Appendix E.17
Electromagnetic Fields and Electromagnetic Interference

Electromagnetic Fields and Electromagnetic Interference Assessment Methodology

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1. Electromagnetic Fields and Electromagnetic Interference Assessment Methodology

1.1 INTRODUCTION

This methodology explains how the NEC FUTURE program will address the potential effects of Electromagnetic Fields (EMF) and Electromagnetic Interference (EMI) that could result from the Tier 1 EIS Alternatives.

This methodology lays out the regulatory framework, involved agencies, expected approvals and outcomes of the Tier 1 EIS process and how information will be applied to Tier 2, project-level assessments. It also identifies data sources, metrics and methods to be used to document existing conditions and environmental consequences. This methodology is subject to revision as the NEC FUTURE program advances and new information is available.

1.2 DEFINITIONS

The following terms, based on definitions used by the U.S. Department of Transportation (U.S. DOT), Federal Railroad Administration (FRA), will be used throughout the methodology:

- *Electromagnetic fields (EMF):* Electric and magnetic fields that occur throughout the electromagnetic spectrum, are found in nature, and are generated both naturally and by human activity. Electric fields describe forces that electric charges exert on other electric charges. Magnetic fields describe forces that a magnetic object or moving electric charge exerts on other magnetic materials and electric charges. Naturally occurring EMFs include the Earth's magnetic field, static electricity, and lightning. EMFs also are created by the generation, transmission, and distribution of electricity (such as the overhead catenary of rail corridors); the use of everyday household electric appliances and communication systems; industrial processes; and scientific research. Natural and human-generated EMFs cover a broad spectrum. EMFs that are nearly constant in time are called "DC" (direct-current) EMFs. EMFs that vary in time are called "AC" (alternating-current) EMFs. AC EMFs are further characterized by their frequency range. AC EMFs further are characterized by their frequency range. Extremely low frequency magnetic fields typically are defined as having a lower limit of 3 to 30 Hz and an upper limit of 30 to 3,000 Hz. Radio frequency (RF) fields resulting from radio and other communications operate at much higher frequencies, often in the range of 500,000 Hz (500 kilohertz [kHz]) to 3 billion Hz (3 gigahertz [GHz]). Typical radio frequency (RF) sources of EMF include cellular telephone towers; broadcast towers for radio and television; airport radar, navigation, and communication systems; high frequency and very high frequency communication systems used by police, fire, emergency medical technicians, utilities, and governments; and local wireless systems such as WiFi or cordless telephone.[1]

[1] California High-Speed Train Project EIR/EIS, Merced to Fresno Section, Page 3.5-1 – 3.5-2

- *Electromagnetic interference (EMI):* Occurs when the EMFs produced by a source adversely affect operation of an electrical, magnetic, or electromagnetic device such as a magnetic resonance imaging (MRI) machine. EMI is of concern at medical and university research facilities along rail corridors that house sensitive imaging equipment that could be adversely affected by EMF from train operations. 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). EMI results from the operation of an electronic device near RF EMF caused by another electronic device. RFs range from 3,000 Hz (3 kHz) to 300 billion Hz (300 GHz). A source that intentionally radiates EMF (e.g., a broadcast station) or one that does so incidentally (e.g., an electric motor) may cause EMI. The terms EMI and RF interference are interchangeable; this report (and the Tier 1 EIS) uses the term EMI.

EMFs associated with electric conventional or high-speed train operations are related to the 60-Hz AC magnetic fields resulting from propulsion currents flowing in the traction power distribution system along either an overhead catenary system (OCS) or electrified third rail, and the rails themselves. RF EMFs are produced by the variety of communications, data transmission, and monitoring systems—both on and off vehicles.

1.3 RELATED RESOURCES

The EMF/EMI effects assessment will use effects assessments from other resources evaluated for the Tier 1 EIS. These related resources are identified in Table 1. Note that the related resource effects assessments will be documented within their respective Tier 1 EIS sections.

Table 1: Related Resource Inputs to EMF/EMI Assessment

Resource	Input to EMF/EMI
Land Cover	▪ Land cover categories as documented in the land cover assessment will be used to identify areas that could include EMF/EMI-sensitive receptors.

Source: NEC FUTURE JV Team, 2014

1.4 AGENCY AND REGULATORY FRAMEWORK

EMF/EMI transmission and exposure limits are not subject to regulation. The United States Department of Commerce (USDOC) National Telecommunications and Information Administration (NTIA) and the Federal Communications Commission (FCC) provide rules and regulations that apply to the apparatus or equipment that intentionally or unintentionally emit EMFs. These rules and regulations are listed in Table 2 and will be considered, consistent with a Tier 1 level of assessment, in the evaluation of EMF/EMI for the NEC FUTURE program. Specific regulatory compliance requirements or applicable guidelines are also addressed in Section 1.4.1 of this methodology.

