Los Angeles County
Metropolitan Transportation Authority

West Santa Ana Branch Transit Corridor

Draft EIS/EIR Appendix V
Final Electromagnetic Field Impact Potential

Metro

WEST SANTA ANA BRANCH TRANSIT CORRIDOR PROJECT

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Final Electromagnetic Field Impact Potential

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ACRONYMS AND ABBREVIATIONS

AC	alternating current
DC	direct current
EMF	electromagnetic field
EMI	electromagnetic interference
FTA	Federal Transit Administration
Hz	Hertz
IEEE	Institute of Electrical and Electronics Engineers
LRT	light rail transit
Mg	milligauss
MPE	maximum permissible exposure
MRI	magnetic resonance imaging
WSAB	West Santa Ana Branch
T	MicroTesla

Electromagnetic fields (EMF) result from electromagnetic emissions, which is energy in the form of photons. The emissions have many natural and human-made sources. The electromagnetic spectrum includes light, radio waves, x-rays, and other energy forms. The commonly known human-made sources of EMF are electrical systems such as electronics, telecommunications, electric motors, and other electrically powered devices. The emissions from these sources are invisible, non-ionizing, and low frequency. Moreover, the emissions spread and weaken as they travel from their source. The Earth's naturally occurring geomagnetic field varies across the face of the planet and changes substantially over a time scale of millennium; however, in any individual location it is relatively constant with minor fluctuations caused by natural events such as solar flares. Human-generated EMFs cause short-duration fluctuations in the naturally occurring geomagnetic field. For purposes of describing the context and effects of the West Santa Ana Branch Project, human-made EMF and associated electromagnetic interference (EMI) produced by the operation of electrically powered transit vehicles are relevant, as is passing vehicles and elevator operations. EMI is the result of an EMF acting on a device.

The dominant source of EMFs for light rail transit (LRT) is the direct current (DC) electric traction system that powers the trains. The DC voltage on the overhead supply wires (i.e., contact wire and messenger) produces a static electric field between the supply wires and ground, and the flow of currents—as trains draw power via pantographs—produces transient magnetic fields as the train travels along the alignment. In addition to the magnetic fields from currents powering the trains, the ferromagnetic mass (steel) of the LRT vehicles distorts the Earth's geomagnetic field, also causing low-level variations in the background magnetic field environment near the alignment.

EMF Emission Levels

EMF has electrical and magnetic field components. The electric fields result from the strength of the electric charge (voltage), with DC generating stronger EMFs than alternating current (AC) at a given voltage. Magnetic fields result from the motion of the charge (current). Electric field strength is measured in units of volts per meter and is greater the higher the voltage. Electric field strength, however, deteriorates rapidly with distance from the source. For example, for a single current-carrying conductor, the rate at which the EMF level decreases is reduced by one-half for every doubling of the distance. For two conductors that carry current in opposite directions, the rate is reduced by one-quarter for every doubling of the distance.

Magnetic field strength has several units of measure; the most commonly used are milligauss (mG) and microTesla (μT). Ten mG equal one μT; 10,000 gauss equal 1 tesla. Magnetic fields also deteriorate with distance, but readily pass through most objects. As such, magnetic fields are typically the emissions of concern when evaluating EMFs. Although modern society increasingly relies on electromagnetic systems, strong magnetic fields are not associated with the normal living and working environment. The Earth's background magnetic field varies around an average of about 500 mG (National Institute of Environmental Health Sciences 2002). Examples of magnetic field intensities from human activities include the following (Federal Railroad Administration 2006):

