

3.5 Electromagnetic Fields and Electromagnetic Interference

Electromagnetic fields (EMF) describe electromagnetic radiation that is on the lower frequency end of the electromagnetic spectrum.¹ The electromagnetic spectrum includes the various wave forms of energy, from electrical fields to radio waves to light to x-rays. Energy frequencies at the high end of the spectrum are termed ionizing because they break chemical bonds and thereby can damage living cells and deoxyribonucleic acid (DNA). Energy frequencies at the lower end are termed non-ionizing since they do not break chemical bonds and would not have the same biological effects as ionizing radiation. EMF can also result in electromagnetic interference (EMI), which can cause disruptions and possibly malfunctions in sensitive equipment.

EMF is both naturally occurring and human-made. Movement within the earth's molten core generates a substantial electromagnetic field. Stars and sunspot activity generate EMF, as do certain biological processes. Human-made sources have become increasingly prevalent in the last 100 or so years and prominent among these are electrical equipment, telecommunications, and electricity supply facilities. Human-made sources of EMF and EMF's environmental effects are the focus of this section because electrification of Caltrain service would require an electrified overhead system and supporting traction power facilities, thereby increasing sources of EMF in the study corridor.

3.5.1 Existing Conditions

3.5.1.1 Regulatory Setting

Neither the federal government nor the State of California has set emission standards for EMF or EMI.

The Federal Drug Administration, Federal Communications Commission, Department of Defense, and United States Environmental Protection Agency (EPA) at various times have considered EMF guidelines, but none has been adopted.

The California Energy Commission (CEC) recommends that transmission lines be designed so electric fields at the edge of rights-of-way (ROW) do not exceed 1.6 kilovolt (kV)/meter (m); no recommendation is provided for magnetic fields, however. The CEC's current position is that EMF exposure at utility ROW limits should not constitute a significant effect "if emissions have been mitigated to the extent achieved by engineering practice" (Exponent Health Group 2001). The California Department of Education has established a policy of "prudent avoidance" for the location of schools in the vicinity of high-voltage power lines.

¹ The frequency of electromagnetic radiation is the rate at which the electromagnetic field changes direction, expressed in terms of cycles per second, or Hertz (Hz). Frequencies of less than around 3,000 Hz are considered extremely low frequency (ELF) and include alternating current electrical fields that oscillate at 60 Hz.

1 3.5.1.2 Environmental Setting

2 Background on EMF

3 Electrical systems produce both electric and magnetic fields. Electric fields result from the strength
4 of the electric charge, while magnetic fields are generated from the motion of the charge. Together
5 these fields are referred to as EMF, which are invisible, non-ionizing, low-frequency radiation.
6 Electric field strength is measured in units of kV/m and is greater the higher the voltage. Magnetic
7 field strength is measured in units of milliGauss (mG), or magnetic flux density, and is greater the
8 higher the current flow. ~~It is also higher for direct current (DC) than for alternating current (AC).~~
9 Another common unit of magnetic field strength is the microTesla (μT), with 10 mG equivalent to
10 one μT .

11 Electric field strength deteriorates rapidly with distance from the source and is easily blocked by
12 most objects, including household objects, buildings, and vegetation. Magnetic fields also decrease
13 rapidly with increasing distance from the source but, unlike electric fields, are not easily blocked.
14 Magnetic fields pass readily through most objects. Magnetic fields are usually the radiation of
15 concern when evaluating EMF.

16 The strength of EMF levels from line sources such as the OCS are proportionate to the reciprocal of
17 distance from the source ($1/x$, where x is the distance from the line).² For example, the field strength
18 at 20 feet from the OCS line would be 50 percent and the field strength at 40 feet would be 25
19 percent of the field strength at 10 feet from the OCS line.

20 EMF Exposure and Health Effects

21 As noted above, EMF can result in EMI, which can cause disruptions and possibly malfunctions in
22 sensitive equipment. In certain situations with sufficiently high exposure, EMF can also result in
23 adverse effects on human health. Considerable research has been undertaken to determine whether
24 EMF at the low frequencies associated with commercial power systems has any health effects.
25 Although some findings conclude otherwise, the great majority of peer-reviewed and accepted
26 studies have found that scientific evidence for any health risks from extremely low-frequency EMF is
27 weak. Objective scientific reviews of animal data, from which some human health risks have been
28 extrapolated, have also concluded that the data are inadequate to indicate a potential risk of cancer,
29 which is the main human health risk assumed for EMF exposure (WHO 2007, IARC 2002, NIEHS
30 1999).

31 One area of continuing debate has been associations of two forms of cancer and extended exposures
32 to EMF: childhood leukemia and, in occupationally exposed adults, chronic lymphocytic leukemia.
33 The associations between cancer and EMF, however, have not been demonstrated in scientifically
34 controlled mechanistic (cause-effect) studies or experimental studies of animals, but according to
35 the World Health Organization (WHO), EMF remains a concern (WHO 2007a).

36 EMF from human-made sources is common and increasing in urban areas. Most people are exposed
37 on a daily basis to a variety of sources and field strengths. The average home in North America has
38 background AC magnetic field levels of approximately 1 mG (WHO 2007b). Background EMF and the

² EMF levels from point sources (such as a hair dryer) attenuate more rapidly than from a line source because the EMF field strength is proportional to the reciprocal of distance from the source squared ($1/x^2$). Thus, the EMF level 40 feet from a point source would be 6.25% of the strength of the field 10 feet from the same point source.

1 durations of EMF exposure at home or at work would be expected to increase in the future as
2 electrical and electronic systems multiply.

3 Examples of magnetic field strengths of 60-Hz appliances commonly found in the home or office and
4 of magnetic field strengths of electric transmission facilities found in many communities are listed in
5 Table 3.5-1. For the first four appliances, exposure to the maximum field strength would be limited
6 in duration due to the character of use of these appliances. The magnetic field strengths for the video
7 display from a television or computer are for a range of models and represent the continuous level
8 of exposure (appliance plus background) a person would experience while observing or working
9 with the product over an extended period. As noted above, EMF levels from point sources such as
10 these decline at a more rapid rate than from line sources such as transmission lines.

11 **Table 3.5-1. Magnetic Field Strengths**

Electrical Appliances in Home or Office	Magnetic Field Strengths
Dishwasher	30 mG (at 1 foot)
Vacuum Cleaner	200 mG (at 1 foot)
Hair Dryer	70 mG (at 1 foot)
Electric Shaver	100 mG (at 1 foot)
Video Display	6 mG (at 1 foot)
Other Environmental Sources	
Electric power distribution/subtransmission lines (4 to 24 kV)	
Within right-of-way	10 to 70 mG (at 1 foot)
Edge of right-of-way	NA
High-voltage transmission lines (115 kV to 500 kV)	
Within right-of-way	30 to 87 mG (at 1 foot)
Edge of right-of-way	7 to 29 mG (at 50 to 65 feet)
Source: NIEHS 2002. kV = kilovolt mG = milliGauss NA = not available	

12
13 Magnetic fields under and alongside the ROW of electric power transmission and distribution lines
14 are also listed in Table 3.5-1. There is considerable range in levels. ~~which are a function of~~
15 ~~the voltage (e.g., a 500-kV line would generate fields approximately four times as strong as a 115-kV~~
16 ~~line), the height of the power line, and the width of the ROW for exposures measured at the edge of~~
17 ~~ROW.~~

18 Magnetic field strength near an electric power line is primarily a function of the current carried by
19 the line and the distance to the measurement location. Electric field strength is roughly equal to the
20 voltage of the line divided by the distance to the measurement location.