Table 2: Federal Agency Roles in Management and Regulation of EMF/EMI

Agency	Regulatory Oversight	Description
United States Department of Transportation (U.S. DOT), Federal Railroad Administration (FRA)	▪ 49 CFR Parts 236.8, 238.225, and 236 Appendix C.	▪ These regulations provide rules, standards, and instructions regarding operating characteristics of electromagnetic, electronic, or electrical apparatus, and regarding safety standards for passenger equipment.
United States Department of Commerce (USDOC), National Telecommunications and Information Administration (NTIA).	▪ 47 CFR Part 15.	▪ Rules and regulations regarding licensed and unlicensed radio frequency transmissions. Part 15 does not govern any device used exclusively in a vehicle, including on HST trains.
United States Federal Communications Commission (FCC)	▪ FCC Regulations at Title 47 CFR 1.1310 are based on the 1992 version of the ANSI/IEEE C95.1 safety standard	▪ First Report and Order Further Notice of Proposed Rule Making and Notice of Inquiry in the Matter of Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies and Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields, Federal Communications Commission

Source: NEC FUTURE JV Team, 2014

1.4.1 Regulatory Compliance

There are no federal criteria or regulations that limit EMF levels. However, several federal and international agency design guidelines are available to assess the potential for adverse impacts from EMF (guidance listed in Table 3).

The Tier 1 EIS will describe the requirements for compliance with the NTIA and FCC regulations which will occur during Tier 2.

Where available, state regulations and best management practices guidance will be considered to refine applicable limits or identify additional areas of concern.[2] Where no formal regulations exist, coordination with state and local regulatory agencies will be undertaken to identify possible areas of concern.

[2] New Jersey, New York, and Massachusetts have adopted standards limiting permissible electric and magnetic field strength along rights of way of transmission lines. Connecticut has published Best Management Practices guidance to be considered when constructing electric transmission lines.

Table 3: Federal/International Agency Design Guidelines in Management of EMF/EMI

Agency	Document
United States Environmental Protection Agency (USEPA)	▪ "EMF in Your Environment, Magnetic Field Measurements of Everyday Electrical Devices", 402-R-92-008, Office of Radiation and Indoor Air, December 1992
National Institutes of Health	▪ "EMF, Electric and Magnetic Fields Associated with the use of Electric Power", National Environmental Health Sciences, June 2002
Environment Law Centre,	▪ "Regulating Power Line EMF Exposure: International Precedents", University of Victoria, April 2005
Institute of Electrical and Electronics Engineers (IEEE)	▪ Standard C95.6, IEEE Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields ▪ Standard C95.6, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz ▪ Both standards have been adopted by the American National Standards Institute (ANSI).
U.S. Department of Commerce, FCC, Office of Engineering and Technology (OET)	▪ Bulletin 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields. OET 65 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).
International Commission on Non-Ionizing Radiation Protection (ICNIRP)	▪ Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 Hz)

Source: NEC FUTURE JV Team, 2014

1.5 METHODOLOGY TO ASSESS EFFECTS

This effects assessment methodology identifies the approach and assumptions for describing existing EMF/EMI levels within the Affected Environment and the environmental consequences of the Tier 1 EIS Alternatives on those EMF/EMI levels and sensitive receptors within the Affected Environment. It identifies data sources, defines the Affected Environment and Context Area considered for EMF/EMI, and the approach for evaluating potential direct effects.[3] Indirect effects, those effects that occur later in time or are further removed in distance, will be addressed in a separate methodology (see Indirect Effects Assessment Methodology).

The properties of EMFs are such that, depending on the configuration of the source, the strength of an EMF decreases in proportion to distance or distance squared, or even more rapidly. Because of their rapid decrease in strength with distance, EMFs in excess of background levels are likely to be experienced only when a receptor is relatively nearby a source. Consequently, only persons on or in close proximity to the proposed passenger rail improvements would be likely to experience such increases. While high-speed train operations associated with Tier 1 EIS Alternatives could introduce

[3] Direct Effects are caused by the action and occur at the same time and place (40 CFR § 1508.8)

some very low but measureable changes in 60-Hz magnetic fields up to 1,000 feet or more from the Representative Route, these low-level changes are not known to be hazardous[4].

An EMF/EMI effects assessment typically includes an inventory of existing background EMF/EMI levels as a basis to evaluate the effects of the proposed improvements. For the NEC FUTURE Tier 1 EIS, in light of the breadth and geographic coverage of the Tier 1 EIS Alternatives and previous relevant studies completed along the NEC,[5] 10–20 representative locations with potentially sensitive receptors will be identified for the purposes of EMF/EMI effects analysis. Sensitive receptors include universities, medical institutions, high-tech businesses, and governmental facilities that use equipment that could be affected by new sources of EMFs. If appropriate, more detailed or site-specific assessments would be completed during subsequent Tier 2 evaluations. The selection of representative locations will be based on the Land Cover assessment of surrounding land types as supplemented with aerial photography and location-specific features identified by local-area experts.

1.5.1 Existing Conditions

FRA will document existing conditions for EMF/EMI at 10–20 representative locations within an established Affected Environment. The Affected Environment is a 2,000-foot swath centered on the Representative Route[6] for each of the Tier 1 EIS Alternatives. The 2,000-foot-swath is intended to:

- Encompass and account for the improvements associated with a Representative Route including infrastructure improvements (such as embankments, aerial structures, track improvements), ancillary facilities (such as stations, yards and parking structures), or service changes.
- Consider a conservative area within which EMF/EMI effects could occur as a result of operation of the Tier 1 EIS Alternatives.
- Include potential sensitive receptors and account for any background levels depending on location and proximity to other sources of EMF.
- Include EMF/EMI sources at varying distances depending on the source strength and distance between the receptor equipment and the source.