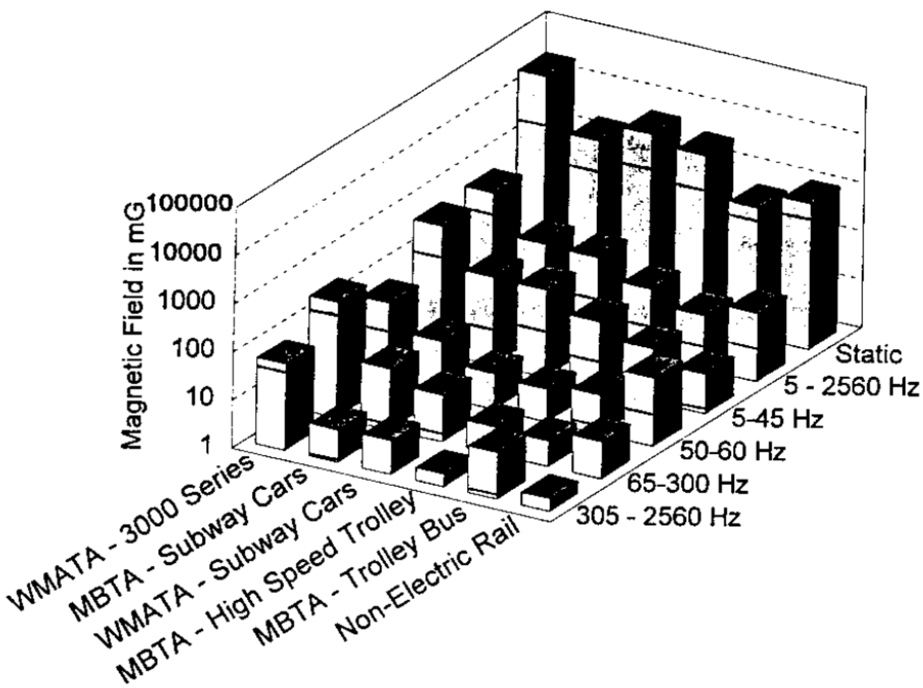
- Overhead power transmission line: 10 to 100 mG directly under transmission lines and less than 10 mG under lateral lines
- Household appliances: 8 to 165 mG (at a distance of 1 foot)

- Rail vehicle (electrically powered): 400 mG (at 43 inches from the vehicle floor) to 1,500 mG (at the vehicle floor level)

EMFs are also measured in terms of their frequency, or the number of times the EMF changes direction in space each second. Natural and human-generated EMFs encompass a broad frequency spectrum. In the United States, the electric power system operates at 60 hertz (Hz), or cycles per second, meaning that the field reverses its direction 60 times per second. Radio and other communications operate at much higher frequencies; many are in the range of 500,000 to 3 billion Hz.

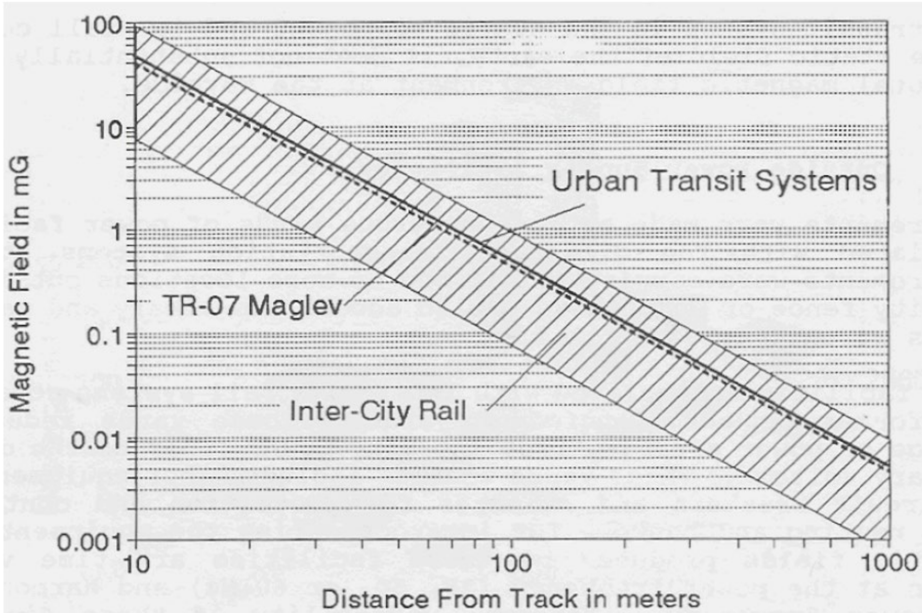
Figure 1 shows typical EMF levels inside transit vehicles, and Figure 2 illustrates levels for different rail transit systems at distance from the tracks.

