3.5 Electromagnetic Fields and Electromagnetic Interference

Since publication of the Draft Environmental Impact Report (EIR)/Environmental Impact Statement (EIS), the following substantive changes have been made to this section:

- Section 3.5.2.1, Federal, was updated regarding the Federal Railroad Administration (FRA) Procedures for Considering Environmental Impacts. Footnotes were added regarding FRA's Environmental Procedures and the updated Council on Environmental Quality (CEQ) regulations issued after release of the Draft EIR/EIS.
- A clarification comparing the modeled high-speed rail (HSR) magnetic field strengths with measured ambient levels was added to Section 3.5.5.3, Sensitive Receptors and Facilities.
- Analysis about the Diridon design variant (DDV) and tunnel design variant (TDV), which was included in Section 3.20 in the Draft EIR/EIS, was incorporated into Impact EMF/EMI#1.
- Text was added to Impact EMF/EMI#2 to describe magnetic field strengths in the resource study area (RSA) and to clarify that higher speeds associated with the design variants would lead to slightly higher electromagnetic field strength.
- Impact EMF/EMI#10 was modified slightly to clarify EMI effects on airports.
- Table 3.5-14 was modified to incorporate the slightly higher field strength that would be generated with the design variants.
- Where appropriate, the verb "would," when used specifically to describe impact avoidance and minimization features (IAMFs) or mitigation measures, as well as their directly related activities, was changed to "will," indicating their integration into project design.

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 HSR in the San Jose to Central Valley Wye Project Extent (project or project extent) to affect potentially sensitive receptors.

In order to reduce the EMF/EMI from the HSR Traction Electrification System, the Authority is installing a 2x25-kilovolt (kV) Autotransformer System that includes a negative feeder (NF) wire located above the overhead contact system (OCS) and running parallel to it. This power configuration allows the majority of the traction power return current to flow in the NF, rather than the running rails. This considerably reduces the size of the current loop, and results in a corresponding reduction in the electromagnetic field.

Analysts identified current and projected sources of EMFs in the RSA based upon field surveys, a review of aerial imagery and government agency databases, and a review of local and state general plans. In addition, analysts identified potentially sensitive receptors within the RSA that may be susceptible to EMFs and EMI produced by the California HSR System. These receptors include adjacent railroads and rail transit systems, airports, residential dwellings, schools, preschools and daycare facilities, public parks, hospitals, commercial and industrial facilities, and agricultural operations (farms), including confined animal agriculture.

> *Purpose*
>
> Electromagnetic interference (EMI) is the disruption of operation of an electronic device when it is in the vicinity of an electromagnetic field (EMF) in the radio frequency (RF) spectrum that is caused by another electronic device. This EMI/EMF analysis was performed to protect sensitive equipment near the proposed alignments and inform the public with regards to any potential health impacts from construction and operation of the project.

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), exposure of livestock to EMF and EMI, interference with electromagnetically sensitive equipment, radio interference, electric shock risks, corrosion potential, interference with adjacent railroads, and interference with adjacent airports.

The following appendices in Volume 2 of this Final EIR/EIS provide additional details on EMF and EMI:

- Appendix 2-D, Applicable Design Standards, describes the relevant design standards for this project.
- Appendix 2-E, San Jose to Merced Project Section Impact Avoidance and Minimization Features, provides the list of all IAMFs incorporated into the project.
- Appendix 2-J, San Jose to Merced Project Section Regional and Local Plans and Policies, provides a list by resource of all applicable regional or local plans and policies.
- Appendix 3.5-A, Preconstruction Electromagnetic Measurement Survey of Locations along the San Jose to Merced Project Section, documents measurement results from a preconstruction electromagnetic survey.

EMF and EMI conditions in the project extent are important because of the potential impacts on the operation of electrical, magnetic, and electromagnetic devices. The following EIR/EIS resource sections provide additional information related to EMFs and EMI:

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

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 electromagnetic 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 electromagnetic device.

EMI is the interference that occurs when the EMF produced by a source adversely affects the operation of an electrical, magnetic, or electromagnetic 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 the HSR operation would consist of the following:

- **Power-frequency electric and magnetic fields from the traction power system and electrical infrastructure**—The traction power system and electrical infrastructure comprise traction power substations (TPSS), switching stations, paralleling stations, electrical lines, emergency generators that provide backup power to the stations in case of power outages, and utility feeder lines. The 25- kV operating voltage of the HSR traction power system would produce 60 Hz electric fields, and 60 Hz magnetic fields would be produced by the flow of currents providing power to the HSR vehicles. Along the tracks, magnetic fields would be produced by the flow of propulsion current to the trains in the OCS and the return current in the NF and the rails.

- **Harmonic magnetic fields from vehicles**—Depending upon the design of power equipment in the HSR 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. Unlike the traction power system, these sources are highly localized in the trains and move along the track with the trains.
- **Radio frequency (RF) fields**—RF fields are any of the electromagnetic 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 and FCC Office of Engineering Technology Bulletin No. 65, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields)*.

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

3.5.1.2 Characteristics of Electromagnetic Radiation

The electromagnetic (EM) spectrum consists of two types of radiation: ionizing and nonionizing. 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 extent.

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.

Table 3.5-1 Relationship between Typical Frequencies and Their Wavelengths

Frequency	Wavelength
1 Hz	186,000 miles
60 Hz	3,100 miles
10 kHz	18.6 miles
10 MHz	98.4 feet
100 MHz	9.8 feet

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[a]
Medium-Voltage Power Distribution Line (4 kV-24 kV)	10–70[a]

Source: NIEHS 2002
mG = milligauss
kV = kilovolts
[a] = Standing beneath the lines, for typical conductor heights for these line voltages

Naturally occurring EMFs consist of both electric fields and magnetic fields that are generated by 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.

While both direct current (DC) and AC electrical devices generate EMFs, the magnetic flux density[1] is much higher for DC than for AC current. The strength of an electric field is proportional to the strength of its electric charge (voltage), while the strength of a magnetic field is proportional to the motion of the charge (current); when no current is flowing in an electrical circuit, only the electrical field is present. The power of an electromagnetic field (i.e., the rate at which energy is transferred) is measured in Watts (W), and the power density (power distributed over a given cross-sectional area perpendicular to the direction of its flow) of the field is measured in Watts per square meter.

Electrical devices generate both near-field and far-field EMFs. Nonradiative near-field behaviors of EMFs dominate close to the device (e.g., within 1–2 wavelengths of their sources), while far-field behaviors dominate at greater distances. Near-field EM strength decreases in proportion to increasing distance from the source, while far-field EM strength decreases in proportion to the square of increasing distance from the source (the so-called *inverse-square law*).

[1] The amount of magnetic flux (the number of magnetic field lines passing through a closed surface, such as a conducting coil, through a unit area taken perpendicular to the direction of the magnetic flux).

EMF Frequencies

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

EMFs are described in terms of their frequency, which is the number of times the EMF increases and decreases in intensity each second. The U.S. 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 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 3–30 Hz and an upper limit of 30–3,000 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 (HF) and very high-frequency (VHF) 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 the 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-kV transmission line and a 115-kV power line are reduced by approximately 97 and 99 percent, respectively.

Table 3.5-3 Typical EMF 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
EMF = electromagnetic field
kV = kilovolt
kV/m = kilovolts per meter
mG = milligauss

EMF Exposure and Health Effects

EMFs can cause EMI, which can disrupt sensitive equipment (e.g., implanted medical devices), possibly triggering a malfunction. At sufficiently high exposure levels, EMFs also directly affect human health. 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 living 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 (IARC 2002; WHO 2007). However, EMF exposure and the potential adverse health effects, remains a human health concern (WHO 2007).

3.5.1.3 Electromagnetic Interference

General Considerations

EMI is an electromagnetic 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).

EMI and Radio Communications

Intentional radio signals exist in a sea of unwanted radio frequency 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.

EMI 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 (University of Michigan 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 1–3 mG, such as magnetic resonance imaging (MRI) systems, electromagnetic interference is possible at distances of up to 200 feet. An installation guide for NMR equipment recommends a separation distance of 100 meters (328 feet) from electric trains (Field Management Services 2009).

3.5.2 Laws, Regulations, and Orders

Federal and state laws, regulations, and orders applicable to EMF and EMI are presented below. The California High-Speed Rail Authority (Authority) would implement the HSR project, including this project extent, in compliance with all federal and state regulations. Regional and local laws, regulations, and orders considered in preparing this analysis are provided in Appendix 2-J.

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 EMF exposure to residences.

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 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 effects from anticipated HSR emissions. For occupational exposure, ICNIRP recommended exposure limits are 417 µT for magnetic fields and 8.333 kV/m (kilovolts per meter) 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*, 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 extremely low-frequency EMFs, which have frequencies of 0 to 3 kHz. The HSR electrification and traction power systems would generate extremely low frequency 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. Note that 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	6.87×10^6/f
	60	9.04×10^3
Arms or legs	<10.7	3.53×10^6
	10.7–3,000	3.79×10^7/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	1.84×10^6/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 electromagnetic radiation (IEEE 2006). The HSR train control and 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 electromagnetic energy. MPE exposure 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 upon 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, the unborn, infants, 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. Part 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 upon a 6-minute averaging time.

The American Council of Governmental Industrial Hygienists (ACGIH 2015) provides 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 Federal Register 28545)

On May 26, 1999, FRA released *Procedures for Considering Environmental Impacts* (FRA 1999). These FRA procedures supplement the Council on Environmental Quality Regulations (40 C.F.R. Part 1500 et seq.) and describe the FRA's process for assessing the environmental impacts of actions and legislation proposed by the agency and for the preparation of associated documents (42 U.S. Code 4321 et seq.).[2,3] The FRA *Procedures for Considering Environmental Impacts* states that "the EIS should identify any significant changes likely to occur in the natural environment and in the developed environment. The EIS should also discuss the consideration given to design quality, art, and architecture in project planning and development as required by U.S. Department of Transportation Order 5610.4." These FRA procedures state that an EIS should consider possible impacts from EMFs and EMI.

[2] While this EIR/EIS was being prepared, FRA adopted new NEPA compliance regulations (23 C.F.R. 771). Those regulations only apply to actions initiated after November 28, 2018. See 23 C.F.R. 771.109(a)(4). Because this EIR/EIS was initiated prior to that date, it remains subject to FRA's Environmental Procedures rather than the Part 771 regulations.

[3] The Council on Environmental Quality issued new regulations on July 14, 2020, effective September 14, 2020, updating the NEPA implementing procedures at 40 C.F.R. Parts 1500-1508. However, this project initiated NEPA before the effective date and is not subject to the new regulations, relying on the 1978 regulations as they existed prior to September 14, 2020. All subsequent citations to Council on Environmental Quality regulations in this environmental document refer to the 1978 regulations, pursuant to 40 C.F.R. 1506.13 (2020) and the preamble at 85 Fed. Reg. 43340.