The FRA will select 10-20 representative locations with potentially sensitive receptors as a basis for analysis and discussion of background sources of EMF generation and EMF/EMI effects.

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[4] *California High-Speed Train Final Program EIR/EIS*, California High-Speed Rail Authority and U.S. Department of Transportation Federal Railroad Administration, Electromagnetic Fields and Electromagnetic Interference, Page 3.6-2

[5] *EMF Monitoring on Amtrak's Northeast Corridor: Post-Electrification Measurements and Analysis*, U.S. Department of Transportation, Office of Research and Development, DOT/FRA/RDV-06/01, Final Report, October 2006

[6] Representative Route refers to a proposed route or potential alignment for a Tier 1 EIS Alternative. The Representative Route includes the physical footprint of the improvements associated with the Tier 1 EIS Alternatives. The horizontal and vertical dimensions of the footprint of the Representative Route are based on prototypical cross-sections for these improvements. The Representative Route is used as a proxy for estimating the potential effects of a route whose location could shift during subsequent project-level reviews

Since the approach to effects assessment for EMF/EMI is based on representative locations, further analysis beyond the Affected Environment will not be conducted for a broader Context Area. Should the Representative Route shift, affects would be considered based on the characteristics of the representative locations.

Table 4: Data Sources for the Evaluation of EMF/EMI

EMF/EMI	Data Source	Data Application
Federal Railroad Administration	▪ EMF Monitoring on Amtrak's Northeast Corridor: Post-Electrification Measurements and Analysis, U.S. DOT Federal Railroad Administration, Office of Research and Development, DOT/FRA/RDV-06/01, Final Report, October 2006	▪ Wayside and onboard measurements of EMF readings for Acela to assess the potential for effects to sensitive receptors within the Affected Environment as well as to passengers or train crews onboard the trains
NJ TRANSIT	▪ Access to the Regions Core Final Environmental Impact Statement, October 2008 ▪ Access to the Regions Core "Environmental Impacts of Electric and Magnetic Fields (EMF)	▪ Findings from previous modeled or empirical data to inform findings re: potential effects of additional electric trains (operating at current or higher speeds) and effects of potential new traction power infrastructure (Overhead Contact Systems; Substations, etc.) ▪ Findings re: effects of increased electric train operations on public health (for both outside or within the vehicles)
California High-Speed Train Final Program EIR/EIS	California High-Speed Train Final Program EIR/EIs (statewide) http://www.hsr.ca.gov/docs/programs/eir-eis/statewide_final_EIR_vol1ch3part2.pdf, Page 3.6-1; and California High-Speed Train; Merced to Fresno Section EMF Footprint Modeling Report (Authority and FRA 2011)	▪ Modeled results for high-speed trains and potential EMF/EMI effects both on-board in areas outside and adjacent to new services
Volpe Center	*Survey and Assessment of Electric and Magnetic Field (EMF) Public Exposure in the Transportation Environment,* Contract No. DTRS-57-96-C-00073, Prepared for DOT-RSPA, Volpe National Transportation Systems Center, Prepared by Electric Research, Principal Investigators Fred M. Dietrich, William L. Jacobs, March 1999, 242 p.	▪ Data and analysis re: the frequency and intensity of EMF for users of electric and high-speed passenger rail systems
National Institute of Environmental Health Sciences (NIEHS)	*EMF: Electric and Magnetic Fields Associated with the Use of Electric Power, June 2002*	▪ Data associated with typical magnetic field levels from other typical magnetic field sources, such as home appliances, occupational equipment, and electric power lines. To be used as a comparison to High-Speed Rail EMF/EMI emissions.

Source: NEC FUTURE JV Team, 2014

1.5.2 Environmental Consequences

FRA will assess environmental consequences for 10–20 representative locations within the Affected Environment.

The following are the steps for assessing potential EMF/EMI environmental consequences of the Tier 1 EIS Alternatives:

1. The potential strength of an EMF and its potential effect decreases with distance from the source. General information related to EMF source strengths and reductions over distance from electrified rail corridors will be obtained from several recent studies on the subject (Table 4).
2. For the 10–20 representative locations identified within the Affected Environment, FRA will establish screening distances to evaluate the effects of EMF on sensitive facilities (government facilities, universities, medical institutions, or high-tech businesses) based on typical train and wayside equipment emission levels. Screening distances and EMF strengths by mode will reflect recent studies conducted for the California High Speed Train Program EIR/EIS as well as field measurements for the NEC (see Table 4). Because magnetic fields are expected to be the dominant EMF effect from Tier 1 EIS Alternatives, these estimates will serve as the basis for the EMF impact analysis. Possible EMI effects from on or off-vehicle systems would be minimal or addressed through vehicle and systems design criteria (See Section 1.5.3).
3. FRA will describe the representative range of potential impacts for Tier 1 EIS Alternatives based on the analysis of representative locations for broad service and equipment type assumptions and established screening distances (as described above in Step 2). FRA will update exposure data as newer data are available or as the specific vehicle/system technology for the Tier 1 EIS Alternatives are identified.
4. FRA will document, based on previously conducted research, the potential EMF/EMI effects to passengers and employees on-board existing and proposed electric trainsets. To date, research has not identified any potential health effects associated with EMF/EMI, however, the available information will be reviewed and findings summarized.

