3.5 Electromagnetic Fields and Electromagnetic Interference

3.5.1 Introduction

This section describes electromagnetic fields (EMF) and electromagnetic interference (EMI), provides information on how these fields are measured, identifies standards that regulate these fields, and evaluates the potential for construction and operation of the San Francisco to San Jose Project Section (Project Section, or project) to affect potentially sensitive receptors.

Purpose:

Electromagnetic interference (EMI) is the disruption or malfunction of an electronic device when it is in the vicinity of an electromagnetic field (EMF) produced by another electronic device. This analysis is performed to protect sensitive and construction equipment, adjacent railway lines, pipelines, cables, and airports near the proposed alignments and inform the public with regards to any potential health impacts from construction and operation of the project. Potential effects from exposure to EMF include health effects, corrosion, electric shock, and electromagnetic interference.

The California High-Speed Rail Authority (Authority) identified current and projected sources of EMFs in the resource study area (RSA) based on field surveys, a review of aerial imagery and government agency databases, and a review of local and state general plans. In addition, potentially sensitive receptors within the RSA that may be susceptible to EMF and EMI produced by the California High-Speed Rail (HSR) System were identified. These receptors include adjacent railroads and rail transit systems, airports, residences, schools, preschools, daycares, public parks, hospitals and other medical facilities, high-technology businesses, research facilities, and commercial and industrial facilities.

Caltrain currently operates a passenger rail service between San Jose and San Francisco in the Caltrain corridor. The baseline EMF assumes the electrification of Caltrain service (as part of the proposed Caltrain Peninsula Corridor Electrification Project [PCEP]) from the 4th and King Street Station in San Francisco to Tamien Station in San Jose. Electrification requires the installation of an overhead contact system (OCS) and supporting traction power distribution facilities and is expected to be complete by 2022. The effects of Caltrain electrification on EMFs and EMI were evaluated by Caltrain in the *Peninsula Corridor Electrification Project Final Environmental Impact Report* (PCEP EIR) (Peninsula Corridor Joint Powers Board [PCJPB] 2015). The EMFs with operations of an electrified Caltrain service constitute the baseline against which the impacts of the project are evaluated. The HSR project would introduce the following changes, the impacts of which are evaluated in this document:

- The HSR project would add new and different trainsets to the Caltrain corridor.
- The HSR project would include track modifications that would allow both HSR and Caltrain trains to operate up to 110 miles per hour (mph), compared to 79 mph under No Project conditions. Trains operating at higher speeds would draw higher currents than trains at lower speeds, resulting in greater EMFs than under No Project conditions.[1] The track modifications would require realignment of the OCS in certain locations, which would mean that electrified wires (and their associated EMFs) would be closer or further away from sensitive receptors than under No Project conditions.
- The HSR project would include operation of new radio communications facilities that generate radio frequency (RF) fields under both project alternatives.
- Under Alternative B, new dedicated viaduct structures with an OCS and traction power substation (TPSS) would be built in San Jose and would generate magnetic fields.

Any necessary equipment upgrades to the traction power systems installed by Caltrain as part of PCEP would be of similar size to and co-located with the PCEP system facilities, such that the original footprint of the traction power facilities would remain unchanged.

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[1] The assumed conditions for this analysis are 16-car HSR trains with a weight of 1,088 tons and maximum current of 930 Amperes, and 6-car Caltrain trains with a weight of 696 tons and maximum current of 425 Amperes.

The EMF and EMI impacts from construction and operation of the project evaluated in this analysis include: exposure of people to EMF and EMI (including future passengers, workers, and neighbors), interference with electromagnetically sensitive equipment, radio interference, corrosion potential, electric shock risks, impacts on adjacent rail lines, and interference with adjacent airports. The following topic is not analyzed in detail in this section because it is not a potential risk:

- Livestock and poultry exposure—The Project Section extends principally through urban and suburban environments between San Francisco and San Jose. No livestock or poultry operations within the RSA were identified that could be exposed to EMF generated by construction or operation of the project.

The following appendices in Volume 2, Technical Appendices, of this Draft Environmental Impact Report (EIR)/Environmental Impact Statement (EIS) provide additional details on EMF and EMI:

- Appendix 2-D, Applicable Design Standards, describes the relevant design standards for the project.
- Appendix 2-E, Project Impact Avoidance and Minimization Features, provides a list of all impact avoidance and minimization features (IAMF) incorporated into the project.
- Appendix 2-I, Regional and Local Plans and Policies, provides a list by resource of all applicable regional or local plans and policies.
- Appendix 3.5-A, Pre-Construction Electromagnetic Measurement Survey of Locations along the San Francisco to San Jose Project Section, documents measurement results from a pre-construction electromagnetic (EM) survey.

EMF and EMI conditions in the Project Section and surrounding San Francisco Bay Area (Bay Area) are important because of the potential impacts on the operation of electrical, magnetic, and EM devices. The following EIR/EIS resource sections provide additional information related to EMF and EMI:

- Section 3.2, Transportation, evaluates impacts of the project alternatives on rail operations within the Project Section.
- Section 3.6, Public Utilities and Energy, evaluates impacts of the project alternatives on public utilities and electric transmission facilities within the Project Section.
- Section 3.11, Safety and Security, evaluates impacts of the project alternatives on the safety and security of adjacent communities along the Project Section.

3.5.1.1 Definition of Terminology

EMFs are electric and magnetic fields. Electric fields are forces that electric charges exert on other electric charges. Magnetic fields are forces that a magnetic object or moving electric charge exerts on other magnetic materials and electric charges. EMFs occur throughout the EM spectrum, are found in nature, and are generated both naturally and by human activity. Naturally occurring EMFs include the earth's magnetic field, static electricity, and lightning. EMFs are also created by the generation, transmission, and distribution of electricity; the use of everyday household electric appliances and communication systems; and industrial processes.

> *Definitions:*
>
> **EMFs** are electric and magnetic fields.
>
> **Electric fields** are forces that electric charges exert on other electric charges.
>
> **Magnetic fields** are forces that a magnetic object or moving electric charge exerts on other magnetic materials and electric charges.
>
> **EMI** is the interference that occurs when the EMF produced by a source adversely affects the operation of an electrical, magnetic, or EM device.

EMI is the interference that occurs when the EMF produced by a source adversely affects the operation of an electrical, magnetic, or EM device. EMI may be caused by a source that intentionally radiates EMFs (such as a television broadcast station) or one that does so incidentally (such as an electric motor). The information presented in this section primarily concerns EMFs at the 60-Hertz (Hz) power frequency and at radio frequencies produced intentionally by communications or unintentionally by electric discharges. EMFs from HSR and Caltrain operations in the Project Section would consist of the following:

- **Power-frequency electric and magnetic fields from the traction power system distribution facilities**—Along the tracks, 60-Hz electric and magnetic fields would be produced by the flow of propulsion currents to the trains in the OCS and its return through the rails and negative feeder wire (NF). Electric and magnetic fields are also generated from electrical equipment, including transformers, at the traction power facilities.
- **Harmonic magnetic fields from vehicles**—Depending on the design of power equipment in the trains, power electronics would produce currents with frequencies in the kilohertz (kHz) range. Potential sources include power conversion units, switching power supplies, motor drives, and auxiliary power systems. These sources are highly localized in the trains, and move along the track as the trains move.
- **RF fields**—RF fields are any of the EM wave frequencies in the range from around 3 kHz to 300 gigahertz (GHz), and they include those frequencies used for communications or radar signals. The HSR system would use a variety of communications, data transmission, and monitoring systems—both on and off vehicles—that operate at radio frequencies. These wireless systems would meet the Federal Communications Commission (FCC) regulatory requirements for intentional emitters (47 Code of Federal Regulations [C.F.R.] Part 15; FCC 1997).

Of these EMFs, the dominant effect is expected to result from the 60-Hz alternating current (AC) magnetic fields from the propulsion currents flowing in the traction power system—that is, the OCS, rails, NF, and traction power facilities. The following sections discuss these concepts in more detail.

3.5.1.2 Characteristics of Electromagnetic Radiation

The EM spectrum consists of two types of radiation—ionizing and nonionizing radiation. A wave's position on the EM spectrum depends on its wavelength. Ionizing radiation—capable of removing electrons from atoms and thus of damaging biological tissues—consists of short-wave or high-frequency radiation, including ultraviolet, x-ray, and gamma ray radiation. Nonionizing radiation consists of long-wave radiation, including radio waves, microwaves, and infrared radiation. Visible light is the portion of the EM spectrum that lies between the infrared (nonionizing) and ultraviolet (ionizing) portions of the EM spectrum. This section addresses the potential impacts that nonionizing, long-wave electromagnetic radiation (EMR) at wavelengths below those of visible light can have on human health and on sensitive electric and electronic equipment and facilities along the Project Section.

Nonionizing EMR consists of waves characterized by variations in electric fields (measured in volts per meter [V/m]) and magnetic fields (measured in Tesla [T] or Gauss [G]). These periodic waves move through a medium, such as air, transferring energy from place to place as they go. The waves move at the speed of light and have dimensions of height, or amplitude; wavelength, or the distance between two adjacent peaks of the wave; and number of cycles per second (Hz), or frequency. Table 3.5-1 shows wavelengths for a range of different frequencies. Table 3.5-2 shows the magnetic field strengths of electrical devices and facilities commonly found in urban areas.

EMFs consist of both electric fields and magnetic fields that are generated by natural sources such as the sun, lightning, biological processes, and currents within the Earth's molten metallic core. Artificial EMFs are intentionally generated by electrical devices, such as television and radio broadcasting towers, hand-held radios, x-ray machines, microwave links, and cellular phones. EMFs of human origin are also unintentionally generated by devices such as electric power transmission and distribution lines, televisions, computers, appliances, ignition systems, and electrical wiring and switches.

Table 3.5-1 Relationship between Typical Frequencies and Their Wavelengths

Frequency	Wavelength
1 Hz	186,000 miles (299,338 kilometers)
60 Hz	3,100 miles (49,890 kilometers)
10 kHz	18.6 miles (29.9 kilometers)
10 MHz	98.4 feet (30.0 meters)
100 MHz	9.8 feet (3.0 meters)

Hz = Hertz
kHz = kilohertz
MHz = megahertz

Table 3.5-2 Typical Magnetic Field Strengths

Electrical Source	Magnetic Field Strength at 1 Foot (mG)
Dishwasher	30
Hair dryer	70
Electric shaver	100
Vacuum cleaner	200
High-voltage power/transmission line (115 kV–500 kV)	30–87[1]
Power distribution line (4 kV–24 kV)	10–70[2]

Source: NIEHS 2002
kV = kilovolts
mG = milligauss
[1] Standing beneath the lines, 90 feet from conductors
[2] Standing beneath the lines, 20 feet from conductors

While both direct current (DC) and AC electrical devices generate EMFs, the magnetic flux density[2] is much higher for DC than for AC current. The strength of an electric field is proportional to the strength of its electric charge (i.e., voltage), while the strength of a magnetic field is proportional to the motion of the charge (i.e., current); when no current is flowing in an electrical circuit, only the electrical field is present. The power of an electric field (i.e., the rate at which energy is transferred) is measured in watts (W), and the power density (i.e., power distributed over a given cross-sectional area perpendicular to the direction of its flow) of the electric field's flux is measured in watts per square meter (W/m^2).

Unit Definitions and Conversions

Hertz (Hz)—Unit of frequency equal to one cycle per second

1 kilohertz (kHz) = 1,000 Hz

1 gigahertz (GHz) = 1 billion Hz

Gauss (G)—Unit of magnetic flux density (intensity) (English units)

1 G = 1,000 milligauss (mG)

Tesla (T)—Unit of magnetic flux density (intensity) (International units)

1 T = 1 million microtesla (µT)

1 G = 100 µT

1 mG = 0.1 µT

Electromagnetic Field Frequencies

EMFs are described in terms of their frequency, which is the number of times the EMF increases and decreases in intensity each second. The United States commercial electric power system operates at a frequency of 60 Hz, or 60 cycles per second, meaning that the field increases and decreases in intensity 60 times per second. Electric power system components are typical sources of electric

[2] The *magnetic flux density* is the number of magnetic field lines passing through a closed surface area, such as a perpendicular to the direction of the magnetic flux.

and magnetic fields. These components include generating stations and power plants, substations, high-voltage transmission lines, and electric distribution lines. Even in areas not adjacent to transmission lines, 60-Hz EMFs are generated by electric power systems and building wiring, electrical equipment, and appliances.

Natural and anthropogenic EMFs cover a broad frequency spectrum. EMFs that are nearly constant in time are called DC EMFs. EMFs that vary in time are called AC EMFs. AC EMFs are further characterized by their frequency range. Extremely low frequency (ELF) magnetic fields are typically defined as having a lower limit of 3 to 30 Hz and an upper limit of 30 to 3,000 Hz. The HSR OCS and electrical transmission, power, and distribution system would primarily generate ELF fields at 60 Hz and at harmonics (multiples) of 60 Hz.

Radio and other communications operate at much higher frequencies, often in the range of 500,000 Hz (500 kHz) to 3 GHz. Typical RF sources of EMFs include antennas on cellular telephone towers; radio and television broadcast towers; airport radar, navigation, and communication systems; high-frequency and very high-frequency communication systems used by police, fire, emergency medical technicians, utilities, and governments and local wireless systems, such as wireless fidelity (WiFi) and cordless telephones.

The strength of magnetic fields is measured either in milligauss (mG), G, T, or microtesla (μT). For comparison, Earth's ambient magnetic field ranges from 500 to 700 mG DC (0.5 to 0.7 G) (50 to 70 μT) at its surface. Average AC magnetic field levels in homes are approximately 1 mG (0.001 G) (0.1 μT), and measured AC values range from 9 to 20 mG (0.009 to 0.020 G) (0.9 to 2 μT) near appliances (Severson et al. 1988). The strength of an EMF rapidly decreases with distance from its source; thus, EMFs higher than background levels are usually found close to EMF sources. For overhead transmission and power lines, the strength of an EMF is typically highest directly under the overhead line and decreases rapidly with increasing distance from the line. Table 3.5-3 shows the typical EMF levels from overhead electrical lines at varying lateral distances from the line tower. EMF levels at a distance of 200 feet from a 230-kilovolt (kV) transmission line and a 115-kV power line are reduced by approximately 97 and 99 percent, respectively.

Table 3.5-3 Typical Electromagnetic Field Levels for Transmission/Power Lines

Voltage of Source	Field Strength at Specified Distances from Source				
	At Source	50 feet	100 feet	200 feet	300 feet
230-kV transmission line electric field strength (kV/m)	2.0	1.5	0.3	0.05	0.01
230-kV transmission line mean magnetic field (mG)	57.5	19.5	7.1	1.8	0.8
115-kV power line electric field strength (kV/m)	1.0	0.5	0.07	0.01	0.003
115-kV power line mean magnetic field (mG)	29.7	6.5	1.7	0.4	0.2

Source: NIEHS 2002
kV = kilovolt
kV/m = kilovolts per meter
mG = milligauss

Electromagnetic Field Exposure and Health Effects

EMFs can cause EMI, which can disrupt sensitive equipment (e.g., implanted medical devices), possibly triggering a malfunction. Extensive research on EMFs has led the majority of scientists and health officials to conclude that low-frequency EMFs have no adverse health effects at typical exposure levels encountered in urban, suburban, or rural environments. Scientific reviews of animal studies, from which some human health risks have been extrapolated, have also concluded that existing data are inadequate to indicate a potential risk of cancer, which is the primary human health concern associated with EMF exposure (International Agency for Research on Cancer 2002; World Health Organization [WHO] 2007). EMFs nevertheless remain a human health concern at high exposure levels (WHO 2007).

3.5.1.3 Electromagnetic Interference

General Considerations

EMI is an EM disturbance from an external source that interrupts or degrades the performance of an electrical device, circuit, or signal. Ambient EMI occurs when EMR intentionally or unintentionally jams, or blocks, another EM signal in free space. Hardware EMI occurs when EMR induces an unintended current in an electrical circuit. To interfere with a radio or microwave signal, the EMI must be at or near the signal frequency. Radio and other communications systems typically operate in the range of 500 kHz to 3 GHz.

Commercial standards developed for electromagnetic compatibility (EMC) both limit EMI generated by electrical devices and reduce susceptibility of electrical devices to external EMI. For example, the Federal Aviation Administration's (FAA) interim EMC commercial standards require aircraft systems to withstand EMFs of up to 200 V/m (FAA 2014).

Electromagnetic Interference and Radio Communications

Intentional radio signals exist in a sea of unwanted RF noise, so radio communications systems and devices are designed to operate in this environment. General frequency ranges are assigned for various types of radio signals, and specific radio frequencies and power output levels are assigned to individual users to minimize the potential for disruptions. Radio equipment is designed to separate the frequency of interest from background noise and to reject transient or unfocused signals.

