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January 12, 2018

RE: Installation of radio base station antennas and associated equipment for a personal wireless services facility to be located on a monopole at 101 Red Brook Road, Mashpee, MA.

PURPOSE

I have reviewed the information pertinent to the proposed installation at the above location. To determine regulatory compliance, including the "Guidelines for DRI Review of Wireless Communications Towers",[i] theoretical calculations of maximal radio-frequency (RF) fields have been prepared. The physical conditions are that BlueSky Towers proposes to build a 150' monopole at 101 Red Brook Road, Mashpee, MA (See Figure 1). The monopole is proposed to host Personal Wireless Services (PWS) provider's directional panel antennas typically installed in three different "arrays" aimed 120° apart. The proposed host PWS providers are **Verizon Wireless and T-Mobile**. The monopole will be designed to accommodate up to two (2) additional providers' antennas, in addition to the Town of Mashpee's EMS equipment.

This report considers the contributions of the **proposed** Verizon Wireless and T-Mobile, plus the Town of Mashpee's EMS equipment, and *possible* two (2) additional PWS provider's transmitters operating at their FCC-licensed capacity. The calculated values of RF fields are presented as a percent of current Maximum Permissible Exposures (%MPE) as adopted by the Federal Communications Commission (FCC),[ii,iii] and those established by the Massachusetts Department of Public Health (MDPH).[iv]

SUMMARY

Theoretical RF field calculations data indicate the summation of the proposed Verizon Wireless and T-Mobile PWS plus the Town of Mashpee's EMS equipment's maximum RF contributions would be within the established RF exposure guidelines; refer to Figure 3. This includes all publicly accessible areas, and the surrounding neighborhood in general. The results support compliance with the pertinent sections of the Massachusetts Department of Public Health regulations regarding PWS facilities, and the FCC's guidelines for RF exposure. Even if the proposed monopole were to be "fully loaded", the summation of the maximum RF contributions would also be within the established RF exposure guidelines; refer to Figure 4.

Based on the results of the theoretical RF fields I have calculated, it is my expert opinion that this facility would comply with all regulatory guidelines for RF exposure with the proposed Verizon Wireless and T-Mobile and possible Town of Mashpee's EMS antenna and transmitter installations.

EXPOSURE LIMITS AND GUIDELINES

RF exposure guidelines enforced by the FCC were established by the American National Standards Institute (ANSI)[v] and the National Council on Radiation Protection and Measurement (NCRP).[vi] The RF exposure guidelines are listed for RF workers and members of the public. The applicable FCC RF exposure guidelines for the public are listed in Table 1, and depicted in Figure 1. All listed values are intended to be averaged over any contiguous 30-minute period.

Table 1: Maximum Permissible Exposure (MPE) Values in Public Areas

Frequency Bands	Electric Fields	Magnetic Fields	Equivalent Power Density
0.3 – 1.34 MHz	614 (V/m)	1.63 (A/m)	(100) mW/cm^2
1.34 - 30 MHz	824/f (V/m)	2.19/f (A/m)	(100) mW/cm^2
30 - 300 MHz	27.5 (V/m)	0.073 (A/m)	0.2 mW/cm^2
300 - 1500 MHz	--	--	f/1500 mW/cm^2
1500 - 100,000	--	--	1.0 mW/cm^2

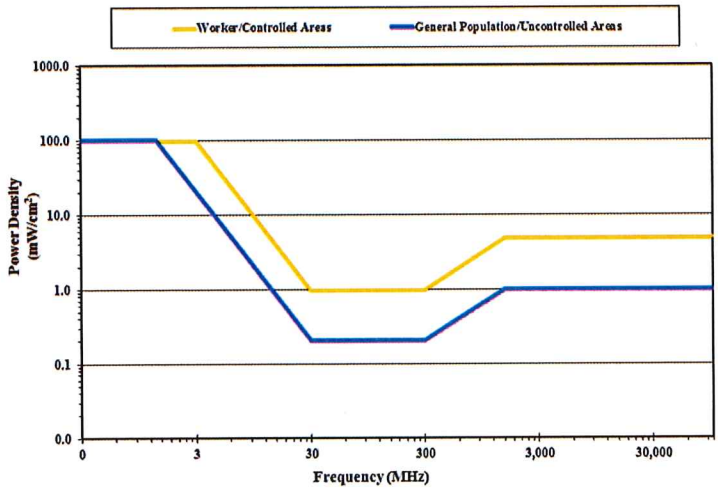

Figure 1: FCC Limits for Maximum Permissible Exposure (MPE)

NOTE: FCC 5% Rule – At multiple transmitter sites, actions necessary to bring the area into compliance with the RF exposure guidelines are the shared responsibility of all licensees whose transmitters produce RF field levels in excess of 5% of the applicable FCC MPEs.