1.5.3 Mitigation Strategies

FRA will develop a menu of potential mitigation measures on a programmatic scale for further consideration in Tier 2. An example of a programmatic mitigation measure for EMF/EMI is design considerations to prevent interference including magnetic field shielding around sensitive equipment or installing RF filters into sensitive equipment.

1.6 TIER 1 EIS OUTCOMES

The Tier 1 EIS EMF/EMI assessment will:

- Identify 10–20 representative locations with receptors sensitive to EMF/EMI from both wayside and onboard sources.
- Assess the potential effects of the Tier 1 EIS Alternatives, at 10 - 20 representative locations, on sensitive receptors based on previous studies or other available data.

- Identify the representative range of potential effects and areas requiring more detailed analysis during Tier 2.
- Identify a menu of potential mitigation strategies.

1.7 APPLICABILITY TO TIER 2 ASSESSMENTS

The Tier 1 Analysis will identify areas where there could be sensitive receptors to EMF/EMI. Tier 2 analyses would refine the specific location and type of sensitive receptors. If warranted, site-specific measurements and/or predictive modeling could be required to further analyze the potential for project-specific EMF/EMI effects.

Application of Effects-Assessment Methodology

17.1 ELECTROMAGNETIC FIELDS AND ELECTROMAGNETIC INTERFERENCE: APPLICATION OF EFFECTS-ASSESSMENT METHODOLOGY

17.1.1 Variations to the Effects-Assessment Methodology

The following variations from the Effects-Assessment Methodology occurred during the process of developing the Tier 1 Draft EIS analysis:

- The FRA identified potentially sensitive receptors, as stated in the methodology. In order to identify receptors that would be more prone to electromagnetic fields and electromagnetic interference (EMF/EMI), only those receptors in close proximity to at-grade construction types were identified. The effects on receptors adjacent to other construction types would likely be mitigated by the cover other construction types provide.

  Potential sensitive receptors were organized further according by the following characteristics:

  - Representative Land Cover: Potentially sensitive receptors would typically be located in either Developed, High-Density, or Developed, Medium Density land cover. Other land cover types based on the special land uses were also considered.
  - Representative Land Use: Land uses known to be potentially effected by EMF/EMI were identified.
  - Observed distance from Representative Route: grouped within 100 feet, 500 feet, and 1,000 feet of the Representative Route

The data presented in the appendix is preliminary. A reevaluation of normal operating conditions using equipment chosen for the Action Alternatives should be conducted as part of subsequent project level analysis.

17.1.2 Data Update

The following variations from the identified data sources in the Effects-Assessment Methodology occurred during the process of developing this Tier 1 Draft EIS analysis:

- Scenarios assuming a “maximum draw” or “worst case” in which EMF/EMI would be produced were analyzed. The scenarios analyze two sources of EMF/EMI:
  - Electric Traction (ET) systems: Typical EMF/EMI effects are simulated under two temporal scenarios: 1) Maximum short duration interferences, and 2) Maximum steady state interferences
  - Communications and Signaling (C&S) Systems: Scenarios involving wireless C&S systems, one that might be employed in the Action Alternatives.

17.1.3 Analytical Approach: Assumptions

Power Supply

The existing NEC high voltage transformers are rated at 40 megavolt amperes (MVA) with 10% impedance losses. The paralleling and switching stations have a rating of 10 MVA, 1.2% impedance losses. Each traction power substation houses two traction transformers, each feeding different electrical sections of the contact line. Each switching station has two autotransformers and each paralleling station has one 50/25 kilovolts (kV) autotransformer.

Overhead Catenary System

The precise Overhead Catenary System (OCS) characteristics of the Action Alternatives are not known however, so an OCS design suitable for 220 mph is assumed. Table 17.1-1 shows the considered geometrical and electrical characteristics.

Table 17.1-1: Assumed OCS Characteristics of the Action Alternatives

OCS	Type	Height [ft]	Length [ft]	Cross section [kcmil]	Resistivity [$\Omega mm^2/m$]
Contact wire track 1	CuMg	19	-8.5	300	0.02778
Messenger wire track 1	Hard drawn copper	23	-8.5	300	0.01825
Contact wire track 2	CuMg	19	8.5	300	0.02778
Messenger wire track 2	Hard drawn copper	23	8.5	300	0.01825
Static wire track 1	ACSR 'Penguin'	23	-20.5	#4/0 AWG	0.02807
Exterior rail track 1	136lb	0	-10.95	12.18 in^2	0.207
Interior rail track 1	136lb	0	-6.05	12.18 in^2	0.207
Interior rail track 2	136lb	0	6.95	12.18 in^2	0.207
Exterior rail track 2	136lb	0	10.95	12.18 in^2	0.207
Static wire track 2	ACSR 'Penguin'	23	20.5	#4/0 AWG	0.02807
Feeder (-) track 1	ACSR 'Eagle'	27	-22.5	556	0.02822
Feeder (-) track 2	ACSR 'Eagle'	27	22.5	556	0.02822

Source: FRA, 2015

The OCS of both tracks is unconnected except at paralleling and switching stations. The return path encloses both rails and statics wires form both tracks and all are considered equipotential.