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

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

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

USEO 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, FCC (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, FCC, Office of Engineering and Technology Bulletin 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields (FCC 1997)

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, FCC (47 C.F.R. Part 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, FCC (47 C.F.R. Part 1.1310, *Radiofrequency Radiation Exposure Limits*)

The FCC regulations at 47 C.F.R. Part 1.1310 are based upon 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 upon 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

Frequency	ANSI/IEEE C95.1 MPE (mW/cm^2)		FCC MPE (mW/cm^2)		OSHA MPE (mW/cm2)
	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. Part 1.1310, Table 1 (FCC); 29 C.F.R. Part 1910.97 (OSHA)
IEEE = American National Standards Institute/Institute of Electrical and Electronics Engineers
cm = centimeter
FCC = Federal Communications Commission
MHz = megahertz
MPE = maximum permissible exposure

mW/cm2 = milliwatts per square centimeter
OSHA = Occupational Safety and Health Administration

U.S. Department of Labor, OSHA (29 C.F.R. Part 1910.97, *Nonionizing Radiation*)

29 C.F.R. Part 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 upon averaging over any 6-minute time interval.

3.5.2.2 State

California Department of Education, California Code of Regulations, Title 5, Section 14010(c)

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

California Public Utilities Commission EMF Guidelines for Electrical Facilities

The California Public Utilities Commission (CPUC) guidelines, based upon 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 (PG&E) facilities subject to the jurisdiction of the CPUC. Similarly, reconductoring and other 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 EMFs from regulated utilities.

Decision D.06-01-042

The August 2004 CPUC decision updates the EMF policy originally defined in D.93.11.013. D.06-01-042 re-affirmed 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 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

All regional and local policies that are applicable to the project are listed in Volume 2, Appendix 2-J. 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 3.1.6.3, Consistency with Plans and Laws, the California Environmental Quality Act (CEQA) and CEQ regulations require a discussion of inconsistencies or conflicts between a proposed undertaking and federal, state, regional, or local plans and laws. Accordingly, this Final 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, Federal, and Section 3.5.2.2, State, govern compliance with EMF limits for construction projects and transportation facilities. EMF assessments are 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. Executive Order prioritizing protection of children from environmental health and safety risks FCC rules for licensed and unlicensed radio frequency transmissions
- FCC guidelines for safe EMF exposure and regulations for radio frequency emission safety levels
- FCC regulations for allocating, assigning, and using radio frequencies
- OSHA standards for permissible worker exposure to non-ionizing radiation
- California regulations on minimum siting distances of power lines from schools
- CPUC decisions that set EMF policies

The Authority, as the lead agency proposing to construct and operate the HSR system, is required to comply with all federal and state laws and regulations and to secure all applicable federal and state permits 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 construct the HSR project so that it is compatible with land use and zoning regulations. For example, the Authority would coordinate design and routing of power transmission and distribution lines and facilities with public utility companies and would take local land use into consideration in the routing of these facilities.

Analysts reviewed 10 regional and local planning and policy documents, with 1 plan (Merced County General Plan) and 4 municipal ordinances containing relevant policies and regulations (Volume 2, Appendix 2-J). The project alternatives are consistent with all goals and policies of these ordinances 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 Appendix 2-J.

3.5.4 Methods for Evaluating Impacts

The evaluation of impacts from EMF and EMI is a requirement of CEQA, and because EMI impacts for the project are reasonably foreseeable, the National Environmental Policy Act (NEPA) requires that they 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 extent to determine the potential EMF and EMI impacts associated with project construction and operations. The methods combine data collection, electromagnetic field 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;[4] 500 feet from the perimeter of the maintenance of way facility, and 500 feet from TPSS facilities, interconnection facilities, and existing PG&E facilities to be modified. 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, residential dwellings, schools, preschools and daycare facilities, public parks, hospitals, commercial and industrial facilities, and agricultural operations (farms).

The 500-foot screening distance of the RSA was defined based upon typical screening distances identified in the Authority Technical Memoranda (TM) 300.07, *EIR/EIS Assessment of the CHST Alignment EMF Footprint* (Footprint Report) (Authority 2012), and project-specific factors. The screening distances in the Footprint Report were used to identify EMF- and EMI-sensitive receptors that might be near enough to the proposed alignment for EMF or EMI impacts to be possible under typical conditions, and the Footprint Report determined that EMF and EMI impacts would be unlikely where sensitive receptors are located beyond these 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 Appendix 2-E. The following IAMFs are applicable to the EMF and EMI analysis:

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

This environmental impact analysis considers these IAMFs as part of the project design. Within 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.

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. These methods apply to both NEPA and CEQA analyses unless otherwise indicated. Refer to Section 3.1.6.4, Methods for Evaluating Impacts, for a description of the general framework for evaluating impacts under NEPA and CEQA. Sections 3.5.4.3 and 3.5.4.4 describe the NEPA and CEQA impact methodologies used to evaluate project impacts from EMFs and EMI. Laws, regulations, and orders (see Section 3.5.2) that regulate EMFs and EMI were also considered in the evaluation of impacts.

Regional and Local Sources of EMFs and EMI

Analysts referred to aerial imagery, surveys, photographs, and FCC databases to identify regional and local sources of EMFs and EMI. Analysts also referred to published reports, such as the *Final EIR for the Peninsula Corridor Electrification Project* (PCJPB 2015), to evaluate existing conditions within the EMF and EMI RSA. The baseline EMF conditions assume the electrification of Caltrain service (as part of the proposed Caltrain Peninsula Corridor Electrification Project [PCEP]) from Scott Boulevard in Santa Clara to Tamien Station in San Jose, requiring the installation of an OCS system and supporting traction power distribution facilities, which is expected to be complete by 2021. The PCEP encompasses all of the San Jose Diridon Station Approach Subsection and a small portion of the Monterey Corridor Subsection.

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[4] 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.

Local Conditions

Analysts conducted a preconstruction survey to measure EMF at 10 locations along the project extent in accordance with technical guidance developed by the Authority. The purpose of the survey was to establish EMF levels that are representative of existing conditions in the RSA. Analysts selected sites 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 documents the process for conducting field survey measurements, describes measurement sites, and discusses the existing EMF levels in the project vicinity.

Sensitive Receptors

Sensitive receptors consist of land uses and facilities susceptible to EMFs and EMI produced by the HSR. These receptors include: railroads and rail transit systems, airports, residential dwellings, schools, preschools and daycare facilities, public parks, hospitals, commercial and industrial facilities, and agricultural operations (farms). Their sensitivity is due to the potential exposure of people and farm animals (e.g., livestock, poultry) to EMFs or because communications systems, sensitive equipment, or other electronic devices are present that could be disrupted by EMFs. Analysts conducted a visual assessment of sensitive land uses as part of field surveys measuring the existing electromagnetic environment (see Appendix 3.5-A for additional information).

EMF and EMI Levels

Analysts performed the following steps 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 in the field, as described in 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.
- Modeled the anticipated EMF levels at a given sensitive receptor as a result of operations of the electrical infrastructure and network upgrade components using typical levels generated by transmission and power lines at various distances (shown in Table 3.5-3).

The Magnetic Field Calculation Model incorporates conservative assumptions for potential HSR EMF impacts from train operations. They represent worst-case conditions by assuming a maximum train current of 930 amperes. Typical operating currents would be approximately 20 percent less. In addition, 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 track centerline increases. These characteristics would be the same for both aboveground and belowground (tunnel) portions of the HSR alignments. For most locations and most times, exposure to EMFs would not be as high as predicted by the Magnetic Field Calculation Model, which predicts peak EMF levels.

The Magnetic Field Calculation Model also identifies how the projected maximum EMF levels would vary with the radial distance from the centerline of the HSR 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 system were predicted and compared to the measured, existing ambient conditions. Because magnetic fields would be expected to be the dominant EMF impact from the HSR operations,[5] these results formed the basis of the EMF impact analysis.

Analysts predicted EMF levels on sensitive receptors associated with the new or modified components of the electrical infrastructure and network upgrades based upon typical EMF levels anticipated to be generated by transmission and power lines at specific distances from the source, as shown in Table 3.5-3. EMFs would also be produced within electric substations, but due to the spacing of electrical equipment, measured field strengths would be low outside the fence lines of the substations. Fields close to substations would be primarily produced by the entering power lines (Western Area Power Administration n.d.).

EMF impacts on sensitive land uses were identified based upon the differences between predicted EMF levels and existing conditions. The data from the 10 site measurement locations were generalized to represent the entire RSA. Where the predicted EMFs generated by the operations of the HSR system and electrical infrastructure and network upgrades would be higher than typical existing levels for exposure, the potential for EMI was used to evaluate the magnitude of potential effects.

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 3.1.6.4). 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.

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

3.5.4.5 Method for Determining Significance under CEQA

CEQA requires an EIR to identify the significant environmental impacts of a project (CEQA Guidelines Section 15126). One of the primary differences between NEPA and CEQA is that CEQA requires a threshold-based impact analysis. Significant impacts are determined by evaluating whether project impacts would exceed the significance threshold established for the resource (Section 3.1.6.4). The Authority is using the following thresholds to determine if a CEQA significant impact from EMF or EMI would occur as a result of the project alternatives. The significance thresholds are based upon relevant research and documentation on potential EMF and EMI safety levels, such as the ANSI/IEEE, FCC, and OSHA safety levels presented in Section 3.5.2. For the CEQA analysis, the project would result in a significant impact from EMFs and EMI if it would:

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

- 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
- Disrupt agricultural activities near the HSR
- Interfere with nearby sensitive equipment, including equipment at hospitals, industrial and commercial facilities, railroads, rail transit systems, or airports

Quantitative 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. Note that these levels are not-to-exceed values, with no allowance for exposure duration. The IEEE Standard C95.6 was formally adopted by the American National Standards Institute 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 2012).

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

Source: IEEE 2002; ACGIH 2015
Hz = hertz
mG = milligauss
V/m = volts per meter

3.5.5 Affected Environment

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

3.5.5.1 Regional and Local Sources of EMFs and EMI

Electromagnetic emissions are generated by a variety of localized, as well as pervasive, wide-scale regional sources. 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, and commercial and civilian transmissions, including amateur radio. Electromagnetic emissions are further characterized by temporal variations, as many EMF emitters operate only occasionally.

The measured regional sources along the project extent include strong telecommunication transmitters that broadcast over large areas, 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 alternatives would also pass within 1,600 feet of the Norman Y. Mineta San Jose International Airport and within 1,400 feet of San Martin Airport, both of which have a large number of RF sources and sensitive receptors. Analysts photographed the sources that were visually identified as near or in the line-of-sight of the measurement locations (see Appendix 3.5-A). Photographs taken at measurement locations along the project extent show the presence of many sources, including police and fire department and FM radio transmitters.

3.5.5.2 Local Conditions

The project extent includes urban and rural areas from San Jose to Carlucci Road, the eastern boundary of the project extent studied in detail in this document. Adjacent land uses are predominantly commercial, industrial, and residential in the urban northern portion of the project extent. East of Gilroy, to the San Joaquin Valley, the land use is rural and consists of agriculture, open space, residential, and some commercial (refer to Section 3.13 for a more detailed discussion of existing land uses). Urban and rural settings have different sensitivities associated with EMFs and EMI:

- Urban areas include more densely spaced residential housing, high-voltage overhead power lines, and associated urban infrastructure. These areas may include laboratories and other facilities that operate EMI-sensitive research or medical devices.
- Rural areas typically have only a few residences, which are sparsely distributed. These areas may have underground pipelines, underground cables, and fencing associated with agricultural operations, including irrigation systems that may be affected by EMFs and EMI.

Analysts determined existing local conditions by measuring EMF levels at representative locations selected through a review of land uses, existing facilities, and infrastructure 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 30 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 segment
- High-emission sites
- Low-emission sites
- Sites with high-sensitivity receptors

Analysts selected 10 measurement sites based upon these considerations. These measurement locations are identified in Table 3.5-8 and shown graphically in Figure 3.5-1 through Figure 3.5-5.