PROPOSED FACILITY LOCATION

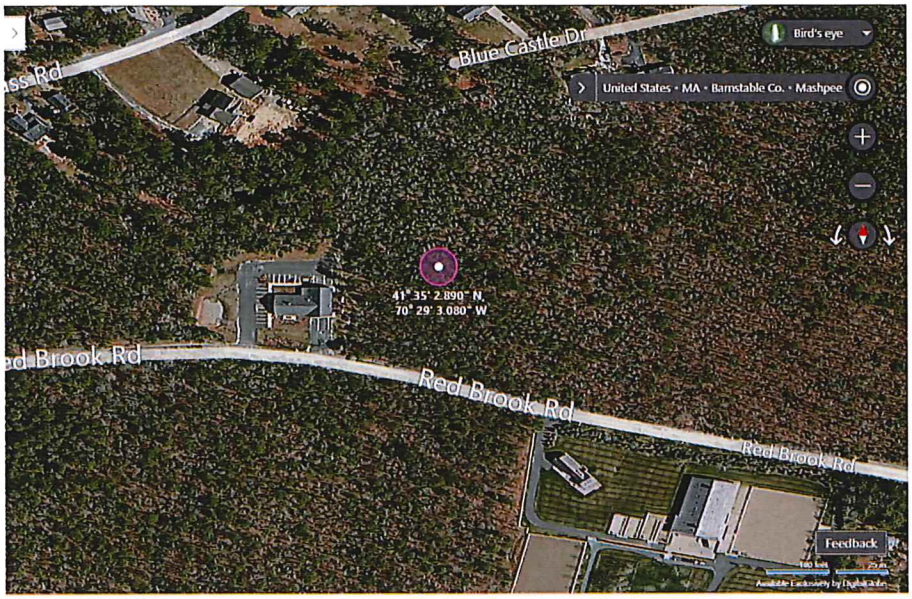

Figure 2: Proposed Location of PWS Compound Including 150' Monopole;
101 Red Brook Road, Mashpee, MA
(41° 35' 02.890" N, -70° 29' 0.0380" W)
(Picture courtesy Bing Maps©2017 and may not represent current conditions)

OBSERVATIONS IN CONSIDERATION WITH FCC RULES §1.1307(B) & §1.1310

Will it be physically possible to stand next to or touch any omnidirectional antenna and/or stand in front of a directional antenna?

NO; access to the monopole will be restricted, and the site will adhere to RF safety guidelines regarding the transmitting antennas, including appropriate signage.

THEORETICAL RF FIELD CALCULATIONS - GROUND LEVELS

METHODOLOGY

These calculations are based on what are called "worst-case" estimates. That is, the estimates assume 100% use of all transmitters simultaneously. Additionally, the calculations make the assumption that the surrounding area is a flat plane. The resultant values are thus conservative in that they over predict actual resultant power densities.

The calculations are based on the following information (See Table 2 data):

1. Effective Radiated Power (ERP).
2. Antenna height (centerline, above ground level (AGL)).
3. Antenna vertical radiation patterns; the source of the negative gain (G) values. "Directional" antennas are designed to focus the RF signal, resulting in "patterns" of signal loss and gain. Antenna radiation patterns display the loss of signal strength relative to the direction of propagation due to elevation angle changes. The gain is expressed as "G^E". See Appendix A for typical antenna radiation patterns for PWS directional panel antennas.

> **Note**: "G" is a unitless factor usually expressed in decibels (dB); where $G = 10^{(dB/10)}$
> For example: for an antenna *gain* of 3 dB, the net factor (G) = $10^{(3/10)} = 2$
> For an antenna *loss* of -3 dB, the net factor (G) = $10^{(-3/10)} = 0.5$

To determine the magnitude of the RF field, the power density (S) from an isotropic RF source is calculated, making use of the power density formula as outlined in FCC's OET Bulletin 65, Edition 97-01:[vii]

$$S = \frac{P \cdot G}{4 \cdot \pi \cdot R^2}$$

Where:
- P → Power to antenna (watts)
- G → Gain of antenna
- R → Distance (range) from antenna source to point of intersection with the ground (feet)
- $R^2 = (\text{Height})^2 + (\text{Horizontal distance})^2$