21 The duration of EMF exposure could be quite short if, for example, one is simply driving by, or
22 extended, if one is in a residence or other structure adjacent to the power line ROW. At a distance of
23 300 feet and at times of average electricity demand, the magnetic fields from many lines can be
24 similar to typical background levels found in most homes (NIEHS 2002).

1 Caltrain Corridor

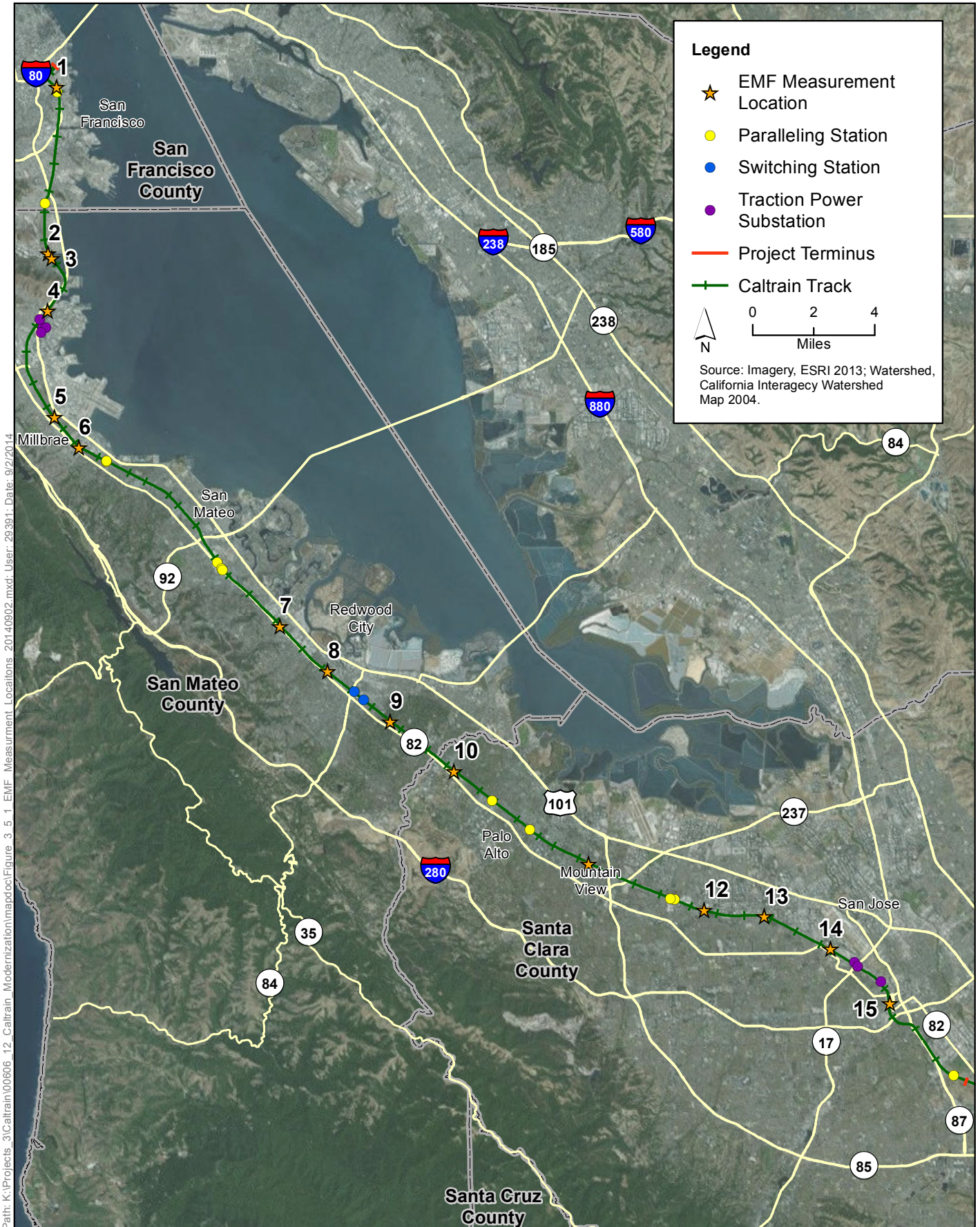
2 The Caltrain corridor proposed for electrification is approximately 51 miles long and passes through
3 urban and suburban environments. Land uses within urbanized areas vary from industrial to
4 commercial to residential. In May and June of 2010, electric and magnetic field measurements were
5 collected at 15 sites along the project corridor from San Francisco to San Jose.³

6 These sites were selected to obtain a cross-section of typical emitters such as power lines and
7 antenna towers, potentially sensitive facilities such as medical facilities and a university, and
8 relatively quiet areas for comparison. The 15 sites, which are shown in Figure 3.5-1, are as follows:

- 9 1. **University of California San Francisco (UCSF):** This location is near downtown San Francisco
10 at the project corridor's closest location to UCSF, at 16th Street where I-280 crosses overhead.
11 UCSF facilities close to the alignment are a potentially sensitive receptor location at the north
12 end of the project corridor. University research facilities often have instrumentation that is
13 susceptible to interference from magnetic field changes.
- 14 2. **Brisbane Fire and Police Departments:** This is a suburban location off of Bayshore Boulevard
15 in Brisbane, adjacent to the proposed alignment near the Tunnel Avenue overpass.
- 16 3. **Brisbane quiet site:** Magnetic field measurements were recorded south of a small park-like
17 area off of Bayshore Boulevard adjacent to the Brisbane Lagoon. This open area was selected as
18 a potential quiet site.
- 19 4. **France Telecom Research & Development (R&D) facility, South San Francisco:** The France
20 Telecom R&D facility is a potential commercial sensitive receptor site that is adjacent to a
21 number of other bio-tech facilities, also sensitive receptors. Measurements were recorded
22 adjacent to the Caltrain corridor on Executive Drive. This location has high-voltage transmission
23 lines.
- 24 5. **Near San Francisco International Airport (SFO), South San Francisco:** Measurements were
25 recorded on Madrone Avenue, a residential street in Millbrae situated between the airport and
26 the Bay Area Rapid Transit (BART)/Caltrain alignment.
- 27 6. **Health Diagnostics and Burlingame Police Department, Burlingame:** Measurements were
28 recorded at the intersection of Trousdale Drive and California Avenue. The Health Diagnostics
29 Facility has magnetic resonance imaging (MRI) and computerized tomography (CT) imaging
30 systems that are potentially sensitive.⁴
- 31 7. **San Carlos quiet site:** This is an open area on the west side of the Caltrain corridor off El
32 Camino Real. Magnetic fields were measured on both sides of corridor, with the east side
33 location along a residential street.
- 34 8. **Valley Radiological, Redwood City:** Measurements were recorded along Brewster Avenue in
35 Redwood City near a potentially sensitive medical facility with MRI equipment.