Table 3.5-8 EMI Measurement Locations

Site	Community	Location	Geographic Coordinates	Notable EMF Sources or Sensitive Receptors
San Jose Diridon Station Approach Subsection				
1	San Jose	Newhall Street / Newhall Drive	37.347447°, (121.923012°)	Adjacent to Avaya Stadium; nearby cell towers; San Jose International Airport communications and aviation RF sources.

Site	Community	Location	Geographic Coordinates	Notable EMF Sources or Sensitive Receptors
2	San Jose	Montgomery Street / Otterson Street	37.328142°, (121.902140°)	Adjacent to the Diridon Caltrain station and PG&E substation.
Monterey Corridor Subsection				
3	San Jose	Communication Hill / Curtner Avenue	37.293722°, (121.865194°)	Mostly residential area, but with significant RF sources nearby, including Santa Clara Sheriff, County Fire Station, and cellular communications. Adjacent to existing ROW.
4	San Jose	Great Oaks Parkway / Las Colinas Road	37.239322°, (121.776080°)	High-technology office park with potentially sensitive receptors, including nearby MRI operators. Adjacent to existing ROW. Suburban/commercial environment.
Morgan Hill and Gilroy Subsection				
5	Coyote	Metcalf Road / Coyote Ranch Road	37.223022°, (121.744592°)	Industrial location between Metcalf power plant (600 MW) and PG&E substation. Adjacent to existing ROW.
6	Morgan Hill	Railroad Avenue / Barrett Avenue	37.118225°, (121.638550°)	Adjacent to existing ROW, across street from the Morgan Hill Police Station. Numerous suburban RF sources.
7	Gilroy	Monterey Highway / Las Animas Avenue	37.028851°, (121.578510°)	Suburban/commercial area in Gilroy with limited local RF sources, adjacent to existing ROW. Magnetic field transients due to existing rail traffic.
8	Hollister	SR 152/ south of Casa de Fruta	36.985247°, (121.383899°)	Along SR 152, 10 miles east of Gilroy. No visible RF sources.
Pacheco Pass Subsection				
9	Santa Nella	Santa Nella Avenue / Fahey Road	37.126085°, (121.015302°)	Quiet site: Agricultural area north of Santa Nella. No local RF emitters. Distribution lines only.
San Joaquin Valley Subsection				
10	Dos Palos	Henry Miller Road / Carlucci Road	37.097787°, (120.680892°)	Quiet site: Agricultural area. Nearest significant RF emitters in Los Banos (8 miles). Distribution lines only.

(Parentheses) indicate negative values.
EMF = electromagnetic fields
EMI = electromagnetic interference
PG&E = Pacific Gas and Electric Company
MW = megawatt
MRI = magnetic resonance imaging
RF = radio frequency
ROW = right-of-way
SR = State Route

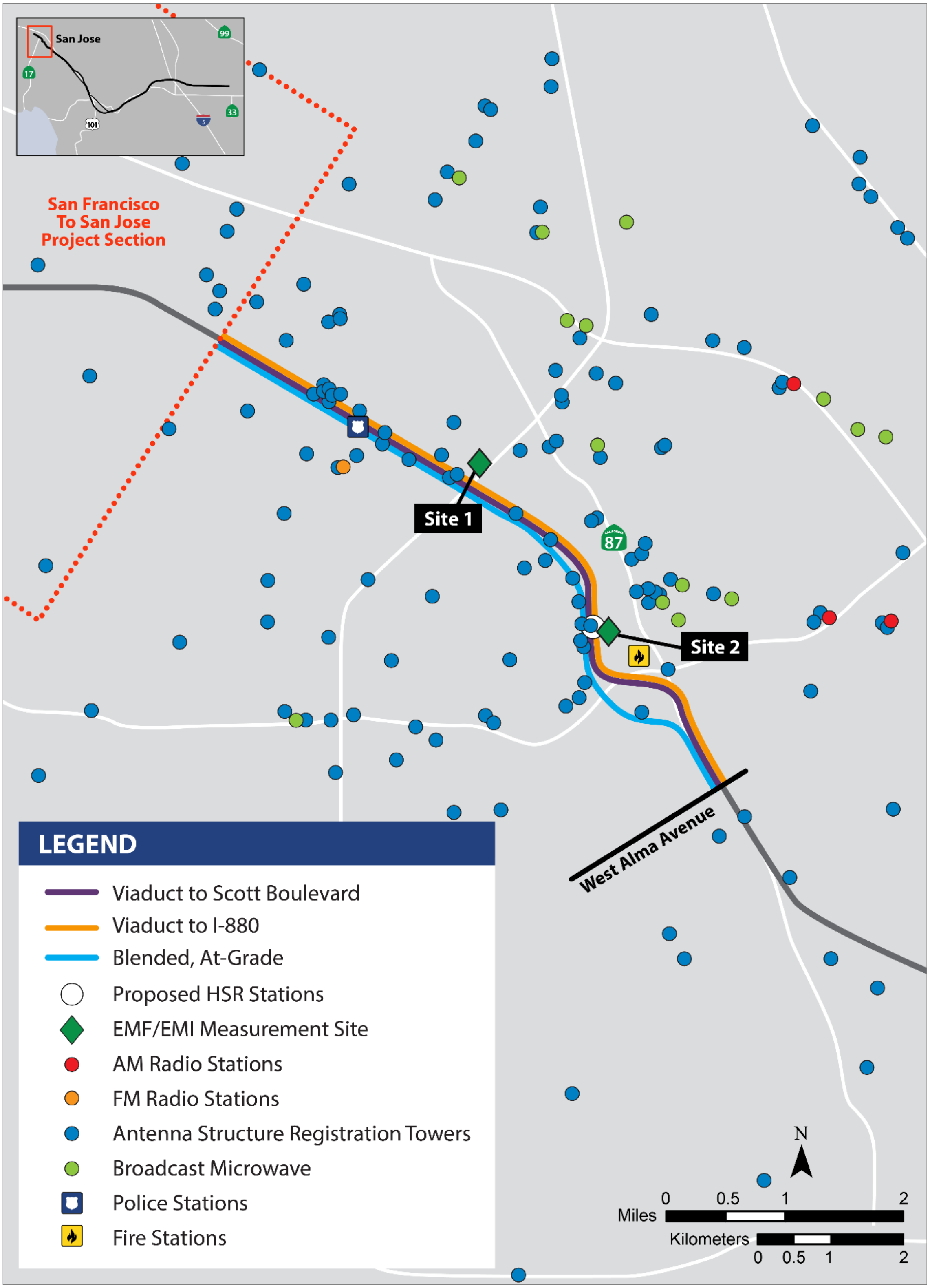

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Figure 3.5-1 EMF Measurement Site Locations with Existing Sources of EMF and EMI: San Jose Diridon Station Approach Subsection

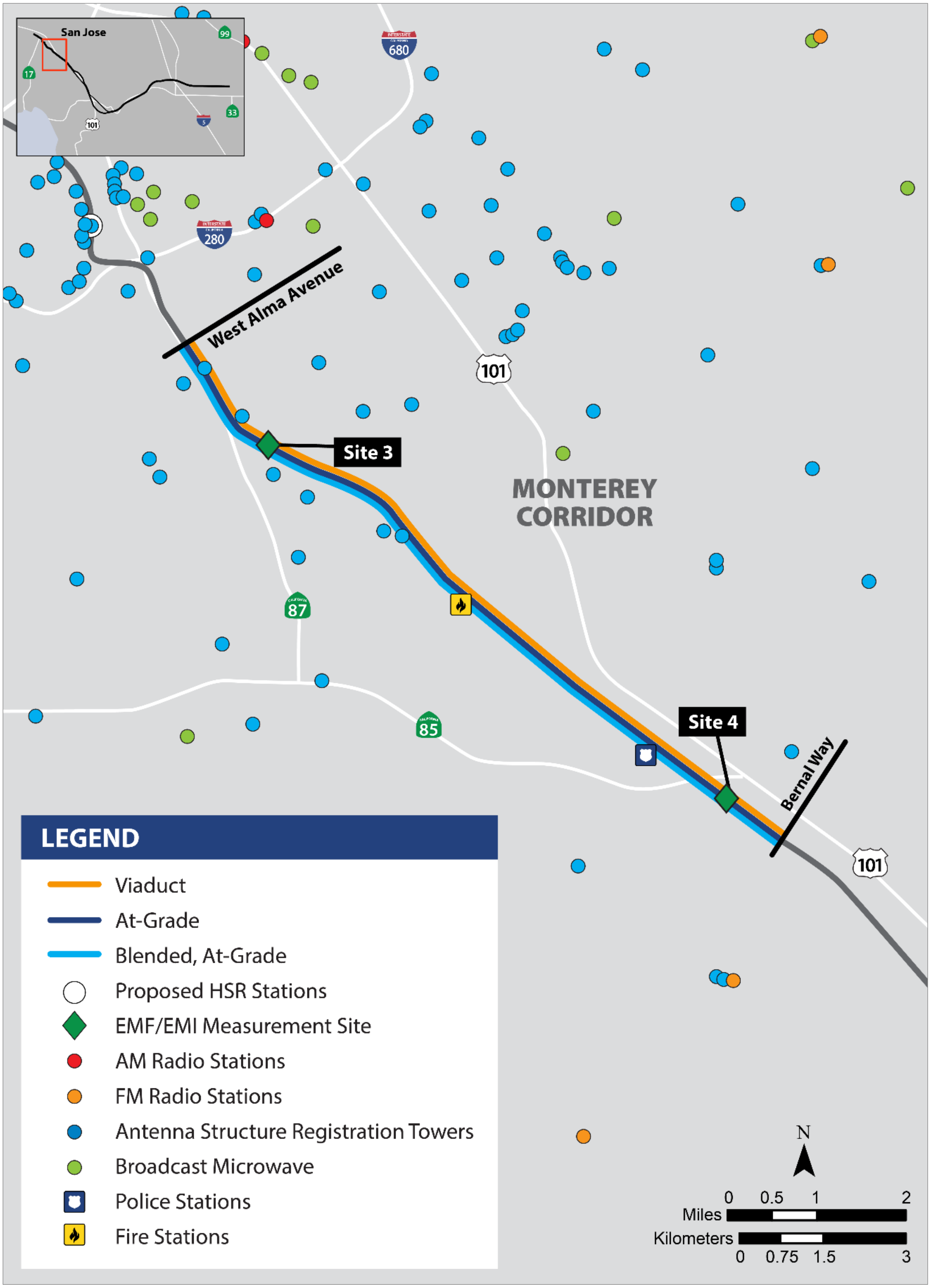

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Figure 3.5-2 EMF Measurement Site Locations with Existing Sources of EMF and EMI: Monterey Corridor Subsection