Electromagnetic Interference and Sensitive Equipment

Research equipment is generally designed to operate within the Earth's natural magnetic field and to compensate for fluctuations of up to 10 mG in that field (Field Management Services 2009). Industries associated with the use, assembly, calibration, or testing of sensitive or unshielded RF equipment, however, are still sensitive to EMI. In particular, fluctuations in the magnetic field can interfere with nuclear magnetic resonance (NMR), nuclear magnetic imaging, and other imaging equipment, such as electron microscopes. Computed tomography and computed axial tomography scanning devices are also sensitive to EMI, as are some semiconductor, nanotechnology, and biotechnology operations. NMR spectrometers are sensitive to time-varying DC magnetic fields of less than 2 mG (Field Management Services 2009). For unshielded equipment that is sensitive to magnetic fields in the range of 1 to 3 mG, such as magnetic resonance imaging (MRI) systems, EMI is possible at distances of up to 200 feet. An installation guide for NMR equipment recommends a separation distance of 328 feet from electric trains (Field Management Services 2009).

3.5.2 Laws, Regulations, and Orders

This section presents federal and state laws, regulations, and orders applicable to EMF and EMI. The California High-Speed Rail Authority (Authority) would implement the HSR project, including the Project Section, in compliance with all federal and state regulations. Regional and local laws, regulations, orders, and plans considered in the preparation of this analysis are provided in Volume 2, Appendix 2-I.

Additionally, several organizations have developed guidelines for EMF exposure, including individual states, the FCC, Occupational Safety and Health Administration (OSHA), Institute of Electrical and Electronics Engineers (IEEE), American National Standards Institute (ANSI), and American Conference of Governmental Industrial Hygienists (ACGIH). Neither the California government nor the U.S. government has regulations limiting exposure of residences to EMF.

EMF exposure guidelines and standards have also been adopted by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in the ELF and RF frequency bands applicable to HSR emissions. The ICNIRP and IEEE standards both address EMF exposure by the general public for the United States and abroad (and have been formally adopted by the European Union); the IEEE standards have been identified in the *Final Program Environmental Impact Report/Environmental Impact Statement (EIR/EIS) for the Proposed California High-*

Speed Train System (Statewide Program EIR/EIS) (Authority and Federal Railroad Administration [FRA] 2005) to assess the potential for health and compatibility impacts from anticipated HSR emissions. For occupational exposure, the ICNIRP-recommended exposure limits are 417 µT for magnetic fields and 8.333 kilovolts per meter (kV/m) for 60-Hz electric fields (ICNIRP 1998).

The IEEE Standard C95.6, *IEEE Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz* (IEEE 2002), which is often referenced in the United States and has been formally adopted by ANSI, specifies maximum permissible exposure (MPE) levels for the general public and for occupational exposure to ELF EMFs, which have frequencies of 0 to 3 kHz. The electrification and traction power systems for the blended system would generate ELF EMFs with frequencies of 60 Hz, which are in the range covered by this standard. The IEEE Standard C95.6 exposure levels are shown in Table 3.5-4 and Table 3.5-5. The IEEE exposure levels are recommendations only, not regulations.

Table 3.5-4 IEEE C95.6 Magnetic Field Maximum Permissible Exposure Levels for the General Public

Body Part	Frequency Range (Hz)	B-Field (mG)
Head and torso	20–759	9.04×10^3
	759–3,000	$6.87 \times 10^6/f$
	60	9.04×10^3
Arms or legs	<10.7	3.53×10^6
	10.7–3,000	$3.79 \times 10^7/f$
	60	632,000

Source: IEEE 2002
/f = divide by the frequency
Hz = hertz
IEEE = Institute of Electrical and Electronics Engineers
mG = milligauss

Table 3.5-5 IEEE C95.6 Electric Field Maximum Permissible Exposure Levels for the General Public

Body Part	Frequency Range (Hz)	E Field (V/m)
Whole body	1–368	5,000
	368–3,000	$1.84 \times 10^6/f$
	60	5,000

Source: IEEE 2002
/f = divide by the frequency
Hz = hertz
IEEE = Institute of Electrical and Electronics Engineers
V/m = volts per meter

In 2006, ANSI adopted IEEE Standard C95.1 as its standard for safe human exposure to nonionizing EMR (IEEE 2006). The HSR radio-based communications systems would use radio signals within the range covered by this standard. The C95.1 Standard specifies MPE levels for whole and partial body exposure to EM energy. MPE levels are lower at 100 to 300 megahertz (MHz) because the human body absorbs the greatest percentage of incident energy at these frequencies. The MPE standards become progressively higher at frequencies above 400 MHz because the human body absorbs less energy at these higher frequencies. The IEEE C95.1 Standard MPEs are based on RF levels averaged over a 30-minute exposure time for the general public. For occupational exposure, the averaging time varies with frequency from 6 minutes at 450 MHz to 3.46 minutes at 5,000 MHz.

Both the IEEE C95.6 and C95.1 standards specify safety levels for occupational and general-public exposure. For each, the exposure levels are frequency dependent. The general-public exposure safety levels are stricter because workers are assumed to have knowledge of occupational risks and are better equipped to protect themselves (e.g., through use of personal safety equipment). The general-public safety levels are intended to protect all members of the public (including pregnant women, infants, the unborn, and the infirm) from short- and long-term exposure to EMFs. The safety levels are also set at 10 to 50 times below the levels at which scientific research has shown harmful effects may occur, thus incorporating a large safety factor (IEEE 2006).

OSHA safety standards for occupational exposure to RF emissions are found at 29 C.F.R. Section 1910.97. The OSHA safety levels do not vary with frequency and are less stringent than the equivalent ANSI/IEEE and FCC MPEs, except for occupational exposure to fields with frequencies above 5,000 MHz, where the OSHA MPE is equal to the C95.1 MPE and is twice that of the FCC MPE. The OSHA MPEs are based on a 6-minute averaging time.

ACGIH recommends that occupational exposures should not exceed 10 G (10,000 mG or 1 μT). ACGIH additionally recommends that workers with pacemakers should not exceed 1 G (1,000 mG or 0.1 μT). The ACGIH 10-G guideline level is intended to prevent effects such as induced currents in cells or nerve stimulation. However, the ACGIH guidelines are for occupational exposure, not general-public exposure.

3.5.2.1 Federal

U.S. Department of Transportation, Federal Railroad Administration, Procedures for Considering Environmental Impacts (64 Fed. Reg. 28545)

The FRA procedures state that an EIS should consider possible impacts from EMFs and EMI.

U.S. Department of Transportation, Federal Railroad Administration (49 C.F.R. § 236.8, 238.225, 229 Appendix F, and 236 Appendix C)

These regulations provide rules, standards, and instructions for operating characteristics of EM, electronic, or electrical apparatus, and safety standards for passenger equipment.

U.S. Environmental Protection Agency, U.S. Presidential Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks

U.S. Presidential Executive Order 13045, issued in 1997, directs federal agencies to make it a priority to identify and assess environmental health and safety risks that may disproportionally affect children and to ensure that policies, programs, activities, and standards address disproportionate risks to children, including risks from EMF exposure.

U.S. Department of Commerce, Federal Communications Commission (47 C.F.R. Part 15)

Part 15 provides rules and regulations regarding licensed and unlicensed RF transmissions. Most telecommunications devices sold in the United States, whether they radiate intentionally or unintentionally, must comply with Part 15. However, Part 15 does not govern any device used exclusively in a vehicle, including in HSR trains.

U.S. Department of Commerce, Federal Communications Commission, Office of Engineering and Technology Bulletin 65

This bulletin provides assistance in evaluating whether proposed or existing transmitting facilities, operations, or devices comply with limits for human exposure to RF fields adopted by the FCC (FCC 1997).

U.S. Department of Commerce, Federal Communications Commission (47 C.F.R. § 2.106, Allocation, Assignment, and Use of Radio Frequencies)

This regulation specifies and regulates allowed uses of the radio spectrum within the United States. The frequency allocations extend from 9 kHz to nearly 300 GHz.

U.S. Department of Commerce, Federal Communications Commission (47 C.F.R. § 1.1310, Radiofrequency Radiation Exposure Limits)

The FCC regulations at 47 C.F.R. Section 1.1310 are based on the 1992 version of ANSI/IEEE C95.1 safety standard. Table 3.5-6 shows MPE contained in the ANSI/IEEE C95.1 and FCC standards at frequencies of 450, 900, and 5,000 MHz, which covers the range of frequencies that may be used by HSR radio systems. FCC MPEs are based on an average time of 30 minutes for exposure of the general public and 30 minutes for occupational exposure. As shown in Table 3.5-6, the differences between the ANSI/IEEE C95.1 and FCC MPEs are minor.

Table 3.5-6 Radio Frequency Emissions Safety Levels Expressed as Maximum Permissible Exposure

	ANSI/IEEE C95.1 MPE (mW/cm²)		FCC MPE (mW/cm²)		OSHA MPE (mW/cm²)
Frequency	Occupational	General Public	Occupational	General Public	Occupational
450 MHz	1.5	0.225	1.5	0.3	10
900 MHz	3.0	0.45	3.0	0.6	10
5,000 MHz	10	1.0	5.0	1.0	10

Sources: IEEE 2006; 47 C.F.R. Section 1.1310, Table 1 (FCC); 29 C.F.R. Section 1910.97 (OSHA)
ANSI/IEEE = American National Standards Institute/Institute of Electrical and Electronics Engineers
FCC = Federal Communications Commission
MHz = megahertz
MPE = maximum permissible exposure
mW/cm^2 = milliwatts per square centimeter
OSHA = Occupational Safety and Health Administration

U.S. Department of Labor, Occupational Safety and Health Administration (29 C.F.R. § 1910.97, Nonionizing Radiation)

29 C.F.R. Section 1910.97 provides safety standards for occupational exposure to RF emissions in the 10 MHz to 100 GHz range. Table 3.5-6 shows MPEs contained in the OSHA standards. The OSHA safety levels do not vary with frequency and are less stringent than the equivalent ANSI/IEEE and FCC MPEs, except for occupational exposure to fields with frequencies above 5,000 MHz, where the OSHA MPE is equal to the C95.1 MPE and is twice that of the FCC MPE. The OSHA MPEs are based on averaging over any 6-minute time interval.

3.5.2.2 State

California Department of Education (Cal. Code Regs., tit. 5, § 14010(c))

This section sets minimum distances for siting school facilities from the edge of power line easements: 100 feet for 50- to 133-kV line, 150 feet for 220- to 230-kV line, and 350 feet for 500- to 550-kV line.

California Public Utilities Commission Electromagnetic Field Guidelines for Electrical Facilities

These California Public Utilities Commission (CPUC) guidelines, based on D.93-11-013 and D.06-01-042, establish priorities among land use classes for EMF mitigation. While the CPUC decisions, general orders, and guidelines do not directly apply to HSR, they are listed because the project consists of modifications to existing Pacific Gas and Electric Company facilities subject to the jurisdiction of the CPUC. Similarly, electrical infrastructure modifications would occur pursuant to the CPUC General Order (GO) 95 (Rules for Overhead Electric Line Construction) and GO 174 (Rules for Electric Utility Substations).

Decision D.93-11-013

The CPUC decision adopted a policy regarding EMF from regulated utilities.

Decision D.06-01-042

The August 2004 CPUC decision updated the EMF policy originally defined in D.93.11.013. D.06-01-042 reaffirmed D.93-11-013 in that health hazards from exposures to EMF have not been established and that state and federal public health regulatory agencies have determined that setting numeric exposure limits is not appropriate. The CPUC also reaffirmed that the existing no-cost and low-cost precautionary-based EMF policy be continued. D.06-01-042 ordered the utilities to convene a utility workshop to develop standard approaches for design guidelines, including a standard table showing EMF mitigation measures and costs.

3.5.2.3 Regional and Local

Volume 2, Appendix 2-I lists regional and local policies that are applicable to the project. The EMF and EMI standards included in regional and local policies restate, or incorporate by reference, the MPE limits and EMI guidelines set forth in federal and state regulations and industry standards described in Section 3.5.2.1, Federal, and Section 3.5.2.2, State.

3.5.3 Consistency with Plans and Laws

As indicated in Section 3.1.5.3, Consistency with Plans and Laws, the California Environmental Quality Act (CEQA) and Council on Environmental Quality (CEQ) regulations require a discussion of inconsistencies or conflicts between a proposed undertaking and federal, state, regional, or local plans and laws. Accordingly, this Draft EIR/EIS describes the inconsistency of the project alternatives with federal, state, regional, and local plans and laws to provide planning context.

Several federal and state laws and implementing regulations listed in Section 3.5.2.1 and Section 3.5.2.2 govern compliance with EMF limits for construction projects and transportation facilities. EMF assessment is highly technical, and several published federal and state guidance documents address how to assess potential impacts. A summary of the federal and state requirements considered in this analysis follows:

- FRA rules, standards, and instructions for operating characteristics of electric and electronic equipment
- FRA safety standards for passengers
- U.S. Presidential Executive Order prioritizing protection of children from environmental health and safety risks
- FCC rules for licensed and unlicensed RF transmissions
- FCC guidelines for safe EMF exposure and regulations for RF emission safety levels
- FCC regulations for allocating, assigning, and using RFs
- OSHA standards for permissible worker exposure to nonionizing radiation
- California regulations on minimum siting distances of power lines from schools
- CPUC decisions that set EMF policies

The Authority, as the lead agency, would require the project to be built and operated in compliance with all federal and state laws and regulations and to secure all applicable federal and state permits or regulatory authorizations prior to initiating construction of the selected alternative. Therefore, there would be no inconsistencies between the project and these federal and state laws and regulations.

The Authority is a state agency and therefore is not required to comply with local land use and zoning regulations; however, it has endeavored to design and build the HSR project so that it is as consistent as possible with land use and zoning regulations. For example, the Authority would design the project to minimize interference with electrical and magnetic devices and comply with state and federal EMI guidelines and standards regarding human exposure limits.

The Authority reviewed 11 relevant local plans and ordinances (Volume 2, Appendix 2-I). These ordinances are concerned largely with RF and sources of EMI (e.g., wireless communications), either restating or directly referencing existing FCC limits and regulations. The project alternatives are consistent with all goals and policies because they would provide adequate electricity, communications, and telecommunications facilities to serve existing and future needs of the system, and these facilities would not create EMI that would interfere with sensitive equipment, emergency services, or transportation systems, including air traffic. The Authority would coordinate with state and local authorities and utilities during design and construction so that critical services would not be affected by EMI. In addition, the project alternatives would be designed to avoid health risks associated with EMF. The project would be consistent with all goals and policies as listed in Volume 2, Appendix 2-I.

3.5.4 Methods for Evaluating Impacts

CEQA requires that impacts be evaluated against baseline conditions, and since project-related EMI is reasonably foreseeable, the National Environmental Policy Act (NEPA) requires that it be evaluated as well. The following sections define the RSA and describe the methods used to establish EMF and EMI baseline conditions along the Project Section to determine the potential EMF and EMI impacts associated with project construction and operations. The methods combine data collection, EMF survey, and mathematical modeling to predict EMF levels from HSR operations.

3.5.4.1 Definition of Resource Study Area

As defined in Section 3.1, Introduction, RSAs are the geographic boundaries within which the environmental investigations specific to each resource topic were conducted. The RSA for EMF and EMI comprises the project footprint for each of the project alternatives plus 500 feet from the track centerline,[3] the perimeter of the light maintenance facility (LMF) sites, radio communications towers, and the TPSS included under Alternative B. The EMF and EMI analysis focuses on the impacts of source EMFs and EMI on sensitive receptors, which include adjacent railroads and rail transit systems, airports, residences, schools, preschools and daycares, public parks, hospitals and other medical facilities, high-technology businesses, research facilities, and commercial and industrial facilities.

This RSA has been defined based on typical screening distances identified in the Authority Technical Memorandum (TM) 300.07, *EIR/EIS Assessment of CHST Alignment EMF Footprint* (Footprint Report) (Authority 2012a), and project-specific factors. Screening distances indicated whether any EMF- and EMI-sensitive receptors would be near enough to the proposed alignment for EMF or EMI impacts to be possible under typical conditions. The Footprint Report determined that EMF and EMI impacts would be unlikely where sensitive receptors were located beyond the screening distances.

3.5.4.2 Impact Avoidance and Minimization Features

IAMFs are project features that are considered to be part of the project and are included as applicable in each of the alternatives for purposes of the environmental impact analysis. The full text of the IAMFs that are applicable to the project is provided in Volume 2, Appendix 2-E. The following IAMFs are applicable to the to the EMF and EMI analysis:

- EMF/EMI-IAMF#1: Preventing Interference with Adjacent Railroads
- EMF/EMI-IAMF#2: Controlling Electromagnetic Fields/Electromagnetic Interference

This environmental impact analysis considers these IAMFs as part of the project design. In Section 3.5.6, Environmental Consequences, each impact narrative describes how these project features are applicable and, where appropriate, effective at avoiding or minimizing potential impacts to less than significant under CEQA.

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[3] Although 60-Hz magnetic fields are generated by the OCS, the HSR track centerline is used as a proxy from which distance to sensitive receptors and other potentially affected land uses is measured.

3.5.4.3 Methods for Impact Analysis

Overview of Impact Analysis

This section describes the sources and methods the Authority used to analyze potential project impacts from EMFs and EMI on sensitive receptors compared to the baseline conditions. These methods apply to both NEPA and CEQA analyses unless otherwise indicated. Refer to Section 3.1.5.4, Methods for Evaluating Impacts, for a description of the general framework for evaluating impacts under NEPA and CEQA. Sections 3.5.4.4, Method for Evaluating Impacts under NEPA, and 3.5.4.5, Method for Determining Significance under CEQA, describe the NEPA and CEQA impact methodologies used to evaluate project impacts from EMFs and EMI. Laws, regulations, and orders (summarized in Section 3.5.2, Laws, Regulations, and Orders) that regulate EMFs and EMI were considered in the evaluation of impacts.