Since: P · G = EIRP (Effective Isotropic Radiated Power) for broadcast antennas, the equation can be presented in the following form:

$$S = \frac{EIRP}{4 \cdot \pi \cdot R^2}$$

In the situation of off-axis power density calculations, apply the negative elevation gain (G^E) value from the vertical radiation patterns with the following formula:

$$S = \frac{EIRP \cdot G^E}{4 \cdot \pi \cdot R^2}$$

Ground reflections may add in-phase with the direct wave, and essentially double the electric field intensity. Because power density is proportional to the *square* of the electric field, the power density may quadruple, that is, increase by a factor of four (4). Since ERP is routinely used, it is necessary to convert ERP into EIRP by multiplying by the factor of 1.64 (the gain of a half-wave dipole relative to an isotropic radiator). Therefore, downrange power density estimates can be calculated by using the formula:

$$S = \frac{4 \cdot (ERP \cdot 1.64) \cdot G^E}{4 \cdot \pi \cdot R^2} = \frac{ERP \cdot 1.64 \cdot G^E}{\pi \cdot R^2} = \frac{0.522 \cdot ERP \cdot G^E}{R^2}$$

To calculate the % MPE, use the formula:

$$\%\ MPE = \frac{S}{MPE} \cdot 100$$

The results of the calculations for the potential maximum RF emissions resulting from the summation of the ***proposed*** Verizon Wireless and T-Mobile PWS and the Town of Mashpee's EMS antennas are depicted in Figure 3 as plotted against linear distance from the base of the monopole in any direction. The results of the calculations for the potential maximum RF emissions resulting from the ***proposed*** Verizon Wireless and T-Mobile PWS and the Town of Mashpee's EMS antennas in addition to **two (2) additional *possible* PWS** carriers (See Table 2 inventory) are similarly depicted in Figure 4. Note that the values have been calculated for a height of 6' AGL in accordance with regulatory rationale. Also, depicted on the graphs are values for a height of 16' AGL (height of a typical 2nd story). A logarithmic scale was used to plot the calculated theoretical %MPE values in order to compare with the MPE limit values of 100% (Public) and 500% (note that 100% Worker limit = 500% Public limit), which are so much larger that they would be off the page in a linear plot. The curves are variable due to the application of the vertical radiation patterns.

ANTENNA INVENTORY

Table 2: Proposed and/or Possible Antenna Inventory
150' Monopole at 101 Red Brook Road, Mashpee, MA

Antenna Centerline (AGL)	Proposed Antenna Configuration	Typical Parameters: ERP & Transmit Frequencies	Typical Use
		***Proposed* by Verizon Wireless**	
146'	3 Sectors of ≤ 4 Panel Antennas Each*	4357 watts ERP;1965-1990,1885-1910 MHz 3035 watts ERP; 860-890 MHz 3035 watts ERP; 698-704, 728-734 MHz 5049 watts ERP; 2110-2155 MHz	PCS CDMA-850 LTE-700 AWS-2100
		***Proposed* by T-Mobile**	
136'	*3 Sectors of ≤ 4 Panel Antennas Each* 20" Flat Array*	*3156 watts ERP;1965-1990,1885-1910 MHz* *2507 watts ERP; 698-704, 728-734 MHz* *3708 watts ERP; 2110-2155 MHz* *4357 watts ERP; 1710-1755 MHz* *3937 watts ERP; 27-31 GHz*	*PCS* *LTE-700* *AWS-2100* *AWS-1700* *Multipoint*
		Possible* Town of Mashpee EMS Equipment *(Hypothetical but possible)	
100'	10' Whip	50 watts ERP; 33.68000 MHz 100 watts ERP; 854.93750 100 watts ERP; 151.13000 100 watts ERP; 154.60000	Fire Dispatch Law Dispatch Public Works Security
		Possible Two (2) Additional PWS Providers Representing a "Fully Loaded" Monopole	
126'	*3 Sectors of ≤ 4 Panel Antennas Each**	*1130 watts ERP in 850 MHz band* *2625 watts ERP in 1950 MHz band* *1968 watts ERP in 700 MHz band* *5613 watts ERP in 2100 MHz bands* *2566 watts ERP; 2300 MHz bands*	*E.g. AT&T:* *UMTS* *PCS* *LTE* *AWS*
116'	*3 Sectors of ≤ 2 Panel Antennas Each**	*1600 watts ERP in 850 MHz band*	*E.g. Nextel:* *EMSR*
116'	*3 Sectors of ≤ 2 Panel Antennas Each**	*2720 watts ERP in 1975 MHz band*	*E.g. Sprint-PCS:* *PCS*