Rolling Stock

Rolling stock assumptions were taken from the Siemens Velaro E trainset, which is composed of eight cars, four cab cars and four control cars. Half of the axles are driven. Table 17.1-2 identifies the general features. The equipment used in the EMF/EMI simulations is similar to the Tier III trainsets used to develop service plans,[1] and is representative of equipment that would likely be used for Intercity Express, Intercity Corridor, and Metropolitan Services.

Decisions about specific fleet composition and equipment procurement for NEC rail services were not made as part of the NEC FUTURE program. Ultimate decisions about rolling stock procurement, including the configuration and maximum speed of high-speed trainsets, will be made over time after completion of this Tier 1 Draft EIS.

[1] Future high-performance dual-mode locomotive or multiple-unit trainset technology is assumed to exist prior to 2040 horizon year.

Table 17.1-2: Rolling Stock Assumptions in the EMF/EMI analysis

Characteristic	Measurement
Vehicle Tare Weight	937,125 lbs = 425 t
Fully loaded Vehicle weight	1,069,425 lbs = 485 t (full-seated weight, 404 passengers
Max speed	217 mph = 350 km/h
Length	656.16 ft = 200 m
Auxiliary equipment power	600 kW
Maximum acceleration	1.230 miles/hs = 0.55 m/s^2
Maximum deceleration:	1.252 miles/hs = 0.56 m/s^2
Maximum traction power	8.8 MW
Total efficiency	84.5%

Source: NEC FUTURE team, 2015

Power Distribution

The location of traction power substations (TPSS), paralleling stations (PS) and switching stations (SWS) in the Action Alternatives are unknown. Table 17.1-3 shows a general assumption of distribution.

Table 17.1-3: Traction power substation, paralleling stations and switching stations locations

Power supply system	Distance along track [Miles]	Difference [miles]
TPSS-01	0	5
PS-1	5	5
PS-2	10	5
PS-3	15	5
SWS-01	20	

Source: NEC FUTURE team, 2015

Estimated Scenarios

Normal Conditions

In normal conditions the worst-case operating scenario is one train per track at a maximum distance from a substation and demanding maximum power. The EMF differs based on distance from a power source in a 2x25kVac system. Three scenarios at a distance of 17.5 miles from the power source have been analyzed:

- One train per track at maximum power demand at MP 17.5. Area 1 between TPS and PS-1.
- One train per track at maximum power demand at MP 17.5. Area 2 between PS-3 and the position of the trains.
- One train per track at maximum power demand at MP 17.5. Area 3 between the position of the trains and SWS-01.

Table 17.1-4 shows the distribution of currents for each area for each OCS conductor.

Table 17.1-4: Normal Conditions. OCS Current Distribution for the Three Considered Areas

OCS conductor	Area 1 [A]	Area 2 [A]	Area 3 [A]
Contact wire. Track 1	-89.6	-128.2	33.7
Messenger wire. Track 1	-138.3	-198.1	52.1
Contact wire. Track 2	-89.6	-128.2	33.7
Messenger wire. Track 2	-138.3	-198.1	52.1
Static wire. Track 1	15.3	84.0	-60.0
Exterior rail. Track 1	15.8	86.8	-62.0
Interior rail. Track 1	13.4	73.8	-52.8
Interior rail. Track 2	13.4	73.8	-52.8
Exterior rail. Track 2	15.8	86.8	-62.0
Static wire. Track 2	15.3	84.0	-60.0
Feeder (-). Track 1	184.2	85.9	85.9
Feeder (-). Track 2	184.2	85.9	85.9