Regional and Local Sources of Electromagnetic Fields and Electromagnetic Interference

The Authority relied upon aerial imagery, surveys, photographs, and FCC databases to identify regional and local sources of EMFs and EMI. Published reports, such as the PCEP EIR (PCJPB 2015), were also referenced to evaluate the baseline conditions within the EMF and EMI RSA with the electrification of Caltrain service.

Local Conditions

A pre-construction survey was conducted to measure EMF at 14 locations along the Project Section in accordance with technical guidance developed by the Authority. The purpose of this survey was to establish EMF levels representative of existing conditions in the RSA. Sites were selected for two different purposes: (a) to obtain measurements for a range of EMF levels, including both high-EMF sites such as those near power lines and antenna towers, and those in relatively quiet areas for comparison, and (b) to document existing EMF levels at sensitive facilities along the alignment such as medical and high-technology facilities. These measurement sites represent a cross section of typical local emitters such as power lines and antenna towers, potentially sensitive facilities such as medical and high-technology facilities, and areas that are relatively free of EMF point sources. Appendix 3.5-A in Volume 2 documents the process for conducting field survey measurements, describes measurement sites, and discusses the existing EMF levels along the Project Section.

For purposes of evaluating effects under NEPA and CEQA, the existing baseline was the present conditions, combined with effects from the PCEP. The corridor electrification that will be done under the PCEP would provide all of the traction power infrastructure for HSR, with the exception of the San Jose TPSS included under Alternative B, and is considered part of the pre-existing EMF environment, although the HSR project would change the baseline conditions by adding different trains, running at higher speeds, realigning portions of the OCS, and adding communications facilities. This analysis evaluates change associated with equipment upgrades at the PCEP traction power facilities to accommodate HSR operations, and the San Jose TPSS under Alternative B as project impacts.

Sensitive Receptors

Sensitive receptors consist of land uses and facilities susceptible to EMF and EMI produced by the project. These receptors include: adjacent railroads and rail transit systems, airports, residences, schools, preschools and daycares, public parks, hospitals and other medical facilities, high-technology businesses, research facilities, and commercial and industrial facilities. Their sensitivity is due to the potential exposure of people to EMFs or because they have communications systems, sensitive equipment, or other electronic devices that could be disrupted by EMFs. The Authority conducted a visual assessment of sensitive land uses as part of field surveys measuring the existing EM environment (see Volume 2, Appendix 3.5-A for additional information).

EMF and EMI Levels

The following steps were performed to predict EMF levels from HSR operations:

- Identified EMF-sensitive land uses through a review of aerial imagery, field visits, county parcel data, and local planning documents
- Measured baseline EMF levels, as described in Volume 2, Appendix 3.5-A
- Calculated the anticipated maximum 60-Hz magnetic fields that a single HSR train would produce using the Magnetic Field Calculation Model, a mathematical model of the HSR traction electrical system

The Magnetic Field Calculation Model incorporates conservative assumptions for the potential HSR EMF impacts of the project, as it assumes a maximum train current of 930 Amperes, which is approximately 20 percent greater than the typical operating current. For example, the projected maximum magnetic fields would exist only for a short period and only in certain locations as the train moves along the track or changes its speed and acceleration. The magnetic field levels would decline rapidly as the lateral distance from the tracks increases. For most locations and most times, exposure to EMF would not be as high as predicted by the model, which predicts peak EMF levels.

The Magnetic Field Calculation Model also identifies how the projected maximum EMF levels would vary with the lateral distance from the centerline of the tracks (used as a proxy for the distance to the source of EMF—the OCS). For the sensitive land uses identified, the maximum EMF levels that would be emitted by the HSR operations were predicted and compared to the measured, existing ambient conditions. Because magnetic fields would be expected to be the dominant EMF impact from HSR operations,[4] these results are the basis for the EMF impact analysis.

EMF impacts on sensitive land uses were identified based on the differences between predicted EMF levels and existing conditions. The data from the 14 site measurement locations were generalized to represent the entire RSA. Where the predicted EMFs generated by project operations would be comparable to or lower than the typical existing levels, no measurable impact would occur and these locations were screened out. Where the predicted EMFs would be higher than typical existing levels for exposure, then the potential for EMI was used to evaluate the magnitude of potential impacts.

3.5.4.4 Method for Evaluating Impacts under NEPA

The CEQ NEPA regulations (40 C.F.R. Parts 1500–1508) provide the basis for evaluating project effects (as described in Section 3.1.5.4). As described in Section 1508.27 of these regulations, the criteria of context and intensity are considered together when determining the severity of the change introduced by the project.

- **Context**—For the analysis of EMF and EMI effects, the *context* would include the existing levels of EMF within the RSA; the location and type of sensitive receptors and land uses along the project corridor, including proximity to sensitive equipment, adjacent railroads, electrical transmission facilities, or railroad towers; and the regulatory setting pertaining to EMF and EMI, including guidelines developed for EMF exposure.
- **Intensity—**For the analysis of EMF and EMI effects, the *intensity* or severity of an effect would assess the magnitude of the change between the existing and modeled EMF levels; the degree to which the proposed project could affect public health by exposing people to EMF health risks in exceedance of applicable standards, exposing people to electric shock, or interfering with implanted biomedical devices; and the degree to which the proposed project could affect public safety by interfering with the operation of nearby railroads, rail transit systems, airports, or other businesses.

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[4] The HSR OCS and distribution system primarily would have 60-Hz magnetic fields, which are much lower than the frequency levels presented in Table 3.5-6.

To inform the severity of an effect, projected levels of EMFs and EMI were compared to No Project Alternative levels. The Authority determined whether the increase would be of sufficient magnitude, frequency, or duration to present a documented health risk to persons living or working in the project vicinity, and whether the increase could interfere with existing operations of an electrical device.

3.5.4.5 Method for Determining Significance under CEQA

The Authority is using the following thresholds to determine if a significant impact under CEQA from EMF or EMI would result from the project alternatives. The significance thresholds are based on relevant research and documentation on potential EMF and EMI safety levels, such as the ANSI/IEEE, FCC, and OSHA safety levels presented in Table 3.5-6. For the CEQA analysis, the project would result in a significant impact from EMF and EMI if it would:

- Expose a person to a documented EMF health risk, including a field intensity over the limit of an applicable standard, an electric shock, or interference with an implanted biomedical device
- Interfere with nearby sensitive equipment, including at hospitals, industrial and commercial facilities, railroads, rail transit systems, or airports

Numerical EMF and EMI thresholds for determining CEQA significance for human exposure and interference are defined as follows:

- **Human exposure**—The MPE limit (IEEE 2002) (Table 3.5-4) for 60-Hz magnetic fields for the instantaneous exposure of the general public is 9.04 G (9,040 mG or 904 μT); the MPE for controlled environments where only employees are present is 27.12 G (27,120 mG or 2,712 μT). The MPE limit (IEEE Standard C95.6) (Table 3.5-5) for 60-Hz electric fields for the general public is 5,000 V/m (5 kV/m). The MPE is 20,000 V/m (20 kV/m) for controlled environments in which only HSR employees would work. Additionally, MPE limits for employees with pacemakers are lower, with a maximum of 1 G (1,000 mG or 100 μT) for exposure to magnetic fields and 1,000 V/m (1 kV/m) for exposure to electric fields. Table 3.5-7 summarizes these numerical limits. These levels are not-to-exceed values, with no allowance for exposure duration. The IEEE Standard C95.6 was formally adopted by ANSI and is used regularly throughout the United States to analyze potential impacts related to EMF. The safety levels established by this standard are well below the levels at which scientific research has shown harmful effects may occur, thus incorporating a large safety factor (IEEE 2006). The HSR electrification and traction systems would mainly generate 60-Hz EMFs, which this standard addresses (IEEE 2002).
- **Interference**—The threshold for determining CEQA significance from EMI is a shift of 2 mG in the background magnetic field. This threshold is also a screening level for potential disturbance to unshielded sensitive equipment as identified in the Footprint Report (Authority 2012a).

Table 3.5-7 Maximum Permissible Exposure Levels to Determine CEQA Significance

Sensitive Receptor Type	Frequency Range (Hz)	Exposure Limit for Magnetic Fields (mG)	Exposure Limit for Electric Fields (V/m)
General public	60	9,040	5,000
HSR employees	60	27,120	20,000
HSR employees with pacemakers	60	1,000	1,000

Sources: *IEEE 2002; ACGIH 2015*
HSR = high-speed rail
Hz = hertz
mG = milligauss
V/m = volts per meter

3.5.5 Affected Environment

This section describes the affected environment related to EMF and EMI in the RSA, including sources of EMF and EMI; local conditions; and receptors susceptible to EMF or EMI impacts along the footprint for each project alternative. This information provides the context for the environmental analysis and evaluation of impacts.

3.5.5.1 Regional and Local Sources of Electromagnetic Fields and Electromagnetic Interference

A variety of localized, as well as pervasive, wide-scale regional sources generate EM emissions. Pervasive sources (e.g., television, radio) are present over large areas extending tens to hundreds of miles from the broadcast antennas and are captured in measurements taken at the various measurement sites. Localized sources are typically substantial only within a few miles of the transmitting antenna, with observed levels above background just at the measurement site nearest the source. Localized RF sources could include law enforcement, fire, and other emergency communications, commercial and civilian transmissions including amateur radio, and others. EM emissions are further characterized by temporal variations, as many EMF emitters operate only occasionally.

The measured regional sources along the Project Section include strong telecommunication transmitters that broadcast over a large area, radars and navigational aids, and electrical substations. These sources include AM and FM radio stations, land mobile radio transmitters, air-to-ground transceivers, cellular telephone antennas, microwave communication links, and television station transmissions. The Project Section is also in the vicinity of two international airports. San Francisco International Airport (SFO) and Norman Y. Mineta San Jose International Airport (SJC) are approximately 1,000 and 1,600 feet from the project footprint, respectively. Sources that were visually identified as near or in the line of sight of the measurement locations were photographed (see Volume 2, Appendix 3.5-A). Photographs taken at measurement locations along the Project Section show the presence of many EM sources including police and fire department and FM radio transmitters.

3.5.5.2 Local Conditions

The Project Section would be within an existing and historic rail corridor, largely within the Caltrain right-of-way from San Francisco to San Jose. Adjacent land uses are urban and suburban and consist of low- to high-density residential housing, mixed-use developments, commercial, industrial, and vacant uses (refer to Section 3.13, Station Planning, Land Use, and Development, for a more detailed discussion of existing land uses). As is typical of urban areas, high-voltage overhead power lines and associated urban infrastructure are prevalent along the Project Section, as are laboratories and medical facilities that operate EMI-sensitive research or medical devices.

The Authority determined existing local conditions by measuring EMF levels at representative locations selected through a review of aerial imagery, field visits, county parcel data, and local planning documents within the RSA. This review concentrated on identifying potentially EMI-sensitive facilities, as well as existing EMF sources, such as power distribution and communications facilities. An initial list of approximately 70 candidate sites was identified for further evaluation. The evaluation criteria, taken from TM 3.4.11, *Measurement Procedure for Assessment of CHSTP Alignment EMI Footprint* (Authority 2010a), favored providing a balanced coverage of:

- The geographic extent of the project
- High-emission sites
- Low-emission sites
- Sites with high-sensitivity receptors

A final group of 14 sites was selected based upon these considerations. These measurement locations are identified in Table 3.5-8 and illustrated on Figure 3.5-1 through Figure 3.5-5. The figures also illustrate the locations of major existing RF emitters in the region, including AM, FM and television transmitters, and cellular communications towers.

Table 3.5-8 Location and Description of Electromagnetic Field Measurement Sites

Site	City	Location	Geographic Coordinates	Notable EMF Sources or Sensitive Receptors
San Francisco to South San Francisco Subsection				
1	San Francisco	C Street/Owens Street	37.767722°, -122.395489°	UCSF Mission Bay Medical Center: An urban location, with university buildings containing sensitive instrumentation including research MRI systems.
2	Brisbane	Bayshore Boulevard/ Valley Drive	37.687718°, -122.399457°	Near the Brisbane Fire Station: Suburban location, in the parking lot of the fire station, which has multiple RF communication systems.
3	Brisbane	Bayshore Boulevard/ Van Waters Road	37.681158°, -122.393923°	Quiet Site: An open area near Brisbane Lagoon.
4	South San Francisco	Gateway Boulevard/ Oyster Point Boulevard	37.660396°, -122.400218°	Gateway Research Park in South San Francisco: Multiple biotechnology tenants operate NMR equipment; transmission lines are located south of the site.
San Bruno to San Mateo Subsection				
5	San Bruno	Monterey Street/ Madrone Street	37.610129°, -122.396565°	Near SFO: RF environment includes SFO, and magnetic field transients[1] due to Caltrain and BART.
6	Burlingame	Trousdale Drive/ California Drive	37.595437°, -122.381704°	Adjacent to the Burlingame Police Station: The police station is a potential RF emitter. A nearby facility has MRI and CT imaging systems that are potentially sensitive to EMI.
San Mateo to Palo Alto Subsection				
7	San Carlos	Old County Road/ Inverness Drive	37.510969°, -122.263314°	Quiet Site: Residential street east of the Caltrain alignment, surrounding areas largely residential/light commercial.
8	Redwood City	Arguello Street/ Brewster Avenue	37.488378°, -122.234697°	Valley Radiological: A potentially sensitive medical facility with MRI.
9	Atherton	Fair Oaks Lane/ Dinkelspiel Station Lane	37.464290°, -122.197755°	Atherton Police Department: A potential emitter with RF communication systems, adjacent to the Atherton Caltrain Station southbound platform. The surrounding community is largely residential.
10	Palo Alto	Urban Lane/Wells Ave	37.440126°, -122.159531°	Palo Alto Medical Center: A potentially sensitive site with medical imaging systems.

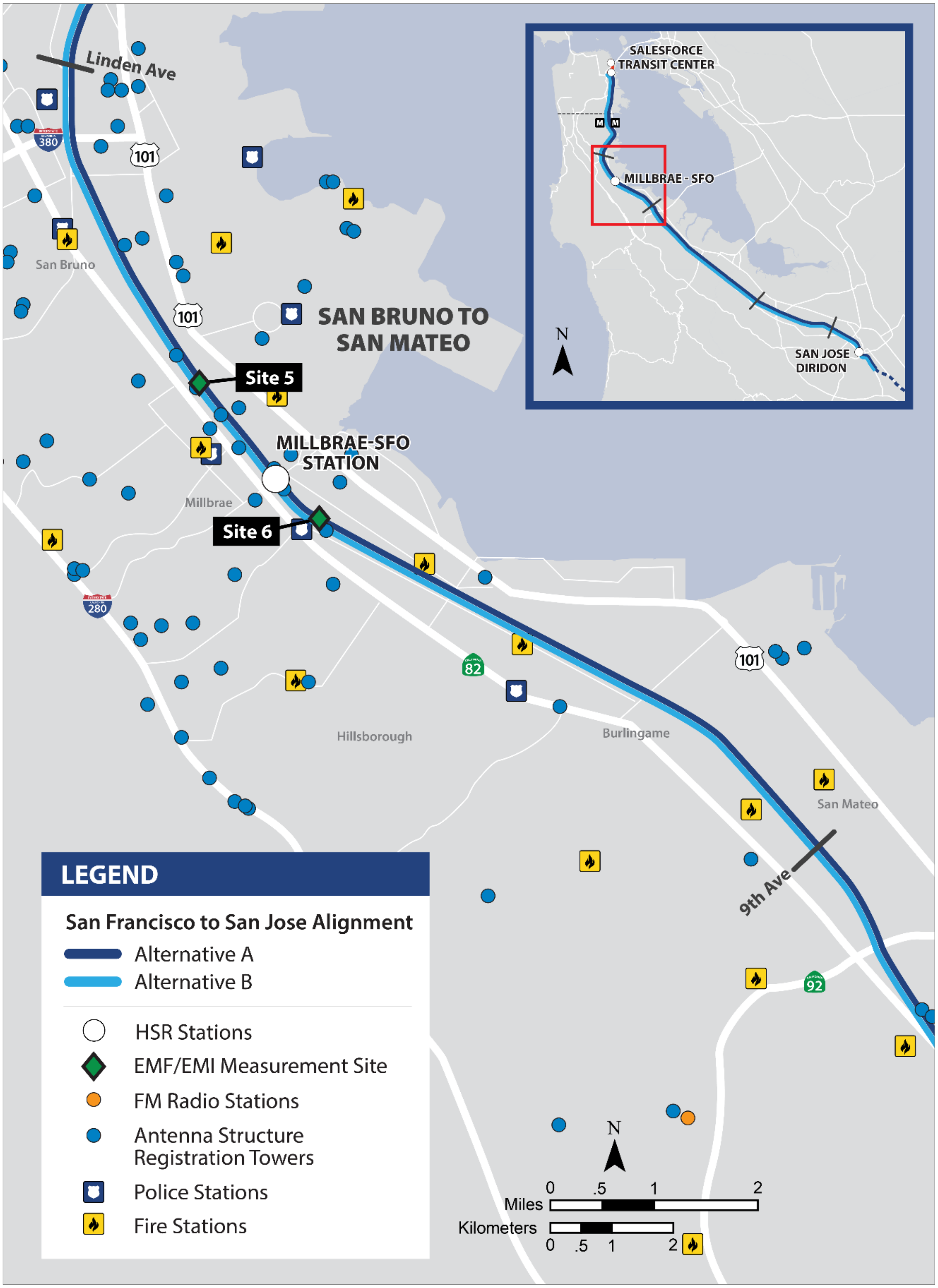
Site	City	Location	Geographic Coordinates	Notable EMF Sources or Sensitive Receptors
Mountain View to Santa Clara Subsection				
11	Mountain View	Franklin Street/Evelyn Avenue	37.395923°, -122.080568°	Near a facility used by the Mountain View Fire and Police Departments, which are potential RF emitters.
12	Sunnyvale	Kifer Road/San Lucar Court	37.373863°, -122.012087°	Evans Analytical (an analytical instrumentation company): A potentially sensitive site with SEM/TEM equipment.
San Jose Diridon Station Approach Subsection				
13	San Jose	Newhall Street/Newhall Drive	37.347447°, -121.923012°	Adjacent to Avaya Stadium; nearby cell towers; SJC communications and aviation RF sources.
14	San Jose	Montgomery Street/ Otterson Street	37.328142°, -121.902140°	Adjacent to San Jose Diridon Station and PG&E substation.

