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May 29, 2017

RE: Installation of radio base station antennas and associated equipment for the Verizon Wireless Personal Wireless Services facility to be located on an existing monopole at 100 Lowder Brook Drive, Westwood, MA.

PURPOSE

I have reviewed the information pertinent to the proposed installation at the above location. To determine regulatory compliance, theoretical calculations of maximal radio-frequency (RF) fields have been prepared. The physical conditions are that Verizon Wireless proposes to mount their personal wireless services (PWS) directional panel antennas (a total of three) on the existing 140' monopole at 100 Lowder Brook Drive, Westwood, MA. The proposed installation will allow Verizon Wireless to continue deployment of their voice/data, Long Term Evolution (LTE), and Advanced Wireless Services (AWS) systems.

This report considers the contributions of all the proposed 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),^{i,iii} and those established by the Massachusetts Department of Public Health (MDPH).ⁱⁱⁱ

SUMMARY

Theoretical RF field calculations data indicate the summation of the existing PWS and proposed Verizon Wireless PWS RF contributions would be within the established RF exposure guidelines; see Figure 4. 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.

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 installation of the proposed Verizon Wireless antenna and transmitter equipment.

Note: The analyses, conclusions and professional opinions are based upon the precise parameters and conditions of this particular site; **Monopole at 100 Lowder Brook Drive, Westwood, 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.

EXPOSURE LIMITS AND GUIDELINES

RF exposure guidelines enforced by the FCC were established by the American National Standards Institute (ANSI) ^{iv} and the National Council on Radiation Protection and Measurement (NCRP).^v 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	Maximum Permissible Exposure (MPE)		
	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/ <i>f</i> (V/m)	2.19/ <i>f</i> (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	--	--	<i>f</i> /1500 mW/cm ²
1500 - 100,000	--	--	1.0 mW/cm ²

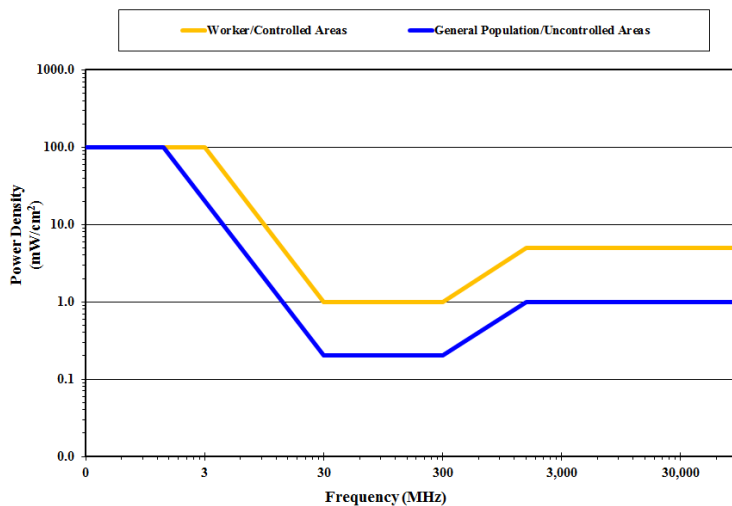


Figure 1: FCC Limits for Maximum Permissible Exposure (MPE)

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.



Figure 2: Existing Monopole (Center) Located at 100 Lowder Brook Drive, Westwood, MA
(Picture courtesy Google Earth^{©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 compound is restricted. The site will adhere to established RF safety guidelines regarding the PWS antennas, including appropriate signage, and restrict access to front of the antennas to trained workers only.

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 information contained in the Table 2 inventory:

- Effective Radiated Power (ERP).
- Antenna height (centerline).
- 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. These patterns (attached **APPENDIX A**) display the loss of signal strength relative to the direction of propagation due to elevation angle changes. The gain is expressed as " G^E ".

