noisiest pieces of equipment. For most construction equipment, the engine, which is usually diesel, is the dominant noise source. This is particularly true of engines without sufficient muffling. For special activities such as impact pile driving and pavement breaking, noise generated by the actual process dominates.

Table 7-29 summarizes FTA (2006) data on noise emissions of construction equipment in terms of averages of the L_{max} values at a distance of 50 feet. Although the noise levels in the table represent typical values, there can be wide fluctuations in the noise emissions of similar equipment. Construction noise at a given noise-sensitive location depends on the magnitude of noise during each construction phase, the duration of the noise, and the distance from the construction activities.

Projecting construction noise requires a construction scenario of the equipment likely to be used and the average utilization factors or duty cycles (i.e., the percentage of time that the equipment operates under full power during each phase). Using the typical sound emission characteristics provided in Table 7-29, it is possible to estimate L_{eq} or L_{dn} at various distances from the construction site.

Table 7-29
Construction Equipment Noise Emission Levels

Equipment Type	Typical Sound Level at 50 feet (dBA)
Backhoe	80
Bulldozer	85
Compactor	82
Air Compressor	81
Concrete Mixer	85
Concrete Pump	82
Crane, Derrick	88
Crane, Mobile	83
Loader	85
Jackhammer	88
Paver	89
Pile Driver, Impact	101
Pump	76
Roller	74
Generator	81
Shovel	82
Dump Truck	88

The noise impact assessment for a construction site is based on the following:

- An estimate of the type of equipment that would be used during each phase of the construction and the average daily duty cycle for each category of equipment.
- Typical noise emission levels for each category of equipment, such as those in Table 7-29.
- Estimates of noise attenuation as a function of distance from the construction site.

Construction noise estimates are always approximate because of the lack of specific information available at the time of the environmental assessment. Decisions about the procedures and equipment to be used are made by the contractor. Project designers usually minimize constraints on how the construction will be performed and the equipment that will be used so that contractors can perform construction in the most cost-effective manner.

Table 7-30 is an example of the noise projections for equipment that is often used during tie-and-ballast track construction. For the calculations, it is assumed that all the equipment is located at the geometric center of the construction work site. In this scenario, an 8-hour L_{eq} of 89 dBA should be expected at a distance of 50 feet from the geometric center of the work site. This calculation in Table 7-20 does not assume any noise mitigation measures or any limits on the contractor about how much noise can be made. With at-grade track construction, the duration of the activities at a specific location along the alignment will be relatively limited, usually a matter of several weeks. As a result, even when there may be noise impacts, the limited duration of the construction can mean that mitigation is not cost-effective.

Table 7-30
Typical Equipment List, At-Grade Track Construction

Equipment Item	Typical Maximum Sound Level at 50 Feet (dBA)	Equipment Utilization Factor (%)	L_{eq} (dBA)
Air Compressor	81	50	78
Backhoe	80	40	76
Crane, Derrick	88	10	78
Bulldozer	85	40	81
Generator	81	80	80
Loader	85	40	81
Jackhammer	88	4	74
Shovel	82	40	78
Dump Truck	88	16	80
Total Workday L_{eq} at 50 feet (8-hour workday)			89

7.4.2.1 UPRR/SR 99 and BNSF Alternatives

By using the criteria in Section 4.1.5 and the noise projection in Table 7-30, and assuming that construction noise is reduced by 6 dB for each doubling of distance from the center of the site, screening distances for potential construction noise impacts can be estimated. These estimates suggest that the potential for construction noise impact would be minimal for commercial and industrial land use, with impact screening distances of 79 feet and 45 feet, respectively. Even for residential land use, the potential for temporary construction noise impact would be limited to locations within approximately 141 feet of the corridor. However, the potential for noise impact from nighttime construction could extend to residences as far as 446 feet. The Authority will work to minimize these potential impacts. Potential construction noise impacts will be evaluated during final design.

7.4.2.2 Heavy Maintenance Facility Alternatives

By using the criteria provided in Table 4-4 and the noise projection in Table 7-30, and assuming that construction noise is reduced by 6 dB for each doubling of distance from the center of the site, screening distances for potential construction noise impact can be estimated. No construction noise impacts are projected for any of the potential HMF sites.

7.4.3 Construction Vibration Impacts

Building damage from construction vibration would only be anticipated from impact pile driving at very close distances to buildings. If piling is more than 25 feet to 50 feet from buildings, or if alternative methods such as push piling or augur piling can be used, damage from construction vibration should not be an issue. Other sources of construction vibration do not generate sufficiently high vibration levels for damage to occur.

8.0 Mitigation Analysis

8.1 Operational Noise Mitigation Measures

Implement Noise Guidelines. The Authority has prepared noise and vibration mitigation guidelines for the project. The guidelines include information related to the type of impact, the cost per benefitted receptor, and other criteria for determining the appropriate locations and types of noise mitigation. Various options exist to address the potentially severe noise effects from HSTs. With input from local jurisdictions and balancing technological factors, such as structural and seismic safety, cost, number of affected receptors, and effectiveness, mitigation measures would be selected and implemented. For example, where moderate increases in noise affect receptors, noise-reducing measures could be implemented, even though not required. Conversely, in rural areas devoid of receptors where severe noise effects are anticipated, it might be appropriate and acceptable not to apply any noise-reducing treatments. The noise guidelines include the following mitigation measures:

- Install sound barriers. Depending on the height and location relative to the tracks, sound barriers can achieve between 5 and 15 dB of noise reduction. The primary requirements for an effective sound barrier are that it must (1) be high enough and long enough to break the line-of-sight between the sound source and the receiver, (2) be constructed of an impervious material with a minimum surface density of 4 pounds per square foot, and (3) not have any gaps or holes between the panels or at the bottom. Because many materials meet these requirements, aesthetics, durability, cost, and maintenance considerations usually determine the selection of materials for sound barriers. Depending on the situation, sound barriers can be visually intrusive. Typically, the sound barriers style is selected with input from the local jurisdiction to reduce the visual effect of barriers on adjacent lands uses. For example, sound barriers could be solid or transparent, of various colors, materials, and surface treatments.

  The maximum sound barrier height would be 14 feet for at-grade sections; however, all sound barriers would be designed to be as low as possible to achieve a substantial noise reduction. Berm and berm/wall combinations are the preferred types of sound barriers where space and other environmental constraints permit. On aerial structures, the maximum sound barrier height would also be 14 feet, but the barrier material used would be limited by engineering weight restrictions for the structure. Sound barriers on the aerial structure should still be designed to be as low as possible to achieve a substantial noise reduction. Sound barriers on aerial structures and at-grade could consist of solid, semitransparent, and transparent materials.

- Work with the communities to determine how the use and height of sound barriers would be determined using jointly developed performance criteria. Other solutions may result in a higher number of residual impacts than reported herein. Options may be to reduce the height of sound barriers and combine barriers with sound insulation or to accept higher noise thresholds than the FRA thresholds. Secondary impacts could potentially occur where sound barriers are installed. Changes to visual and aesthetic qualities and the existing environment might occur and are addressed in Section 3.16 (Aesthetics and Visual Quality) of the Draft EIR/EIS.

- Install building sound insulation. Sound insulation of residences and institutional buildings to improve the outdoor-to-indoor noise reduction is a mitigation measure that can be provided when the use of sound barriers are not feasible in providing a reasonable level (5 to 7 dB) of noise reduction. Although this approach has no effect on noise in exterior areas, it may be the best choice for sites where sound barriers are not feasible or desirable and for buildings where indoor sensitivity is of most concern. Substantial improvements in building sound insulation (on the order of 5 to 10 dB) can often be achieved by adding an extra layer of glazing to windows, by sealing holes in exterior surfaces that act as sound leaks, and by providing forced ventilation and air conditioning so that windows do not need to be opened. Establish performance criteria to balance existing noise events and ambient roadway noise conditions as factors for determining mitigation measures.

- Purchase properties severely affected by noise. Another option for avoiding noise impacts is for the authority to purchase residences likely to be affected by HST operations or to acquire easements for such residences by paying the homeowners to accept the future noise conditions. This approach is usually taken only in isolated cases where other mitigation options are infeasible, impractical, or too costly.

Tables 8-1 through 8-4 show the number and length of sound barriers that would be cost-effective for the HST alternatives based on implementation of the noise mitigation guidelines.