BART = Bay Area Rapid Transit
CT = computed tomography
EMF = electromagnetic fields
MRI = magnetic resonance imaging
NMR = nuclear magnetic resonance
PG&E = Pacific Gas and Electric Company
RF = radio frequency
SEM = scanning electron microscopy
SFO = San Francisco International Airport
SJC = Norman Y. Mineta San Jose International Airport
TEM = transmission electron microscopy
UCSF = University of California, San Francisco
[1] Magnetic field transients are momentary changes in current, voltage, or frequency, which occur during Caltrain and BART train passbys on the adjacent tracks (140 feet from this measurement point).

Source: Cavell 2018

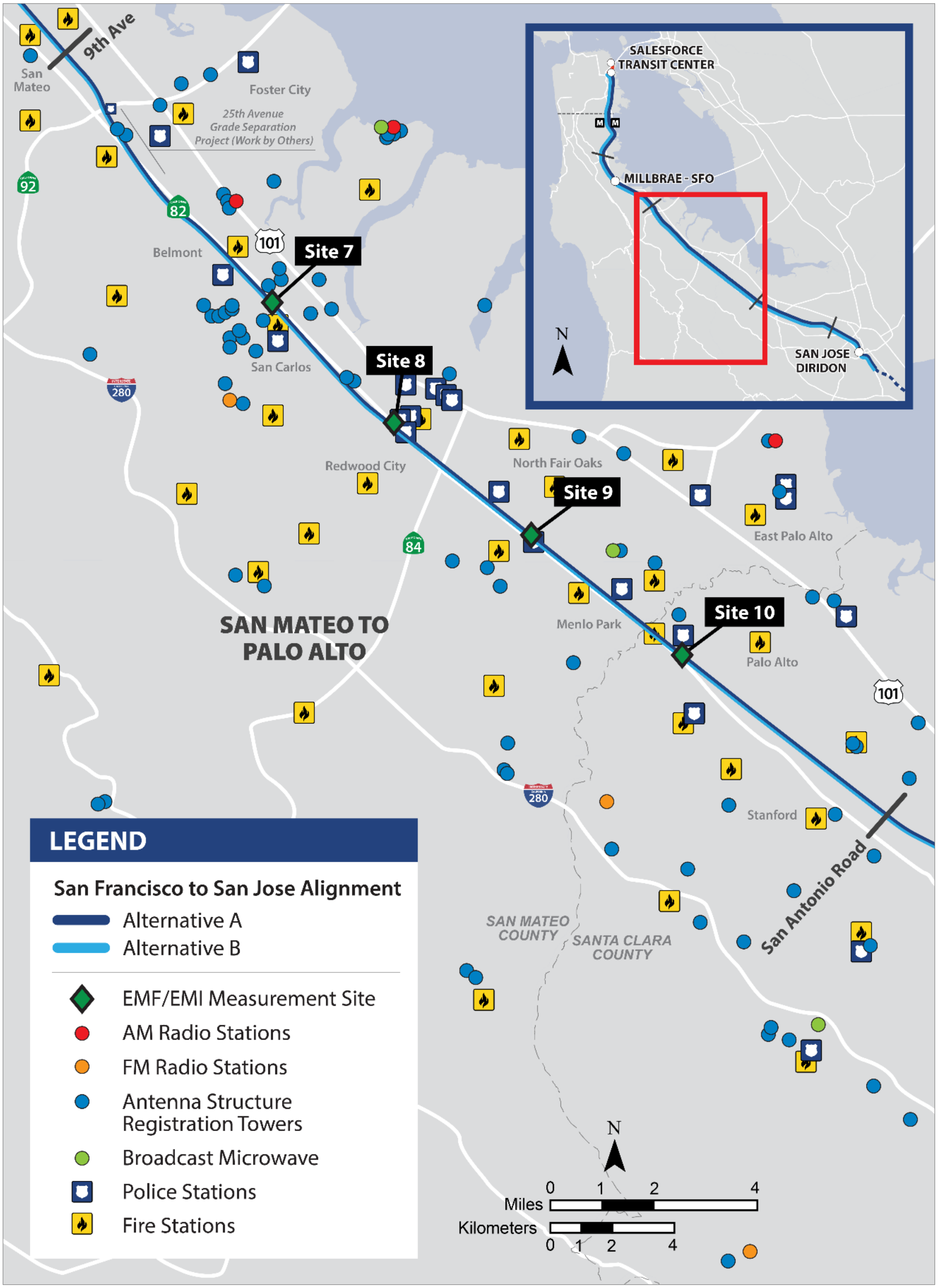
APRIL 2019

Figure 3.5-1 EMF Measurement Site Locations with Existing Sources of EMF and EMI: San Francisco to South San Francisco Subsection



Source: Cavell 2018 APRIL 2019

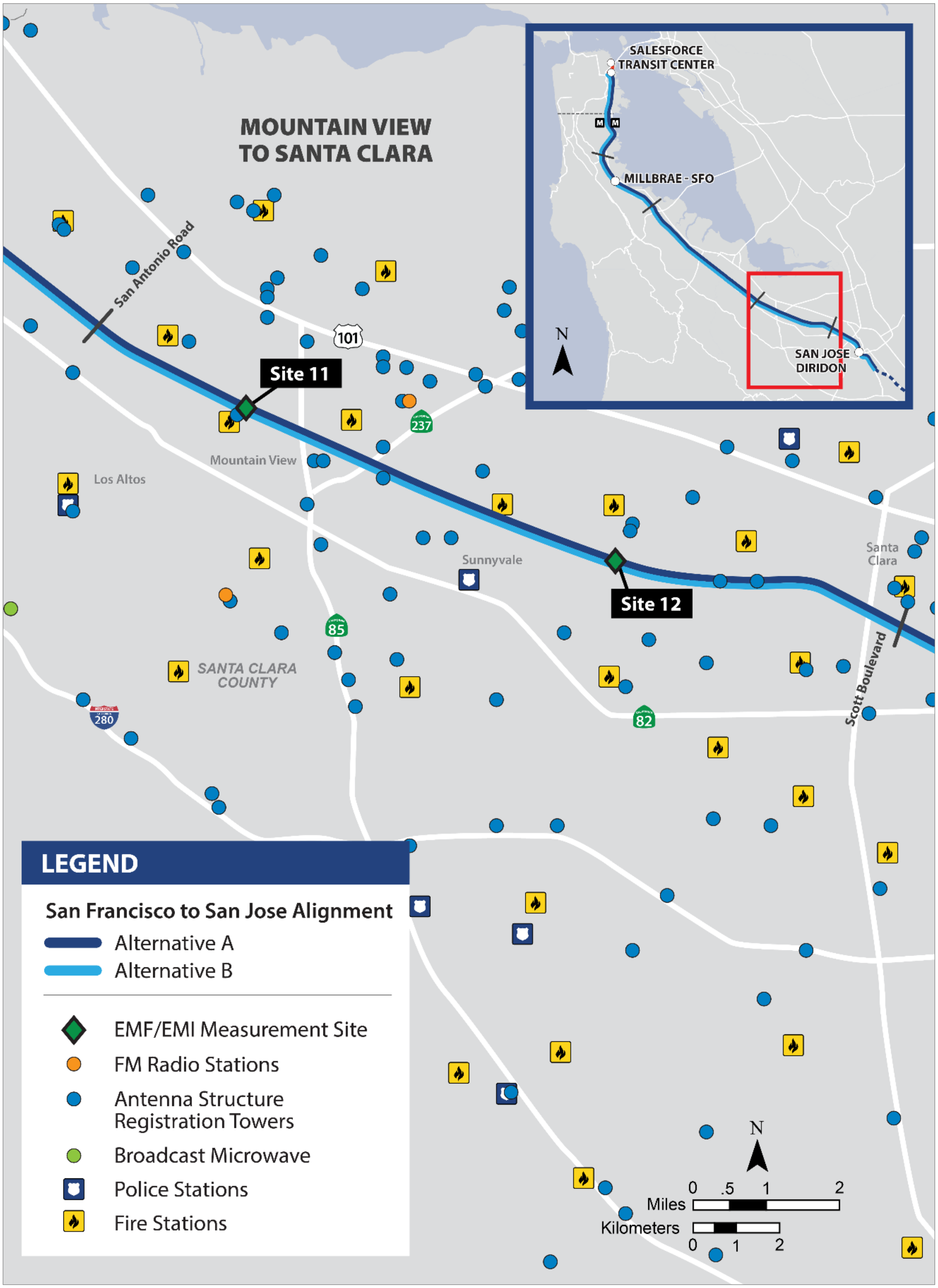
Figure 3.5-2 EMF Measurement Site Locations with Existing Sources of EMF and EMI: San Bruno to San Mateo Subsection



Source: Cavell 2018

APRIL 2019

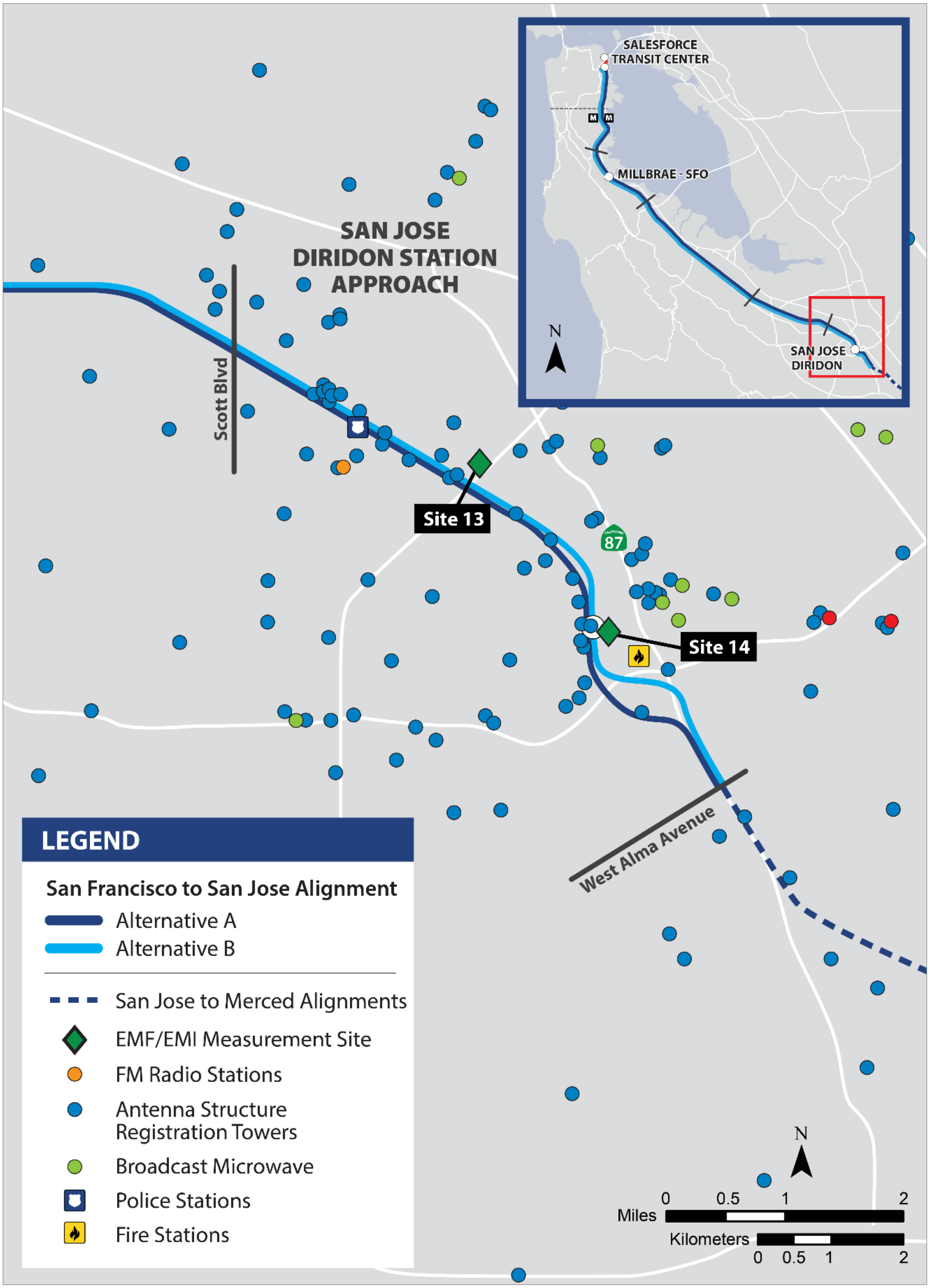
Figure 3.5-3 EMF Measurement Site Locations with Existing Sources of EMF and EMI: San Mateo to Palo Alto Subsection



Source: Cavell 2018

OCTOBER 2018

Figure 3.5-4 EMF Measurement Site Locations with Existing Sources of EMF and EMI: Mountain View to Santa Clara Subsection



Source: Cavell 2018

APRIL 2019

Figure 3.5-5 EMF Measurement Site Locations with Existing Sources of EMF and EMI: San Jose Diridon Station Approach Subsection

The field survey measured RF levels from 10 kHz to 6 GHz, which encompasses many different applications, including broadcast radio and digital television signals, fixed and mobile communications, cellular telephones, and radar and navigation systems. In general, high measured RF levels were observed throughout the Project Section because of the density of development and infrastructure. Typical power-frequency magnetic field levels within the Project Section were quantified to characterize typical DC and ELF (i.e., up to 1,000 Hz) sources such as high-voltage transmission lines, electrical distribution lines, and electrical substations or generating equipment. The maximum or peak 60-Hz magnetic fields recorded in this survey varied widely from approximately 0.1 mG to approximately 17 mG, depending primarily on the measurement locations' proximity to local distribution and transmission power lines (Table 3.5-9). The field survey measurement results are discussed in detail in Volume 2, Appendix 3.5-A.

Table 3.5-9 summarizes the distance of the measurement site from the nearest track, and the measured electric field and AC (60-Hz) magnetic field strengths at each of the measurement sites within the project RSA. The electric field and magnetic field strengths all fall within expected limits for this type of urban and suburban environment.

Table 3.5-9 Measured 60-Hertz Magnetic Field Strengths

Site/Community	Distance from Nearest Blended System Track (feet)	Measured Electric Field[1] (V/m)	Field Intensity (mW/cm^2)	Measured 60-Hz Magnetic Field (mG)
San Francisco to South San Francisco Subsection				
1 - San Francisco	155 (Alt A, B)	10.8	0.016	0.39
2 - Brisbane	27 (Alt A) 68 (Alt B)	7.3	0.007	0.09
3 - Brisbane	55 (Alt A, B)	15.1	0.030	0.14
4 - South San Francisco	90 (Alt A, B)	13.5	0.024	0.09
San Bruno to San Mateo Subsection				
5 - San Bruno	130 (Alt A, B)	9.1	0.011	0.57
6 - Burlingame	25 (Alt A, B)	13.6	0.025	6.85
San Mateo to Palo Alto Subsection				
7 - San Carlos	70 (Alt A) 50 (Alt B)	18.4	0.045	7.42
8 - Redwood City	145 (Alt A, B)	17.4	0.040	0.97
9 - Atherton	40 (Alt A, B)	15.3	0.031	0.27
10 - Palo Alto	50 (Alt A, B)	14.3	0.027	0.93
Mountain View to Santa Clara Subsection				
11 - Mountain View	95 (Alt A, B)	17.2	0.039	0.04
12 - Sunnyvale	260 (Alt A, B)	17.4	0.040	1.67

Site/Community	Distance from Nearest Blended System Track (feet)	Measured Electric Field[1] (V/m)	Field Intensity (mW/cm^2)	Measured 60-Hz Magnetic Field (mG)
San Jose Diridon Station Approach Subsection[2]				
13 - San Jose	245 (Alt A, Alt B (I-880)) 170 (Alt B (Scott))	14.9	0.059	5.12
14 - San Jose	260 (Alt A) 235 (Alt B)	21.5	0.123	16.8

Alt = Alternative
Hz = Hertz
mG = milligauss
mW/cm^2 = milliwatts per square centimeter
V/m = volts per meter
[1] Maximum observed electric field strength in any frequency band
[2] For the San Jose Diridon Station Approach Subsection, Alternative B (Viaduct to I-880) is abbreviated as "(I-880)" and Alternative B (Viaduct to Scott Boulevard) is abbreviated as "(Scott)."