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 the FCC OET Bulletin 65, Edition 97-01^{vi} :

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

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: $P \cdot G = \text{EIRP}$ (Effective Isotropic Radiated Power) for broadcast antennas, the equation can be presented in the following form:

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

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:

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

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; this is readily done by multiplying the ERP by the factor of 1.64, which is the gain of a half-wave dipole relative to an isotropic radiator. Therefore, downrange power density estimates can be calculated by using the formula:

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

To calculate the % MPE, use the formula:

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

The results of the calculations for the potential RF emissions resulting from the *existing PWS* antennas only 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 RF emissions resulting from the summation of the *proposed Verizon Wireless PWS and existing PWS* providers' antennas (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 values of 100%, which is so much larger that it 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 Possible Antenna Inventory
Monopole at 100 Lower Brook Drive, Westwood, MA**

Antenna Centerline (≈ AGL)	FCC Licensee	Typical Parameters: ERP & Tx Frequencies [†]	Typical Use [‡]
Proposed Verizon Wireless Antenna Inventory			
104'	Verizon Wireless	4357 watts @ 1865-1870 MHz	PCS / LTE PCS
		3035 watts @ 700 MHz	LTE
		5049 watts @ 2150 MHz	AWS
Existing PWS Antenna Inventory			
135' *	PWS/PCS/AWS	1130 watts @ 850 MHz	GSM
		1950 watts @ 1950-1965 MHz	PCS
		1968 watts @ 700 MHz	LTE
		4677 watts @ 2350-2360 MHz	UMTS
		2566 watts @ 2100 MHz	LTE
125' *	PWS/PCS	5809 watts @ 1950-1965 MHz	PCS
115' *	PWS/ESMR	1094 watts @ 870-880 MHz	ESMR

Table Notes:

[†] Central frequencies –vs. – exact Tx frequencies used to account for multiple channels.

[‡] Tx use (i.e. “duty cycle”) assumed to be 100%; even for 2-way radio

* Typical 10’ spacing between PWS antennas to minimize cross-radio interference

Abbreviations:

AWS: Advanced Wireless Services (“streaming data”)

CDMA: Code Division Multiple Access (“cellular voice”)

ESMR: Enhanced Specialized Mobile radio

GSM: Global System for Mobile Communications (aka “2G”)

LTE : Long Term Evolution (aka “4G”)

PCS: Personal Communication System

UMTS: Universal Mobile Telecommunications System (aka “3G”)