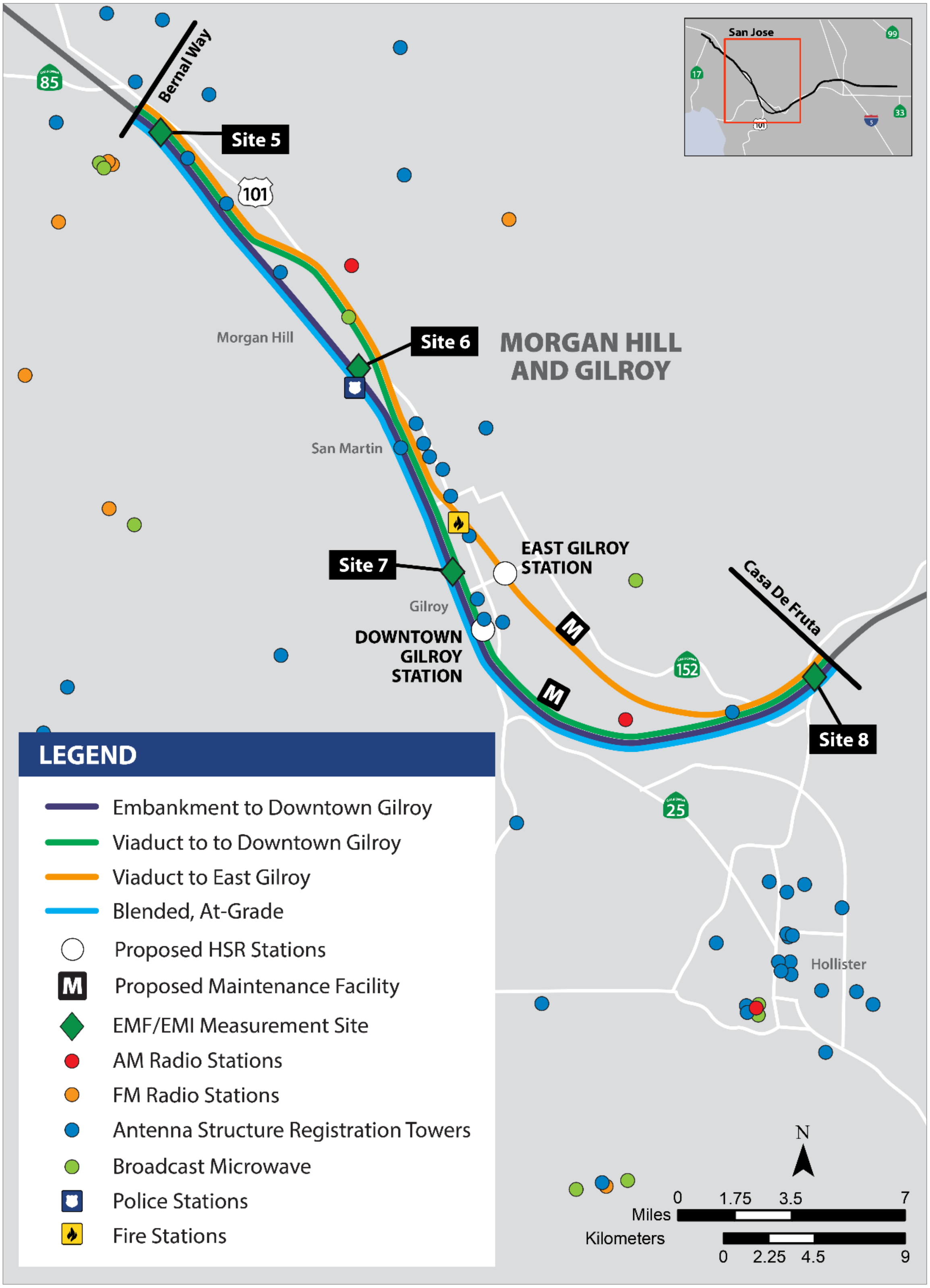

Figure 3.5-3 EMF Measurement Site Locations with Existing Sources of EMF and EMI: Morgan Hill and Gilroy Subsection

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Figure 3.5-4 EMF Measurement Site Locations with Existing Sources of EMF and EMI: Pacheco Pass Subsection

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Figure 3.5-5 EMF Measurement Site Locations with Existing Sources of EMF and EMI: San Joaquin Valley Subsection

Analysts conducting 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, analysts observed the highest RF levels in San Jose and other urban areas. The survey also quantified typical power-frequency magnetic field levels along the project extent to characterize typical DC and ELF (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 0.01 mG to approximately 47 mG, depending primarily upon the measurement locations' proximity to local distribution and transmission power lines (Table 3.5-8). The field survey measurement results are discussed in detail in Appendix 3.5-A.

Table 3.5-9 summarizes the distance of the measurement site from the centerline of the nearest HSR track, the measured electric field and AC (60-Hz) magnetic field strengths, and the modeled maximum HSR electromagnetic field strengths at each of the measurement sites. The variation in AC magnetic field strengths fall within expected limits for the urban and rural environments of the project extent. The modeled HSR AC field strengths at the same locations are typically 10 to 100 times greater than the background level, with the actual field strength depending on the HSR track centerline-to-site distance.

Table 3.5-9 Measured and Modeled 60 Hz Magnetic Field Strengths

Site / Community	Distance from Centerline of Nearest HSR Track (feet)	Measured Electric Field Strength[1] (V/m)	Measured Electric Field Strength[1] (mW/cm2)	Measured 60 Hz Magnetic Field (mG)	Modeled 60 Hz Magnetic Field Single Train (mG)
San Jose Diridon Station Approach Subsection					
1 – San Jose	245 (Alternatives 1, 4) 170 (Alternatives 2, 3)	14.9	0.059	5.12	2.3 4.1
2 – San Jose	235 (Alternatives 1, 2, 3) 260 (Alternative 4)	21.5	0.123	16.8	2.3 1.8
Monterey Corridor Subsection					
3 – San Jose	115 (Alternatives 1, 2, 3) 100 (Alternative 4)	18.5	0.091	0.02	9.7 12.9
4 – San Jose	100 (Alternative 2) 130 (Alternatives 1, 3) 35 (Alternative 4)	5.8	0.009	0.69	12.9 7.6 109
Morgan Hill and Gilroy Subsection					
5 – Coyote	450 (Alternatives 1, 3) 530 (Alternative 2) 610 (Alternative 4)	54.7	0.795	47.20	0.6 0.4 0.3
6 – Morgan Hill	8 (Alternative 2)[2,3] 75 (Alternative 4)	5.7	0.009	0.52	177[3] 23.1
7 – Gilroy	140 (Alternatives 1, 2)[4] 235 (Alternative 4)	13.3	0.047	0.14	6.5 2.3
8 – Hollister	420 (Alternatives 1, 2, 4) 455 (Alternative 3)	6.4	0.011	0.01	0.7 0.6

Site / Community	Distance from Centerline of Nearest HSR Track (feet)	Measured Electric Field Strength[1] (V/m)	Measured Electric Field Strength[1] (mW/cm2)	Measured 60 Hz Magnetic Field (mG)	Modeled 60 Hz Magnetic Field Single Train (mG)
Pacheco Pass Subsection					
9 – Santa Nella	125 (All Alternatives)	11.4	0.034	1.61	82.8[5]
San Joaquin Valley Subsection					
10 – Dos Palos	55 (All Alternatives)	26.3	0.183	0.11	44.4

[1] Maximum observed electric field strength in any frequency band.
[2] Site 6 is located approximately 3,200 feet from Alternatives 1 and 3 and is therefore outside the resource study area for these alternatives.
[3] Site 6 is located approximately 8 feet from the HSR track centerline for Alternative 2, and, in the event that Alternative 2 is constructed, the current use at that location would be replaced with HSR infrastructure. The modeled 60 Hz magnetic field strength shown is at 22 feet (the minimum distance from the HSR track centerline to the fence line at the edge of the right-of-way) and would represent the next nearest land use.
[4] Site 7 is located approximately 4,700 feet from Alternative 3 and is therefore outside the resource study area for this alternative.
[5] Site 9 is located on the HSR track centerline for all alternatives, and, in the event that any of the alternatives is constructed, the current use at that location would be replaced with HSR infrastructure. The modeled 60 Hz magnetic field strength shown is at 22 feet (the minimum distance from the HSR track centerline to the fence line at the edge of the right-of-way) and would represent the next nearest land use.
Hz = Hertz
mG = milligauss
mW/cm2 = milliwatts per square centimeter
V/m = volts per meter

As noted in Section 3.5.4.3, Methods for Impact Analysis, the baseline EMF conditions assume the electrification of Caltrain service from Scott Boulevard in Santa Clara to Tamien Station in San Jose. Along this portion of the RSA, the electrification and upgrades would increase the EMFs generated near the tracks above the measured levels identified in Table 3.5-9. Sources of EMFs associated with the PCEP include the traction power distribution system (including traction power substations, paralleling stations, and a switching station), the OCS 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: aboard passenger cars, at rail overpasses, within and outside of the Caltrain right-of-way, and proximate to traction power substations.

Table 3.5-10 Estimated EMF Field Strength for Caltrain Operations (frequency of 60 Hz)

Location	Electric Field (kV/m)	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
[1] Estimates for a location 58 feet from the track centerline.
[2] Estimates for a location approximately 15 feet from the track centerline.
EMF = electromagnetic fields
Hz = hertz
kV/m = kilovolt per meter
mG = milligauss
N/A = not applicable

3.5.5.3 Sensitive Receptors and Facilities

Table 3.5-11 shows 62 discrete receptors and facilities within the RSA potentially affected by HSR system construction and operation. The table includes the receptor/facility type, location, project alternatives potentially affecting the receptor/facility, proximity of the receptor/facility to the HSR track and project footprint, and the modeled maximum HSR field strengths for a single train at each receptor/facility location. These receptors/facilities were identified based upon their proximity to the HSR alignment or associated infrastructure, such as substations or maintenance areas, proximity to HSR construction activities, or both. Similarly, Table 3.5-12 identifies four discrete facilities within the RSA in relationship to electrical infrastructure and network upgrades, along with projected electric and magnetic field strengths at each location.

In addition to the project infrastructure, existing rail systems, buried pipelines, ungrounded metallic fencing, and other linear receptors of concern are known to occur in the RSA and have potential EMI concerns.