Table Notes:

* Antenna configuration based on "typical" installations at similar ground-based sites.
AWS: Advanced Wireless Services
CDMA: Code Division Multiple Access (cellular voice)
EMSR: Enhanced Specialized Mobile Radio
LTE: Long Term Evolution ("4G")
PCS: Personal Communication System
UMTS: Universal Mobile Telecommunication System

RESULTS OF THEORETICAL RF FIELD CALCULATIONS

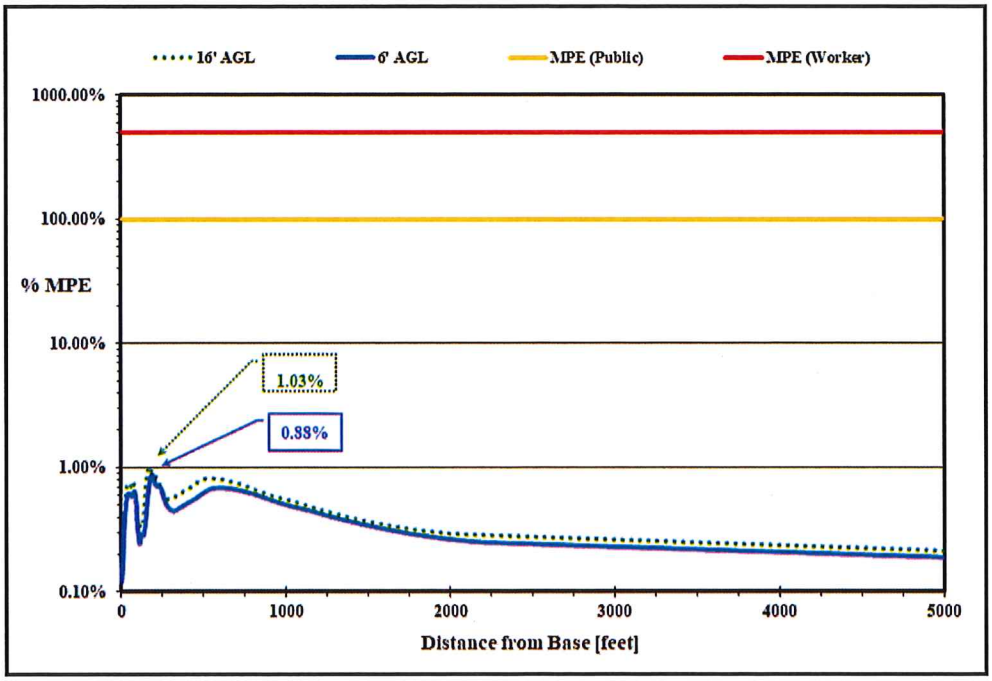

Figure 3: Theoretical Cumulative Maximum Percent MPE - vs. – Distance (Proposed Combined Verizon Wireless and T-Mobile PLUS the Town of Mashpee's EMS RF Contributions)