³ The measurements were collected for the California High Speed Rail analysis of existing conditions along the corridor. The electric field measurements were within the 10 kilohertz (kHz) to gigahertz (GHz) frequency bands, which are well above the frequency bands applicable to Caltrain. Therefore, background electric fields measurements from the study are not applicable to the Proposed Project and are not discussed further. Information on background electric fields at 60 Hz within the project area is currently unavailable.

⁴ The City of Burlingame noted that there are also facilities with potentially sensitive electrical equipment near Trousdale Drive and California Avenue in Burlingame as well.



Path: K:\Projects_3\Caltrain\00606_12_Caltrain_Modernization\mapdoc\Figure 3.5.1 EMF Measurement Locations 20140902.mxd; User: 29391; Date: 9/2/2014

Figure 3.5-1
EMF Measurement Locations
 Peninsula Corridor Electrification Project

Note: This figure replaces Figure 3.5-1 from the Draft EIR

- 1 9. **Atherton Police Department:** The Atherton Police Facility, off Fair Oaks Lane in Atherton, is a
2 potential emitter with Radio Frequency (RF) communication systems, adjacent to the Atherton
3 Caltrain stop. Magnetic fields were recorded moving laterally from the Caltrain corridor in a
4 southwest direction.
- 5 10. **Palo Alto Medical Center:** This facility is a potentially sensitive site with medical imaging
6 systems. Measurements were recorded in the parking area near Urban Lane, and magnetic fields
7 were recorded along the bike path behind the facility, closest to the Caltrain tracks.
- 8 11. **Mountain View Caltrain Station:** Magnetic field measurements were recorded along the
9 Caltrain platform and stationary measurements were recorded next to the tracks to capture
10 magnetic fields due to Caltrain and Santa Clara Valley Transportation Authority (VTA)
11 operations.
- 12 12. **St. Jude Medical Center and Evans Analytical, Sunnyvale:** Both facilities near South Wolfe
13 Avenue are potentially sensitive sites. Magnetic field measurements were recorded along both
14 sides of the South Wolfe Avenue overpass, starting at Kifer Road.
- 15 13. **Motorola and Intel, Santa Clara:** These two sites are high-profile companies in Santa Clara that
16 are potentially sensitive facilities. Magnetic field measurements were recorded around
17 perimeter of one of the facilities on Walsh Avenue.
- 18 14. **Mineta San Jose International Airport:** Measurements were recorded at a site situated at the
19 south end of Brokaw Road adjacent to the airport.
- 20 15. **PG&E substation, San Jose:** This measurement site is south of the San Jose Caltrain Diridon
21 Station, at the end of Otterson Street, off South Montgomery Street.

22 **Background DC Magnetic Fields**

23 Table 3.5-2 summarizes the peak maximum, minimum, and range for static or DC magnetic fields at
24 the measurement sites. The difference between the minimum and maximum measurements,
25 referred to as the “shift,” affects the potential for interference with sensitive instrumentation
26 requiring a stable magnetic field environment. The greater the shift, the greater the likelihood for
27 the magnetic field source to disturb the sensitive equipment (Electric Research & Management
28 Vibro-Acoustic Consultants 2010).

1 **Table 3.5-2. DC Magnetic Field Data Summary**

ID ^a	Description	DC Field (milliGauss)		
		Min	Max	Range
1	University of California SF campus adjacent to Interstate 280	357.1	367.9	10.8
2	Brisbane Fire and Police Departments	466.9	470.1	3.2
3	Brisbane quiet site	484.2	486.8	2.7
4	France Telecom research and development facility	457.8	463.8	6
5	Near San Francisco International Airport/BART	430.5	533.5	103
6	Health Diagnostics and Burlingame Police Department	506.3	526.4	20.1
7	San Carlos quiet site	492.5	493.1	0.6
8	Valley Radiological	528.1	533.5	5.4
9	Atherton Police Department	508.8	515.4	6.6
10	Palo Alto Medical Center	638.8	640.1	1.3
11	Mountain View VTA and Caltrain station	357.8	466.1	108.4
12	St. Jude Medical Center	540	552.8	12.8
13	Motorola and Intel	481.1	484.5	3.4
14	Near Mineta San Jose International Airport	472.2	474.3	2.1
15	PG&E substation	450.9	455.7	4.8

Source: Electric Research & Management Vibro-Acoustic Consultants 2010

^a See Figure 3.5-1 for the site locations.

2
3 As shown in Table 3.5-2, the two locations showing the greatest DC magnetic field variation were
4 the Mountain View Caltrain platform (see Site 11 in Figure 3.5-1) with a shift of 108.4 mG, and a
5 neighborhood street near the San Francisco International Airport (Site 5) with a shift of 103.0 mG.
6 For the Mountain View location, large DC magnetic field shifts were produced by operation of VTA
7 electric trains. For the location near the San Francisco International Airport location, DC magnetic
8 field shifts were produced by operation of BART electric trains. At a number of locations, DC shifts
9 were typically produced by passing vehicles. At Site 13, the 3.4 mG shift is due exclusively to a
10 passing freight train. The location with the least shift was the open space set back from El Camino
11 Real in San Carlos (Site 7), and the next least shift was at Palo Alto Medical Center, which is beside a
12 bike trail and the Caltrain corridor. The 1.3 mG shift at this location (Site 10) was produced by a
13 passing northbound Caltrain⁵ (Electric Research & Management Vibro-Acoustic Consultants 2010).

14 **Background AC Magnetic Fields**

15 Table 3.5-3 summarizes the AC magnetic fields measured along 10-foot intervals moving away from
16 the Caltrain ROW. The largest 60 Hz magnetic fields were recorded at Site 4, near transmission lines
17 crossing the Caltrain corridor in South San Francisco, and at Site 15, adjacent to a PG&E substation.
18 A wide range of magnetic fields were recorded at both the fixed locations and along the spatial
19 profiles. The lowest fields were found at Site 2 near the Brisbane Fire Department facility and at the
20 fixed location for Site 14 adjacent to the Mineta San José International Airport (not close to any

⁵ The existing diesel-powered Caltrain service has diesel-electric locomotives that generate an EMF through the electric motors powered by the diesel-engine. The EMF generated by the existing Caltrain service would be effectively replaced with EMF associated with the Proposed Project. The difference, or *delta*, in EMF between the existing service and the Proposed Project represents the net impact of the Proposed Project.

1 power lines). Because the AC magnetic fields vary markedly with position, the spatial profiles are
 2 especially useful for providing context to the fixed position measurements. Fixed position
 3 measurements provide a general characterization of temporal variation at the test location, and the
 4 profile measurements provide a view of spatial variation. The highest fields are associated with
 5 close proximity to power lines or power company utility equipment (Electric Research &
 6 Management Vibro-Acoustic Consultants 2010).