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

Site ID	Facility	Location	Alternative	Distance to Centerline of Nearest HSR Track (feet)	Distance to Construction Easement, (feet)	Modeled 60 Hz Magnetic Field – Single Train (mG)
San Jose Diridon Station Approach Subsection						
1	Reed Street Dog Park	888 Reed Street, Santa Clara	2, 3 1, 4	75 65	Adjacent	24.1 32.2
2	Larry J. Marsalli Park	1425 Lafayette Street, Santa Clara	2, 3 1, 4	410 340	Adjacent	0.77 1.1
3	Santa Clara Police Department	601 El Camino Real, Santa Clara	2, 3 1, 4	80 155	Adjacent	20.3 5.3
4	San Jose International Airport[1]	1701 Airport Boulevard, San Jose	2, 3 1, 4	1,630 1,710	1,510	0.05 0.05
5	Newhall Park	972 Newhall Street, San Jose	2, 3 1, 4	250 320	190	2.0 1.2
6	Bellarmine College Preparatory	960 West Hedding Street, San Jose	1, 2, 3 4	200 100	Adjacent	3.2 12.9
7	College Park	Elm Street and Hedding Street, San Jose	2, 3 1 4	710 650 625	Adjacent	0.24 0.29 0.31
8	Guadalupe River Trail, Reach 6	Woz Way to Virginia Street, San Jose	1, 2, 3 4	Adjacent 740	Adjacent	148 0.22
9	Theodore Lenzen Park	Stockton Avenue and Lenzen Street, San Jose	1, 2, 3 4	960 480	300	0.13 0.53
10	Cahill Park	West San Fernando Street & Wilson Avenue, San Jose	1, 2, 3 4	360 335	190	0.96 1.1

Site ID	Facility	Location	Alternative	Distance to Centerline of Nearest HSR Track (feet)	Distance to Construction Easement, (feet)	Modeled 60 Hz Magnetic Field – Single Train (mG)
11	San Jose Fire Department Station 30	454 Auzerais Avenue, San Jose	1, 2, 3 4	640 2,000	160	0.30 0.03
12	Los Gatos Creek Trail	East Main Street at College Avenue, San Jose	1, 2, 3, 4	Adjacent	Adjacent	148
13	Gardner Elementary School	502 Illinois Avenue, San Jose	1, 2, 3 4	225 850	60	2.5 0.17
14	Biebrach Park	Delmas Street and Virginia Street, San Jose	1, 2, 3 4	1,080 390	910	0.10 0.81
15	Fuller Park	Fuller Avenue & Park Avenue, San Jose	1, 2, 3 4	500 Adjacent	440	0.46 148
16	Tamien Child Care Center	1197 Lick Avenue, San Jose	1, 2, 3 4	270 215	120	1.7 2.7
17	Class I Bikeway	Willow Street to Curtner Avenue, San Jose	1, 2, 3, 4	Adjacent	Adjacent	148
18	Highway 87 Bikeway	Along Highway 87, San Jose	1, 2, 3, 4	Adjacent	Adjacent	148
19	Jesse Frey Community Garden	West Alma Avenue and Belmont Way, San Jose	1, 2, 3 4	770 805	375	0.20 0.19
20	Three Creeks Trail	Highway 87 to Senter Road, San Jose	1, 2, 3, 4	Adjacent	Adjacent	148
Monterey Corridor Subsection						
21	Communications Hill Trail	Grassina Street to Communications Hill Boulevard, San Jose	1, 2, 3, 4	150	Adjacent	5.7
22	San Jose Fire Department Station 18	4430 Monterey Highway, San Jose	1, 3 2 4	100 150 220	Adjacent	12.9 5.7 2.6
23	Edenvale Gardens Regional Park	200 Edenvale Avenue, San Jose	1, 3 2 4	185 130 60	35	3.7 7.6 36.4
24	San Jose Police Department South Station	6087 Great Oaks Parkway, San Jose	1, 3 2 4	280 235 175	165	1.6 2.3 4.1

Site ID	Facility	Location	Alternative	Distance to Centerline of Nearest HSR Track (feet)	Distance to Construction Easement, (feet)	Modeled 60 Hz Magnetic Field – Single Train (mG)
Morgan Hill and Gilroy Subsection						
25	Great Oaks Research Park	23 Las Colinas Lane, San Jose	1, 3 2 4	285 255 185	55	1.5 1.9 3.7
26	Metcalf Park	Forsum Road, San Jose	1, 3 2 4	425 450 520	340	0.68 0.61 0.45
27	Fisher Creek Trail	Monterey Highway to Santa Teresa Boulevard, San Jose	1, 2, 3, 4	Adjacent	Adjacent	148
28	Coyote Creek Parkway	Coyote Ranch Road, San Jose	1, 2, 3, 4	Adjacent	Adjacent	148
29	Coyote Creek Trail	Hellyer Avenue to Metcalf Road, San Jose	1, 3 2 4	30 100 140	Adjacent	148 12.9 6.5
30	Charter School of Morgan Hill	9530 Monterey Road, Morgan Hill	1, 3 2 4	110 135 40	Adjacent	10.6 7.0 82.8
31	Central High School (annex)	85 Tilton Avenue, Morgan Hill	2 4	325 250	260	1.2 2.0
32	Paramit Manufacturing	18735 Madrone Parkway, Morgan Hill	2 4	230 340	70	2.2 1.1
33	Sanchez Park	Sanchez Drive, Morgan Hill	2 4	360 260	180	0.96 1.8
34	Butterfield Professional Center	295-345 Digital Drive, Morgan Hill	2 4	60 140	Adjacent	36.4 6.5
35	Shadow Mountain Baptist School	17810 Monterey Road, Morgan Hill	2 4	415 330	315	0.72 1.1
36	El Toro Elementary School	455 E Main Street, Morgan Hill	2 4	1,320 1,400	90	0.07 0.06
37	Lewis H. Britton Middle School	80 W Central Avenue, Morgan Hill	2 4	800 720	380	0.19 0.23
38	Gavilan College	17060 Monterey Road, Morgan Hill	2 4	515 440	Adjacent	0.46 0.64
39	Morgan Hill Community and Cultural Center	17000 Monterey Road, Morgan Hill	2 4	515 440	Adjacent	0.46 0.64

Site ID	Facility	Location	Alternative	Distance to Centerline of Nearest HSR Track (feet)	Distance to Construction Easement, (feet)	Modeled 60 Hz Magnetic Field – Single Train (mG)
40	Barrett Elementary School	895 Barrett Avenue, Morgan Hill	1, 3	300	260	1.4
41	Morgan Hill Police Department	16200 Vineyard Boulevard, Morgan Hill	2 4	150 65	40	5.7 30.9
42	San Martin/Gwinn Elementary School	13745 Llagas Avenue, San Martin	1, 2, 3 4	360 440	230	1.0 0.64
43	A+ Learning Center Preschool	13570 Depot Street, San Martin	1, 2, 3 4	155 235	25	5.3 2.3
44	San Martin Airport[1]	13030 Murphy Avenue, San Martin	1, 2, 3 4	1,400 1,480	700	0.06 0.06
45	Santa Clara County Fire Department, Masten Station	10810 No Name Uno, Gilroy	3	700	480	0.25
46	Rucker Elementary School	325 Santa Clara Avenue, Gilroy	3	310	240	1.3
47	Davis Poultry Farms	155 Santa Clara Avenue, Gilroy	1, 2 4	120 210	55	8.9 2.9
48	Christopher High School	850 Day Road, Gilroy	1, 2, 3, 4	3,800	60	0.01
49	St. Louise Regional Hospital	9400 No Name Uno, Gilroy	3	1,100	100	0.10
50	South Valley Middle School	385 IOOF Avenue, Gilroy	1, 2 4	545 665	Adjacent	0.41 0.28
51	Gilroy Preparatory School	277 Ioof Avenue, Gilroy	1, 2 4	Adjacent 130	Adjacent	148 148
52	Rebekah Children's Center	290 Ioof Avenue, Gilroy	1, 2 4	225 320	Adjacent	2.5 1.2
53	San Ysidro Park	7700 Murray Avenue, Gilroy	1, 2, 3 4	1,570 1,660	120	0.05
54	Wheeler Tot Lot	250 West 6th, Gilroy	1, 2 4	1,140 1,065	475	0.09 0.11
55	Forest Street Park	7325 Forest Street, Gilroy	1, 2 4	530 620	145	0.44 0.32
56	Anchorpoint Christian School	2320 Pacheco Pass Highway, Gilroy	3	630	Adjacent	0.3

Site ID	Facility	Location	Alternative	Distance to Centerline of Nearest HSR Track (feet)	Distance to Construction Easement, (feet)	Modeled 60 Hz Magnetic Field – Single Train (mG)
Pacheco Pass Subsection						
57	San Luis Reservoir Wildlife Management Area	30 miles east of Gilroy, south side of Pacheco Pass along SR 152, Merced and Santa Clara Counties	1, 2, 3, 4	Adjacent (in tunnel)	Adjacent	148
58	San Luis Reservoir State Recreation Area	On SR 152, 7 miles west of I-5, 33 miles east of Gilroy, Merced and Santa Clara Counties	1, 2, 3, 4	1,000	890	0.12
59	Cottonwood Creek Wildlife Area	36 miles east of Gilroy, northeast of SR 152, Merced and Santa Clara Counties	1, 2, 3, 4	Adjacent (in tunnel)	Adjacent (in tunnel)	148
San Joaquin Valley Subsection						
60	Los Banos Wildlife Area	4 miles northeast of Los Banos, Merced County	1, 2, 3, 4	155	60	5.3
61	Soares Dairy Farms	14155 Badger Flat, Los Banos	1, 2, 3, 4	30	Adjacent	150
62	Talbott Sheep	20654 Henry Miller Road, Los Banos	1, 2, 3, 4	170	85	4.4

[1] Although San Jose International Airport and San Martin Airport are located outside of the resource study area, they are included in this analysis as sensitive receptors given the safety-critical nature of radio-based systems and uncertainties about the locations of much of the equipment within each airport.
HSR = high-speed rail
Hz = Hertz
mG = milligauss

Table 3.5-12 Sensitive Receptors and Facilities Potentially Affected by Electrical Infrastructure and Network Upgrades

Site ID[1]	Facility	Location	Distance to Nearest Network Upgrade (feet)	Distance to Nearest Interconnection Facility (feet)	Estimated Electric Field Strength (kV/m)	Estimated Magnetic Field Strength (mG)
San Jose Diridon Station Approach Subsection						
4	San Jose International Airport	1701 Airport Boulevard, San Jose	300	N/A	0.003	0.2
Morgan Hill and Gilroy Subsection						
37	Lewis H. Britton Middle School	80 West Central Avenue, Morgan Hill	Adjacent	75	0.5	6.5
48	Christopher High School	850 Day Road, Gilroy	Adjacent	N/A	0.5	6.5
53	San Ysidro Park	7700 Murray Avenue, Gilroy	130	N/A	0.07	1.7

[1] Sensitive receptors listed in this table are also listed in Table 3.5-11.
kV/m = kilovolts per meter
mG = milligauss
N/A = not applicable

3.5.6 Environmental Consequences

3.5.6.1 Overview

This section discusses the potential impacts associated with EMF/EMI generated by the No Project Alternative and the project alternatives during project construction and operation. This section evaluates impacts of EMF/EMI on sensitive receptors and facilities including humans, livestock, sensitive equipment, schools, underground pipelines and cables, adjoining rail systems, 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. Operational 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 IAMFs to address EMF and EMI that are described in Volume 2, Appendix 2-E. These features assure compliance with EMI/EMF 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 will 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.

3.5.6.2 No Project Impacts

As discussed in Section 3.18, Regional Growth, the population in the project vicinity 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 EMFs and EMI, as well as sensitive receptors. The analysis of potential impacts of the No Project Alternative considers the effects of conditions forecasted by current land use and transportation plans in the vicinity of the project extent, 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 2012). Section 3.19, Cumulative Impacts, identifies planned and other reasonably foreseeable future projects anticipated to be constructed in the region to accommodate projected growth, 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 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 non-directional (cellular and broadcast) antennas that result in EMFs and EMI, could continue and would likely increase within the project extent. Population growth alone would result in additional use of electricity and RF communications, consistent with that currently found in the urban and rural environments in the RSA. In addition, the development of new schools, hospitals, police stations, and other facilities with sensitive equipment could 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 (such as wireless data communication). As a result, generation of EMFs and EMI that might affect people, and sensitive receptors would continue to increase in the area. 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 could involve demolition of existing structures; clearing and grubbing; handling, storing, hauling, excavating, and placing fill; pile driving; and construction of aerial structures, bridges, road modifications, utility upgrades and relocations, HSR electrical systems, and railbeds. PG&E network upgrades would require extension of underground and/or overhead power transmission lines to three TPSSs that would be constructed as part of the project for all alternatives, and would include reconductoring of overhead electric utilities that may involve use of helicopters for equipment installation. Section 2.8, Construction Plan, further describes construction activities.