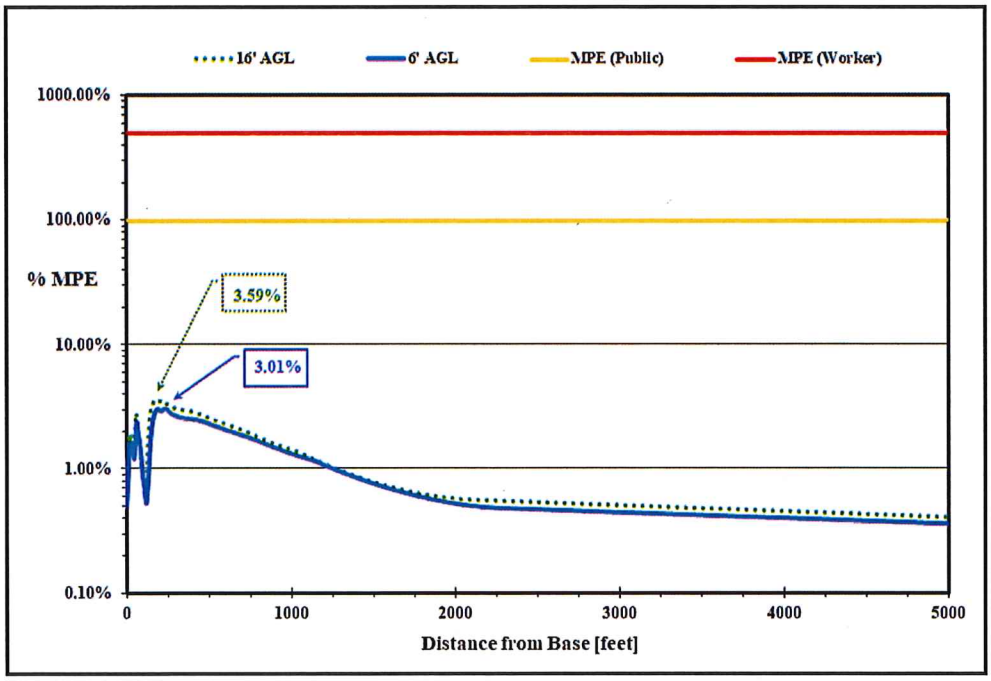

Figure 4: Theoretical Cumulative Maximum Percent MPE - vs. – Distance ("Fully Loaded Monopole" RF Contributions)

CONCLUSION

Theoretical RF field calculations data indicate the summation of the proposed Verizon Wireless and T-Mobile PWS plus the Town of Mashpee's EMS equipment's maximum RF contributions would be within the established RF exposure guidelines; refer to Figure 3. This includes all publicly accessible areas, and the surrounding neighborhood in general. The results support compliance with the pertinent sections of the Massachusetts Department of Public Health regulations regarding PWS facilities, and the FCC's guidelines for RF exposure. Even if the proposed monopole were to be "fully loaded", the summation of the maximum RF contributions would also be within the established RF exposure guidelines; refer to Figure 4.

The number and duration of calls passing through PWS facilities cannot be accurately predicted. Thus, in order to estimate the highest RF fields possible from operation of these installations, the maximal amount of usage was considered. Even in this so-called "worst-case", the resultant increase in RF field levels are far below established levels considered safe.

Based on the results of the theoretical RF fields I have calculated, it is my expert opinion that this facility would comply with all regulatory guidelines for RF exposure with the proposed Verizon Wireless and T-Mobile and possible Town of Mashpee's EMS antenna and transmitter installations.

Feel free to contact me if you have any questions.

Sincerely,

Donald L. Haes, Jr., Ph.D
Certified Health Physicist

Note: The analyses, conclusions and professional opinions are based upon the precise parameters and conditions of this particular site; **Monopole at 101 Red Brook Road, Mashpee, MA**. Utilization of these analyses, conclusions and professional opinions for any personal wireless services installation, existing or proposed, other than the aforementioned has not been sanctioned by the author, and therefore should not be accepted as evidence of regulatory compliance.

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STATEMENT OF CERTIFICATION

1. I certify to the best of my knowledge and belief, the statements of fact contained in this report are true and correct.

2. The reported analyses, opinions, and conclusions are limited only by the reported assumptions and limiting conditions, and are personal, unbiased professional analyses, opinions and conclusions.

3. I have no present or prospective interest in the property that is the subject of this report and I have no personal interest or bias with respect to the parties involved.

4. My compensation is not contingent upon the reporting of a predetermined energy level or direction in energy level that favors the cause of the client, the amount of energy level estimate, the attainment of a stipulated result, or the occurrence of a subsequent event.

5. This assignment was not based on a requested minimum environmental energy level or specific power density.

6. My compensation is not contingent on an action or event resulting from the analyses, opinions, or conclusions in, or the use of, this report.

7. The consultant has accepted this assessment assignment having the knowledge and experience necessary to complete the assignment competently.

8. My analyses, opinions, and conclusions were developed and this report has been prepared, in conformity with the *American Board of Health Physics* (ABHP) statements of standards of professional responsibility for Certified Health Physicists.