As part of the baseline condition, the PCEP (construction of which is anticipated to be completed by 2022) would increase the magnetic fields generated near the tracks above the measured levels identified in Table 3.5-9. Sources of EMFs associated with PCEP include the traction power distribution system (including TPSSs, paralleling stations, and a switching station), the OCS system and NF system, and train motors on the electrical multiple units. Table 3.5-10 summarizes the calculated field strengths for the electrified Caltrain service at several general locations: onboard passenger cars, at rail overpasses, within and outside of the Caltrain right-of-way, and proximate to TPSSs. TPSSs would generate the most substantial EMF of the traction power facilities. The elements making up the traction power system would be the dominant EMF sources throughout the Caltrain corridor and the levels shown represent baseline conditions following construction of the PCEP. The field strengths from the traction power system diminish rapidly with distance from the tracks but remain the primary contributor to the baseline environment within the RSA. For 7 of the 14 locations shown in Table 3.5-9, the EMF levels resulting from Caltrain operations would determine the baseline level out to the limit of the RSA. At the remaining 7 locations, Caltrain-generated levels remain the dominant source out to distances ranging from 60 to 250 feet.

Table 3.5-10 Estimated Electromagnetic Field Strength for Caltrain Operations

Location	Electric Field (kV/m)	60-Hz Magnetic Field (mG)	
		Average/Off-Peak	Maximum
Passenger coach	0.0015–0.002	52	305
Overpass	N/A	11.6–15.1	29.3
Outside right-of-way[1]	0.35	1.9–4.5	11.4
Within right-of-way[2]	0.48	4–11	35–41
Traction power substation	0.136 (average) 0.744 (maximum)	15	110

Source: PCJPB 2015
Hz = Hertz
kV/m = kilovolt per meter
mG = milligauss
N/A = not applicable
[1] Estimates for a location 58 feet from the track centerline.
[2] Estimates for a location approximately 15 feet from the track centerline.

3.5.5.3 Sensitive Receptors and Facilities

Table 3.5-11 identifies 76 discrete facilities within the RSA with the potential to be affected by construction and operation of the project. The table includes the receptor/facility type, location, proximity of the receptor/facility to the tracks and project footprint at each receptor/facility location. These receptors/facilities were identified based on their proximity to the blended system tracks, stations, LMF, or associated infrastructure, proximity to construction activities, or both. Of these 76 receptors/facilities, 73 fall within the RSA for both project alternatives. The exceptions are sites 70 (Alternative A only), and sites 8 and 67 (Alternative B only).

Table 3.5-11 Sensitive Receptors and Facilities Potentially Affected by Project Construction and Operations

Site ID	Facility	Location	Distance to Nearest Blended System or HSR Track (feet)	Distance to Construction Easement (feet)
San Francisco to South San Francisco Subsection				
1	San Francisco Fire Department #8	36 Bluxome Street, San Francisco	465 (Alt A, B)	330
2	UCSF Mission Bay Medical Center	1650 Owens Street, San Francisco	170 (Alt A, B)	110
3	Esprit Park	Minnesota and 19th Street, San Francisco	400 (Alt A, B)	>1,000
4	Progress Park	Indiana and 25th Street, San Francisco	350 (Alt A, B)	>1,000
5	RISE Institute	1760 Cesar Chaves Street, San Francisco	477 (Alt A, B)	>1,000
6	City College of San Francisco, Southeast Center	1800 Oakdale, San Francisco	100 (Alt A, B)	150
7	KIPP Bayview Academy	1060 Key Avenue, San Francisco	465 (Alt A, B)	>1,000
8	Intermune Corporation	3280 Bayshore Boulevard, Brisbane	345 (Alt B)	233 (Alt B)
9	Brisbane Fire Department	3445 Bayshore Boulevard, Brisbane	155 (Alt A) 78 (Alt B)	Adjacent
10	Genentech Gateway Campus	681 Gateway Boulevard, South San Francisco	360 (Alt A, B)	>1,000
San Bruno to San Mateo Subsection				
11	Bayshore Circle Park	Bayshore Boulevard and Atlantic, San Bruno	360 (Alt A, B)	>1,000
12	Belle Air Elementary School (includes Belle Air Preschool)	450 3rd Avenue, San Bruno	530 (Alt A, B)	>1,000
13	Lions Park	500 1st Avenue, San Bruno	150 (Alt A, B)	>1,000
14	Lomita Park Elementary	200 St Helena, San Bruno	180 (Alt A, B)	255

Site ID	Facility	Location	Distance to Nearest Blended System or HSR Track (feet)	Distance to Construction Easement (feet)
15	San Francisco International Airport[1]	San Francisco County	1,000 (Alt A, B)	>1,000
16	Health Diagnostics	1860 El Camino Real, Burlingame	218 (Alt A, B)	110
17	Village Park	1535 California Drive, Burlingame	160 (Alt A, B)	>1,000
18	Central County Fire Department #36	1399 Rollins Road, Burlingame	360 (Alt A, B)	91
19	Burlingame Police Department	1111 Trousdale Drive, Burlingame	105 (Alt A, B)	20
20	Burlingame High School	1 Mangini Way, Burlingame	350 (Alt A, B)	610
21	Stanbridge Academy	515 East Poplar Avenue, San Mateo	410 (Alt A, B)	425
22	Alpine Park	Alpine & Carolan, Burlingame	135 (Alt A, B)	>1,000
23	Central County Fire Department #34	799 California Drive, Burlingame	190 (Alt A, B)	770
24	Petite Sorbonne Preschool	319 Santa Inez Avenue, San Mateo	200 (Alt A, B)	190
25	Kinder Academy Montessori	300 Santa Inez Avenue, San Mateo	340 (Alt A, B)	330
San Mateo to Palo Alto Subsection				
26	Trinta Park	150 19th Avenue, San Mateo	55 (Alt A) 45 (Alt B)	Adjacent
27	La Esquelita Christian Academy	2075 Palm Avenue, San Mateo	165 (Alt A) 160 (Alt B)	120
28	The Burkard School	2333 Palm Avenue, San Mateo	65 (Alt A, B)	25
29	Alexander Park	400 Yorkshire Way, Belmont	440 (Alt A) 415 (Alt B)	395
30	Laureola Park	503 Old County Road, San Carlos	380 (Alt A) 360 (Alt B)	300
31	Redwood High School	1968 Old County Road, Redwood City	100 (Alt A) 110 (Alt B)	55
32	Valley Radiological	801 Brewster Avenue, Redwood City	155 (Alt A, B)	195
33	Roselli Park	Pennsylvania & Maple, Redwood City	45 (Alt A, B)	170
34	Wings Learning Center	1201 Main Street, Redwood City	63 (Alt A, B)	15

Site ID	Facility	Location	Distance to Nearest Blended System or HSR Track (feet)	Distance to Construction Easement (feet)
35	RCSD Child Development Services - Garfield Children's Center	3600 Middlefield Road, Menlo Park	445 (Alt A, B)	415
36	IHSD, INC - Menlo Park Head Start Center	3500 Middlefield Road, Menlo Park	315 (Alt A, B)	285
37	Atherton Town Offices	91 Ashfield Road, Atherton	200 (Alt A, B)	160
38	Holbrook-Palmer Park	150 Watkins Avenue, Atherton	45 (Alt A, B)	25
39	Lydian Academy	815 El Camino Real, Menlo Park	400 (Alt A, B)	537
40	Burgess Park	701 Laurel Street, Menlo Park	190 (Alt A, B)	880
41	El Camino Park	155 El Camino Real, Palo Alto	50 (Alt A, B)	>1,000
42	University Park Fire Station #1	301 Alma Street, Palo Alto	180 (Alt A, B)	>1,000
43	Palo Alto Medical Foundation	795 El Camino Real, Palo Alto	160 (Alt A, B)	485
44	AltSchool PBC	930 Emerson Street, Palo Alto	370 (Alt A, B)	340
45	Palo Alto High (includes Palo Alto Special Education and Adult Education)	50 Embarcadero Road, Palo Alto	70 (Alt A, B)	180
46	Peers Park	1899 Park Boulevard, Palo Alto	25 (Alt A, B)	>1,000
47	Jerry Bowdin Park	2380 High Street, Palo Alto	95 (Alt A, B)	>1,000
48	Robles Park	4116 Park Boulevard, Palo Alto	240 (Alt A, B)	65
49	Palo Alto Infant-Toddler Center	4111 Alma Street, Palo Alto	180 (Alt A, B)	>1,000
50	Crescent Park Community Child Care	4161 Alma Street, Palo Alto	155 (Alt A, B)	>1,000
Mountain View to Santa Clara Subsection				
51	Rengstorff Park	201 Rengstorff Avenue, Mountain View	100 (Alt A, B)	75
52	Khan Lab School	1200 Villa Street, Mountain View	212 (Alt A, B)	>1,000
53	Mountain View Fire Department	1000 Villa Street, Mountain View	240 (Alt A, B)	665
54	View High School	655 Evelyn Avenue, Mountain View	238 (Alt A, B)	>1,000

Site ID	Facility	Location	Distance to Nearest Blended System or HSR Track (feet)	Distance to Construction Easement (feet)
55	Evans Analytical	810 Kifer Road, Sunnyvale	280 (Alt A, B)	>1,000
56	Bracher Park	2560 Alhambra Drive, Santa Clara	85 (Alt A, B)	>1,000
San Jose Diridon Station Approach Subsection[2]				
57	Reed Street Dog Park	888 Reed Street, Santa Clara	65 (Alt A, B (I-880)) 75 (Alt B (Scott))	Adjacent
58	Larry J. Marsalli Park	1425 Lafayette Street, Santa Clara	340 (Alt A, B (I-880)) 410 (Alt B (Scott))	Adjacent
59	Santa Clara Police Department	601 El Camino Real, Santa Clara	155 (Alt A, B (I-880)) 80 (Alt B (Scott))	Adjacent
60	San Jose International Airport[1]	1701 Airport Boulevard, San Jose	1,710 (Alt A, B (I-880)) 1,630 (Alt B (Scott))	>1,000
61	Newhall Park	972 Newhall Street, San Jose	320 (Alt A, B (I-880)) 250 (Alt B (Scott))	>1,000
62	Bellarmine College Preparatory	960 West Hedding Street, San Jose	100 (Alt A) 200 (Alt B)	Adjacent
63	College Park	Elm Street and Hedding Street, San Jose	625 (Alt A) 650 (Alt B (I-880)) 710 (Alt B (Scott))	Adjacent
64	Guadalupe River Trail, Reach 6	Woz Way to Virginia Street, San Jose	740 (Alt A) Adjacent (Alt B)	Adjacent
65	Theodore Lenzen Park	Stockton Avenue and Lenzen Street, San Jose	480 (Alt A) 960 (Alt B)	300
66	Cahill Park	West San Fernando Street & Wilson Avenue, San Jose	335 (Alt A) 360 (Alt B)	190
67	San Jose Fire Department Station 30	454 Auzerais Avenue, San Jose	2,000 (Alt A) 640 (Alt B)	160 (Alt B)
68	Los Gatos Creek Trail	East Main Street at College Avenue, San Jose	Adjacent (Alt A, B)	Adjacent
69	Gardner Elementary	502 Illinois Avenue, San Jose	850 (Alt A) 225 (Alt B)	320 (Alt A) 60 (Alt B)
70	Biebrach Park	Delmas Street and Virginia Street, San Jose	390 (Alt A) 1,080 (Alt B)	Adjacent (Alt A)
71	Fuller Park	Fuller Avenue & Park Avenue, San Jose	Adjacent (Alt A) 500 (Alt B)	Adjacent (Alt A) 440 (Alt B)
72	Tamien Child Care Center	1197 Lick Avenue, San Jose	215 (Alt A) 270 (Alt B)	120

Site ID	Facility	Location	Distance to Nearest Blended System or HSR Track (feet)	Distance to Construction Easement (feet)
73	Class I Bikeway	Willow Street to Curtner Avenue, San Jose	Adjacent (Alt A, B)	Adjacent
74	Highway 87 Bikeway	Along SR 87, San Jose	Adjacent (Alt A, B)	Adjacent
75	Jesse Frey Community Garden	West Alma Avenue and Belmont Way, San Jose	805 (Alt A) 770 (Alt B)	375
76	Three Creeks Trail	Highway 87 to Senter Road, San Jose	Adjacent (Alt A, B)	Adjacent

Alt = Alternative
Hz = Hertz
IHSD = Institute for Human and Social Development
mG = milligauss
PBC = Public Benefit Corporation
RCSD = Redwood City School District
UCSF = University of California, San Francisco
[1] Although the San Francisco International Airport and San Jose International Airport are outside the resource study area, they are included in this analysis as sensitive receptors given the safety-critical nature of the airports' radio-based systems and uncertainties about the locations of much of the airport equipment.
[2] For the San Jose Diridon Station Approach Subsection, Alternative B (Viaduct to I-880) is abbreviated as "(I-880)" and Alternative B (Viaduct to Scott Boulevard) is abbreviated as "(Scott)."

In addition to the sensitive receptors, existing passenger and freight rail systems operated by Caltrain, Union Pacific Railroad, and Bay Area Rapid Transit (BART), buried pipelines, ungrounded metallic fencing, and other linear receptors of concern are known to occur in the RSA and have potential EMI concerns. The existing rail systems within the project corridor potentially susceptible to EMI include signal systems, grade crossing systems, and by 2022, an OCS system, auto-transformer power feed system, and traction power distribution system consisting of TPSSs, switching stations, and paralleling stations that the PCJPB is building as part of the PCEP. The RSA also includes numerous underground pipelines (natural gas, water, and oil) that run parallel or transverse to the existing rail corridor. This infrastructure is ubiquitous in the RSA and is present in all five subsections under both project alternatives.

3.5.6 Environmental Consequences

3.5.6.1 Overview

This section discusses the potential impacts from EMF and EMI that could result from implementing the project alternatives. This section evaluates potential impacts of EMF and EMI on sensitive receptors and facilities including humans, sensitive equipment, schools, underground pipelines and cables, adjacent railroads, and airport communication systems.

Project construction would generate RF fields from occasional radio transmissions and DC magnetic field disturbances from movement of large construction vehicles and equipment. These impacts would be intermittent, occurring only during construction, and would be primarily restricted to the construction areas. Operations and maintenance activities would affect local EMF and EMI levels, potentially increasing EMF exposure of sensitive receptors or causing nuisance shocks. These impacts could be either temporary, occurring intermittently during operations of the project, or permanent, occurring continuously during operations.

The Authority has incorporated two IAMFs to address EMF and EMI that are described in Volume 2, Appendix 2-E. Both IAMFs reference the Implementation Stage Electromagnetic Compatibility Program Plan (ISEP) and relevant sections of the *California High-Speed Train Project Design Criteria* (Authority 2014a, 2014b). These documents include the features and procedures for complying with EMF and EMI standards by specifying standard design practices for electronic equipment, requiring coordination with adjacent railroad engineering departments, designing the

HSR system to international guidelines, and complying with federal and state laws and regulations pertaining to EMF and EMI. Prior to the activation of any potentially interfering HSR systems, the Authority would contract with a qualified engineering professional to validate the efficacy of design provisions preventing interference.

The IAMFs differ from mitigation measures in that they are part of the project and would be implemented by the Authority as a binding commitment included in the project approval. In contrast, mitigation measures may be available to further reduce, compensate for, or offset project impacts that the analysis identifies under NEPA or concludes are significant under CEQA. As discussed in the following sections, there would be no significant impacts under CEQA associated with EMFs or EMI under either of the project alternatives. No mitigation measures are required.

3.5.6.2 No Project Impacts

As discussed in Section 3.17, Regional Growth, the population in the Bay Area is expected to grow through 2040 (see Section 2.6.1.1, Projections Used in Planning). Development in the region to accommodate the population and employment increase would continue under the No Project Alternative, resulting in associated increases in sources of EMF and EMI as well as sensitive receptors. The analysis of the No Project Alternative considers the impacts of conditions forecasted by current land use and transportation plans in the vicinity of the project, including planned improvements to the highway, aviation, conventional passenger rail, freight rail, and port systems through the 2040 planning horizon. Without the HSR project, the forecasted population growth would increase pressure to expand highway and airport capacities. The Authority estimates that additional highway and airport projects (up to 4,300 highway lane miles, 115 airport gates, and 4 airport runways) would be needed to achieve equivalent capacity and relieve the increased pressure (Authority 2012b). Section 3.18, Cumulative Impacts, identifies planned and other reasonably foreseeable future projects anticipated to be built in the region to accommodate the projected growth in the area, including shopping centers, industrial parks, transportation projects, and residential developments.