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

Construction of the project alternatives would require use of 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 any of the project alternatives; only the locations of construction activities would differ among the alternatives. Construction effort for the Diridon design variant (DDV) and tunnel design variant (TDV) would be approximately the same as the alternatives without the design variants and would occur in the same general locations, and thus DDV and TDV construction would not result in any change in the generation of EMFs during construction.

Three livestock and poultry operations and one wildlife area are within the RSA of the project alternatives (sites 47, 61, 62, and 59 in Table 3.5-11). Studies conducted in response to concerns about impacts on farm animals and wildlife documented little impact from EMFs. With regard to dairy production, McGill University conducted a study that exposed cows in pens to controlled EMF levels of 300 mG and 10 kV/m, the projected magnetic and electric fields that occur at ground level under a 735-kV line at full load. The researchers measured melatonin levels, prolactin levels, milk production, milk-fat content, dry-matter intake by cows, and reproductive outcomes. While a few statistically significant changes in these factors were found, none of the changes were outside the normal range for cows (McGill University 2006). The study concluded that the EMF exposure did not harm the cows or reduce milk productivity.

Various studies cited by other researchers regarding EMFs and wildlife suggest a range of effects similar to livestock, from nonexistent to relatively small to positive. One study, conducted at exposure levels between 50 and 100 mG, suggested a beneficial application for extremely low frequency EMFs in broiler chickens to fight a common parasitic infection called coccidiosis (Golder Associates 2009). These studies concluded that EMF exposure at levels that would exceed levels that would be generated during project construction would not harm farm animals or reduce their productivity (Golder Associates 2009). Therefore, EMFs generated by construction of any of the project alternatives would not disrupt agricultural operations because they would not affect livestock and poultry productivity.

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 closely to the equipment in question to cause interference. As an example, articulated buses (approximately 50,000 pounds) produce magnetic field shifts of approximately 0.5 mG at a distance of 70 feet (ERM 2007). For a construction vehicle with twice the mass of an articulated bus, the magnetic field shift would be 1 mG at 70 feet or 2 mG at 50 feet. Because the magnitude of this disturbance would decrease with distance, construction vehicles would pose no reasonable interference risk to magnetically sensitive equipment at pass-by 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 located more than 50 feet from construction easements (see Table 3.5-11). An exception would occur under Alternative 1, which would conduct construction within 15 feet of the Butterfield Professional Center. The design of all alternatives, including Alternative 1, will avoid interference to sensitive equipment at this facility through preconstruction review and design of features that avoid potential interference with neighboring land uses, in accordance with federal and state laws requiring avoidance of EMI (EMI/EMF-IAMF#2).

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.

CEQA Conclusion

The impact under CEQA would be less than significant for all alternatives because EMF generated during construction would be below levels known to disrupt agricultural activities or result in a documented health risk. 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, with one exception, all receptors likely to operate sensitive equipment subject to potential interference are located more than 50 feet from the construction easements, where any such magnetic shifts would be below the 2-mG threshold. The one exception, the Butterfield Professional Center, would be within 15 feet of construction under Alternative 1; however, project features would avoid potential interference at this facility and the impact on nearby sensitive facilities would be less than significant under any alternative. 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 mitigation.

Operations Impacts

Operations of the project alternatives would involve the movement of electric trains, as well as the operations and maintenance of the rail, associated structures and utilities, fencing, power system, train control, and communications. All these activities could generate EMF and interfere with the operation of electrical, magnetic, or electromagnetic devices. Additionally, HSR operations could affect adjacent rail signal systems or corrode underground pipelines or cables. Section 2.6, Operations and Service Plan, more fully describes HSR operations and maintenance activities.

Impact EMF/EMI#2: Permanent Human Exposure to EMFs

HSR operations would result in permanent, but intermittent, EMF exposure to passengers (general public) on the HSR train station platforms and HSR employees working within the HSR right-of-way. The four project alternatives would use the same technology and operate at the same intensity, so overall EMF emissions would be largely similar for any of the project alternatives. The general public also would be exposed permanently to EMFs from electrical infrastructure and network upgrade facilities, and utility employees working within interconnection facilities would be exposed to EMFs during their occupation of these facilities for maintenance activities. There would be some differences between the alternatives due to differences in alignments and speeds, but as discussed below, the field levels for both levels are far below the relevant thresholds.[6]

As shown in Table 3.5-11, modeled HSR magnetic field strengths at these locations range from less than 0.1 mG to approximately 150 mG (median value 1.5 mG) and are generally higher than the ambient field strengths shown in Table 3.5-9, which fall between 0.01 mG and 50 mG (median value 0.6 mG). For the survey sites listed in Table 3.5-9, measured ambient levels were lower than the predicted HSR levels at 7 of the 10 locations, and higher than the predicted HSR levels at 3 locations. At some sites and for some alternatives, the track alignment falls partially within the site boundaries (noted as “adjacent” in Table 3.5-9). At those sites with overlap, and in the event that an alternative is constructed, the current use at that location would be replaced with HSR infrastructure. The modeled 60-Hz magnetic field strength shown in the table is at 30 feet (the minimum distance from the HSR track centerline to the fence line at the edge of the right-of-way) and would represent the next nearest land use.

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. Table 3.5-13 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 HSR track centerline. In all cases, the predicted EMF value would be less than the most restrictive

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[6] Due to slightly higher speeds in the area of the DDV, HSR train operations would generate slightly higher EMFs in the DDV area for Alternative 4 with the DDV than Alternative 4 without the DDV, but still would be well below the threshold levels.

MPE limits (for HSR employees with pacemakers) of 1 kV/m for electric fields and 1,000 mG for magnetic fields. MPE limits are identified in Table 3.5-7.

Table 3.5-13 Summary of HSR Exterior EMF Levels

EMF Modeled Analysis	Platform: 16 Feet from HSR Track Centerline	Fence Line: 30 Feet from HSR Track Centerline	Resource Study Area: 500 Feet from HSR Track 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 2011a
EMF = electromagnetic field
HSR = high-speed rail
mG = milligauss
V/m = volts per meter

Due to higher speeds in the areas of the design variants, HSR train operations would generate slightly higher EMFs in the DDV and TDV areas than the alternatives without the DDV and TDV.

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). The Authority will employ a 2x25 kV traction power supply system with an NF wire running above and parallel to the overhead contact system, which reduces the total magnetic field created by the supply current flowing in the OCS and the return currents flowing in the NF and rails. This arrangement would differ in some cases from those employed by the Acela Express and TGV systems and, in general, would be expected to produce magnetic fields that are lower than the quoted values on the other HSR systems that utilize a 1x25-kV system. For example, the electrified Northeast Corridor used by the Acela Express is not strictly 2x25 kV; some sections are 1x12.5 kV or 11.5 kV, and the magnetic fields in the sections without the negative return feeder would be higher than in sections with the 2x25-kV traction system arrangement (Authority 2010b). Based upon the results of magnetic field measurements at other existing HSR systems and the use of the 2x25-kV supply by the Authority for its HSR system, EMF exposure levels would be below the most restrictive MPE limits and not create a documented EMF health risk to HRS passengers and employees.

Exposure of the general public outside of the HSR system (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 HSR track centerline as shown in Table 3.5-13). 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 (see Table 3.5-7). Overall, Alternatives 1 and 2 would be directly adjacent to one more sensitive receptor (receptors directly adjacent to the HSR system would be exposed to the highest levels of EMF from HSR operations) relative to Alternatives 3 and 4 (Table 3.5-11).

As shown in Table 3.5-11, four sensitive receptors (sites 4, 37, 48, and 53) are located adjacent to or near electrical infrastructure and network upgrade facilities. Scattered residences are located along the length of the Spring to Llagas and Green Valley to Llagas 115 kV power line and adjacent to Site 3–San Jose and Site 4–Gilroy. The proximity of sensitive receptors to the electrical infrastructure and network upgrades would be the same for all alternatives. Sensitive receptors along the length of the upgraded power lines and interconnection facilities would not be exposed to a change in baseline EMF conditions because the voltage would not change, and the proximity of the electrical lines to sensitive receptors would be the same (EMF levels are a function of voltage and distance). Furthermore, the reconductoring would occur pursuant to the CPUC General Order (GO) 95 (Rules for Overhead Electric Line Construction) and GO 174 (Rules for Electric Utility Substations). Similarly, utility workers temporarily occupying interconnection facilities for maintenance activities would not be exposed to levels of EMF above baseline conditions.

CEQA Conclusion

The impact under CEQA would be less than significant for all alternatives because the EMFs generated during operations of the HSR system would fall well below the applicable MPE limits, and, therefore, the general public and HSR employees would not be exposed to a documented EMF health risk. HSR train operation EMFs would not have significant effects under CEQA even at the maximum speeds with the design variants on receptors that are located at the same distance or closer to the alignment than receptors along the DDV and TDV segments. Exposure of the general public and utility workers to EMFs from electrical infrastructure and network upgrade facilities also would not exceed baseline conditions. Therefore, CEQA does not require mitigation.

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

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 et al. 2002; Trigano et al. 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 occur only inside traction power distribution and interconnection facilities, which are unmanned and inaccessible to the general public. Electric fields exceeding these limits may also occur directly beneath 230-kV tie-in lines; levels would fall well below this limit outside of the line right-of-way.

In addition to traction power distribution and interconnection facilities, emergency standby generators produce EMFs and would be located at passenger stations and at other traction power facilities. The emergency standby generators are also 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, HSR workers, or other members of the public with implanted medical devices. The Implementation Stage EMC Program Plan (ISEP) (EMI/EMF-IAMF#2) will require posting signs at the TPSS, switching and paralleling stations, and on tie-line structures, warning persons with an implanted medical device of the potential for high levels of EMFs. With regard to power lines proposed to be reconductored, there would be no change in baseline conditions because the voltage and the proximity of the electrical lines to sensitive receptors would remain the same.

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 unstaffed, and workers would only enter them periodically to perform routine maintenance. In accordance with the ISEP, persons with an implanted medical device would not be permitted near these facilities and sites.

CEQA Conclusion

The impact under CEQA would be less than significant for all alternatives because the public and workers with implanted medical devices would not be exposed to an EMF health risk. Traction power distribution facilities, interconnection facilities, and emergency standby generators, which could produce EMF levels that will interfere with implanted medical devices, will be inaccessible to the general public and administratively restricted from workers with implanted medical devices per EMI/EMF-IAMF#2 and the ISEP. In addition, the ISEP and EMI/EMF-IAMF#2 prescribe that signs posted around these facilities warn persons with implanted medical devices of high levels of EMFs. Therefore, CEQA does not require mitigation.

Impact EMF/EMI#4: Livestock and Poultry Exposure

As noted in the discussion for Impact EMF/EMI#1, three livestock and poultry operations and one state wildlife area are within the RSA (Sites 47, 61, 62, and 59 in Table 3.5-11). The wildlife area and two of the agricultural operations are within the RSA for Alternatives 1 through 4, and the third agricultural operation is within the RSA for Alternatives 1, 2, and 4. However, studies conducted in response to concerns about impacts on farm animals and wildlife found that exposure to EMF levels exceeding those produced by the HSR system and associated electrical infrastructure and network upgrades would have no effect on the productivity of livestock and poultry and no effect on wildlife.