Figure 1. Comparison of EMF Levels inside Electric Rail Vehicles



Source: Federal Transit Administration (FTA) 2008

Figure 2. Comparison of EMF Levels at Distance from Tracks for Typical Electric Rail Vehicles



Source: FTA 2008

Health Effects

The federal government and State of California have not established regulatory limits for EMF exposure. Decades of research, along with broad reviews of the research literature by numerous independent health and safety organizations (including government entities that address the safety of EMFs) have not resulted in regulatory limits. Magnetic fields from the planned DC traction system for the Project would be transient in nature and relatively slow, quite unlike power line AC magnetic fields that alternate continuously 60 times per second (60 Hz). Consensus guidelines for EMF exposure do exist for preventing established short-term adverse effects across a wide range of frequencies.

The FTA has released guidelines for preventing and reducing environmental health and safety impacts from transit-generated EMFs (FTA 2008). Although exposure safety levels were not identified specifically, compliance with referenced consensus standards and guidelines is encouraged to ensure the health and safety of all, including wearers of electronic implants. The most relevant of these is "C95.6: IEEE [Institute of Electrical and Electronics Engineers] Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz" (IEEE 2002). The C95.6 Standard establishes maximum permissible exposure (MPE) levels to protect the general public that vary by frequency. The MPE levels for frequencies between 1 and 20 Hz (where the majority of EMF from light rail vehicles is generated) ranges from 1,180,000 mG at static to 9,040 mG at 20 Hz. The MPE levels decrease to 2,290 mG at 3 kilohertz (Table 1).

Table 1. Maximum Permissible Exposure Limits for the General Public

Frequency range (f) (Hz)	Field Strength (mG)
<0.153	$1.18x10^6$
0.153 – 20	$1.81X10^5/f$
20-759	$9.04X10^3$
759-3,000	$6.87X10^6/f$

Source: IEEE 2002
Notes: Permissible levels are for exposure to the head and torso.
f= frequency range; Hz = hertz; mG = milligauss

Electromagnetic Interference

The federal government and State of California have not established regulatory EMI thresholds for sensitive equipment. EMF from light rail operations generally has no adverse impact on typical electric or electronic systems. For example, EMF from a project would not be expected to cause interference with computers, hard-drives, televisions, cellular telephones, Wi-Fi, communications systems, etc. There is, however, evidence that sensitive highly specialized equipment and instruments could be adversely affected by a project's magnetic fields. Such sensitive equipment and instruments are often used at university research, medical imaging, semiconductor, nanotechnology, and biotechnology facilities. Examples of sensitive equipment that could be affected by light rail magnetic fields include electron microscopes and magnetic resonance imaging (MRI) machines.

Land uses with potentially sensitive equipment that may be affected by EMI from light rail operations could include research, manufacturing, medical, and possibly military facilities. Many facilities use tools and equipment that depend upon the Earth's steady geomagnetic field for reliable operation. Certain high-sensitivity instruments and equipment require a stable background magnetic field environment and are potentially susceptible to EMI. The location of this type of equipment or instruments is typically found at university research, medical imaging, and high-tech (semiconductor, biotechnology) facilities. EMI may temporarily interfere with the operation of sensitive equipment. Sensitivity to shifts in the background field is specific to each instrument and how it is being used.

Typical thresholds at which a change in the static levels of magnetic fields could affect sensitive instruments are identified in Table 2. The distance at which equipment could be affected varies by the type and sensitivity of the equipment. Equipment that is very sensitive, such as electron microscopes, could be affected by the changes in the levels of EMF generated by the Project at distances several hundred feet away from the tracks.

Electronic household appliances are generally not affected by EMI since they generate EMF fields (8 to 165 mG at 1 foot) that would exceed the levels generated by external sources. Accordingly, residential and general commercial land uses are not sensitive to EMI.