The following provide three additional mitigation measures to be considered for severe noise effects from HSTs:

- **Special trackwork at crossovers and turnouts**. HST wheels rolling over rail gaps at switches and frogs associated with turnouts where tracks merge or divert from the main line can increase noise by approximately 6 dBA. As a result, turnouts can be a major source of noise impacts if they are located in NSAs. If turnouts cannot be moved away from sensitive areas, special types of trackwork are available that eliminate the gaps.

- **Vehicle noise specification**. In the procurement of an HST vehicle technology, the Authority can set performance limits for noise levels to reduce community noise impacts throughout the corridor. Depending on the available technology, this could significantly reduce the number of impacts throughout the corridor.

- **Additional Noise Analysis Following Final Design.** If final design or final vehicle specifications results in changes to the assumptions underlying the noise analysis, reassess noise impacts and recommendations for mitigation and provide supplemental environmental documentation, as required by CEQA and NEPA.

As discussed in Section 4.1.1, FRA states that in implementing noise impact criteria, severe impacts should be mitigated unless there are truly extenuating circumstances that prevent implementation of mitigation measures. At the moderate impact level, more discretion should be used, and other project-specific factors should be included in the consideration of mitigation. These other factors include the existing level, the predicted level of increase over existing noise levels, the types and numbers of noise-sensitive land uses affected, the noise sensitivity of the properties, the effectiveness of the mitigation measures, community views, and the cost of mitigating noise to more acceptable levels.

Figures 8-1 through 8-4 show potential noise mitigation locations for the UPRR/SR 99 Alternative, the BNSF Alternative, the Hybrid Alternative, and the Castle Commerce Center HMF site. These are the locations where the noise guidelines have been applied. Figures 8-5 through 8-8 show potential sound barrier locations for the UPRR/SR 99 Alternative, the BNSF Alternative, the Hybrid Alternative, and the Castle Commerce Center HMF site, which are the resulting potential sound barrier locations after applying the noise guidelines. Tables 8-1 through 8-4 summarize the sound barriers that would be cost-effective for each HST alternative.