7 **Table 3.5-3. AC Magnetic Fields Measured along the Project Corridor**

ID ^a	Description	60 Hz AC Field (milliGauss)	
		Min	Max
1	University of California SF campus adjacent to Interstate 280	0.07	8.35
2	Brisbane Fire and Police Departments	0.03	0.36
3	Brisbane quiet site	0.14	1.38
4	France Telecom research and development facility	0.75	18.4
5	Near San Francisco International Airport/BART	0.58	1.92
6	Health Diagnostics and Burlingame Police Department	1.21	9.43
7	San Carlos quiet site	0.14	9.15
8	Valley Radiological	0.26	10.77
9	Atherton Police Department	0.22	3.12
10	Palo Alto Medical Center	1.28	11.82
11	Mountain View VTA and Caltrain station	0.12	1.14
12	St. Jude Medical Center	0.22	2.77
13	Motorola and Intel	0.05	3.75
14	Near Mineta San Jose International Airport	0.06	0.99
15	PG&E substation	1.81	17.64

Source: Electric Research & Management Vibro-Acoustic Consultants 2010

^a See Figure 3.5-1 for the site locations.

8
 9 The measurement results summarized in Tables 3.5-2 through 3.5-3 are typical of built
 10 environments (Electric Research & Management/Vibro-Acoustic Consultants 2010).

11 **3.5.2 Impact Analysis**

12 **3.5.2.1 Methods for Analysis**

13 Caltrain electrification would increase the electric and magnetic fields generated near the tracks
 14 above the background levels described in Tables 3.5-2 and 3.5-3 above. The proposed design for the
 15 system near major substations was incorporated into a model of two- and (existing) four-track
 16 electrified operations to calculate EMF fields at critical, maximum load points along the Caltrain
 17 corridor under electrification conditions. The system was simulated with peak and off-peak trains
 18 drawing power from the overhead contact system (OCS) and power supply network. EMF field
 19 strengths were estimated over an alignment cross-section extending 58 feet beyond the centerline

1 of the outside track.⁶ This yielded a profile of potential EMF exposures both within and alongside the
2 railroad ROW. The maximum calculated EMF represents a worst case situation for EMF exposure.

3 Electric and magnetic field levels aboard passenger coaches and at track overpasses were not
4 calculated for Caltrain as vehicle specifications have not yet been finalized. Average and maximum
5 fields at these locations were estimated by examining the performance of ~~two other relevant~~
6 ~~systems~~: Amtrak's electrified Northeast Corridor (NEC) service, which extends from Washington,
7 D.C. to Boston, and France's Train A Grande Vitesse (TGV) system, which provides electrified high-
8 ~~speed intercity rail service.~~⁷ The NEC's segment from Boston to New Haven is
9 assumed to be representative of Caltrain due to similarities in system design (25 kVA 60 Hz OCS).

10 While equipment used to construct the Proposed Project could potentially generate EMF and EMI,
11 the levels would not be substantially higher than those generated at a typical construction site.
12 Consequently, construction of the Proposed Project would not cause significant EMF or EMI at
13 nearby sensitive facilities. The following discussion therefore focuses on Proposed Project
14 operations.

15 The impacts of Project Variant 1 and Project Variant 3 are discussed below the impact analysis of the
16 Proposed Project.

17 3.5.2.2 Thresholds of Significance

18 While there are no formally adopted federal or state EMF thresholds applicable to the Proposed
19 Project, several professional organizations have developed guidelines for EMF exposure, including
20 the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the Institute of
21 Electrical and Electronics Engineers (IEEE), and the American Conference of Governmental
22 Industrial Hygienists (ACGIH). EMF standards suggested by these organizations address low-
23 frequency (i.e., 60-hertz) EMF exposure to the general public and workers in an occupational setting
24 as well as EMF exposure for workers with pacemakers and other electronic implants.

25 A recent 2014 study (Napp et al. 2014) of EMF sensitivity of implanted defibrillators (also referred
26 to as Implantable Cardioverter-Defibrillators or ICDs) concludes that extremely low-frequency (as in
27 50 to 60 Hz power frequencies) daily-life electromagnetic fields do not disturb sensing capabilities
28 of ICDs. The study of 15 different ICD models in 110 patients indicated no interference for all but
29 one of the ICD models studies at levels below 10 kV/m electrical field or 5000 milligauss (mG)
30 magnetic field at maximum sensitivity. The one outlier ICD model had no interference below 1 kV/m
31 electrical field or 1,000 mG magnetic field. As discussed below, the PCEP EMF fields would be well
32 below 1 kV/M for the electrical field and 1,000 mG for the magnetic field.

33 Based on the published professional standards and the ICD study described above, Table 3.5-4
34 summarizes the EMF thresholds used to define a significant impact with respect to public and
35 occupational exposure for this EIR.

⁶ This distance is roughly representative of the distance from the tracks to occupied structures. Distances vary and some occupied structures may be closer and others further from the tracks.

⁷ Amtrak NEC from Boston to New Haven is a 25kV, 60 Hz AC system, the same as the proposed electrified Caltrain system. ~~The French TGV measurements apply 50 Hz AC-powered segments, with power supply via a 24kV network.~~

1 **Table 3.5-4. EMF Thresholds of Significance for Public and Occupational Exposure**

Receptor	Electric Field (kV/m)	Magnetic Field (mG)
General Public ^a	4.2	833
Employees ^b	25	10,000
<u>Individuals with pacemakers^c</u>	<u>1</u>	<u>1,000</u>
<u>Individuals with implanted medical devices^d</u>	<u>1</u>	<u>1,000</u>

^a These levels are based on the ICNIRP (1998), Maximum Permissible Exposure limits for the general public.

^b These levels are based on the ACGIH (2013) recommended standards for occupational exposures.

^c These levels are based on the ACGIH (2013) recommended standards for occupational exposures.

^d These levels are based on the ACGIH (2013) recommended standards for occupational exposures and are consistent with interference thresholds determined in a recent study of implanted defibrillators (Napp et al. 2014).

kV/m = kilovolt per meter

mG = milliGauss

2

3 For evaluating interference levels for sensitive equipment, significant impacts would occur if the

4 Proposed Project would substantially increase background magnetic field levels.

5 **3.5.2.3 Impacts and Mitigation Measures**

Impact EMF-1	Substantially increase electromagnetic fields along the Caltrain corridor
Level of Impact	Less than significant

6 **Operation**

7 Sources of EMF associated with the Proposed Project would be the TPFs (which are the traction

8 power substations, paralleling stations and a switching station), the OCS, and train motors on the

9 electrical multiple units (EMUs). Passengers and employees onboard the trains, as well as receptors

10 adjacent to the Caltrain corridor (e.g., general public, maintenance workers) may be exposed to EMF

11 generated by the Proposed Project.