Table 2. Static Magnetic Field Thresholds for Sensitive Instruments

Instrument	Static Field Change Threshold
Research nuclear magnetic resonance spectrometer	0.5 mG
Research mass spectrometer	0.5 mG
Magnetic resonance imaging	4 mG
Electron microscopes and X-ray analyzers (Hitachi and JEOL)	1 mG/5 min, (0.3 mG/5 min ac)[1]
Scanning electron microscope (FEI–Philips)	1 mG @ dc and other low frequencies (3 mG @ 60 Hz)

Source: Bracken 2000
Notes: [1] Rate of change to the magnetic field over a 5-minute period at 60 Hz.
ac = alternating current; dc = direct current; Hz = hertz; mG = milligauss; min = minutes
Static Field Change = change in the magnetic field background levels.

Review of EMF Impact Potential

Potential Health Impacts

Substantial research has been conducted worldwide on the potential health effects of EMF. A wide variety of scientific methods have been used for these studies, and there are no conclusive findings regarding the health effects of low-level EMF typical of electrically powered rail vehicles. Magnetic fields from the planned DC traction system for the Project would be short-duration disturbances and relatively low frequency compared to power line AC magnetic fields that alternate continuously at 60 Hz. Comparing levels in Figure 1 and Figure 2 to the C95.6 Standard in Table 1 (IEEE 2002) indicates that EMF levels produced by LRT vehicles, under all anticipated conditions, would be well below the threshold limits across the range of frequencies. Based on these findings, no project-specific analysis was conducted to assess potential EMF impacts of the Project on human health.

Assessment of EMI Impacts on Sensitive Equipment

As shown in Figure 2, EMF levels near rail transit decrease rapidly from approximately 100 mG at 30 feet from the tracks to less than 1 mG at 300 feet. As shown in Table 2, highly sensitive equipment in research, manufacturing, or medical facilities could be affected by EMF levels as low as 0.5 mG. Land uses within a conservative screening distance of 1,000 feet from the project alignment were reviewed. Table 3 lists all identified land uses in categories that could include EMF-sensitive equipment. The types of education and operations at these facilities were reviewed to assess whether they have research electron microscopes or medical MRI equipment. Health centers were contacted to determine if they have MRI equipment, and neither the Bellflower Health Center nor Angeles Community Health has such equipment. All other facilities were eliminated based on the nature of their operations.

Because no facilities with EMF-sensitive equipment were found within 1,000 feet of the Project, the Project would not affect EMF-sensitive equipment operations.

Table 3. Land Uses within 1,000 feet of the Project Alignment that Could Include EMF-sensitive Equipment.

Facility Name	Category	Distance (feet)	EMF-sensitive Equipment
Fremont College	College	720	none
PCI College	College	930	none
The Fashion Institute of Design & Merchandising-Los Angeles	College	680	none
United Education Institute-Huntington Park Campus	College	280	none
American Auto Institute	College	190	none
Cerritos Dental Implant Center	Dentist	60	none
Cerritos Eye Medical Center	Medical	150	none
Mighty Kidz Pediatrics	Medical	440	none
Children's Dental Building	Dental	980	none
Minkus Family Medicine, Inc	Medical	570	none
The Brace Place & Kids Dentistry	Dentist	190	none
Sanchez Medical Center	Medical	650	none
Kids Western Dental & Orthodontist	Dentist	480	none
Hollydale Veterinary Hospital	Veterinarian	530	none
Bell Medical Clinic	Medical	460	none
Angeles Community Health Center	Medical	490	none
DaVita Huntington Park Dialysis	Medical	870	none
Rio Hondo Mental Health Clinic	Medical	290	none
Bellflower Health Center	Medical	260	none
World Energy (AltAir Fuels)	Refinery	480	none
Providence Speech and Hearing Center	Audiologist	220	none
San Antonio Mental Health Clinic	Medical	520	none

Source: Compiled on behalf of Metro in 2020

Reference

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