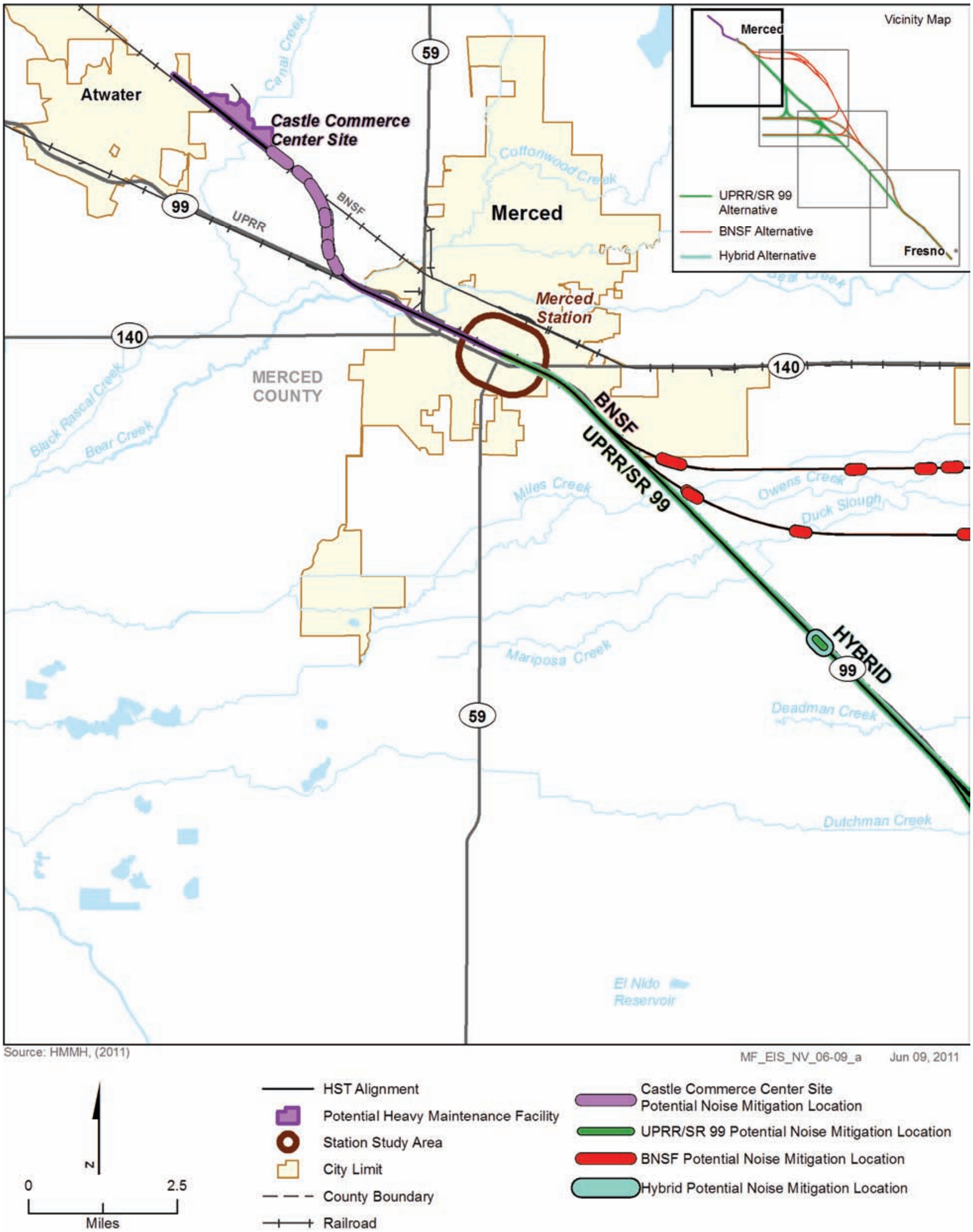


Figure 8-1
Potential Noise Mitigation Locations in the Merced Project Vicinity

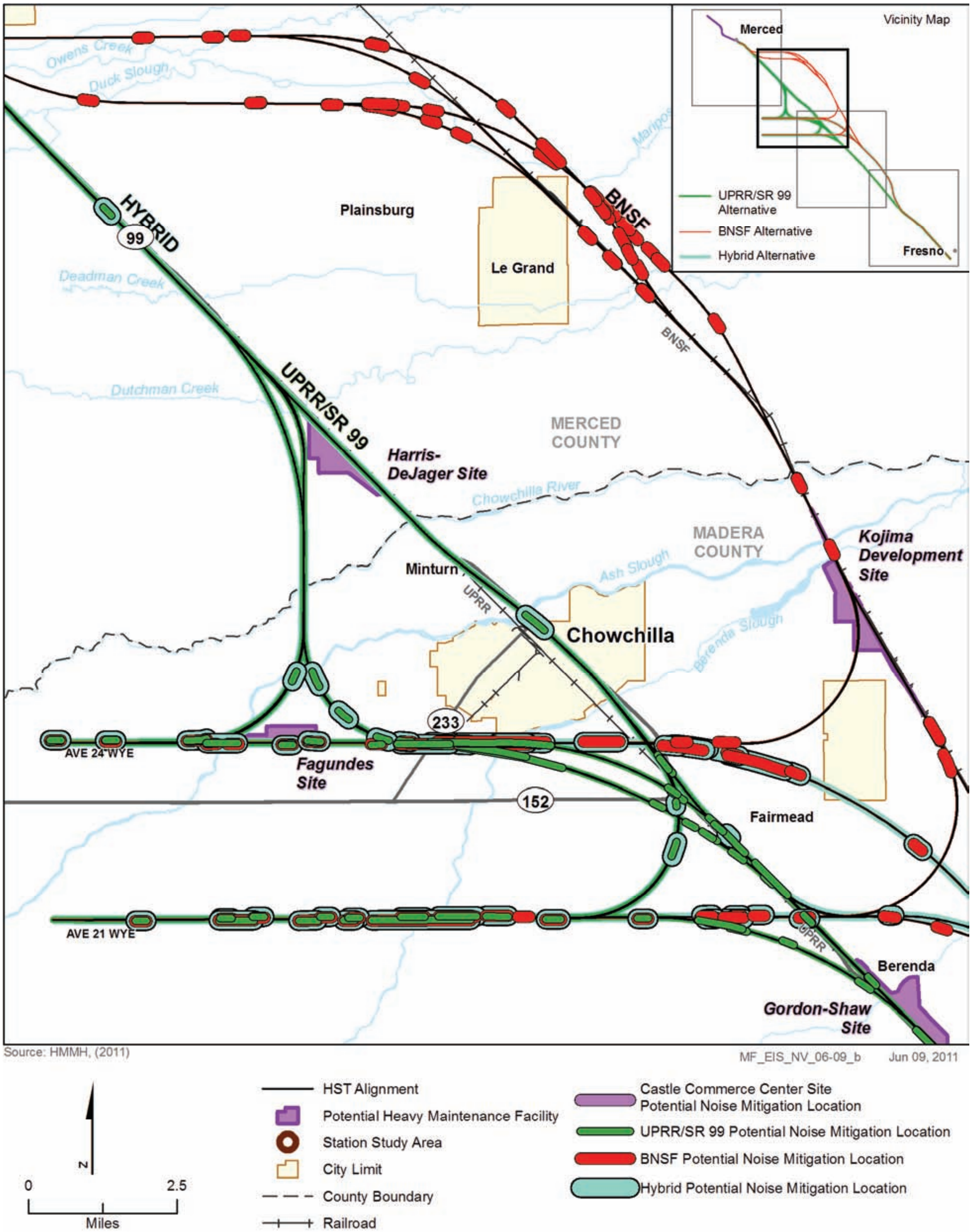


Figure 8-2
Potential Noise Mitigation
Locations in the Chowchilla Project Vicinity