12 Table 3.5-5 summarizes the calculated field strengths for electrified Caltrain service at five general

13 locations: aboard coaches/passenger cars, at rail overpasses, within the Caltrain ROW, alongside the

14 railroad ROW, and proximate to traction power substations. Traction power substations would

15 generate the most substantial EMF of the TPFs). Amtrak’s electrified NEC service and France’s TGV

16 ~~were was~~ was used as a proxy proxies to define field strengths aboard passenger cars, near the traction

17 power substations, and at overpasses. This approach was used because new Electric Multiple Unit

18 (EMU) vehicle specifications for Caltrain are not yet finalized and it is likely that Caltrain EMF levels

19 would be somewhat similar to these values (i.e., similarities of the proposed Caltrain power delivery

20 system to that of the NEC system). EMF exposure levels outside the track ROW and at the edge of the

21 ROW were estimated for Caltrain using the methodology described above.

1 **Table 3.5-5. Estimated EMF Field Strength for Caltrain Operations (frequency of 60 Hz)**

Location	Electric Field (kV/m)	Magnetic Field (mG)	
		Average/Off-Peak	Max
Passenger Coach ^a	1.5-2.0 0.0015 – 0.002	52	305
Overpass ^b	N/A	11.6 – 15.1 118	29.3-467
Outside track right-of-way ^c	0.35	1.9-4.5	11.4
Edge of right-of-way ^d	0.48	4-11	35-41
Traction power substation ^e	0-22.2 0.136 (avg.) 0.744 (max)	15	110
Threshold ^f	1/ 4.2/25	833-10,000	833-10,000

^a Data are from Amtrak’s Northeast Corridor (NEC) (Dietrich et al 1993 ~~Exponent Health Group 2001~~); because of the similarity of the proposed Caltrain power system to the NEC system, measurements of magnetic fields within NEC passenger cars can be used as estimates of field intensities in Caltrain passenger coaches. ~~For reference, average and maximum magnetic field levels measured for France’s Train A Grande Vitesse (TGV) are 31 and 165 mG, respectively.~~ It is assumed the NEC and TGV values would approximate bracket the Electromagnetic fields (EMF) field strengths generated in Caltrain passenger cars operating on an electrified system.

^b Data are from overpasses on the NEC (FRA 2006). Electrical fields were below the detection levels of the electric field probe, France’s TGV (Federal Railroad Administration 1993).

^c Calculations were made for 58 feet (four tracks) from the track centerline. This represents approximately where structures might be located or where there are public rights-of-way. Current distributions assumed in the analysis are higher than predicted under future service levels and therefore represent a worst case analysis (Exponent Health Group 2001).

^d The calculated field strength at the right-of-way edge, approximately 15 feet from the track. Current distributions assumed in the analysis are higher than predicted under future service levels and therefore represent a worst case analysis (Exponent Health Group 2001).

^e Data are from Amtrak’s NEC (FRA 2006 ~~Exponent Health Group 2001~~) for EMF levels from 0 – 3,000 Hz frequency for 10 traction power station locations.

^f Thresholds from Table 3.5-4.

Kv/m = kilovolt per meter

mG = milliGauss

2
3 The dominant magnetic field is the 60Hz field, with lesser amounts in other frequency ranges. This is
4 demonstrated by field wayside monitoring of passbys by the electrified Acela and regional trains on
5 the 25 kV 60 Hz portion of the NEC, which indicated levels from 5 to 15 meters for different
6 frequency bands as follows: 7.2 to 0.2 mG (2 – 48 Hz), 53.1 to 4.8 mG (48 – 62 Hz), 3.8 to 0.4 mG (62
7 – 302 Hz), and 1.2 to 0.4 mG (302 – 3,000 Hz) (FRA 2006). The field is at its strongest during
8 passbys.

9 The EMF fields from electrified Caltrain operations along the ROW would be highest during peak
10 operations, lessening during lower volume periods to become nominal during the late night when
11 Caltrain service is discontinued or only line maintenance is proceeding. As shown in Table 3.5-5,
12 average EMF fields for the NEC were measured at 0.0015 to 0.002 ~~1.5 to 2~~ kV/m (electric) and 52
13 mG (magnetic). EMF fields within the passenger coaches were not estimated for Caltrain because
14 new vehicle specifications are yet to be finalized. Maximum magnetic field strength, experienced
15 when a vehicle is accelerating rapidly or operating a dense, multi-train track segment, was found to
16 be several times the average EMF exposure, measured at 305 mG on NEC trains. It is assumed that

1 EMF field strengths generated in Caltrain passenger cars operating on an electrified system would
2 be similar to these average and maximum values.

3 Wayside EMF exposure levels would vary by proximity to the outside track’s centerline. The field
4 strengths for Caltrain of 0.35 kV/m (electric) and 1.9 mG average and 11.4 mG maximum (magnetic)
5 were estimated at approximately 58 feet from the track. This approximates where public access
6 points and occupied structures would be located. Estimates for locations at the edge of the railroad
7 ROW were 0.48 kV/m (electric) and ranged from 4 mG to 41 mG (magnetic). The higher values at
8 the edge of ROW, which would be expected because that location is closer to the source of electric
9 current (OCS), are about three times the field strength at 58 feet from centerline.

10 Additional information on expected EMF generated from the Proposed Project can be derived from
11 the Federal Railroad Administration’s 2006 report *EMF Monitoring on Amtrak’s Northeast Corridor*
12 *(NEC): Post-Electrification Measurements and Analysis* (FRA 2006). The dominant field from
13 Amtrak’s NEC is 25-kV from a 60-Hz ac system, the same as the Proposed Project; therefore, it is
14 reasonable to assume that the measured effects of NEC’s electrification would be similar to the
15 potential effects of the Proposed Project. Table 3.5-6 summarizes the measured EMF field strengths
16 for several systems, including detailed measurements taken within the Amtrak NEC. Measurements
17 were taken in proximity to traction power stations, near the tracks during train pass-bys, and inside
18 passenger compartments.

19 **Table 3.5-6. Measured Magnetic and Electric Field Values - Amtrak Northeast Corridor^a**

Magnetic Field Measurements Proximate to Traction Power Stations^b			
(frequency 0–3,000 Hz) magnetic field expressed in expressed in mG	Minimum	Maximum	Average
Pre-Electrification Measurements	0.0	12.9	1.6 <u>2.0</u>
Post-Electrification Measurements	0.1 <u>0.2</u>	110.3	14.7
Electric Field Measurements Proximate to Traction Power Stations^b			
(frequency 0–3,000 Hz) electric field expressed in kV/m	Minimum	Maximum	Average
Pre-Electrification Measurements	0	3.16 <u>0.106</u>	0.33 <u>0.020</u>
Post-Electrification Measurements	0	22.2 <u>0.744</u>	4.1 <u>0.136</u>
Magnetic Field Measurements at Three Distances from Five Electrified Train Pass-Bys			
(frequency 0–3,000 Hz) magnetic field expressed in mG	5 m (16.5 feet)	10 m (33.0 feet)	15 m (49.5 feet)
Minimum	25	3	negligible
Maximum	84	25	7
Average	54.4	11.4	2.0
Magnetic Field Measurements within Passenger Compartments^c			
(frequency 2–3,000 Hz) magnetic field expressed in mG	Head	Waist	Ankle
Average Values	19.2	18.4	19.1

^a Data collected as part of Post-Electrification Measurement & Analysis study, for electrified portion of Northeast Corridor extending from New Haven, Connecticut to Boston, Massachusetts.

^b Long-term measurements taken at 10 traction power station locations.

^c Measurements averaged from seven train systems operating along Northeast Corridor.