Under the No Project Alternative, recent development trends would be anticipated to continue, leading to increasing levels of EMFs and more occurrences of EMI. Existing land would be converted for residential, commercial, and industrial development, as well as for transportation infrastructure, to accommodate growth, increasing the use of and potential conflicts with EMFs. Use of electricity and RF communication equipment, including high-voltage transmission/power lines and directional and nondirectional (cellular and broadcast) antennas that result in EMFs and EMI, would continue and would likely increase within the RSA. Population growth alone would result in additional use of electricity and RF communications. In addition, the development of new schools, hospitals, police stations, and other facilities with sensitive equipment would increase the prevalence of receptors potentially sensitive to EMI.

The projected growth through 2040 would increase the use of electricity and RF communications because of increased development, greater use of electrical devices, and technological advances in wireless transmission (e.g., wireless data communication). As a result, generation of EMFs and EMI that might affect people and sensitive receptors would continue and would be expected to increase in the area. Under the No Project Alternative, the PCEP (planned for completion in 2022) would increase EMF levels along the existing Caltrain rail corridor. This and other planned development and transportation projects that could occur under the No Project Alternative would likely include building and equipment design features intended to address increased levels of EMF and EMI. Planned development would be required to comply with federal and state laws and regulations pertaining to EMF and EMI.

3.5.6.3 Project Impacts

Construction Impacts

Construction of the project alternatives would consist predominantly of track modifications, relocation of OCS poles, and installation of communication radio towers, four-quadrant gates at at-grade crossings, and perimeter fencing along the right-of-way. Construction would also involve roadway modifications, station modifications, modifications to or construction of new structures, and construction of the new Brisbane LMF and additional passing tracks (under Alternative B). Activities associated with building this infrastructure include establishing equipment and materials storage areas close to construction sites; demolishing existing structures to expand existing station areas; clearing and grubbing; handling, storing, hauling, excavating, and placing fill; possible pile driving; and building bridges, road modifications, and utility relocations. Construction activities are described in Chapter 2, Alternatives.

Impact EMF/EMI#1: Temporary Impacts from Use of Construction Equipment

Construction activities would use heavy equipment, trucks, and light vehicles, which, like all motor vehicles, generate EMFs. EMFs generated by motor vehicles, however, consist of highly localized fields and would attenuate within a few feet of each vehicle (Ferrari et al. 2001). The construction equipment, communications equipment, and construction activities would be effectively the same for either of the project alternatives; only the locations of construction activities would differ slightly between the alternatives.

Movement of large construction vehicles could result in transient changes to the static (DC) magnetic field. While such changes could interfere with some equipment, construction vehicles must be both very large and operate very close to the equipment in question to cause interference. As an example, vehicles weighing 50,000 pounds produce magnetic field shifts of approximately 0.5 mG at a distance of 70 feet (Electric Research and Management, Inc. 2007). For a construction vehicle with twice this mass, the magnetic field shift would be 1 mG at 70 feet or 2 mG at 50 feet. The magnitude of this disturbance would decrease with distance. Construction vehicles would pose no reasonable interference risk to magnetically sensitive equipment at passby distances greater than 50 feet because any magnetic shift at this distance would be below 2 mG. In general, all receptors that would be likely to operate sensitive equipment subject to potential interference by large construction equipment would be more than 50 feet from construction easements (see Table 3.5-11).

EMI during construction could be generated from occasional licensed radio transmissions between construction vehicles. As indicated in Section 3.5.1.1, Definition of Terminology, the HSR project would adhere to 47 C.F.R. Part 15 and its general provision that devices may not cause interference, must accept interference from other sources, and must prohibit the operation of devices once the operator is notified by the FCC that the device is causing interference. Adherence to these provisions would control the generation of EMI from communication equipment during construction activities. Unintended EMFs from use of construction vehicles, heavy equipment, and electric motors would be minor, and radio communications systems used on construction sites would comply with FCC regulations. Construction of the project would not be a source of EMI that could cause electric shocks; interfere with implanted medical devices; interfere with unshielded sensitive equipment; or affect the operation of nearby railroads, airports, or other businesses. Construction activities would also not result in EMF exposure to workers or to the public that exceeds the MPE limits summarized in Table 3.5-4 through Table 3.5-7.

CEQA Conclusion

The impact under CEQA would be less than significant for both project alternatives because EMF generated during construction would be below levels known to result in a documented health risk (Table 3.5-4 through Table 3.5-7). Shifts in the magnetic field from the movement of large construction equipment would not exceed the threshold of 2 mG for interference with sensitive equipment because all receptors likely to operate sensitive equipment subject to potential interference are more than 50 feet from the construction easements, where any such magnetic shifts would be below the 2-mG threshold. In addition, radio transmissions would comply with FCC regulations designed to prevent EMI, avoiding interference with equipment operated by nearby railroads, airports, schools, or other businesses. Therefore, CEQA does not require any mitigation.

Operations Impacts

Operations of the project alternatives would involve scheduled train travel along the blended system through the Bay Area, as well as inspection and maintenance along the track and railroad right-of-way and at stations, and on structures, fencing, power system, positive train control, and communications. Chapter 2 more fully describes operations and maintenance activities.

The baseline EMF assumes operation of the PCEP, including an OCS, auto-transformer power feed system, and traction power distribution system consisting of TPSSs, switching stations, and paralleling stations, which would accommodate HSR operations. This analysis evaluates the operations impacts of the additional infrastructure and train operations specific to the HSR systems along the blended corridor and in the portion of fully dedicated HSR corridor under Alternative B.

As shown in Table 3.5-9, the surveyed baseline 60-Hz magnetic field strengths varied substantially, ranging from 0.04 to 16.8 mG, with an average value of 3.0 mG. The predicted single-train magnetic field strengths at the same locations also vary, with the field strength depending on the track-to-site distance and are shown in Table 3.5-12. Projected levels range between 2.1 and 183 mG, and are on average 100 times greater than the measured background level.

Table 3.5-12 Predicted Magnetic Field Strengths at Measurement Locations

Site/Community	Distance from Nearest Track (feet)	Predicted 60-Hz Magnetic Field – Single Train Intensity (mG)
1 - San Francisco	155 (Alt A, B)	5.3
2 - Brisbane	27 (Alt A) 68 (Alt B)	183.0 28.2
3 - Brisbane	55 (Alt A, B)	43.4
4 - South San Francisco	90 (Alt A, B)	16.0
5 - San Bruno	130 (Alt A, B)	7.6
6 - Burlingame	25 (Alt A, B)	215.0
7 - San Carlos	70 (Alt A) 50 (Alt B)	26.6 52.6
8 - Redwood City	145 (Alt A, B)	6.1
9 - Atherton	40 (Alt A, B)	82.8
10 - Palo Alto	50 (Alt A, B)	52.6
11 - Mountain View	95 (Alt A, B)	14.3
12 - Sunnyvale	260 (Alt A, B)	1.8
13 - San Jose[1]	245 (Alt A, Alt B (I-880)) 170 (Alt B (Scott))	2.3 4.1
14 - San Jose[1]	260 (Alt A) 235 (Alt B)	1.8 2.3

Alt = Alternative
[1] For the San Jose Diridon Station Approach Subsection, Alternative B (Viaduct to I-880) is abbreviated as “(I-880)” and Alternative B (Viaduct to Scott Boulevard) is abbreviated as “(Scott).”

The baseline conditions for this analysis are typically dominated by the effects of the PCEP upgrades and associated Caltrain operations within 100 feet of the right-of-way centerline. At the minimum fence line distance of 30 feet from the alignment centerline, the baseline level would be

41 mG. The predicted 60-Hz single-train magnetic field strength at the same fence line distance (30 feet) would be 177 mG. Thus, the fence line operational field strength would typically exceed the background by just over a factor of four. This margin persists roughly to a distance of 150 to 250 feet from the fence line, at which point the baseline levels at some locations would approach or exceed the HSR field strengths. At the limits of the RSA (500 feet), background sources such as local distribution lines and other infrastructure typically would match or exceed the HSR-generated levels.

Table 3.5-13 shows the predicted magnetic field strength at either the nearest point of any receptor building, or, in the case of parks or other public areas, the nearest property boundary. The operational 60-Hz magnetic field strengths range from 0.05 mG to a high of 148 mG. The average value across receptor locations is 21 mG compared to the baseline average of 8 mG. The impact sections that follow more fully discuss the implications of this increase.

Table 3.5-13 Predicted Magnetic Field Strengths at Receptor Locations

Site ID	Facility	Distance to Nearest Blended System or HSR Track (feet)	Predicted 60-Hz Magnetic Field—Single Train (mG)
San Francisco to South San Francisco Subsection			
1	San Francisco Fire Department #8	465 (Alt A, B)	0.6
2	UCSF Mission Bay Medical Center	170 (Alt A, B)	4.4
3	Esprit Park	400 (Alt A, B)	0.8
4	Progress Park	350 (Alt A, B)	1.0
5	RISE Institute	477 (Alt A, B)	0.5
6	City College of San Francisco	100 (Alt A, B)	12.9
7	KIPP Bayview Academy	465 (Alt A, B)	0.6
8	Intermune Corporation	345 (Alt B)	0.1
9	Brisbane Fire Department	155 (Alt A) 78 (Alt B)	5.3
10	Genentech Gateway Campus	360 (Alt A, B)	3.2
San Bruno to San Mateo Subsection			
11	Bayshore Circle Park	360 (Alt A, B)	1.0
12	Belle Air Elementary School (includes Belle Air Preschool)	530 (Alt A, B)	0.4
13	Lions Park	150 (Alt A, B)	5.7
14	Lomita Park Elementary	180 (Alt A, B)	3.9
15	San Francisco International Airport[1]	1,000 (Alt A, B)	0.1
16	Health Diagnostics	218 (Alt A, B)	2.6
17	Village Park	160 (Alt A, B)	5.0
18	Central County Fire Department #36	360 (Alt A, B)	1.0
19	Burlingame Police Department	105 (Alt A, B)	11.7
20	Burlingame High School	350 (Alt A, B)	1.0

Site ID	Facility	Distance to Nearest Blended System or HSR Track (feet)	Predicted 60-Hz Magnetic Field—Single Train (mG)
21	Stanbridge Academy	410 (Alt A, B)	0.7
22	Alpine Park	135 (Alt A, B)	7.0
23	Central County Fire Department #34	190 (Alt A, B)	3.5
24	Petite Sorbonne Preschool	200 (Alt A, B)	3.2
25	Kinder Academy Montessori	340 (Alt A, B)	1.1
San Mateo to Palo Alto Subsection			
26	Trinta Park	55 (Alt A) 45 (Alt B)	65.2
27	La Esquelita Christian Academy	165 (Alt A) 160 (Alt B)	4.9 5.2
28	The Burkard School	65 (Alt A, B)	32.2
29	Alexander Park	440 (Alt A) 415 (Alt B)	0.7
30	Laureola Park	380 (Alt A) 360 (Alt B)	1.0
31	Redwood High School	100 (Alt A) 110 (Alt B)	12.9
32	Valley Radiological	155 (Alt A, B)	5.3
33	Roselli Park	45 (Alt A, B)	65.2
34	Wings Learning Center	63 (Alt A, B)	32.9
35	RCSD Child Development Services - Garfield Children's Center	445 (Alt A, B)	0.6
36	IHSD, INC - Menlo Park Head Start Center	315 (Alt A, B)	1.3
37	Atherton Town Offices	200 (Alt A, B)	3.2
38	Holbrook-Palmer Park	45 (Alt A, B)	65.2
39	Lydian Academy	400 (Alt A, B)	0.8
40	Burgess Park	190 (Alt A, B)	3.5
41	El Camino Park	50 (Alt A, B)	52.6
42	University Park Fire Station #1	180 (Alt A, B)	3.9
43	Palo Alto Medical Foundation	160 (Alt A, B)	5.0
44	AltSchool PBC	370 (Alt A, B)	0.6
45	Palo Alto High	70 (Alt A, B)	26.6
46	Peers Park	Adjacent (Alt A, B)	148.0
47	Jerry Bowdin Park	95 (Alt A, B)	14.3
48	Robles Park	240 (Alt A, B)	2.2

Site ID	Facility	Distance to Nearest Blended System or HSR Track (feet)	Predicted 60-Hz Magnetic Field—Single Train (mG)
49	Palo Alto Infant-Toddler Center	180 (Alt A, B)	3.9
50	Crescent Park Community Child Care	155 (Alt A, B)	5.3
Mountain View to Santa Clara Subsection			
51	Rengstorff Park	100 (Alt A, B)	12.9
52	Khan Lab School	212 (Alt A, B)	2.8
53	Mountain View Fire Department	240 (Alt A, B)	2.2
54	View High School	238 (Alt A, B)	2.2
55	Evans Analytical	280 (Alt A, B)	1.6
56	Bracher Park	85 (Alt A, B)	17.9
San Jose Diridon Station Approach Subsection[2]			
57	Reed Street Dog Park	65 (Alt A, B (I-880)) 75 (Alt B (Scott))	32.2 24.1
58	Larry J. Marsalli Park	340 (Alt A, B (I-880)) 410 (Alt B (Scott))	1.1 0.8
59	Santa Clara Police Department	155 (Alt A, B (I-880)) 80 (Alt B (Scott))	5.3 20.3
60	San Jose International Airport[1]	1,710 (Alt A, B (I-880)) 1,630 (Alt B (Scott))	0.1 0.1
61	Newhall Park	320 (Alt A, B (I-880)) 250 (Alt B (Scott))	2.0 1.2
62	Bellarmine College Preparatory	100 (Alt A) 200 (Alt B)	12.9 3.2
63	College Park	625 (Alt A) 650 (Alt B (I-880)) 710 (Alt B (Scott))	0.3 0.3 0.2
64	Guadalupe River Trail, Reach 6	740 (Alt A) Adjacent (Alt B)	0.2 148.0
65	Theodore Lenzen Park	480 (Alt A) 960 (Alt B)	0.5 0.1
66	Cahill Park	335 (Alt A) 360 (Alt B)	1.1 1.0
67	San Jose Fire Department Station 30	2,000 (Alt A) 640 (Alt B)	0.1 0.3
68	Los Gatos Creek Trail	Adjacent (Alt A, B)	148.0
69	Gardner Elementary	850 (Alt A) 225 (Alt B)	0.2 2.5

Site ID	Facility	Distance to Nearest Blended System or HSR Track (feet)	Predicted 60-Hz Magnetic Field—Single Train (mG)
70	Biebrach Park	390 (Alt A) 1,080 (Alt B)	0.8 0.1
71	Fuller Park	Adjacent (Alt A) 500 (Alt B)	148.0 0.5
72	Tamien Child Care Center	215 (Alt A) 270 (Alt B)	2.7 1.7
73	Class I Bikeway	Adjacent (Alt A, B)	148.0
74	Highway 87 Bikeway	Adjacent (Alt A, B)	148.0
75	Jesse Frey Community Garden	805 (Alt A) 770 (Alt B)	0.2 0.2
76	Three Creeks Trail	Adjacent (Alt A, B)	148.0

Adjacent = Some portion of the receptor property falls within the nominal right-of-way of the indicated alignment (within 25 feet of the nearest track).
Alt = Alternative
Hz = Hertz
IHSD = Institute for Human and Social Development
mG = milligauss
PBC = Public Benefit Corporation
RCSD = Redwood City School District
UCSF = University of California, San Francisco
[1] Although the San Francisco International Airport and San Jose International Airport are outside the resource study area, they are included in this analysis as sensitive receptors given the safety-critical nature of the airports' radio-based systems and uncertainties about the locations of much of the airport equipment.
[2] For the San Jose Diridon Station Approach Subsection, Alternative B (Viaduct to I-880) is abbreviated as "(I-880)" and Alternative B (Viaduct to Scott Boulevard) is abbreviated as "(Scott)."

Impact EMF/EMI#2: Permanent Human Exposure to Electromagnetic Fields

HSR operations would result in permanent, but intermittent, EMF exposure to passengers (general public) on the HSR train station platforms, and HSR and Caltrain employees working within the right-of-way. The two project alternatives would use the same technology and would operate at the same intensity, so EMF emissions would be largely the same for either of the project alternatives.

Operation of the HSR system would generate 60-Hz electric and magnetic fields on and adjacent to trains, including in passenger station areas. The design of the project would substantially limit and control EMF. The system being installed by Caltrain (and by HSR at the Brisbane LMF) is a 2x25-kV Autotransformer System that includes an NF above the OCS and running parallel to the OCS. This power configuration allows the transfer of most of the traction power return current flowing in the running rails to the NF which considerably reduces the size of the loop formed by the supply current in the OCS and the return current in the NF.

Table 3.5-14 presents predicted EMF levels that passengers or members of the public could be exposed to at a station platform, at the fence line, and 500 feet from the track centerline. In all cases, the predicted EMF value would be less than the most restrictive MPE limits (for employees with pacemakers, as identified in Table 3.5-7) of 1 kV/m for electric fields and 1,000 mG for magnetic fields.

EMF levels due to project operations at other locations, including the 14 survey sites shown in Table 3.5-12 and at the 77 sensitive receptor locations shown in Table 3.5-13 are in almost all cases elevated above the baseline levels, typically by a factor of two to three. While the levels are elevated with respect to the baseline condition, the field strengths do not approach even the most stringent MPE limit value of 1,000 mG (Table 3.5-7).