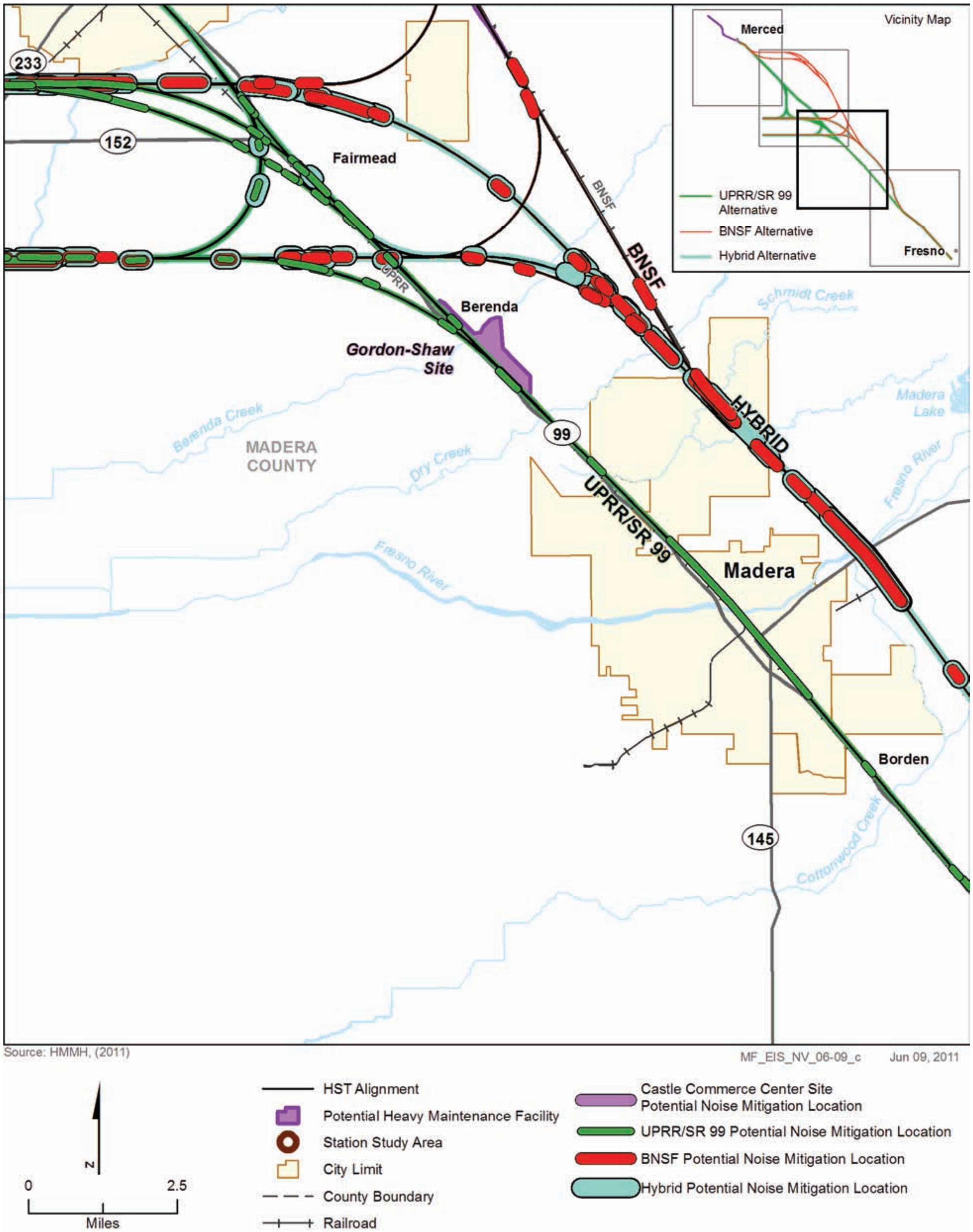


Figure 8-3
Potential Noise Mitigation Locations in the Madera Project Vicinity

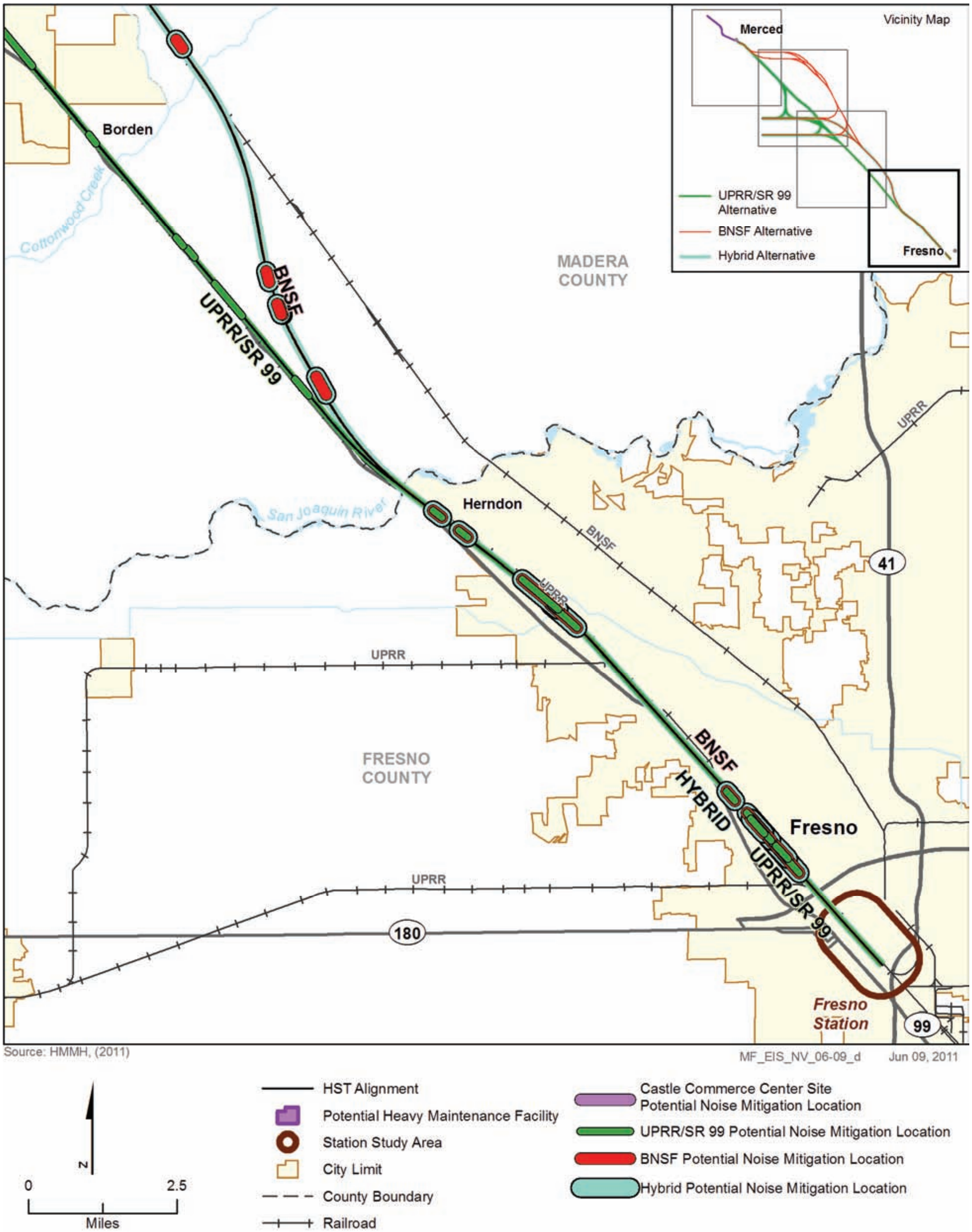


Figure 8-4
Potential Noise Mitigation Locations in the Fresno Project Vicinity

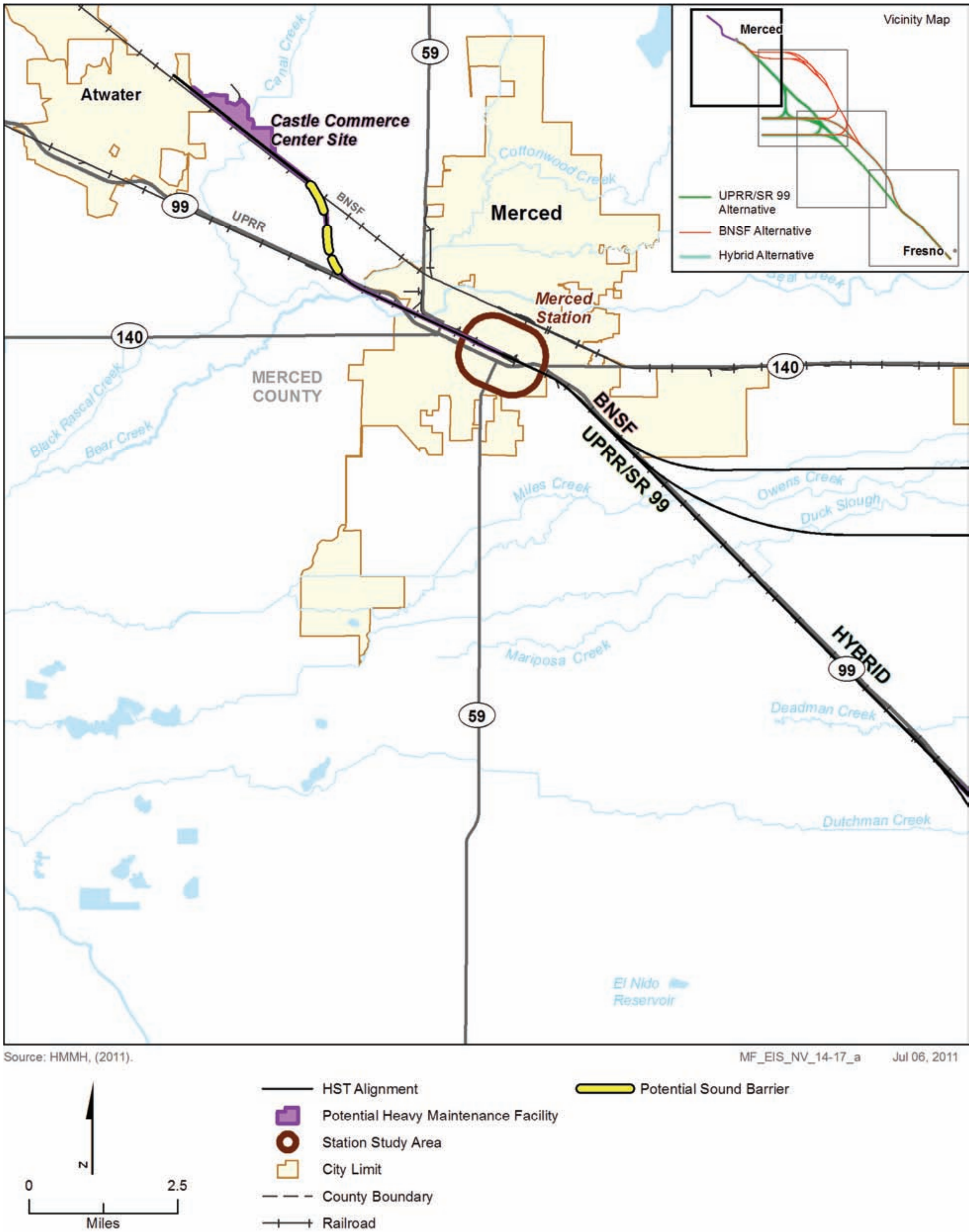


Figure 8-5
Potential Sound Barrier
Locations in the Merced Project Vicinity

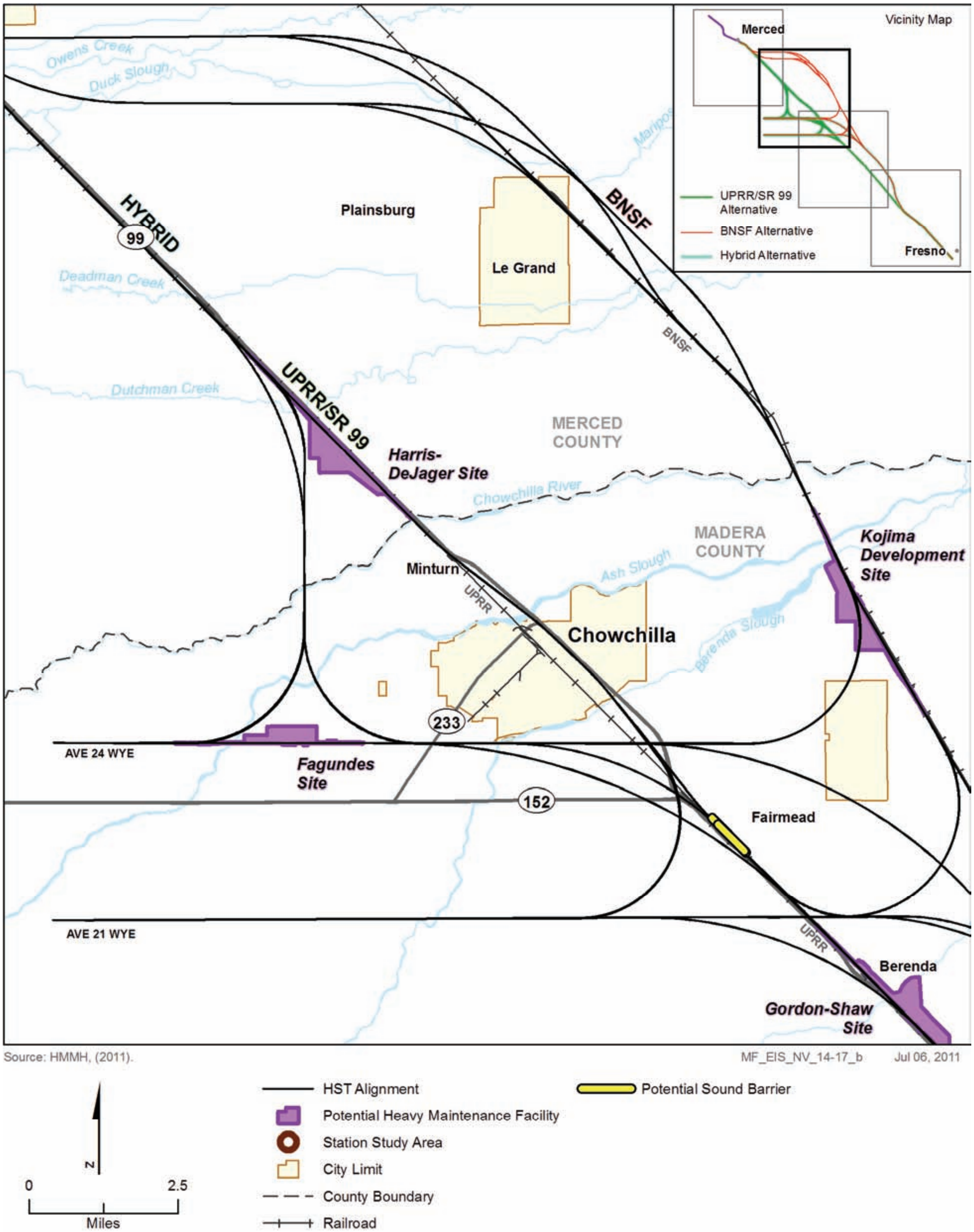


Figure 8-6
Potential Sound Barrier
Locations in the Chowchilla Project Vicinity

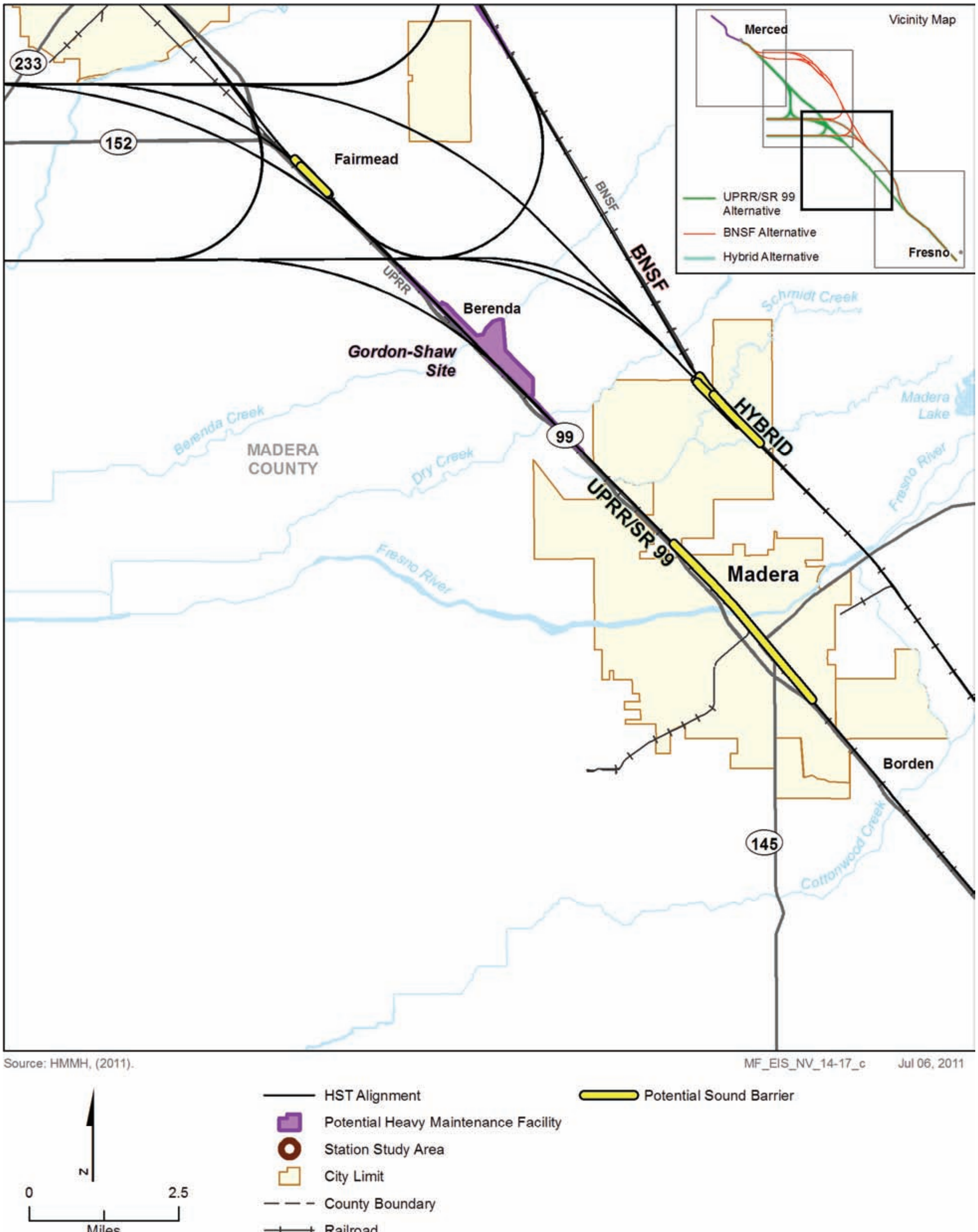