Source: FRA 2006.

hZ = hertz

kV/m = kilovolt per meter

m = meter

mG = milliGauss

1 As shown in Table 3.5-6, post-electrification magnetic field measurements near traction power
 2 ~~substations facilities~~ were substantially higher than the pre-electrification values; the same is true
 3 for the electric field measurements. However, the measured post-electrification values were far
 4 below ~~established public health exposure limits~~ the EMF thresholds used for this EIR for the general
 5 public, workers, and individuals with pacemakers or implanted medical devices. Magnetic field
 6 measurements associated with train pass-bys and inside passenger compartments were an order of
 7 magnitude less than the TPF ~~TPS~~ values. Similar exposure levels are expected along the Caltrain
 8 ROW, which as shown in Table 3.5-5, would also well below ~~the EMF exposure limits for the general~~
 9 public and employees thresholds used for this EIR, and which would be minor in comparison with
 10 the background levels (see Tables 3.5-2 and 3.5-3).

11 In addition to reducing the number of large primary substations, another advantage of the auto-
 12 transformer feed arrangement proposed for implementation along the Caltrain corridor is its
 13 potential to reduce EMF and EMI. These fields are reduced because the arrangement includes two
 14 parallel aerial feeders, one on each side of the alignment in which currents in the parallel feeders
 15 flow in the opposite direction to that in the main catenary conductors. This tends to cancel EMF and
 16 EMI effects created by current flow in the main OCS.

17 For the reasons discussed above, there would be no significant health risks from the electrified
 18 Caltrain operations. This impact would be less than significant.

19 With Project Variant 1, PS7 would be located along Alma Avenue instead of near Kurte Park. As
 20 noted above, EMF levels at the perimeter of the traction power facilities, including paralleling
 21 stations, would be below health levels of concerns and thus Project Variant 1 would not change the
 22 impact analysis of the Proposed Project. With Project Variant 3, there would be periodic use of
 23 electric locomotives as backup trains to EMUs when under repairs or maintenance. The EMF levels
 24 noted above for the NEC are representative of levels for electric locomotives (the Acela is an electric
 25 locomotive system) and thus use of electric locomotives would not meaningfully change the EMF
 26 levels and any associated health risks of the Proposed Project.

Impact EMF-2	Substantially increase electromagnetic interference along the Corridor
Level of Impact	Significant
Mitigation Measure	EMF-2: Minimize EMI effects during final design
Level of Impact after Mitigation	Less than significant

27 **Operation**

28 The main sources, or generators, of transient EMI disturbances from electrification would be
 29 switching currents produced by switching loads, relays, power controllers, and switch mode power
 30 supplies associated with operation of the OCS or the TPFs. High-current electronic switches and
 31 controls are capable of producing transient signals that can be transmitted along the power supply
 32 network to other electronic systems. Magnetic fields would also be generated by paralleling and
 33 switching stations, as well as traction power substations.

34 These fields could affect the signal systems of the freight rail, BART, SCVTA and/or affect highly
 35 sensitive electronic equipment, such as certain medical imaging equipment.

1 **Potential EMI Concerns for Freight Signal Systems**

2 As described in Chapter 2, Project Description, the Proposed Project will protect the existing
3 railroad signal system, the grade crossing system, and the Positive Train Control system from
4 electromagnetic interference created by the 25kv AC system by:

- 5 • designing the catenary system using proven solutions that minimize the effect of EMI;
- 6 • providing sufficient shielding for electronic equipment;
- 7 • installing specialized components, such as filters, capacitors, and inductors; and
- 8 • ensuring that the electric vehicles are designed with a frequency that does not interfere with the
9 frequency of the grade crossing warning system.

10 The U.S. utility electric system covers the country with hundreds of thousands of miles of high
11 voltage (>60 kV) transmission lines and millions of miles of distribution lines operating at voltages
12 up to 25 kV, both three phase and single phase. Union Pacific operates their railroads every day in
13 close proximity to these electric utility power systems and their distribution and transmission lines.
14 The power system EMFs do not cause EMI that interferes with either the safe or dependable
15 operation of the railroads. This is because the practices and steps necessary to achieve and
16 demonstrate electromagnetic compatibility (“EMC”) between railways and electric utility power
17 systems are conventional, fully understood, and routine, within the U.S. and around the world. The
18 practices and steps necessary to achieve and demonstrate EMC between electrified and non-
19 electrified railways are similar to those used for electric utility power systems, and are also
20 conventional, fully understood, and routine.

21 In 2000, Amtrak commissioned a 25 kV 60 Hz extension to the Northeast Corridor (NEC) electrified
22 network on the 160 miles of track between New Haven, Connecticut and Boston, Massachusetts. The
23 NEC electrification system has supplied 25kV 60 Hz power to Amtrak’s Acela trains for operations
24 up to 150 mph in a safe and efficient manner for over 13 years. The Amtrak route has demonstrated
25 the viability and compatibility of 25kV electrification in areas where freight and diesel passenger
26 operations share the 25kV electrified tracks in the states of Connecticut, Rhode Island and
27 Massachusetts without impacts to their operations. The ability of 25kV electrification to be used for
28 joint high-speed and commuter rail operations has led to the conversion of New Jersey Transit’s
29 North Jersey Coast Line from lower voltage to 25kV in 2002.

30 Diesel locomotives run compatibly side-by-side and on shared tracks with electric trains on the NEC
31 and its connected commuter railroads in areas of dense, critical rail service, presently up to 150
32 mph. The NEC electric trains have power systems that are similar to those planned for the PCEP. The
33 NEC electric train traction voltage and current levels are similar to those planned for PCEP. The NEC
34 electrified and non-electrified tracks have similar signal systems to those broadly and routinely used
35 on electric rail transit lines across the U.S. The electrified and non-electrified commuter railroads
36 connected to the NEC have grade crossing systems that are similar to those used on sections of the
37 Union Pacific lines and to those broadly and routinely used on light rail and commuter rail lines
38 across the U.S.

39 The Denver Rapid Transit District and its concessionaire Denver Transit Partners (DTP) are building
40 the Eagle P3 Commuter Rail Project (EP3), a 37-mile 25 kV ac electrified railway that runs parallel to
41 Union Pacific and the BNSF tracks for lengthy sections between downtown Denver and the airport.
42 In some sections of significant length, the distance between an EP3 electrified track and the adjacent
43 BNSF and Union Pacific track is 25 feet or less. The EP3 will have signal and grade crossing systems

1 similar to those broadly and routinely used on light rail and commuter rail lines across the U.S. The
2 25kV electrification of the Denver EP3 will also be compatible with the adjacent freight railroad PTC
3 signaling and grade crossing systems. For the EP3 project, DTP, BNSF, and Union Pacific exchanged
4 technical information, performed joint engineering studies and analysis, and where needed took
5 individual and joint action to ensure EMC of the two lines.

6 In short, there are numerous well-established and contemporary precedents for the straightforward
7 integration of conventional railroads with electrified railroads like the PCEP.

8 The PCEP will follow AREMA, IEEE and standards used by AMTRAK on the NEC for 25 kV 60 Hz
9 electrification. The present track circuits existing on the Caltrain corridor are, for the most part,
10 General Electric Transportation System (GETS) Electrocode 4 (EC 4) track circuits between
11 interlockings and DC track circuits within interlockings. The PCEP will convert the EC 4 track
12 circuits to Electrified Electrocode track circuits and steady energy 200 Hz track circuits within
13 interlockings. These products were developed specifically by the manufacturers for use on
14 electrified railroads. They have been deployed and safely and reliably maintained in service for
15 many years.