Source: NEC FUTURE team, 2015

Data Matrices

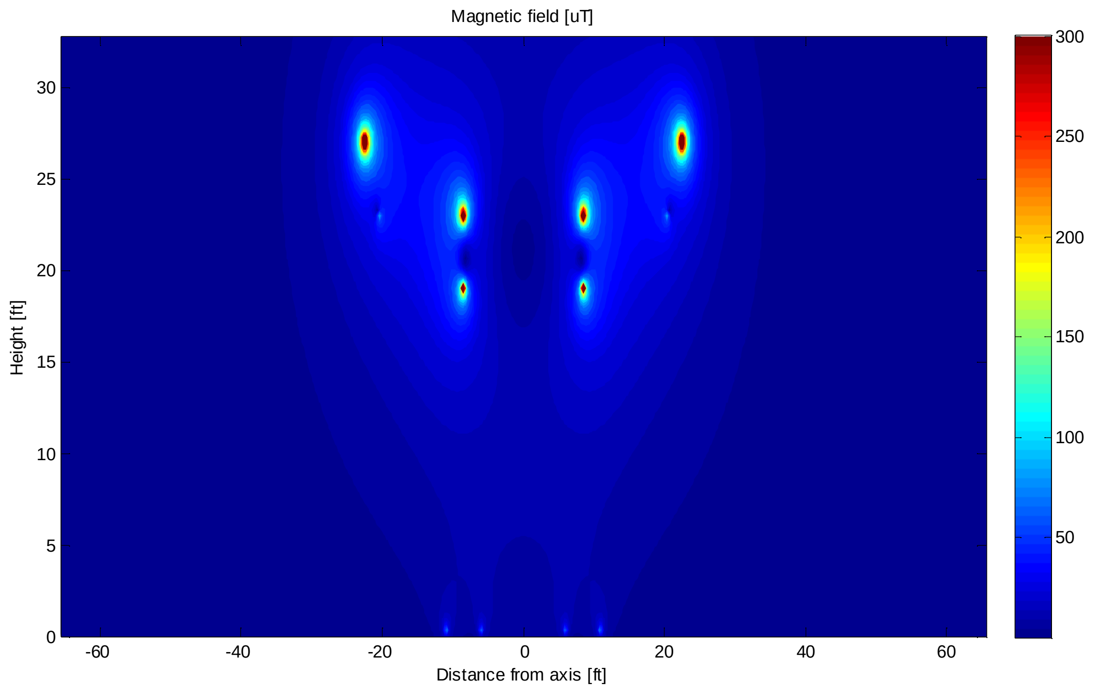
17. Electromagnetic Fields and Electromagnetic Interference

17.2 RESULTS OF ELECTROMAGNETIC FIELD MAGNITUDE ANALYSIS

The magnitude of electromagnetic field is presented in three different formats:

- A filled contour plot that displays electromagnetic density at the source and immediate vicinity. Intensity is displayed by color. A filled contour plot shows the sources of the field and how it quickly decreases, but it is not a useful plot to assess numbers.
- A line plot of magnetic flux density versus distance from axis at four differences heights: 1, 3, 10, and 30 feet. This kind of representation shows also how quickly electromagnetic field decreases and it is comparatively useful to assess quantities.
- A table with minimal distances from axis to reduced magnetic field below several selected thresholds. With this data is easy to define a zone around the track to meet allowable limits specified. Four thresholds have been selected from 1uT – 0.001uT.

Figure 17-1: Steady State OCS Current Distribution: Normal Conditions, Area 1 between TPS and PS-1



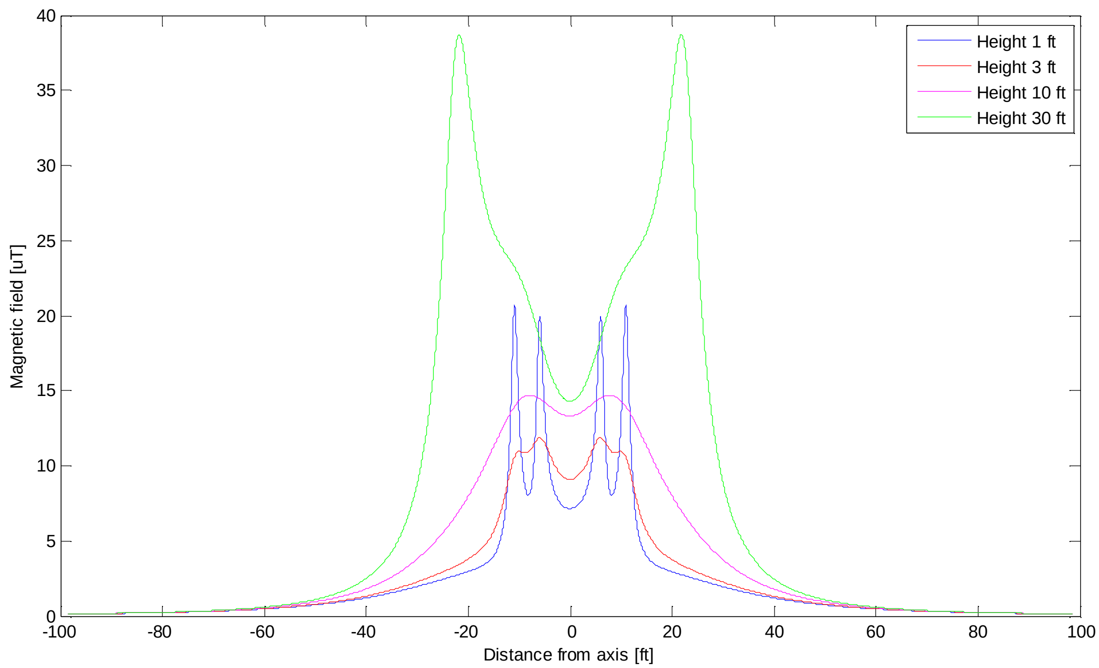


Table 17.2-1: Area 1 between TPS and PS-1 – Minimum distance (ft) from axis under several magnetic field thresholds by height