Figure 8-7
Potential Sound Barrier
Locations in the Madera Project Vicinity

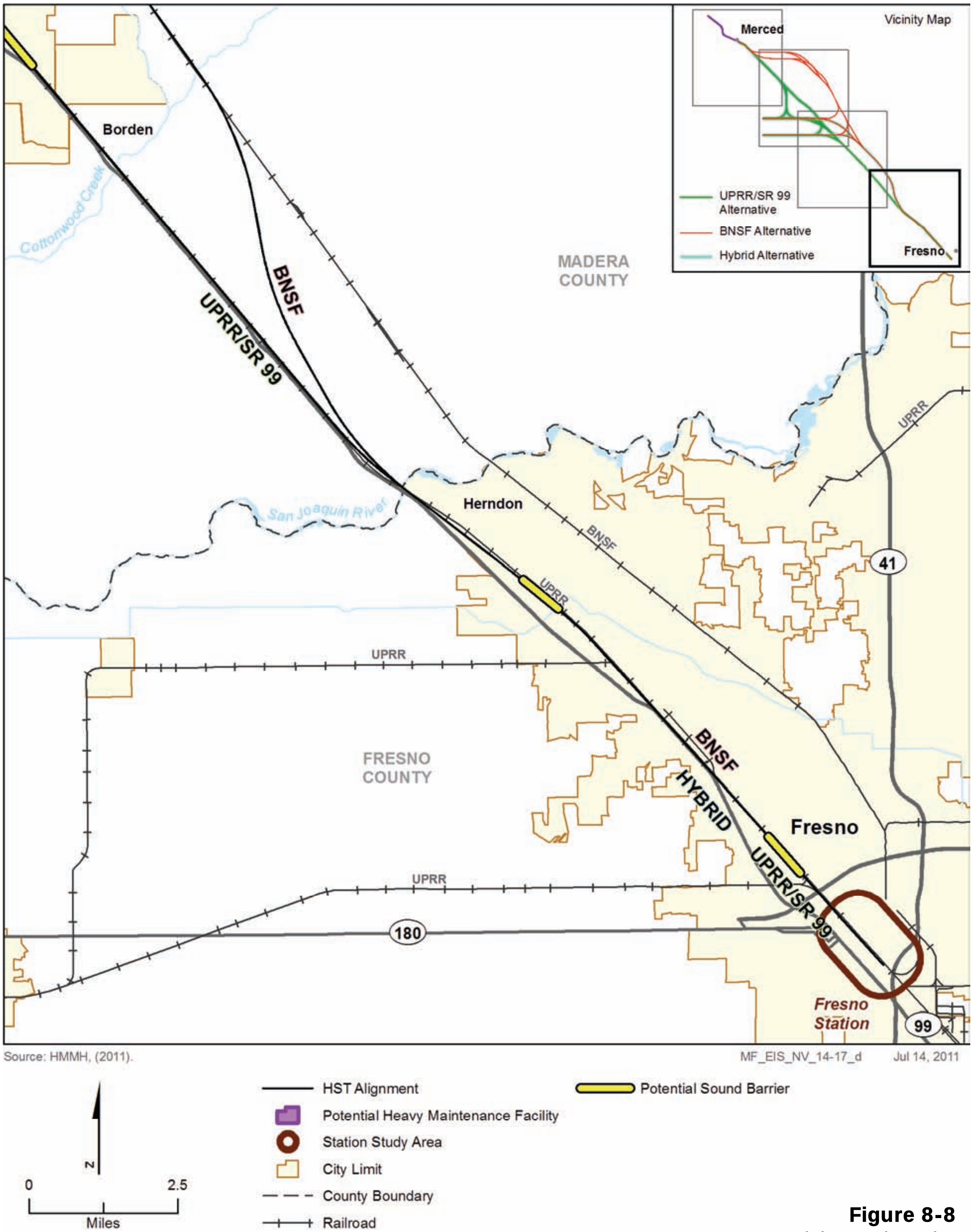


Figure 8-8
Potential Sound Barrier
Locations in the Fresno Project Vicinity

Table 8-1
Potential UPRR/SR 99 Alternative Sound Barriers

UPRR/SR 99 Alternative Barriers				
# of Cost-Effective Barriers	Total Length (feet)	# of Severe Receptors Protected (# of Total Receptors Protected)	# of Severe Impacts Eliminated	# of Residual Severe Impacts
4	30,100	699 (898)	702	0