16 The PCEP will replace all track circuits that currently exist on the Caltrain corridor, including the
17 Union Pacific-owned tracks MT-1 and the controlled siding with the track circuits mentioned above.
18 This will be done to insure compatibility with the new 25 kV 60 Hz electrification. If Union Pacific
19 owned tracks that are parallel to the Caltrain corridor are not electrified, they will be equipped with
20 the same signal equipment used on the PCEP to ensure that no interference will take place from the
21 25 kV Hz electrical energy in close proximity to their operation.

22 The signal equipment to be implemented on this project is equipment that is currently operating on
23 the NEC. There are both high speed passenger trains and slower speed freight trains operating over
24 the same segment of tracks. There are also several areas where the freight tracks merge onto the
25 corridor that are non-electrified. The PCEP will be employing engineering standards and equipment
26 already in place and tested to FRA standards in the same environment as the NEC.

27 The track circuits mentioned will be replaced as stated above. The Constant Warning Time (CWT)
28 devices that currently exist will not function when the electrification is energized and the impedance
29 bonds are installed and will be removed. The grade crossing issues will be treated in two methods.

- 30 • The CBOSS PTC project is presently installing a solution for CBOSS equipped trains (both diesel
31 and EMU) to activate the crossings with CWT. CBOSS will be communicating directly with the
32 grade crossings through a Wayside Interface Unit (WIU) to initiate the crossing warning device.
- 33 • For non-Caltrain trains without CBOSS, the DEIR project description, Section 2.3.5, *At-Grade*
34 *Warning Devices*, discusses the proposed solution. The technical solution identifies is to install
35 audio frequency overlays (AFOs), also known as track circuits, at fixed locations along the
36 Caltrain ROW, allowing the at-grade crossing gates to function safely through an audio
37 frequency that can be used non-Caltrain equipment. An AFO is a sensor that activates the at-
38 grade crossings when the train is approaching. The AFOs are also the backup system for Caltrain
39 equipment in case there is a failure of the CBOSS system for any reason.

40 The PCEP will be employing Bonding and Grounding standards that are presently in place on the 25
41 kV 60 Hz section of the NEC. These methods have been proven and in place for many years and
42 inspected under the authority of the FRA. Proper grounding and cross bonding of adjacent tracks
43 will be designed and constructed so that return currents are properly channeled back to the

1 substations. The PCEP final signal design will also be using signal standards in place on electric
2 railroads for use of shielded cable and limited use of lightning arrestors to mitigate these issues.

3 The autotransformer based feeder system not only provides field cancelation due to close proximity
4 between OCS conductors and negative feeder conductors, but also institutes the preferred path for
5 return current to flow to the traction power substation. Most return current returns via the
6 overhead autotransformer feeder than the running rail structure, so that leakage currents to ground
7 can be minimized. Concerns related to induced voltages caused by magnetic fields are being
8 addressed by instituting cross bonding cable connections to equalize the voltage potentials of all
9 running rails of the electrified and adjacent non-electrified tracks that are in the vicinity of the
10 overhead catenary system. These cross bond connections, in addition to incorporating industry
11 recognized signal detection systems that were designed specifically for electrification, eliminate
12 concerns of rail imbalance and compatibility of the signal detection system. It is a well-recognized
13 fact that most leakage currents to ground occur “in-section” (within a feeding section where one or
14 more trains are demand or generating power), before the autotransformers have a chance to
15 rebalance the outgoing current in the OCS and the return current in the negative feeders.
16 Quantifying the return current distribution through simulation studies based on the Caltrain system
17 conditions will be part of the work of the system design team in final design stages.

18 Initial Traction Power system design efforts begins with developing a model to size OCS distribution
19 components, input the available rail return structure (where track structures are set) and
20 determining substation spacing purposely in the absence of any influences of return paths via
21 earth/ground. This is to ensure that the electrical current carrying components are conservatively
22 sized to allow for a safety and reliability with respect to OCS voltages for proper train operation and
23 rail potential rise for those nearby the track area.

24 The amount of propulsion current entering the earth is mainly attributed to the bonding between
25 rails and static/ground wires via impedance bonds, and to the leakage conductance between rails
26 and ground. The static/ground wires are connected to the ground through distributed grounding
27 systems including OCS pole foundations and concentrated grounding in substations (supply
28 substations, autotransformer substations and switching station, etc.). This is mainly due to
29 consideration of meeting safety requirements on accessible voltages during normal operations, and
30 touch and step voltages during fault conditions. Ballast resistivity values that are suitable for the
31 railroad signal system must be maintained for the correction function of the signal system, which
32 limits the extent of direct leakage current from rails to ground. The overall grounding system to
33 meet the safety requirements will be part of the system work of the system design team in final
34 design stages.

35 The design approach to employ track circuit equipment compatible with AC traction power, in
36 addition to cross bonding of running rails in the areas adjacent to the electrified tracks, will alleviate
37 concerns related to EMF/EMI issues with the freight signal system. Additional ground resistivity
38 measurements are necessary to perform final design calculations of accessible voltages, step and
39 touch voltage along the line to establish any additional bonding/grounding interconnections.

40 The major system components of railroad signaling/communications and railroad traction power
41 system have been developed over time based upon the manufacturer’s product lines, and have
42 successfully operated on the identical power system proposed for Caltrain, namely Amtrak’s
43 Northeast Corridor North End Electrification. Through careful system studies and designs in the
44 design stages, comprehensive integration tests in the commissioning stages, close coordination with

1 all concerned parties, any potential incompatibility between the Caltrain electrification system and
2 other systems will be effectively addressed.

3 **Potential EMI Effects to BART**

4 BART operates a direct current-based system adjacent to and under the JPB ROW from Millbrae to
5 San Bruno and has expressed concern about stray currents and other EMI effects from the PCEP on
6 the BART system.

7 As noted above, the PCEP will be employing engineering standards and equipment already in place
8 and tested to FRA standards in the same environment as the NEC. The NEC includes several
9 segments of parallel third-rail commuter rail systems, such as the 750 VDC third rail for the Long
10 Island Rail road trains in the East River Tunnels in New York City and the 650 VDC MBTA Orange
11 Line in Boston for 4 miles between Back Bay and Forest Hills, including 8 MBTA Orange Line
12 stations (FRA 2003). In Europe, there are several 25 kVA high-speed rail systems running parallel to
13 1,500 VDC overhead systems such as the HSL-Zuid in the Netherlands.

14 Similar to the conclusion above relative to freight signal systems, there are workable solutions to
15 provide for electromagnetic compatibility of the two different system. Through careful system
16 studies and designs in the design stages, comprehensive integration tests in the commissioning
17 stages, close coordination with all concerned parties, any potential incompatibility between the
18 Caltrain electrification system and the BART system will be effectively addressed.

19 **Potential EMI Effects to Other Sensitive Electric Equipment**

20 ~~However,~~ The generation of new EMFs could potentially result in interference with sensitive
21 equipment located adjacent to the Caltrain corridor (such as at the Palo Alto Medical Center) or
22 could affect other equipment ~~such as adjacent BART train control and communication circuits.~~

23 However, as shown in Table 3.5-6, magnetic fields generated by the Proposed Project outside the
24 Caltrain ROW would be minor in comparison with background concentrations and threshold levels.
25 The intensity of these fields would dissipate as a function of distance. Accordingly, generated
26 magnetic fields generated by the Proposed Project would decrease rapidly with distance and would
27 be substantially lower at nearby sensitive receptors where sensitive equipment may be located. As
28 noted above, the autotransformer power system proposed for use tends to reduce EMF and EMI
29 effects because of the self-cancelling resulting from bi-directional current flows in the feeder and
30 contact wires.