Table 3.5-14 Summary of HSR Exterior Electromagnetic Field Levels

EMF Modeled Analysis	Platform: 16 Feet from Alignment Centerline	Fence Line: 30 Feet from Alignment Centerline	Study Area: 500 Feet from Alignment Centerline
Magnetic field (mG) single-train HSR	720	177	Less than 1
Electric field (V/m) single-train HSR	810	110	Less than 1

Source: Authority 2011
EMF = electromagnetic field
HSR = high-speed rail
mG = milligauss
V/m = volts per meter

Passengers and HSR employees inside the HSR trains also would be exposed to EMFs. Magnetic field measurements were made in the passenger compartments on board other HSR systems such as the Acela Express (119 mG) and the French Train à Grande Vitesse (TGV) A (165 mG), as well as in the operator's cab of the Acela Express (58 mG) and French TGV A (367 mG) (FRA 2006). Measured EMF exposure levels inside these existing HSR systems were below the most restrictive MPE limits of 1,000 mG for the HSR employees with pacemakers (IEEE 2002). As part of PCEP, the PCJPB would install an OCS with a 2x25-kV supply with an NF running parallel to the contact wire that reduces the magnetic field and the return current in the rails. This arrangement would differ in some cases from the systems employed by the Acela Express and TGV systems and, in general, would be expected to produce magnetic fields that are equal to or lower than the quoted values on the other HSR systems. For example, the electrified Northeast Corridor used by the Acela Express is not 2x25 kV; some sections are 1x12.5 kV or 11.5 kV and the magnetic fields in these sections without the negative return feeder would be higher than with a 2x25-kV traction system arrangement (Authority 2010b). Based on the results of magnetic field measurements at other existing HSR systems and the use of the 2x25-kV supply for the blended system, EMF exposure levels would be below the most restrictive MPE limits and not create a documented EMF health risk to HSR passengers and employees.

Exposure of the general public outside of the Caltrain corridor (e.g., nearby adjacent businesses, residences, hospitals, schools, parks, and other facilities) to magnetic and electric fields from HSR operations would not exceed 177 mG and 110 V/m, respectively (measured at 30 feet from the track centerline as shown in Table 3.5-13). For the additional TPSS facility in San Jose under Alternative B, the magnetic and electric field strengths at the TPSS perimeter fence would not exceed 20 mG and 1,500 V/m, respectively. These anticipated magnetic and electric fields would be below the MPE limit for exposure of the general public to magnetic fields of 9,040 mG and to electric fields of 5,000 V/m.

CEQA Conclusion

The impact under CEQA would be less than significant for both alternatives because the EMFs generated during HSR operations would fall well below the applicable MPE limits; consequently, the general public and HSR employees would not be exposed to a documented EMF health risk. Therefore, CEQA does not require any mitigation.

Impact EMF/EMI#3: Exposure of People with Implanted Medical Devices to Electromagnetic Fields

Passengers and members of the public with implanted medical devices are especially sensitive to EMFs. Magnetic fields of 1,400 to 24,000 mG (1 to 12 G) may interfere with implanted medical devices (Dawson 2002; Trigano 2005). The ACGIH has recommended magnetic and electric field exposure limits of 1,000 mG and 1 kV/m, respectively, for people with pacemakers (ACGIH 2015). EMF levels exceeding these limits would only occur only inside traction power distribution facilities, which would be installed as part of PCEP and would serve the blended system. These facilities would be unmanned and inaccessible to the general public. Levels would fall well below this limit outside of the right-of-way.

In addition to traction power distribution facilities, emergency standby generators produce EMF and would be located at the 4th and King Street Station, Millbrae Station, San Jose Diridon Station, and the Brisbane LMF. The standby generators would also be in secure work areas and inaccessible to the general public. Because the traction power distribution and emergency standby generators would only be accessible to authorized personnel, they would not present a health risk to HSR passengers or other members of the public with implanted medical devices.

EMF levels above the recommended limits for employees with implanted medical devices could exist inside traction power distribution facilities, interconnection facilities, traction power switching and paralleling facilities, and the emergency standby generator rooms. These facilities and sites would be unmanned, and workers would only enter them periodically to perform routine maintenance. EMF/EMI-IAMF#2, through the ISEP, would make sure that persons with an implanted medical device would not be permitted near these facilities and sites. In addition, signs posted around these facilities would warn persons with implanted medical devices of high levels of EMFs. Because the same project features would apply for both alternatives, the impacts would also be the same.

CEQA Conclusion

The impact under CEQA would be less than significant for both alternatives because the public and workers with implanted medical devices would not be exposed to an EMF health risk. Traction power distribution facilities and emergency standby generator facilities, which can produce EMF levels that could interfere with implanted medical devices, would be inaccessible to the general public and administratively restricted from workers with implanted medical devices. Therefore, CEQA does not require any mitigation.

Impact EMF/EMI#4: Interference with Sensitive Equipment

Medical and high-technology facilities commonly contain equipment that could be affected by EMI, including equipment sensitive to small variations in the surrounding magnetic field (e.g., medical MRI scanners, NMR spectrometers) and focused-beam devices (e.g., electron microscopes, ion-writing systems). As described in the Footprint Report, a shift in the magnetic field of 2 mG or greater is the screening level for assessing potential impacts on this type of sensitive equipment (Authority 2012a). Other forms of equipment sensitive to EMFs include those susceptible to RF interference, such as fire and police radio services. Impacts on school radio systems are discussed under Impact EMF/EMI#5: Electromagnetic Interference with Schools.

Four potentially sensitive medical facilities—University of California, San Francisco (UCSF) Medical Center Mission Bay, Health Diagnostics in Burlingame, Valley Radiological in Redwood City, and Palo Alto Medical Foundation (Sites 2, 16, 32, and 43, respectively, in Table 3.5-11)—and three industrial/research facilities—Intermune Corp in Brisbane, Genentech Gateway Campus in South San Francisco, and Evans Analytical in Sunnyvale (Sites 8, 10, and 55, respectively, in Table 3.5-11) operate magnetically sensitive imaging equipment (i.e., MRI, e-beam CT scanners, and scanning electron microscopes/transmission electron microscopes) in the RSA. Each of these facilities is within the RSA for both project alternatives, with the exception of Intermune Corp (Site 8), which is near the West Brisbane LMF and is within the RSA for Alternative B only. Of these facilities, five (UCSF Medical Center, Genentech, Health Diagnostics, Valley Radiological, and Palo Alto Medical) could be exposed to magnetic shifts of 2 mG or greater, from operations under either project alternative. Ten receptors including police and fire departments in San Francisco, Brisbane, Burlingame, San Mateo County, Palo Alto, Mountain View, Santa Clara, San Jose, and a municipal office in Atherton (Sites 1, 9, 18, 19, 23, 37, 42, 53, 59, and 67, respectively in Table 3.5-11) may be sensitive to RF interference. All ten receptors are within the RSA for Alternative B, while nine of these receptors are within the RSA for Alternative A.

RF interference from HSR radio systems used for communication would be avoided through the design characteristics and project features (IAMFs). The Authority would require that communications equipment procured for HSR use, including commercial and noncommercial off-the-shelf products, comply with FCC regulations designed to prevent EMI with other equipment or hazards to persons. The HSR project design for communications equipment would also comply with the ISEP under EMF/EMI-IAMF#2, which provides detailed EMC design criteria for the HSR systems and equipment. As part of the ISEP, the Authority would confirm compatibility of the HSR with other users' radio systems, such as those for police and fire departments, and thus avoid potential RF interference. In addition, the Authority has acquired two dedicated frequency blocks, one block each for Northern and Southern California, and each with a width of 4 MHz, for use by automatic train control systems. These blocks are in the 700-MHz spectrum and are dedicated for HSR use and therefore not subject to interference from or with other users. Communications systems at stations may operate at WiFi frequencies to connect to stationary trains; channels would be selected to avoid EMI with other users (Authority 2011, 2014a, 2016).

The potential for interference with sensitive equipment in use at medical facilities and high-technology facilities would be addressed through the Authority's Electromagnetic Compatibility Program Plan (EMCPP) and the design criteria of the project. The EMCPP defines the HSR system's EMC objective, which provides a performance standard of compatibility with equipment of all neighboring facilities. In conformance with the EMCPP and ISEP (TM 300.10), the Authority and its contractors would coordinate with third-party owners of sensitive facilities and equipment in the vicinity of the HSR system and, if necessary, take specific steps to avoid any potential interference (EMF/EMI-IAMF#2). Chapters 22 and 26 of the HSR Design Criteria Manual describe the EMI-related features that could be used to minimize impacts on sensitive equipment, such as equipment siting and grounding of equipment (Authority 2014b). The Authority would also conduct tests prior to HSR operations to confirm equipment is not affected. These project features would minimize the potential for interference with sensitive equipment at medical buildings and high-technology facilities.

CEQA Conclusion

The impact under CEQA would be less than significant for both alternatives because communications equipment procured for HSR use would comply with FCC regulations designed to prevent EMI interference with sensitive equipment or persons. The HSR project design also would comply with TM 300.10, which provides detailed EMC design criteria for the HSR systems and equipment with other equipment. The Authority would coordinate with third parties to identify nearby sensitive equipment with the potential to be affected by HSR operations, including the HSR communication system and, if necessary, take specific steps to avoid these impacts and ascertain compatibility, including performing tests to confirm equipment is free from impacts (EMF/EMI-IAMF#2). RF interference would be avoided because the project would include use of dedicated frequency blocks and procurement of communications equipment meeting FCC regulations. The potential for interference with high-technology electronic devices would be minimized through project design intended to prevent EMI with identified neighboring uses. Therefore, CEQA does not require any mitigation.

Impact EMF/EMI#5: Electromagnetic Interference with Schools

The project would use radio-based communication systems, raising the concern that HSR communication equipment used during operation would result in EMI with WiFi or other wireless communications systems in use at nearby schools and colleges. The following 25 schools, universities, and childcare centers were identified within the RSA for both project alternatives (the site numbers refer to Table 3.5-11):

- RISE Institute, San Francisco (Site 5)
- City College of San Francisco, Southeast Center, San Francisco (Site 6)
- KIPP Bayview Academy, San Francisco (Site 7)
- Belle Air Elementary School (includes Belle Air Preschool), San Bruno (Site 12)
- Lomita Park Elementary, San Bruno (Site 14)

- Burlingame High School, Burlingame (Site 20)
- Stanbridge Academy, San Mateo (Site 21)
- Petite Sorbonne Preschool, San Mateo (Site 24)
- Kinder Academy Montessori, San Mateo (Site 25)
- La Esquelita Christian Academy, San Mateo (Site 27)
- The Burkard School, San Mateo (Site 28)
- Redwood High School, Redwood City (Site 31)
- Wings Learning Center, Redwood City (Site 34)
- Redwood City School District Child Development Services - Garfield Children's Center, Menlo Park (Site 35)
- Institute for Human and Social Development, INC - Menlo Park Head Start Center, Menlo Park (Site 36)
- Lydian Academy, Menlo Park (Site 39)
- AltSchool PBC, Palo Alto (Site 44)
- Palo Alto High, Palo Alto (Site 45)
- Palo Alto Infant-Toddler Center, Palo Alto (Site 49)
- Crescent Park Community Child Care, Palo Alto (Site 50)
- Khan Lab School, Mountain View (Site 52)
- View High School, Mountain View (Site 54)
- Bellarmine College Preparatory, San Jose (Site 62)
- Gardner Elementary, San Jose (Site 69)
- Tamien Child Care Center, San Jose (Site 72)

HSR radio systems would transmit radio signals from antennas at stations and along the track alignment and on locomotives and train cars. The Authority has acquired two dedicated frequency blocks for use by the enhanced automatic train control systems (Authority 2011, 2014a, 2016). WiFi frequencies to be used by HSR would be selected to avoid EMI with other users, including WiFi systems used at nearby schools.

The Authority would implement an ISEP during project planning and implementation to support EMC with radio systems operated by neighboring uses, including schools and colleges. From the planning stage through system design, the Authority would perform EMC/EMI safety analyses, which would include identification of existing nearby radio systems, design of systems to prevent EMI with identified neighboring uses, and incorporation of these project features into bid specifications used to procure radio systems (EMF/EMI-IAMF#2).

During operations, the Authority would conduct monitoring and evaluation of communication system performance to minimize the potential for HSR-generated EMF to affect school communication systems. Moreover, most radio systems procured for HSR use are expected to be commercial off-the-shelf systems conforming to FCC regulations at 47 C.F.R. Part 15, which contain emissions requirements designed to support EMC among users and systems. The Authority would require all noncommercial off-the-shelf systems procured for HSR use to be certified in conformity with FCC regulations for Part 15, Sub-Part B, Class A devices. HSR radio systems would also meet emissions and immunity requirements contained in the European Committee for Electrotechnical Standardization (CENELEC) EN 50121-4 Standard for railway signaling and telecommunications operations that are designed to support EMC with other radio users (CENELEC 2006).

CEQA Conclusion

The impact under CEQA would be less than significant for both alternatives because radio systems would use frequency blocks dedicated to HSR use. All HSR equipment would meet FCC regulations (47 C.F.R. Part 15), which would avoid the potential for interference. Monitoring and evaluation of system performance would be ongoing during operations to support EMC with other radio users. Therefore, CEQA does not require any mitigation.

Impact EMF/EMI#6: Potential for Corrosion of Underground Pipelines and Cables and Adjoining Rail

As part of PCEP, the PCJPB would install the 2x25-kV traction electrification system that would deliver AC current to the HSR trains through the OCS contact wire, with return current flowing from the trains back to the traction power distribution facilities through the NFs, steel rails, and static wires. Operation of HSR trains on the system would generate higher AC currents than is expected for Caltrain operations. With this electrification system, most of the return current to the TPSS in the rails would be transferred to the along-track NFs. While most return current would be carried by the NF back to the TPSS, some return current would find a path through rails to the ground through leakage paths.

Linear metallic objects such as buried pipelines or cables, or adjoining rails, could carry some AC ground current depending upon the type and water content of the intervening soils (see Section 3.9, Geology, Soils, Seismicity, and Paleontological Resources). AC ground currents have a much lower propensity to cause corrosion in parallel conductors than the DC currents used by rail transit lines such as BART or the Los Angeles County Metropolitan Transportation Authority (Hosokawa 2006; Brenna et al. 2014). Nonetheless, such stray AC currents might cause corrosion by galvanic action.

Because the project must comply with federal regulations, the Authority would require the contractor to follow the ISEP to avoid and minimize the potential for impacts on underground pipelines and cables, including requiring the grounding of pipelines. If adjacent pipelines and other linear metallic structures are not sufficiently grounded through direct contact with earth, the Authority would include additional grounding of pipelines and other linear metallic objects, in coordination with the affected owner or utility, as part of the construction of the HSR system. Alternatively, insulating joints or couplings may be installed in continuous metallic pipes to prevent current flow. Both alternatives would be adjacent to pipelines and other linear metallic structures and include project features (EMF/EMI-IAMF#2) that would avoid the potential for corrosion from ground currents.

CEQA Conclusion

The impact under CEQA would be less than significant for both alternatives because project features would avoid and minimize interference with sensitive equipment from corrosion by arranging for the grounding of nearby ungrounded linear metal structures or insulating metallic pipes to prevent current flow. Therefore, CEQA does not require any mitigation.

Impact EMF/EMI#7: Potential for Nuisance Shocks

Nuisance shocks can occur when induced electrical currents build voltage in ungrounded linear metal structures that are capable of conducting electric current. EMFs from the voltage and currents running through the OCS would have the potential to induce voltage and current in nearby conductors, such as ungrounded metal fences alongside the alignment. This impact would be more likely where long (i.e., 1 mile or more), ungrounded fences run parallel to the alignment and are electrically continuous throughout that distance. Such voltages could potentially cause a nuisance shock to anyone who touches such a fence. Most metal structures adjacent to the alignment should already be properly grounded through compliance with National Electrical Code guidelines for building and electrical system safety and lightning protections. Nevertheless, the potential for unidentified, ungrounded structures along the alignment exists.

To avoid possible shock hazards to people, the project design would include grounding of HSR fences, non-HSR parallel metal fences, and other linear metal structures (with the cooperation of the affected owner or utility) within a specified lateral distance of the alignment (EMF/EMI-IAMF#2). In addition, insulating sections could be installed in fences to prevent the possibility of current flow. Ungrounded fences with a potential for nuisance shocks would be identified as part of the EMC coordination effort. Such measures would minimize the potential for nuisance shocks. For cases where such fences are purposely electrified, site-specific insulation design measures would be designed and implemented to minimize the potential for nuisance shocks. Both project alternatives would be adjacent to parallel metal features and would avoid possible shock hazards by identifying and grounding ungrounded infrastructure.

CEQA Conclusion

The impact under CEQA would be less than significant for both alternatives because project features would avoid and minimize the potential for nuisance shocks by grounding nearby ungrounded linear metal structures or insulating purposely electrified fences to prevent current flow. Consequently, people would not be exposed to a substantial EMF health risk. Therefore, CEQA does not require any mitigation.