Table 8-2
Potential BNSF Alternative Sound Barriers

BNSF Alternative Barriers				
# of Cost-Effective Barriers	Total Length (feet)	# of Severe Receptors Protected (# of Total Receptors Protected)	# of Severe Impacts Eliminated	# of Residual Severe Impacts
5	23,000	138 (334)	139	0

Table 8-3
Potential Hybrid Alternative Sound Barriers

Hybrid Alternative Barriers				
# of Cost-Effective Barriers	Total Length (feet)	# of Severe Receptors Protected (# of Total Receptors Protected)	# of Severe Impacts Eliminated	# of Residual Severe Impacts
5	26,700	161 (421)	159	0

Table 8-4
Potential Castle Commerce Center Sound Barriers

Castle Commerce Center Barriers				
Number of Cost-Effective Barriers	Total Length (feet)	Number of Severe Receptors Protected (number of receptors protected)	Number of Severe Impacts Eliminated	Number of Residual Severe Impacts
3	5,600	69 (150)	69	0

8.1.1 UPRR/SR 99 Alternative

8.1.1.1 North-South Alignment

Table 8-5 presents preliminary recommendations for mitigation of severe impacts from operational noise for the UPRR/SR 99 Alternative during the design year (2035). Table 8-5 summarizes the sound barriers that were found to be cost-effective for the UPRR/SR 99 Alternative based on the noise mitigation guidelines. The table presents sound barrier heights and lengths required to eliminate severe impacts. The results are preliminary, and will be refined based on the noise and vibration mitigation guidelines being prepared by the Authority. Sound barriers are just one noise mitigation option, and the barriers listed in this section will be studied in more detail to determine if they meet the mitigation guideline requirements. At locations where barriers do not meet the requirements, other noise mitigation options, such as building sound insulation and noise easements, will be examined.

Table 8-5
Recommendations for Mitigation of Operational Noise for UPRR/SR 99 Alternative North-South Alignment

Receptor Location		Total Number of Sound Barriers	Total Length (feet)	Height[a] Range (feet)	Number of Severe Residual Impacts
Northern Section					
(No mitigation required in the northern section)					
Central Section					
Deadman Creek to Dry Creek (north of Madera Acres) (East Chowchilla design option with Ave 24 Wye)	Northbound track	1	3,300	14	0
Deadman Creek to Dry Creek (north of Madera Acres) (East Chowchilla design option with Ave 21 Wye)	(No cost-effective sound barriers for the East Chowchilla design option with Ave 21 Wye)				
Deadman Creek to Dry Creek (north of Madera Acres) (West Chowchilla design option with Ave 24 Wye)	Northbound track	1	4,400	14	0
Southern Section					
Dry Creek (north of Madera Acres) to Clinton Avenue	Northbound track	1	18,400	14	0
Lake Street, Madera to Clinton Avenue	Northbound track	1	4,000	14	0

[a] Height above top of rail.

Cost-effective sound barriers are given by receptor location along the alignment and the side of the alignment. Table 8-5 summarizes the number of cost-effective sound barriers, side of track, total length, range of barrier heights, and the number of severe residual impacts within each segment of the corridor. All barrier heights are referenced to the top-of-rail elevation. Five sound barriers, with a combined length of approximately 33,400 feet and ranging in height from 10 feet to 14 feet, are recommended for the UPRR/SR 99 Alternative north-south alignment.

8.1.1.2 Ave 24 Wye

Table 8-6 presents preliminary recommendations for mitigation of severe impacts from operational noise for the UPRR/SR 99 Alternative with the Ave 24 Wye during the design year (2035). As shown in Table 8-6, no sound barriers were found to be cost-effective for the UPRR/SR 99 Alternative with the Ave 24 Wye. Sound barriers are just one noise mitigation option, and the barriers listed in this section will be studied in more detail to determine if they meet the mitigation guideline requirements. At locations where barriers do not meet the requirements, other noise mitigation options, such as building sound insulation and noise easements, will be examined.

Table 8-6
Recommendations for Mitigation of Operational Noise for UPRR/SR 99 Alternative with Ave 24 Wye

Receptor Location	Total Number of Sound Barriers	Total Length (feet)	Height[a] Range (feet)	Number of Severe Residual Impacts
East Chowchilla Design Option with Ave 24 Wye	(No cost-effective sound barriers for the Ave 24 Wye)			
West Chowchilla Design Option with Ave 24 Wye	(No cost-effective sound barriers for the Ave 24 Wye)			

[a] Height above top of rail.

8.1.1.3 Ave 21 Wye

Table 8-7 presents preliminary recommendations for mitigation of severe impacts from operational noise for the UPRR/SR 99 Alternative with Ave 21 Wye during the design year (2035). As shown in Table 8-7, no sound barriers were found to be cost-effective for the UPRR/SR 99 Alternative with the Ave 21 Wye. Sound barriers are just one noise mitigation option, and the barriers listed in this section will be studied in more detail to determine if they meet the mitigation guideline requirements. At locations where barriers do not meet the requirements, other noise mitigation options, such as building sound insulation and noise easements, will be examined.

Table 8-7
Recommendations for Mitigation of Operational Noise for UPRR/SR 99 Alternative with Ave 21 Wye

Receptor Location	Total Number of Sound Barriers	Total Length (feet)	Height[a] Range (feet)	Number of Severe Residual Impacts
Ave 21 Wye	(No cost-effective sound barriers for the Ave 21 Wye)			

[a] Height above top of rail.

8.1.2 BNSF Alternative

8.1.2.1 North-South Alignment

Table 8-8 presents preliminary recommendations for mitigation of severe impacts from operational noise for the BNSF Alternative during the design year (2035). Table 8-8 presents the sound barriers that were found to be cost-effective for the BNSF Alternative based on the noise mitigation guidelines. The sound barrier heights and lengths required to eliminate severe impacts are provided. The results are preliminary and will be refined based on the noise and vibration mitigation guidelines being prepared by the Authority. Sound barriers are just one noise mitigation option, and the barriers listed in this section will be studied in more detail to determine if they meet the mitigation guideline requirements. At locations where barriers do not meet the requirements, other noise mitigation options, such as building sound insulation and noise easements, will be examined.

Table 8-8
Recommendations for Mitigation of Operational Noise for BNSF Alternative North-South Alignment

Receptor Location		Total Number of Sound Barriers	Total Length (feet)	Height[a] Range (feet)	Number of Severe Residual Impacts
Northern Section					
(No cost-effective sound barriers in the northern section)					
Central Section					
Chowchilla River (county line) to Lake Street, Madera (Ave 24 Wye)	Northbound track	1	4,600	12	0
Chowchilla River (county line) to Lake Street, Madera (Ave 21 Wye)	Northbound track	1	4,600	12	0
Southern Section					
Lake Street, Madera to Clinton Avenue	Northbound track	1	4,000	14	0
[a] Height above top of rail.					

Cost-effective sound barriers are given by receptor location along the alignment and the side of the alignment. Table 8-8 summarizes the number of cost-effective sound barriers, side of track, total length, range of barrier heights, and the number of severe residual impacts within each section of the alignment. All barrier heights are referenced to the top-of-rail elevation. Four sound barriers, with a combined length of approximately 16,500 feet and ranging in height from 10 feet to 14 feet, are recommended for the BNSF Alternative north-south alignment.