31 The auto-transformer system was chosen for the Proposed Project over the direct center feed
32 system in large part because of the success of similar installed and operating systems in the United
33 States, Europe and other parts of the world in minimizing the effects of both EMI and EMF. The
34 Proposed Project's spacing of the traction power substations, paralleling stations and switching
35 station, and, hence, of the auto-transformers, is about 5 miles (10 facilities along 51 miles). The
36 Amtrak NEC system has the auto-transformers spaced 6 to 8 miles apart. During the design of the
37 NEC project, the assessment of potential longitudinal induced voltages showed that they should not
38 be greater than what occurs with typical utility distribution systems of comparable voltage. In this
39 respect, the NEC project was designed and tested to levels of less than 20 volts during actual
40 trainload, and significantly less than the 430-volt design recommendation during fault conditions.

41 With Project Variant 1, PS7 would be located along Alma Avenue instead of near Kurte Park but EMF
42 levels and the potential for EMI along the OCS or at the TPFs would be the same as for the Proposed

1 Project. With Project Variant 3, there would be periodic use of electric locomotives as backup trains
2 to EMUs when under repairs or maintenance. The EMF levels and the potential for EMI would be
3 approximately the same as for the Proposed Project.

4 **Conclusion**

5 However, despite the extremely low potential for adverse EMI effects, there remains the possibility
6 of effects on sensitive equipment. Therefore, Mitigation Measure EMF-2 will require that EMI be
7 further assessed on a site-specific basis during final project design to ensure avoidance of significant
8 EMI effects above baseline conditions. With the current design and site-specific considerations
9 included in Mitigation Measure EMF-2, EMI impacts would be less than significant.

10 **Mitigation Measure EMF-2: Minimize EMI effects during final design, Monitor EMI effects** 11 **during testing, commission and operations, and Remediate Substantial Disruption of** 12 **Sensitive Electrical Equipment**

13 The potential for EMI effects shall be minimized by ensuring that all electronic equipment is
14 operated with a good electrical ground and that proper shielding is provided for electronic
15 system cords, cables, and peripherals. Installing specialized components, such as filters,
16 capacitors, and inductors, can also reduce EMI susceptibility of certain systems. The design of
17 the system will consider and incorporate, where practicable, the latest standards relevant to
18 minimizing the effects of EMI on other systems, including the Caltrain and BART signal systems.

19 During final design, detailed analyses shall be undertaken to determine the specific levels of any
20 voltages that could be induced onto paralleling longitudinal conductors and, if significant
21 voltages were to be identified, mitigation measures shall be developed in accordance with the
22 relevant industry accepted IEEE and/or MIL (Military) standards. The final design shall utilize
23 proven technologies for catenary system components, and the technical specifications shall be
24 written to assure that damage during construction to the conductors or hardware will be
25 minimized to the greatest extent practicable.

26 Proven design standards have been developed and shall be followed to mitigate any identified
27 effects. For instance, the NEC installed 25 kV electrification system, counter poise ground wires
28 were installed in some locations, and additional bonding between the aerial ground conductors
29 was used as well. The specific design features shall be developed during final design, in
30 accordance with the published standards.

31 Union Pacific, SCVTA and BART operate sensitive electric equipment in or adjacent to the right-
32 of-way. The following are required to ensure that significant EMI effects to the freight and
33 passenger rail signal systems and operations are avoided:

- 34 ● The JPB shall work with Union Pacific, SCVTA, BART and other rail operators during project
35 design to ensure that signal systems and other sensitive electric equipment for other freight
36 or passenger rail facilities are not disrupted by EMI from the PCEP OCS. The JPB shall
37 provide plans for controlling EMI levels near Union Pacific, SCVTA, and BART facilities for
38 review and input.
- 39 ● EMI levels shall be evaluated during testing and commissioning period for the Project and
40 the JPB shall coordinate with Union Pacific SCVTA and BART to evaluate whether any
41 interference effects occur to sensitive electric equipment. Where interference is detected

- 1 that disrupt operations of this equipment, the JPB shall remedy the disruption prior to
2 revenue operations.
- 3 ● After commissioning, EMI impacts shall be monitored during the first year of project
4 operation on at least a quarterly and reporting shares with Union Pacific, SCVTA, and BART.
5 Andy identified disruption of electric equipment shall be immediately remedied.
 - 6 ● If at any time, PCEP operation causes EMI interfering with signaling, automatic grade
7 crossing warning devices, train control or other equipment necessary for safe and reliable
8 operation of freight and passenger trains in the corridor, the JPB shall require shutdown and
9 modification of the PCEP electrical system in the affected area and shall eliminate any
10 disruption identified,
 - 11 ● The JPB shall be responsible for all costs to evaluate, design, monitor, and remediate any
12 project-related EMI disruption of sensitive electric equipment of other passenger or freight
13 rail systems.
- 14 ~~during final design~~ For non-rail systems, the following will be required:
- 15 ● The JPB will make a good faith effort to coordinate with local cities, ~~BART~~, UCSF, France
16 Telecom, Health Diagnostics, Valley Radiological, Palo Alto Medical Foundation, St. Jude
17 Medical Center, Evans Analytical, Motorola and Intel (and any other facilities located
18 adjacent to the ROW with sensitive equipment and requesting such consultation) to
19 determine whether their facilities would be susceptible to EMI effects.
 - 20 ● During final design, the JPB shall evaluate the specific EMI levels associated with the PCEP
21 system at the identified sensitive facilities and determine the appropriate controls necessary
22 to avoid disruption of sensitive equipment prior to testing and commissioning of the system.
 - 23 ● EMI levels shall be evaluated during testing and commissioning period for the Project and
24 the JPB shall coordinate with the identified sensitive facilities to evaluate whether any
25 substantial interference effects are occurring due to system operation. Where substantial
26 interference is detected that disrupt operations of sensitive electric equipment, the JPB shall
27 remedy the disruption prior to commissioning of electrified operations through EMF
28 controls and/or shall provide shielding of sensitive equipment.
 - 29 ● After commissioning, EMI impacts shall be monitored during the first year of project
30 operation and reporting shared with any of the identified sensitive facilities. Any identified
31 disruption of sensitive electric equipment shall be immediately remedied.
 - 32 ● If the PCEP operations causes substantial EMI interference with sensitive electric equipment
33 during, the JPB shall identify and eliminate the substantial interference through additional
34 EMF control measures and/or provide shielding for the sensitive equipment.
 - 35 ● The JPB shall be responsible for all costs to evaluate, design, monitor, and remediate any
36 project-related EMI disruption of sensitive electric equipment.
- 37 ~~If substantial negative effects associated with the Proposed Project were to be identified above~~
38 ~~baseline conditions, specific design measures shall be developed by the JPB to address localized~~
39 ~~EMI effects of the Proposed Project.~~