Date: January 12, 2018

Donald L. Haes, Jr., Ph.D
Certified Health Physicist

APPENDIX A

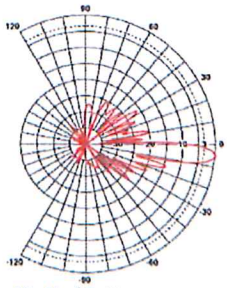
Technical Specifications

Electrical Specifications

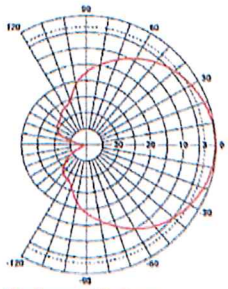
Frequency Range, MHz	1710-2170
Antenna Type	Panel Dual Polarized
Electrical Down Tilt Option	Variable
Gain, dBi (dBd)	18.4 (16.3)
Electrical Downtilt, deg	0-10 , 0-10
Horizontal Beamwidth, deg	65
VSWR	< 1.5:1
Vertical Beamwidth, deg	5.9 to 7.7
1st Upper Sidelobe Suppression, dB	> 18
Upper Sidelobe Suppression, dB	> 18 all
Polarization	Dual pol +/-45°
Front-To-Back Ratio, dB	>26 (typically 28)
Maximum Power Input, W	300
Isolation between Ports, dB	> 30
Lightning Protection	Direct Ground
3rd Order IMP @ 2 x 43 dBm, dBc	> 150 (155 Typical)

Mechanical Specifications

Rated Wind Speed, km/h (mph)	160 (100)
Survival Wind Speed, km/h (mph)	200 (125)
Max Wind Loading Area, m² (ft²)	0.29 (2.9)
Maximum Thrust @ Rated Wind, N (lbf)	380 (185)
Front Thrust @ Rated Wind, N (lbf)	380 (185)
Reflector Material	Aluminum
Radiating Element Material	Brass
Radome Material	Fiberglass
Connector Type	(2) 7-16 DIN Female
Connector Location	Bottom
Mount Type	Downtilt
Mounting Hardware	APM40-2
Weight w/o Mtg Hardware, kg (lb)	8.5 (18.7)
Packing Dimensions, HxWxD, mm (in)	1439 x 237 x 260 (56.6 x 9.3 x 10.3)
Dimensions - HxWxD, mm (in)	1349 x 175 x 80 (53.1 x 6.9 x 3.15)
Shipping Weight, kg (lb)	14.5 (31.9)



Vertical Pattern



Horizontal Pattern

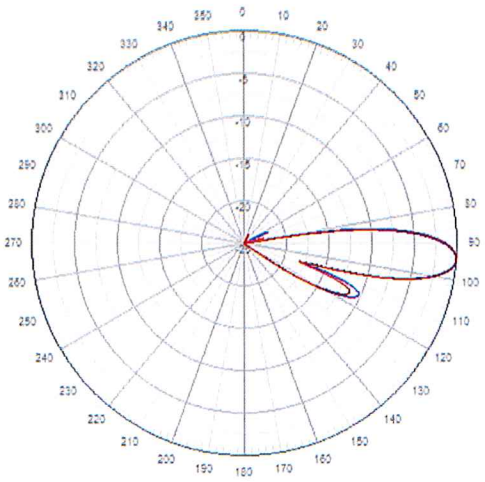
Antenna Radiation Patterns for Typical PWS Directional Panel Antenna; PCS Frequencies

COMMSCOPE® **Base Station Antennas**

Model: LNX-6514DS-VTM

Legend

Description	Port	Frequency	Tilt	Cut	Color
Dual Polarization	Port 1 +45	750	4	V	
Dual Polarization	Port 2 -45	750	4	V	



Antenna Radiation Patterns for Typical PWS Directional Panel Antenna; LTE Frequencies

ENDNOTES

[i]. Cape Cod Commission, *Guidelines for DRI Review of Wireless Communications Towers*, Technical Bulletin 97-001, Section IX (A) Monitoring and Maintenance, Adopted 10/9/97, Revised 3/4/99.

[ii]. Federal Register, Federal Communications Commission Rules; *Radiofrequency radiation; environmental effects evaluation guidelines* Volume 1, No. 153, 41006-41199, August 7, 1996. (47 CFR Part 1; Federal Communications Commission).

[iii]. Telecommunications Act of 1996, 47 USC; Second Session of the 104th Congress of the United States of America, January 3, 1996.

[iv]. 105 CMR 122.000: Massachusetts Department of Public Health, *Non-Ionizing Radiation Limits for: The General Public from Non-Occupational Exposure to Electromagnetic Fields, Employees from Occupational Exposure to Electromagnetic Fields, and Exposure from Microwave Ovens*.

[v]. ANSI/IEEE C95.1-1999: American National Standard, *Safety levels with respect to human exposure to radio frequency electromagnetic fields, from 3 kHz to 300 GHz* **(Updated in 2010)**.

[vi]. National Council on Radiation Protection and Measurements (NCRP); *Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields*, NCRP Report 86, 1986.

[vii]. OET Bulletin 65: Federal Communications Commission Office of Engineering and Technology, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*; Edition 97-01, August 1999.