8.1.2.2 Ave 24 Wye

Table 8-9 presents preliminary recommendations for mitigation of severe impacts from operational noise for the BNSF Alternative with the Ave 24 Wye during the design year (2035). Table 8-9 presents the sound barriers that were found to be cost-effective for the BNSF Alternative with the Ave 24 Wye based on the noise mitigation guidelines. The sound barrier heights and lengths required to eliminate severe impacts are provided. The results are preliminary and will be refined based on the noise and vibration mitigation guidelines being prepared by the Authority. Sound barriers are just one noise mitigation option, and the barriers listed in this section will be studied in more detail to determine if they meet the mitigation guideline requirements. At locations where barriers do not meet the requirements, other noise mitigation options, such as building sound insulation and noise easements, will be examined.

Table 8-9

Recommendations for Mitigation of Operational Noise for BNSF Alternative with Ave 24 Wye

Receptor Location		Total Number of Sound Barriers	Total Length (feet)	Height[a] Range (feet)	Number of Severe Residual Impacts
Ave 24 Wye	Southbound (eastbound) track	1	5,200	12	0
[a] Height above top of rail.					

Cost-effective sound barriers are given by receptor location along the alignment and the side of the alignment. Table 8-9 summarizes the number of cost-effective sound barriers, side of track, total length, range of barrier heights, and the number of residual impacts within each section of the alignment. All barrier heights are referenced to the top-of-rail elevation. One sound barrier, with a length of approximately 5,200 feet and a height of 12 feet, is recommended for the BNSF Alternative with the Ave 24 Wye.

8.1.2.3 Ave 21 Wye

Table 8-10 presents preliminary recommendations for mitigation of severe impacts from operational noise for the BNSF Alternative with the Ave 21 Wye during the design year (2035). Table 8-10 presents the sound barriers that were found to be cost-effective for the BNSF Alternative with the Ave 21 Wye based on the noise mitigation guidelines. The sound barrier heights and lengths required to eliminate severe impacts are provided. The results are preliminary and will be refined based on the noise and vibration mitigation guidelines being prepared by the Authority. Sound barriers are just one noise mitigation option, and the barriers listed in this section will be studied in more detail to determine if they meet the mitigation guideline requirements. At locations where barriers do not meet the requirements, other noise mitigation options, such as building sound insulation and noise easements, will be examined.

Cost-effective sound barriers are given by receptor location along the alignment and the side of the alignment. Table 8-10 summarizes the number of cost-effective sound barriers, side of track, total length, range of barrier heights, and the number of residual impacts within each section of the alignment. All barrier heights are referenced to the top-of-rail elevation. One sound barrier, with a length of approximately 4,600 feet and a height of 12 feet, is recommended for the BNSF Alternative with the Ave 21 Wye.

Table 8-10
Recommendations for Mitigation of Operational Noise for BNSF Alternative with Ave 21 Wye

Receptor Location		Total Number of Sound Barriers	Total Length (feet)	Height[a] Range (feet)	Number of Severe Residual Impacts
Ave 21 Wye	Southbound (eastbound) track	1	4,600	12	0
[a] Height above top of rail.					

8.1.3 Hybrid Alternative

8.1.3.1 North-South Alignment

Table 8-11 presents preliminary recommendations for mitigation of severe impacts from operational noise for the Hybrid Alternative during the design year (2035). Table 8-11 presents the sound barriers that were found to be cost-effective for the Hybrid Alternative based on the noise mitigation guidelines. The sound barrier heights and lengths required to eliminate severe impacts are provided. The results are preliminary and will be refined based on the noise and vibration mitigation guidelines being prepared by the Authority. Sound barriers are just one noise mitigation option, and the barriers listed in this section will be studied in more detail to determine if they meet the mitigation guideline requirements. At locations where barriers do not meet the requirements, other noise mitigation options, such as building sound insulation and noise easements, will be examined.

Cost-effective sound barriers are given by receptor location along the alignment and the side of the alignment. Table 8-11 summarizes the number of cost-effective sound barriers, side of track, total length, range of barrier heights, and the number of residual impacts within each section of the alignment. All barrier heights are referenced to the top-of-rail elevation. Six sound barriers, with a combined length of approximately 30,000 feet and ranging in height from 10 feet to 14 feet, are recommended for the Hybrid Alternative north-south alignment.

Table 8-11
Recommendations for Mitigation of Operational Noise for Hybrid Alternative North-South Alignment

Receptor Location		Total Number of Sound Barriers	Total Length (feet)	Height[a] Range (feet)	Number of Severe Residual Impacts
Northern Section					
(No mitigation required in the northern section)					
Central Section					
Deadman Creek (south of Le Grand) to Lake Street, Madera (Ave 24 Wye)	Northbound track	1	5,900	14	0
	Southbound track	1	5,450	14	0

Receptor Location		Total Number of Sound Barriers	Total Length (feet)	Height[a] Range (feet)	Number of Severe Residual Impacts
Deadman Creek (south of Le Grand) to Lake Street, Madera (Ave 21 Wye)	Northbound track	1	5,900	14	0
	Southbound track	1	5,450	14	0
Southern Section					
Lake Street, Madera to Clinton Avenue	Northbound track	1	4,000	14	0
[a] Height above top of rail.					

8.1.3.2 Ave 24 Wye

Table 8-12 presents preliminary recommendations for mitigation of severe impacts from operational noise for the Hybrid Alternative with the Ave 24 Wye during the design year (2035). As shown in Table 8-12, no sound barriers were found to be cost-effective for the Hybrid Alternative with the Ave 24 Wye. Sound barriers are just one noise mitigation option, and the barriers listed in this section will be studied in more detail to determine if they meet the mitigation guideline requirements. At locations where barriers do not meet the requirements, other noise mitigation options, such as building sound insulation and noise easements, will be examined.

Table 8-12
Recommendations for Mitigation of Operational Noise for Hybrid Alternative with Ave 24 Wye

Receptor Location	Total Number of Sound Barriers	Total Length (feet)	Height[a] Range (feet)	Number of Severe Residual Impacts
Ave 24 Wye	(No cost-effective sound barriers for the Ave 24 Wye)			
[a] Height above top of rail.				

8.1.3.3 Ave 21 Wye

Table 8-13 presents preliminary recommendations for mitigation of severe impacts from operational noise for the Hybrid Alternative with the Ave 21 Wye during the design year (2035). As shown in Table 8-13, no sound barriers would be cost-effective for the Hybrid Alternative with the Ave 21 Wye. Sound barriers are just one noise mitigation option, and the barriers listed in this section will be studied in more detail to determine if they meet the mitigation guideline requirements. At locations where barriers do not meet the requirements, other noise mitigation options, such as building sound insulation and noise easements, will be examined.

Table 8-13
Recommendations for Mitigation of Operational Noise for Hybrid Alternative with Ave 21 Wye

Receptor Location	Total Number of Sound Barriers	Total Length (feet)	Height[a] Range (feet)	Number of Severe Residual Impacts
Ave 21 Wye	(No cost-effective sound barriers for the Ave 21 Wye)			

[a] Height above top of rail.

8.1.4 Heavy Maintenance Facility Alternatives

Table 8-14 presents preliminary recommendations for mitigation of severe impacts from operational noise for the Castle Commerce Center HMF lead tracks during the design year (2035). Table 8-14 presents the sound barriers that were found to be cost-effective for the Castle Commerce Center HMF based on the noise mitigation guidelines. The sound barrier heights and lengths required to eliminate severe impacts are provided. The results are preliminary, and will be refined based on the noise and vibration mitigation guidelines being prepared by the Authority. Sound barriers are just one noise mitigation option, and the barriers listed in this section will be studied in more detail to determine if they meet the mitigation guideline requirements. At locations where barriers do not meet the requirements, other noise mitigation options, such as building sound insulation and noise easements, will be examined.

Table 8-14
Recommendations for Mitigation of Operational Noise for Castle Commerce Center HMF Lead Track

Receptor Location		Total Number of Sound Barriers	Total Length (feet)	Height[a] Range (feet)	Number of Severe Residual Impacts
Castle Commerce Center Lead Track	Northbound track	2	3,000	12	0
	Southbound track	1	2,600	14	0

[a] Height above top of rail.

Cost-effective sound barriers are given by receptor location along the alignment and the side of the alignment. Table 8-14 summarizes the number of cost-effective sound barriers, side of track, total length, range of barrier heights, and the number of residual impacts within each section of the alignment. All barrier heights are referenced to the top-of-rail elevation. Three sound barriers, with a combined length of 5,600 feet arranging in height from 12 to 14, feet are recommended for the Castle Commerce Center HMF lead tracks.