CEQA Conclusion

The impact under CEQA would be less than significant under any of the alternatives because several studies documented that EMFs do not reduce livestock or poultry productivity and would therefore not disrupt nearby agricultural activities. The three livestock and poultry operations in the RSA would be unaffected by operation of HSR trains. There would be no effect on wildlife. Therefore, CEQA does not require mitigation.

Impact EMF/EMI#5: 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 effects on this type of sensitive equipment (Authority 2012). Other forms of equipment sensitive to EMFs include those susceptible to RF interference, such as fire and police radio services. Effects on school radio systems are discussed under Impact EMF/EMI#6, EMI Effects on Schools.

Within the RSA, a medical facility, St. Louise Regional Hospital (Site 49 in Table 3.5-11), and three high-technology facilities, Great Oaks Research Park, Paramit Manufacturing, and Butterfield Professional Center (Sites 25, 32, and 34 in Table 3.5-11), operate magnetically sensitive imaging equipment (MRI or CT scanners) and other potentially sensitive instrumentation. Alternative 4 could expose the Great Oaks Research Park to magnetic shifts exceeding 2 mG. Alternative 2 could expose Paramit Manufacturing to a magnetic shift exceeding 2.2 mG, potentially affecting sensitive equipment at this location. Alternatives 2 and 4 would result in magnetic field shifts of 36 mG and 6.5 mG, respectively, at the Butterfield Professional Center. Six police and fire department facilities in the cities of Santa Clara, San Jose, and Morgan Hill, and Santa Clara County (Sites 3, 11, 22, 24, 41, and 45 in Table 3.5-11) operate radio systems that may be sensitive to RF interference. The six identified facilities susceptible to EMI are located within the Diridon Station Approach, Monterey Corridor, and Morgan Hill and Gilroy Subsections. Four sites would be located in the Alternative 1 RSA, five sites in the Alternative 2 RSA, five sites in the Alternative 3 RSA, and four sites in the Alternative 4 RSA.

RF interference from HSR radio systems used for enhanced automatic train control, data transfer, and communications will be avoided through design characteristics and project features (IAMFs). The Authority would require that communications equipment procured for HSR use, including commercial and non-commercial off-the-shelf products, comply with FCC regulations designed to prevent EMI with other equipment or hazards to persons. The HSR project design also will comply with TM 300.10, CHSTP Implementation Stage EMC Program Plan (ISEP), which provides detailed electromagnetic compatibility design criteria for the HSR systems and equipment (EMI/EMF-IAMF#2). As part of the ISEP, the Authority would confirm compatibility of the HSR with other users' radio systems, such as those of 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, each with a width of 4 MHz, for use by automatic train control systems. These blocks are in the 700 MHz spectrum and dedicated for HSR use, and therefore are 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 2011b, Authority 2014a, Authority 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 ensuring compatibility with equipment of all neighboring facilities. In conformance with the EMCPP and ISEP (TM 300.10), the Authority and its contractors will 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 (EMI/EMF-IAMF#2). Chapters 22 and 26 of the *California High-Speed Rail 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 operation of the HSR system to confirm sensitive equipment would not be 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 all 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 electromagnetic compatibility design criteria for the HSR systems and equipment with other equipment. The Authority will coordinate with third parties to identify nearby sensitive equipment with the potential to be affected by the HSR system and, if necessary, take specific steps to avoid these effects and ascertain compatibility, including performing tests to confirm equipment is free from impacts (EMI/EMF-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 mitigation.

Impact EMF/EMI#6: EMI Effects on Schools

The project would use radio systems for the enhanced automatic train control, data transfer, and communications systems, raising the concern that HSR operations could result in EMI with the radio systems in use at nearby schools and colleges. The following 19 schools, universities, and childcare centers were identified within the RSA (12 in Alternative 1, 15 in Alternative 2, and 11 in Alternative 3, and 15 in Alternative 4) (see Table 3.5-11):

- Bellarmine College Preparatory (site 6)
- Gardner Elementary School (site 13)
- Tamien Child Care Center (site 16)
- Charter School of Morgan Hill (site 30)
- Central High School (annex) (site 31)
- Shadow Mountain Baptist School (35)
- El Toro Elementary School (site 36)
- Lewis Britton Middle School (site 37)
- Gavilan College (site 38)
- Barrett Elementary School (site 40)
- San Martin/Gwinn Elementary School (site 42)
- A+ Learning Center Preschool (site 43)
- Rucker Elementary School (site 46)
- Christopher High School (site 48)
- South Valley Middle School (site 50)
- Gilroy Preparatory School (site 51)
- Rebekah Children's Center (site 52)

- Wheeler Tot Lot (site 54)
- Anchorpoint Christian School (site 56)

HSR radio systems would transmit radio signals from antennas located 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 2011b, 2014a, 2016). WiFi frequencies used at HSR stations 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 will perform EMC/EMI safety analyses, which will 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 (EMI/EMF-IAMF#2).

During operations, the Authority would conduct monitoring and evaluation of system performance to minimize the potential for HSR-generated EMFs 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 non-commercial 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 EN 50121-4 Standard for railway signaling and telecommunications operations (CENELEC 2015) that are designed to support EMC with other radio users.

CEQA Conclusion

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

Impact EMF/EMI#7: Potential for Corrosion of Underground Pipelines and Cables and Adjoining Rail

TPSSs located every 30 miles would deliver AC current to the HSR trains through the OCS, with return current flowing from the trains back to the TPSSs through the steel rails and NF wires. While most return current would be carried back to the TPSS by the NF, some of the rail return current could find a path from the rails to the ground via 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 Bay Area Rapid Transit 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. All four alternative alignments would be adjacent to pipelines and other linear metallic structures and include project features (EMI/EMF-IAMF#2) that will minimize the potential for corrosion from ground currents.

CEQA Conclusion

The impact under CEQA would be less than significant for all 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 mitigation.

Impact EMF/EMI#8: 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 and ungrounded metal irrigation systems alongside the HSR alignment. This effect would be more likely where long (1 mile or more), ungrounded fences or irrigation systems run parallel to the HSR and are electrically continuous throughout that distance. Such voltages could potentially cause a nuisance shock to anyone who touches such a fence or irrigation system or any animal that comes into contact with these features. An example of an ungrounded metal irrigation system would be a center pivot system on rubber tires. By contrast, the Vermeer-type metal irrigation system is grounded by its metal wheels, and therefore offers less shock hazard. Any surface pipe-metal irrigation system would be grounded through its contact with the ground. Long, ungrounded fences and metal irrigation systems are more common in rural areas than urban areas. Most metal structures adjacent to the HSR should already be properly grounded through compliance with National Electrical Code guidelines for building and electrical system safety and lightning protections. Nevertheless, the potential exists for unidentified, ungrounded structures along the HSR alignment.

To avoid possible shock hazards to humans or animals, the project design will include grounding of HSR fences, non-HSR parallel metal fences, and parallel metal irrigation systems (with the cooperation of the affected owner or utility) within a specified lateral distance of the HSR alignment (EMI/EMF-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 (Authority 2014a). Furthermore, modifications to PG&E facilities would be implemented pursuant to the CPUC GO 95 (Rules for Overhead Electric Line Construction) and GO 174 (Rules for Electric Utility Substations), minimizing the potential for nuisance shocks. For cases where fences would be purposely electrified, site-specific insulating measures will be designed and implemented to minimize the potential for nuisance shocks (Authority 2014b). All four 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 all 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 mitigation.

Impact EMF/EMI #9: Effects on Adjacent Existing Rail Lines

Signal systems control the movement of trains on the existing Union Pacific Railroad (UPRR) tracks that would parallel HSR track for large sections between Scott Boulevard in Santa Clara to Bloomfield Avenue in Gilroy. These signal systems serve three general purposes:

- Warning 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.
- Warning 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.

- Showing 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.

Railroad signal systems operate in several ways but generally are based upon the principle that the railcar metal wheels and axles electrically connect the two running rails. 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.

The HSR OCS would carry 60 Hz AC electric currents of up to 930 amperes per train. Interference between the HSR 60 Hz currents and a nearby freight railroad signal system, which will be avoided with incorporation of agreements with railroads (EMI/EMF-IAMF#1), could occur under the following conditions:

- The high electrical currents flowing in the OCS and the return currents in the overhead NF, HSR rails, and ground could induce 60 Hz voltages and currents in existing parallel railroad tracks. If an adjoining freight railroad track parallels the HSR tracks for a long enough distance (i.e., several miles), the induced voltage and current in the adjoining freight railroad tracks could interfere with the normal operation of the signal system so that it indicates there is no freight train present, when in fact one is (or it indicates the presence of a freight train when in fact no train is there). These conditions exist for much of the HSR alignment through the Monterey Highway Corridor and Morgan Hill and Gilroy Subsections, where the HSR alignment would be parallel and adjacent to freight railroad tracks.
- Higher-frequency EMI from several HSR sources (e.g., electrical noise from the contact on the pantograph sliding along the contact conductor, from electrical equipment on board the train, or from the cab radio communication system) could cause electrical interaction with the adjoining freight railroad signal or communication systems.

The EMI concerns for the northern portion of the project alignment have been addressed as part of the proposed PCEP (PCJPB 2016). Within the project extent, this electrification work extends from Scott Boulevard in Santa Clara to Tamien Station in San Jose, encompassing all the San Jose Diridon Station Approach Subsection and a small portion of the Monterey Corridor Subsection. The electrification and upgrades to the blended HSR/Caltrain corridor (see Section 2.5.2, HSR Alternatives for the San Jose to Central Valley Wye Project Extent) would be designed for compatibility with existing signal systems of adjacent freight and passenger rail by ensuring proper electrical grounding and shielding; the installation of specialized components, such as filters, capacitors, and inductors, and the incorporation of design standards to prevent the effects of EMI on signal systems. Furthermore, the Peninsula Joint Powers Board would implement Mitigation Measure EMF-2: Minimize EMI effects during final design, monitor EMI effects during testing, commission and operations, and remediate substantial disruption of sensitive electrical equipment, to reduce EMI impacts to a less than significant level (PCJPB 2015).

There remain large sections of parallel UPRR track, from Tamien Station to Bloomfield Avenue in Gilroy, that would have potential EMI impacts under each alternative:

- Alternative 1—24.4 miles of parallel track
- Alternative 2—31.4 miles of parallel track
- Alternative 3—16.4 miles of parallel track
- Alternative 4—33.0 miles of parallel track

The HSR contractor will work with the engineering departments of freight railroads that parallel the HSR line to apply the standard design practices that a non-electric railroad must use when an electric railroad or electric power lines are installed next to its tracks (EMI/EMF-IAMF#1). These standard design practices include assessment of the specific track signal and communication equipment in use on nearby sections of existing rail lines, evaluation of potential impacts of HSR EMFs and radio-frequency interference (RFI) on adjoining railroad equipment and application of suitable design provisions on the adjoining rail lines to prevent interference. These standard design and operational practices would prevent the possible effects 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 (EPRI 2006).

Design provisions often include replacing specific 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, providing filters for sensitive communication equipment and potentially relocating or reorienting radio antennas. These design provisions would be put in place and determined to be adequately effective prior to the activation of potentially interfering systems of the HSR system.

CEQA Conclusion

The impact under CEQA would be less than significant for all 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 modify or upgrade their signal systems as needed to avoid interference from HSR operations. Therefore, CEQA does not require mitigation.