Minimum distance for reduced magnetic field [ft]				
Magnetic Field Threshold [uT]	Measurement Height [ft]			
	1	3	10	30
1	43.7	45.2	49.0	51.3
0.1	109.1	109.5	110.3	109.6
0.01	291.1	291.4	291.9	292.5
0.001	1202.2	1202.8	1204.7	1210.0

Source: NEC FUTURE, 2015
Microtesla = μT (1μT = 0.001mT)

Figure 17-2: Steady State OCS Current Distribution: Normal Conditions, Area 2 between PSA-3 and Trains

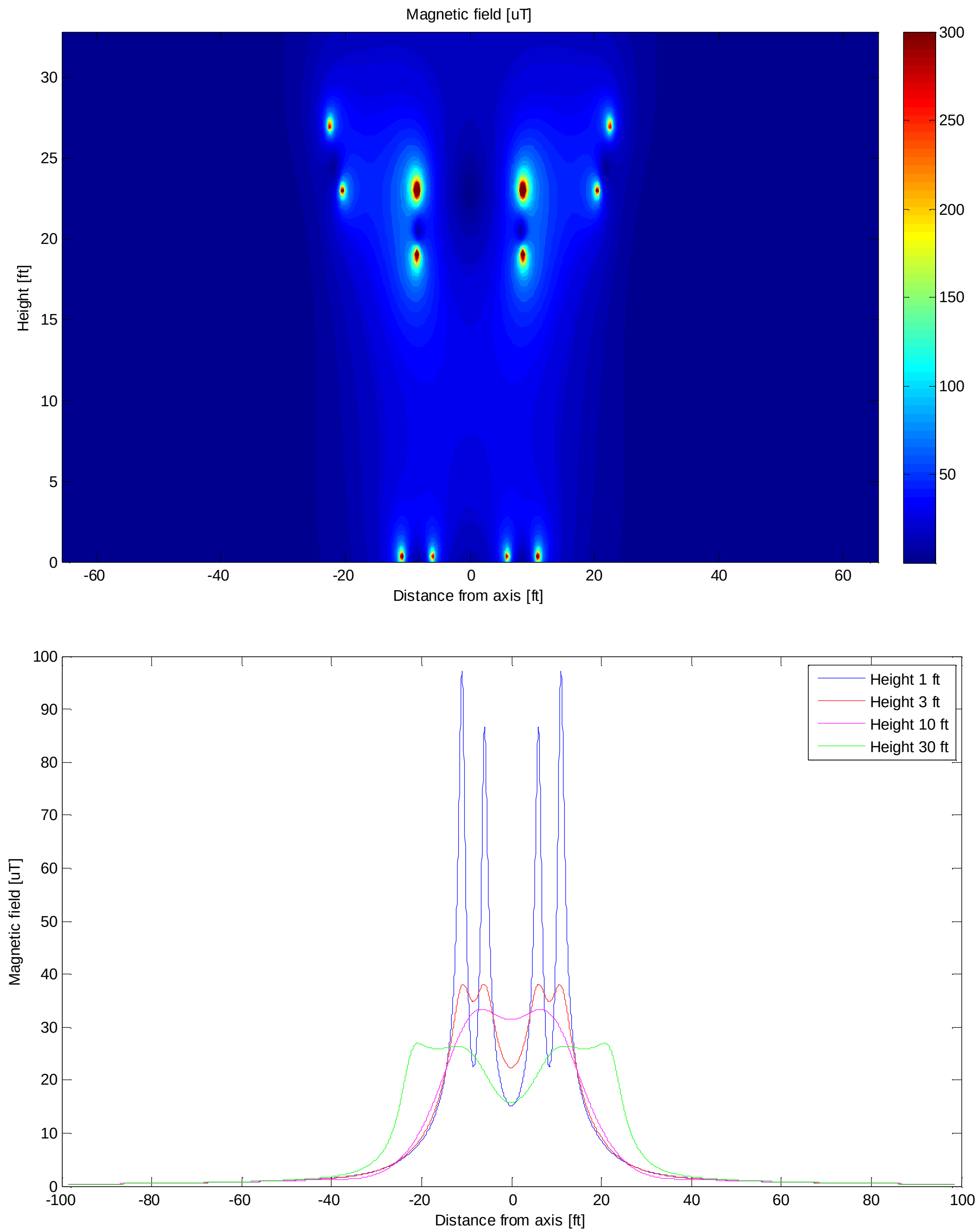


Table 17.2-2: Area 2 between PS-3 and train – Minimum distance (ft) from axis under several magnetic field thresholds by height

Minimum distance for reduced magnetic field [ft]				
Magnetic Field Threshold [uT]	Measurement Height [ft]			
	1	3	10	30
1	51.8	51.8	51.1	54.3
0.1	195.1	195.0	194.6	192
0.01	745.2	744.6	742.4	736
0.001	5552.9	5552.6	5551.9	5549.6

Source: NEC FUTURE, 2015
Microtesla = μT (1μT = 0.001mT)

Figure 17-3: Steady State OCS Current Distribution: Normal Conditions, Area 3 between Trains and SWS-01