8.2 Operational Vibration Mitigation Measures

The assessment assumes that the HST vehicle wheels and track are maintained in good condition with regular wheel truing and rail grinding. In addition, the following approaches would also reduce ground-borne vibration from HST operations:

- **Ballast Mats:** A ballast mat consists of a pad made of rubber or rubber-like material placed on an asphalt or concrete base with the normal ballast, ties, and rail on top. The reduction in ground-borne vibration provided by a ballast mat is strongly dependent on the frequency content of the vibration and the design and support of the mat.

- **Tire-Derived Aggregate (TDA):** Also known as shredded tires, a typical TDA installation consists of an underlayment of 12 inches of nominally 3-inch size tire shreds or chips wrapped with filter fabric, covered with 12 inches of sub-ballast and 12 inches of ballast above that to the base of the ties. Tests suggest that the vibration attenuation properties of this treatment are midway between that of ballast mats and floating slab track. Although this is a low-cost option, it has only recently been installed on two light rail transit systems in the United States (San Jose and Denver), and its long-term performance is unknown.

- **Floating Slabs:** Floating slabs consist of thick concrete slabs supported by resilient pads on a concrete foundation; the tracks are mounted on top of the floating slab. Most successful floating slab installations are in subways; their use for at-grade track is less common because they are only used where there is a concrete base such as the subway tunnel invert or a slab track. Floating slabs are designed to provide vibration reduction at lower frequencies than other treatments, such as resilient rail fasteners, but they are expensive.

- **Special Trackwork at Crossovers and Turnouts:** Because the impacts of HST wheels over rail gaps at track turnout locations increase HST vibration by about 10 VdB, turnouts are a major source of vibration impact when they are located in sensitive areas. If turnouts cannot be relocated away from sensitive areas, another approach is to use special types of trackwork that eliminate the gap.

- **Property Acquisitions or Easements:** Additional options for avoiding vibration impacts (and noise impacts) are for the Authority to purchase residences likely to be affected by train operations or to acquire easements for such residences by paying the homeowners to accept the future train vibration conditions. These approaches are usually taken only in isolated cases where other mitigation options are infeasible, impractical, or too costly.

There are two vibration impacts projected for the BNSF Alternative with the Le Grand design options. However, neither impact exceed the thresholds established in the noise and vibration mitigation guidelines for vibration mitigation; therefore no vibration mitigation is proposed.

8.3 Construction Noise and Vibration Mitigation Measures

8.3.1 Construction Noise Mitigation Measures

Construction activities will be conducted in conformance with noise restrictions included in contract documents to be developed as part of the bidding process. These documents may include specific residential property line noise limits along with noise monitoring requirements during construction to verify compliance with the limits. This approach allows the contractor flexibility to meet the noise limits in the most efficient and cost-effective manner. The contractor would have the flexibility of either prohibiting certain noise-generating activities during nighttime hours or providing additional noise control measures to meet these noise limits. Noise control mitigation for nighttime or daytime may include the following measures, as necessary, to meet required noise limits:

- Install a temporary construction site sound barrier near a noise source.

- Avoid nighttime construction in residential neighborhoods.

- Locate stationary construction equipment as far as possible from noise-sensitive sites.

- Re-route construction-related truck traffic along roadways that will cause the least disturbance to residents.

- During nighttime work, use smart back-up alarms, which automatically adjust the alarm level based on the background level, or switch off back-up alarms and replace with spotters.
- Use low-noise emission equipment.
- Implement noise-deadening measures for truck loading and operations.
- Monitor and maintain equipment to meet noise limits.
- Line or cover storage bins, conveyors, and chutes with sound-deadening material.
- Use acoustic enclosures, shields, or shrouds for equipment and facilities.
- Use high-grade engine exhaust silencers and engine-casing sound insulation.
- Prohibit aboveground jack-hammering and impact pile driving during nighttime hours.
- Minimize the use of generators to power equipment.
- Limit use of public address systems.
- Grade surface irregularities on construction sites.
- Use moveable sound barriers at the source of the construction activity.
- Limit or avoid certain noisy activities during nighttime hours.

To mitigate noise related to pile driving, the use of an augur to install the piles instead of a pile driver would greatly reduce the noise levels. If pile driving is necessary, the only mitigation would be to limit the time of day the activity can occur. Pile driving is not expected at most construction locations.

8.3.2 Construction Vibration Mitigation Measures

Building damage from construction vibration would only be anticipated from impact pile driving at very close distances to the buildings. If piling is more 50 feet from buildings, or if alternative methods such as push piling or augur piling can be used, damage from construction vibration should not be an issue. Other sources of construction vibration do not generate sufficiently high vibration levels for damage to occur. In any locations of concern, pre-construction surveys would be conducted to document the existing condition of buildings in case there was an issue during or after construction.

With the incorporation of the appropriate noise mitigation measures, impacts from construction-generated vibration should not be significant. To provide additional assurance, a complaint resolution procedure will also be implemented to rapidly address vibration problems that may develop during construction.

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10.0 Preparer Qualifications

Carl E. Hanson is a co-founder of Harris Miller Miller & Hanson Inc. (HMMH), one of the leading noise and vibration consulting firms in the United States. Dr. Hanson specializes in noise and vibration control engineering projects, particularly related to rail transportation. He is active in a wide range of rail transportation projects, including noise control designs for vehicles and facilities, compliance tests, environmental assessment, community measurement programs, and expert testimony. He has been especially active in the area of HST and maglev systems, having conducted research and consulting projects in the United States and Europe. He was the lead author of the two guidance manuals used throughout the United States for rail projects: the *Transit Noise and Vibration Impact Assessment* (FTA 2006) and the *High Speed Ground Transportation Noise and Vibration Impact Assessment* (FRA 2005). He is a licensed professional engineer in three states, a Fellow of the Institute of Noise Control Engineering, an active participant on committees of American Railway and Maintenance-of-Way Association, and a member of the international committee for the International Workshop on Railway Noise. He earned a Ph.D. degree in Acoustics at MIT (1970), an MS in Mechanical Engineering at MIT (1967), and a BS in Aero Engineering from University of Minnesota (1965).

Lance D. Meister is a vice president/principal consultant at HMMH. He is the leader of HMMH's Rail/Transit Group, specializing in rail and transit noise and vibration projects. Mr. Meister has over 15 years of experience on BRT, LRT, rail transit, freight rail, and high-speed rail projects. He is one of the primary instructors of the FTA Transit Noise and Vibration Impact Assessment course, which is taught throughout the country, and is one of the co-authors of the *Transit Noise and Vibration Impact Assessment* (FTA 2006).

Timothy M. Johnson is a senior consultant at HMMH. He provides noise and vibration modeling and analysis support to rail and transit projects at HMMH. His wide range of experience includes environmental assessments for transportation projects and noise and vibration mitigation design work. Mr. Johnson received a BS in Mechanical Engineering with an Acoustics Concentration from the University of Hartford (2002). Prior to joining HMMH, Mr. Johnson worked as an audiovisual consultant.

Ruth Anne Mazur is a consultant at HMMH with a BA in Acoustics from Columbia College Chicago (2009). Her coursework involved topics in environmental and architectural acoustics, as well as acoustical testing and modeling. Ms. Mazur completed the FTA Transit Noise and Vibration Impact Assessment course in November 2009. She is involved in noise and vibration measurement and analysis at HMMH, particularly in rail transportation projects. Prior to joining HMMH, Ms. Mazur worked in an acoustical testing laboratory and gained experience in reverberation time measurements and analysis.

Robert D. Behr is a senior consultant at HMMH specializing in noise and vibration control projects with a particular emphasis on aircraft and helicopter operations. He has been especially involved in numerous airport land use compatibility plans within the state of California and several Federal Aviation Administration 14 CFR Part 150 studies dealing with airport noise compatibility plans. In addition, he has conducted extensive document reviews for various projects to determine existing local and state noise regulations or noise elements directly related to transportation noise sources. He earned an MS in Aeronautical Engineering from the Air Force Institute of Technology (1976) and a BS in Aeronautical Engineering from the United States Air Force Academy (1968).