Impact EMF/EMI#10: EMI Effects on Airports

Airports operate radio and other electronic systems that are potentially susceptible to EMI from other radio systems. The project alternatives pass within approximately 1,600 feet of San Jose International Airport and 1,400 feet of San Martin Airport. Although both airports are outside the RSA, they have been included in this analysis as sensitive receptors given the safety-critical nature of radio-based systems and uncertainties about the location 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 radio frequencies. 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 (Shooman 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. Part 2.106) to minimize the potential of EMI from all other radio services. With one minor exception[7], 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.

To minimize interference from HSR communication systems, 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 (since 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 non-commercial off-the-shelf products, complies with FCC regulations designed to prevent EMI with other equipment. The Authority will comply with the ISEP requirements during project planning and implementation to ensure compatibility with radio systems operated by San Jose International Airport and San Martin Airport (EMI/EMF-IAMF#2). Potential impacts would be avoided through implementation of

7 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.

EMI/EMF-IAMF#2, which will provide the necessary third-party coordination through the EMCPP and ISEP. During the planning stage through system design, the Authority would perform additional EMC/EMI safety analyses, including:

- Coordination with FAA's Spectrum Engineering Office and airport staff, as necessary
- Identification of existing airport radio systems
- Selection of systems to prevent EMI with identified airport uses, and incorporation of these requirements into bid specifications used to procure radio systems

Recognizing that FAA requirements regarding EMI exceed the normal FCC limits, the implementation stage ISEP would also include monitoring and evaluation of system performance for compatibility with airport systems. This would include verifying that airport radio navigation aids are free of interference from pantograph arcing. Because the same project features would apply for all alternatives, the effects would be the same.

CEQA Conclusion

The impact under CEQA would be less than significant for all 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. In addition, during the planning and implementation stage, the Authority would design the HSR systems to prevent EMI with identified neighboring uses and monitor system performance to support ongoing compatibility. Therefore, CEQA does not require mitigation.

3.5.7 Mitigation Measures

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

3.5.8 Impact Summary for NEPA Comparison of Alternatives

As described in Section 3.1.6.4, the effects 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 upon the context and intensity of the change that would be generated by construction and operation of the project. Table 3.5-14 compares the project impacts by alternative, followed by a summary of the impacts.

Temporary construction activity for all four project alternatives would cause fluctuations in EMF levels, although the practical effects would be limited to within 50 feet of the project footprint and comply with FCC regulations. EMF fluctuations that could be generated by construction vehicle movements related to Alternative 2 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 all of the four alternatives would not exceed levels which could affect human health or livestock and poultry productivity. Potential interference with sensitive equipment associated at the Butterfield Professional Center under Alternatives 1, 3, and 4 will be addressed through compliance with federal and state laws requiring the project to avoid EMI (EMI/EMF-IAMF#2).

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, the Authority would coordinate with third parties to identify nearby sensitive equipment with the potential to be affected by the HSR system and, if necessary, identify appropriate mitigation to avoid these effects, including performing tests to confirm equipment is not adversely affected.

Table 3.5-14 Comparison of Project Alternative Impacts for EMFs and EMI

Impacts	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Impact EMF/EMI#1: Temporary Impacts from Use of Construction Equipment	Construction activities would occur more than 50 feet from facilities with known sensitive equipment. Therefore, these facilities would not be exposed to EMF generated by construction equipment. No individuals would be exposed to EMF levels that exceed human health standards. EMF generated during construction would be below levels known to disrupt agricultural activities.	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. Construction activities would occur within 15 feet of the Butterfield Professional Center, a facility with known sensitive equipment. EMF generated during construction would be below levels known to disrupt agricultural activities.	Same as Alternative 1	Same as Alternative 1
Impact EMF/EMI#2: Permanent Human Exposure to EMFs	HSR operations would expose the general public and HSR employees and passengers to EMF inside and outside the HSR system. Inside the HSR system, EMF exposure levels would be below the most restrictive MPE limits. Outside the HSR system, EMF levels would not exceed the MPE thresholds for humans.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1 without the design variants. With the design variants, HSR train operations would generate slightly higher EMFs in the DDV and TDV areas than the alternatives without the DDV and TDV.
Impact EMF/EMI#3: Exposure of People with Implanted Medical Devices to EMFs	EMF levels generated inside traction power distribution and interconnection facilities and produced by emergency standby generators would be above the recommended limits for people with implanted medical devices. However, the public and workers with implanted medical devices would be restricted from accessing these facilities.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Impacts	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Impact EMF/EMI#4: Livestock and Poultry Exposure	Several studies documented that EMFs do not affect livestock or poultry productivity and would therefore not disrupt nearby agricultural activities. The three livestock and poultry operations in the RSA would be unaffected by operation of HSR trains.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Impact EMF/EMI#5: Interference with Sensitive Equipment	The RSA includes one facility with sensitive equipment; however, this facility would not be exposed to a magnetic shift greater than 2 mG.	The RSA includes three facilities with sensitive equipment, two of which would be exposed to a magnetic shift greater than 2 mG. The Authority would coordinate with third parties to identify sensitive equipment at the known receptors and, if necessary, identify appropriate mitigation, including performing tests to confirm equipment is not adversely affected.	The RSA includes two facilities with sensitive equipment, although neither would be exposed to a magnetic shift greater than 2 mG.	The RSA includes three facilities with sensitive equipment, two of which would be exposed to a magnetic shift greater than 2 mG. Coordination with third parties would be the same as under Alternative 2.
Impact EMF/EMI#6: EMI Effects on Schools	Dedicated frequency blocks for the HSR system and compliance with FCC regulations for all HSR equipment would not generate interference at the 12 schools within the Alternative 1 RSA.	Same as Alternative 1 for the 15 schools within the Alternative 2 RSA.	Same as Alternative 1 at the 11 schools within the Alternative 3 RSA.	Same as Alternative 1 at the 15 schools within the Alternative 4 RSA.
Impact EMF/EMI#7: Potential for Corrosion of Underground Pipelines and 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 1	Same as Alternative 1	Same as Alternative 1

Impacts	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Impact EMF/EMI#8: 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 1	Same as Alternative 1	Same as Alternative 1
Impact EMF/EMI#9: Effects on Adjacent Existing Rail Lines	There are 24.4 miles of parallel UPRR track susceptible to EMI impacts under Alternative 1. Project features include working with the engineering departments of adjacent parallel railroads to modify or upgrade their signal systems to prevent interference from HSR generated EMI.	There are 31.4 miles of parallel UPRR track susceptible to EMI impacts under Alternative 2. Project features would be the same as Alternative 1.	There are 16.4 miles of parallel UPRR track susceptible to EMI impacts under Alternative 3. Project features would be the same as Alternative 1.	There are 33.0 miles of parallel UPRR track susceptible to EMI impacts under Alternative 4. Project features would be the same as Alternative 1.
Impact EMF/EMI#10: EMI Effects on Airports	The project alternatives would pass within 1,600 feet of San Jose International Airport and within 1,400 feet of San Martin 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 1	Same as Alternative 1	Same as Alternative 1

Authority = California High-Speed Rail Authority
CEQA = California Environmental Quality Act
EMF = electromagnetic fields
EMI = electromagnetic interference
FAA = Federal Aviation Administration
FCC = Federal Communications Commission
HSR = high-speed rail
MPE = maximum permissible exposure
NEPA = National Environmental Policy Act
RSA = resource study area
UPRR = Union Pacific Railroad

EMF levels exceeding those that would be generated by the HSR system have been documented not to affect livestock and poultry productivity. As a result, none of the four alternatives would disrupt agricultural operations.

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. These facilities would be inaccessible to the general public, and the ISEP would restrict workers with implanted medical devices from accessing traction power distribution facilities, interconnection facilities, and emergency standby generators. In addition, signs posted around these facilities would warn persons with implanted medical devices of high levels of EMFs.

The project includes project features (EMI/EMF-IAMF#2) that will 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. 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, the Authority would coordinate with third parties to identify nearby sensitive equipment with the potential to be affected by the HSR system and, if necessary, identify appropriate mitigation to avoid these effects, including performing tests to confirm equipment is free from impacts.

Dedicated frequency blocks for the HSR system and compliance with FCC regulations for all HSR equipment would avoid the potential for interference at schools. 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 systems to prevent EMI with identified neighboring uses.

To preclude possible interference with adjacent existing rail lines, the HSR contractor will work with the engineering departments of freight railroads that parallel the HSR line to apply the standard design practices that a non-electric railroad must use when an electric railroad or electric power lines are installed next to its tracks (EMI/EMF-IAMF#1). These standard design practices include assessment of the specific track signal and communication equipment in use on nearby sections of existing rail lines, evaluation of potential impacts of HSR EMFs and RFI on adjoining railroad equipment and application of suitable design provisions on the adjoining rail lines to prevent interference. Ground currents generated by operation of the project are not expected to result in potential corrosion of adjoining rail. Features of the project include arranging for the grounding of nearby ungrounded linear metal structures or insulating metallic pipes to prevent current flow so that corrosion will not occur. The project also would ground nearby ungrounded linear metal structures so that electric shocks would not occur. In the case of purposely electrified fences, site-specific insulating measures will be designed and implemented.

Effects on adjacent railroad lines and facilities from operations of the project alternatives would be avoided through preconstruction design coordination with adjacent railroads to modify or upgrade their signal systems as needed to avoid interference from HSR operations. Alternative 4 has the greatest amount of adjacent railroad facilities with 33.0 miles of parallel track, followed by Alternatives 2, 1, and 3 with 31.4 miles, 24.7 miles, and 16.4 miles, respectively.

The HSR radio system would use dedicated frequency blocks and meet FCC regulations (47 C.F.R. Part 15) for EMI. HSR equipment would be selected in consultation with FAA RFI 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 effect would be the same for all project alternatives.

3.5.9 CEQA Significance Conclusions

As described in Section 3.1.6.4, 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 3.5-15 identifies the CEQA significance determinations for each impact discussed in Section 3.5.6, Environmental Consequences.

Table 3.5-15 CEQA Significance Conclusions and Mitigation Measures for the EMFs and EMI

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 all alternatives: Preconstruction review and project features will 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 EMFs	Less than significant for all alternatives: EMF levels inside and outside the HSR system 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 EMFs	Less than significant for all alternatives: The public and workers with implanted medical devices would be restricted from accessing these facilities.	No mitigation measures are required	N/A
Impact EMF/EMI#4: Livestock and Poultry Exposure	Less than significant for all alternatives: EMF generated during construction would be below levels known to disrupt agricultural activities.	No mitigation measures are required	N/A
Impact EMF/EMI#5: Interference with Sensitive Equipment	Less than significant for all alternatives: Coordination with third parties will 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#6: EMI Effects on Schools	Less than significant for all alternatives: Dedicated frequency blocks for the HSR system and compliance with FCC regulations for all HSR equipment would avoid interference with schools.	No mitigation measures are required	N/A
Impact EMF/EMI#7: Potential for Corrosion of Underground Pipelines and Cables and Adjoining Rail	Less than significant for all alternatives: The 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#8: Potential for Nuisance Shocks	Less than significant for all alternatives: The 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#9: Effects on Adjacent Existing Rail Lines	Less than significant for all alternatives: The project would work with adjacent parallel railroads to modify or upgrade their signal systems to avoid interference from HSR operations.	No mitigation measures are required	N/A
Impact EMF/EMI #10: EMI Effects on Airports	Less than significant for all alternatives: The 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

N/A = not applicable