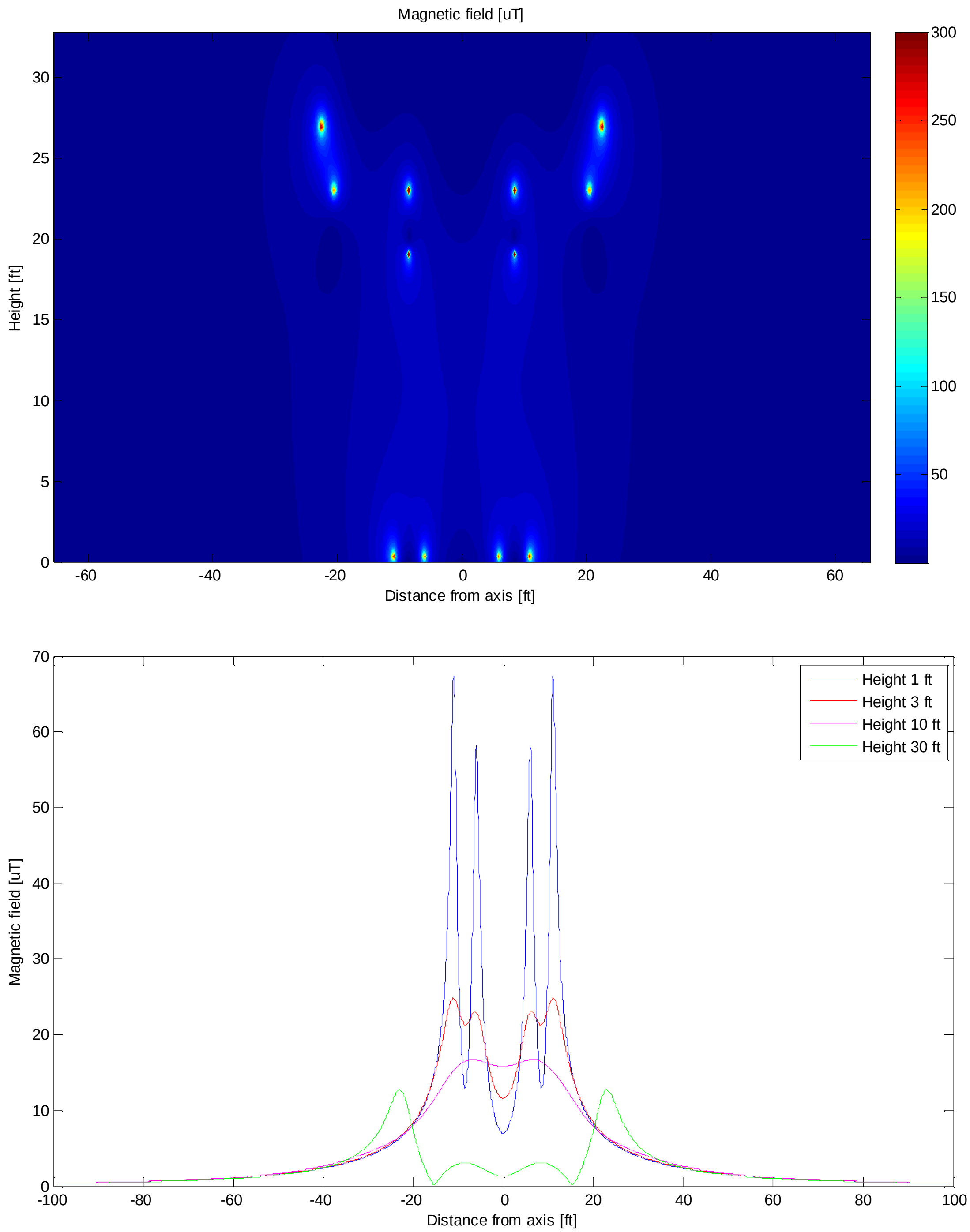


Table 17.2-3: Area 3 between trains and SWS-01 – Minimum distance (ft) from axis under several magnetic field thresholds by Height

Minimum distance for reduced magnetic field [ft]				
Magnetic Field Threshold [uT]	Measurement Height [ft]			
	1	3	10	30
1	62.3	62.6	63.2	60.2
0.1	194.7	194.6	193.9	190.8
0.01	677.9	677.4	675.4	669.1
0.001	4162.8	4162.4	4161.1	4157.1

Source: NEC FUTURE, 2015
Microtesla = μT (1μT = 0.001mT)

17.3 SUMMARY OF ANALYSIS

The most conservative values in every situation are summarized in the table below.

Table 17.3-1: Steady state – Normal operation

Minimum distance for reduced magnetic field [ft]				
Magnetic Field Threshold [uT]	Measurement Height [ft]			
	1	3	10	30
1	62.3	62.6	63.2	60.2
0.1	195.1	195	194.6	192
0.01	745.2	744.6	742.4	736
0.001	5552.9	5552.6	5551.9	5549.6

Source: NEC FUTURE, 2015

The threshold chosen to limit areas where EMI for very sensitive EMF equipment due to high speed rail lines can be expected in operational conditions is 0.01 µT. The maximum EMF/EMI expected for normal operation is approximately 745-feet.