Impact EMF/EMI#8: Impacts on Adjacent Existing Rail Lines

Signal systems control the movement of trains on the existing railroad tracks in the Caltrain corridor and adjacent existing tracks between San Francisco and San Jose. In addition to signals used for Caltrain service operations, there are adjacent lines used by freight service as well as BART. These signal systems serve three general purposes:

- To warn drivers of street vehicles that a train is approaching. The rail signal system turns on flashing lights and warning bells; some crossings lower barricades to stop traffic.
- To warn train engineers of other train activity on the same track a short distance ahead and advise the engineer that the train should either slow or stop. This is done by using changing, colored (green, yellow, or red) trackside signals in older railroads and by cab indications in newer railroads.
- To show railroad dispatchers in a central control center where trains are located on the railway so that train movements can be controlled centrally for safety and efficiency.

Rail systems also use electronic control equipment for track switches along the corridor. Railroad signal systems operate in several ways, but are generally based on the principle that the railcar metal wheels and axles electrically connect the two running rails. An AC or DC voltage applied between the rails by a signal system would be shorted out (i.e., reduced to a low voltage) by the rail-to-rail connection of the metal wheel-axle sets of a train. This low-voltage condition is detected and interpreted by the signal system to indicate the presence of a train on that portion of track.

As part of the PCEP currently under construction by PCJPB, electrification and signal system upgrades would be designed to protect the existing signal systems of adjacent passenger rail, freight rail, and BART by installing proper electrical grounding and shielding; installing specialized components, such as filters, capacitors, and inductors; and incorporating design standards to minimize the impacts of EMI on signal systems. Further, the PCJPB would implement a mitigation measure (Mitigation Measure EMF-2) designed to minimize EMI impacts during final design; monitor EMI impacts during testing, commission and operations; and remediate substantial disruption of sensitive electrical equipment, to reduce PCEP EMI impacts to a less-than-significant level (PCJPB 2015).

The EMF strength from the HSR radio communication towers along the corridor would be similar to or below levels currently observed in the project corridor and would operate at frequencies that would avoid EMI with other RF services. The EMF strength from operation of trains at faster speeds (110 mph vs. 79 mph) than currently planned by the PCJPB for the PCEP and the realignment of certain parts of the OCS would result in slightly higher levels of EMF than those with the PCEP alone.

The PCEP EMC improvements address potential impacts of HSR operations on signal and controls for other rail services. Furthermore, the HSR contractor would work with the engineering departments of Caltrain, freight railroads, and BART—all of which parallel the HSR line—to apply standard design practices when communication equipment or facilities are installed next to its tracks (EMF/EMI-IAMF#1). These standard design practices include assessment of the specific track signal and other communication equipment in use on nearby sections of existing rail lines, evaluation of potential impacts of HSR EMFs and RF interference on adjoining railroad equipment and application of suitable design provisions on the adjoining rail lines to prevent interference. Design provisions often include providing filters for sensitive communication equipment and potentially relocating or reorienting radio antennas. These standard design and operational practices would prevent the possible impacts that HSR operation might otherwise cause: disruption of the safe and dependable operation of the adjacent railroad signal system, resulting in train delays or hazards, or disruption of the road crossing signals, stopping road traffic from crossing the tracks when no train is there (Electric Power Research Institute 2006). These provisions would be put in place and determined to be adequately effective prior to the activation of potentially interfering HSR systems and would apply equally to the blended system and the dedicated HSR track with a separate OCS and traction power system in the southern portion of the Project Section under Alternative B.

CEQA Conclusion

The impact under CEQA would be less than significant for both project alternatives because interference with sensitive equipment of adjacent rail lines would be avoided, and there would be no impact on rail operations. The project features include working with the engineering departments of adjacent parallel railroads to avoid interference from HSR operations. Therefore, CEQA does not require any mitigation.

Impact EMF/EMI#9: Electromagnetic Interference with Airports

Airports operate radio and other electronic systems that are potentially susceptible to EMI from other radio systems. The project alternatives pass within 1,000 and 1,600 feet of SFO and SJC, respectively. While both airports are outside of the RSA, they have been included in this analysis as sensitive receptors given the safety-critical nature of the airports' radio-based systems and uncertainties about the locations of much of the equipment within each airport.

Airports and commercial aircraft are electronically complex. Navigation systems such as marker beacons, distance-measuring equipment, traffic-alert and collision-avoidance systems, microwave-landing systems, and global positioning systems operate across a wide range of RFs. EMI is an ongoing concern for aircraft electronic systems. Historically, EMI from high-powered sources such as radar and broadcast transmitters have resulted in numerous aviation incidents and accidents (National Aeronautics and Space Administration 1994). As a result, such sources are carefully considered in all aspects of design and certification of modern avionics. In addition, the radio spectrum for all aeronautical services has been coordinated and protected by federal law (47 C.F.R. § 2.106) to minimize the potential of EMI from all other radio services. With one minor exception,[5] all communications, instrument landing systems, and navigation services for U.S. aircraft operate in frequency bands exclusively reserved for those purposes. To comply with existing FCC requirements, HSR-related radio services would avoid these frequency bands. This mutually exclusive arrangement would also protect HSR communications systems from EMI due to airport and aircraft emissions.

The Authority has acquired two frequency blocks in the 700-MHz band dedicated to the HSR system (Authority 2016). In addition to avoiding frequency bands used by airport communication systems (because the HSR communication systems are within a dedicated frequency block that is not shared with other users, including airport communication systems), the Authority would require that communications equipment procured for HSR use, including commercial and

[5] Primary Air Surveillance Radars operate in shared-use bands. Even in this case, these shared uses are federally licensed and managed to avoid mutual interference.

noncommercial off-the-shelf products, complies with FCC regulations designed to prevent EMI with other equipment. The Authority would comply with the ISEP requirements during project planning and implementation to support compatibility with radio systems operated by SFO and SJC (EMF/EMI-IAMF#2). From the planning stage through system design, the Authority would perform EMC and EMI safety analyses, which would include:

- Coordination with the FAA spectrum engineering office and airport staff, as necessary;
- Identification of existing airport radio systems; and,
- Selection of systems to prevent EMI with identified airport uses, and incorporation of these requirements into bid specifications used to procure radio systems.

The ISEP would also include monitoring and evaluation of system performance to maintain compatibility with airport systems. Because the same project features would apply for both alternatives, the impacts would also be the same.

CEQA Conclusion

The impact under CEQA would be less than significant for both alternatives because radio systems used during project operations would not interfere with sensitive equipment at airports. The Authority has acquired dedicated frequency blocks for the HSR system, and all HSR equipment would meet FCC regulations (47 C.F.R. Part 15) for EMI, which would minimize the potential for interference. Therefore, CEQA does not require any mitigation.

3.5.7 Mitigation Measures

There would be no significant impacts under CEQA associated with EMFs or EMI under either of the project alternatives. No mitigation measures are required.

3.5.8 Impact Summary for NEPA Comparison of Alternatives

As described in Section 3.1.5.4, the effect of project actions under NEPA are compared to the No Project condition when evaluating the impact of the project on the resource. The determination of effect is based on the context and intensity of the change that would be generated by construction and operation of the project. Table 3.5-15 compares the project impacts by alternative, followed by a summary of the impacts.

Table 3.5-15 Comparison of Project Alternative Impacts for Electromagnetic Fields and Electromagnetic Interference

Impacts	Alternative A	Alternative B
Impact EMF/EMI#1: Temporary Impacts from Use of Construction Equipment	Temporary construction activity would cause fluctuations in EMF levels, although the practical effects would be limited to within 50 feet of the project footprint and would comply with FCC regulations. No individuals would be exposed to EMF levels that exceed human health standards.	Similar to Alternative A
Impact EMF/EMI#2: Permanent Human Exposure to Electromagnetic Fields	HSR operations would expose the general public and HSR employees to EMF inside and outside the system right-of-way. Inside the right-of-way, EMF exposure levels would be below the most restrictive MPE limits. Outside the right-of-way, EMF levels would not exceed the MPE thresholds for humans.	Same as Alternative A

Impacts	Alternative A	Alternative B
Impact EMF/EMI#3: Exposure of People with Implanted Medical Devices to Electromagnetic Fields	EMF levels generated inside traction power distribution and interconnection facilities that serve the blended system, and produced by emergency standby generators would be above the recommended limits for people with implanted medical devices. EMF/EMI-IAMF#2 through the ISEP would avoid impacts by restricting the public and workers with implanted medical devices from accessing these facilities.	Same as Alternative A
Impact EMF/EMI#4: Interference with Sensitive Equipment	The RSA includes six medical or industrial/research facilities with sensitive equipment, five of which would be exposed to a magnetic shift of greater than 2 mG. As part of EMF/EMI-IAMF#2, the Authority would coordinate with third parties to identify sensitive equipment at the known receptors with sensitive equipment. Procedures and project design measures included in the EMCPP, ISEP, and HSR Design Criteria Manual, including performing tests to confirm equipment is not adversely affected, would avoid impacts.	The RSA includes seven facilities with sensitive equipment, five of which would be exposed to a magnetic shift of greater than 2 mG. Coordination with third parties would be the same as Alternative A.
Impact EMF/EMI#5: Electromagnetic Interference with Schools	Dedicated frequency blocks for the HSR system and compliance with FCC regulations for all HSR equipment would not generate interference at the 25 schools within the RSA of Alternative A.	Same as Alternative A
Impact EMF/EMI#6: Potential for Corrosion of Underground Pipelines, Cables, and Adjoining Rail	The project would ground adjacent ungrounded linear metal structures or insulate metallic pipes to prevent current flow that could result in corrosion.	Same as Alternative A
Impact EMF/EMI#7: Potential for Nuisance Shocks	The project would ground nearby ungrounded linear metal structures or insulate purposely electrified fences to prevent current flow.	Same as Alternative A
Impact EMF/EMI#8: Impacts on Adjacent Existing Rail Lines	PCJPB is replacing all track circuit types on adjoining rail lines such that adjacent rail signaling systems will not be susceptible to EMI. As specified in EMF/EMI-IAMF#1, project features include working with the engineering departments of adjacent parallel railroads to prevent interference from HSR-generated EMI.	Same as Alternative A
Impact EMF/EMI#9: Electromagnetic Interference with Airports	The project alternatives would pass within 1,000 feet of San Francisco International Airport and 1,600 feet of the Norman Y. Mineta San Jose International Airport. HSR communications equipment would use dedicated frequency allocations and relevant FAA engineering offices would be consulted during project design to confirm no interference.	Same as Alternative A

EMF = electromagnetic fields
EMI = electromagnetic interference
FAA = Federal Aviation Administration
FCC = Federal Communications Commission
HSR = high-speed rail
mG = milligauss
MPE = maximum permissible exposure
NEPA = National Environmental Policy Act
PCJPB = Peninsula Corridor Joint Powers Board
RSA = resource study area

Temporary construction activity for both alternatives would cause fluctuations in EMF levels, although the practical impacts would be limited to within 50 feet of the project footprint and would comply with FCC regulations. EMF fluctuations that could be generated by construction vehicle movements related to Alternatives A or B would attenuate below background levels at all construction locations adjacent to facilities known to have sensitive equipment, and, therefore, construction activities would not affect any sensitive equipment at these locations because of shifts in the magnetic field. Similarly, EMFs generated during construction of either alternative would not exceed levels that could affect human health. Potential interference with sensitive equipment at the Palo Alto Medical Center under both alternatives would be addressed through pre-construction review and coordination with the Palo Alto Medical Center to avoid potential interference with neighboring land uses in accordance with federal and state laws requiring the project to avoid EMI (EMF/EMI-IAMF#2).

The project includes features (EMF/EMI-IAMF#2) that would avoid interference with sensitive equipment that could result from a shift in the magnetic field from HSR operations. RF interference would be avoided because the project includes use of dedicated frequency blocks and procurement of communications equipment meeting FCC regulations. Radio communications systems would comply with FCC regulations designed to prevent EMI, which would avoid interference with equipment operated by nearby railroads, airports, schools, or other businesses. The potential for interference with medical and other high-technology electronic devices would be minimized through project design intended to prevent EMI with identified neighboring uses. In addition, as described in the ISEP, the Authority would coordinate with third parties to identify nearby sensitive equipment with the potential to be affected by HSR operations and make sure the project design eliminates any impacts, including performing tests to confirm equipment is not adversely affected.

The public and workers with implanted medical devices would be restricted from accessing traction power distribution facilities, interconnection facilities, and emergency standby generator facilities, avoiding potential interference with these devices. The public and workers with implanted medical devices would, therefore, not be exposed to harmful EMF levels at traction power distribution facilities, interconnection facilities, and emergency standby generators. Per EMF/EMI-IAMF#2, and as required under the ISEP, signs posted around these facilities would warn persons with implanted medical devices of high levels of EMFs.

Dedicated frequency blocks for the HSR communication system and compliance with FCC regulations for all HSR equipment would avoid the potential for interference at 25 schools within the RSA for both project alternatives. The HSR radio system would use dedicated frequency blocks, and all HSR equipment would meet FCC regulations (47 C.F.R. Part 15), thereby minimizing potential EMI with school equipment. In addition, during the planning stage, the Authority would identify users of existing nearby radio systems and design the HSR communication system to prevent EMI with identified neighboring uses.

Ground currents generated by operation of the project are not expected to result in potential corrosion of adjacent rail operated by others. Project features include arranging for the grounding of nearby ungrounded linear metal structures or insulating metallic pipes to prevent current flow so that corrosion would not occur. The project also would maintain the insulation of purposely electrified fences.

Impacts on adjacent railroad lines and facilities from operations of the project alternatives would be avoided through pre-construction design coordination with adjacent railroads. As part of the PCEP, the PCJPB would replace all track circuit types on the adjoining rail lines with other types developed for operation on or near electric railways or adjacent to parallel utility power lines. Therefore, adjacent rail signaling systems would not be susceptible to EMI associated with HSR operation of communication radio towers or changes in EMFs due to changes in speeds.

The HSR radio system would use dedicated frequency blocks and would meet FCC regulations (47 C.F.R. Part 15) for EMI. HSR equipment would be selected in consultation with FAA RF interference specialists. Dedicated frequency allocations for HSR communications equipment and coordination with the relevant FAA engineering offices during the project design would avoid the potential for any interference with sensitive systems. The impact would be the same for both project alternatives.

3.5.9 CEQA Significance Conclusions

As described in Section 3.1.5.4, the impacts of project actions under CEQA are evaluated against thresholds to determine whether a project action would result in no impact, a less-than-significant impact, or a significant impact. Table 3.5-16 identifies the CEQA significance conclusions for each impact discussed in Section 3.5.6.

Table 3.5-16 CEQA Significance Conclusions and Mitigation Measures for Electromagnetic Fields and Electromagnetic Interference

Impacts	Impact Description and CEQA Level of Significance before Mitigation	Mitigation Measure	CEQA Level of Significance after Mitigation
Impact EMF/EMI#1: Temporary Impacts from Use of Construction Equipment	Less than significant for both alternatives: Pre-construction review and project features would comply with federal and state laws requiring the project to avoid EMI.	No mitigation measures are required	N/A
Impact EMF/EMI#2: Permanent Human Exposure to Electromagnetic Fields	Less than significant for both alternatives: EMF levels inside and outside the right-of-way would not exceed the MPE thresholds for humans.	No mitigation measures are required	N/A
Impact EMF/EMI#3: Exposure of People with Implanted Medical Devices to Electromagnetic Fields	Less than significant for both alternatives: The public and workers with implanted medical devices would be restricted from accessing facilities with elevated EMF.	No mitigation measures are required	N/A
Impact EMF/EMI#4: Interference with Sensitive Equipment	Less than significant for both alternatives: Coordination with third parties would identify sensitive equipment, develop measures to avoid interference and perform tests to confirm equipment is free from impacts.	No mitigation measures are required	N/A
Impact EMF/EMI#5: Electromagnetic Interference with Schools	Less than significant for both alternatives: Dedicated frequency blocks for the HSR system and compliance with FCC regulations for all HSR communication equipment would avoid interference with schools.	No mitigation measures are required	N/A
Impact EMF/EMI#6: Potential for Corrosion of Underground Pipelines and Cables and Adjoining Rail	Less than significant for both alternatives: Project would ground nearby ungrounded linear metal structures or insulate metallic pipes to prevent current flow.	No mitigation measures are required	N/A

Impacts	Impact Description and CEQA Level of Significance before Mitigation	Mitigation Measure	CEQA Level of Significance after Mitigation
Impact EMF/EMI#7: Potential for Nuisance Shocks	Less than significant for both alternatives: Project would ground nearby ungrounded linear metal structures or insulate purposely electrified fences to prevent current flow.	No mitigation measures are required	N/A
Impact EMF/EMI#8: Impacts on Adjacent Existing Rail Lines	Less than significant for both alternatives: Project would work with adjacent parallel railroads to avoid interference from HSR operations.	No mitigation measures are required	N/A
Impact EMF/EMI#9: Electromagnetic Interference with Airports	Less than significant for both alternatives: Project would use dedicated frequency allocations for HSR communications equipment and coordinate with the relevant FAA engineering offices during project design to avoid interference with sensitive systems.	No mitigation measures are required	N/A

EMF = electromagnetic field
EMI = electromagnetic interference
MPE = maximum permissible exposure
N/A = not applicable