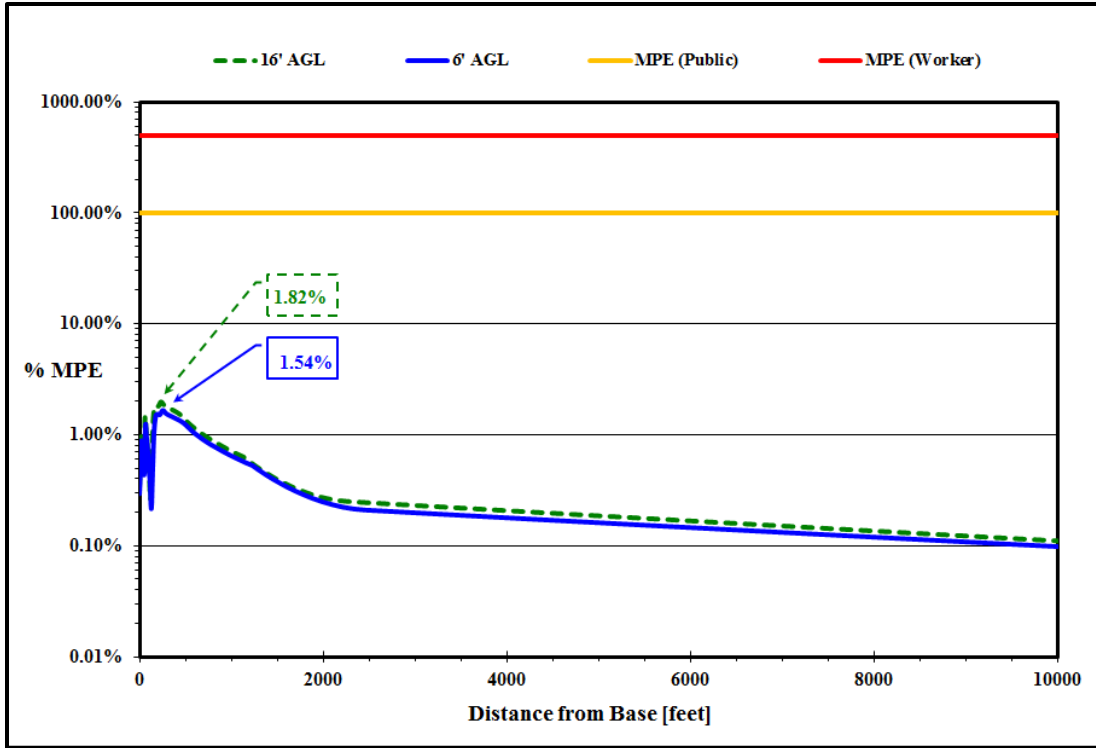


Figure 3: Theoretical Cumulative Maximum Percent MPE - vs. – Distance
(Existing PWS RF Contributions)

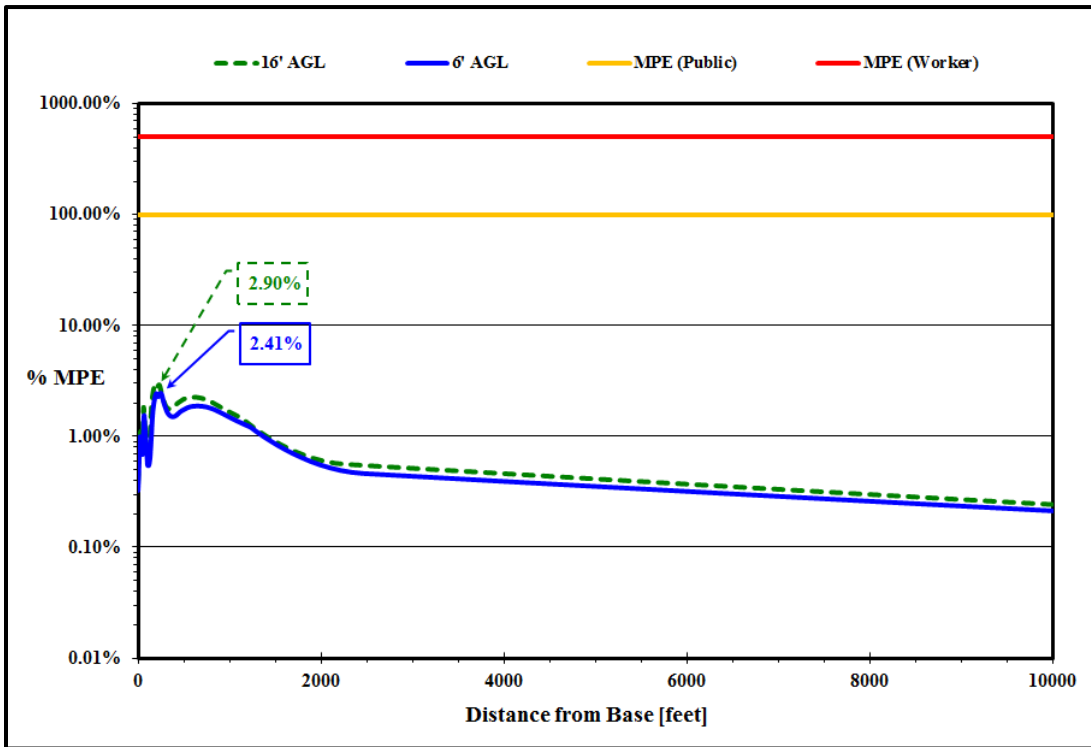


Figure 4: Theoretical Cumulative Maximum Percent MPE - vs. – Distance
(Existing PWS and Proposed Verizon Wireless RF Contributions)

CONCLUSION

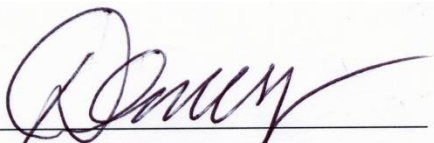
Theoretical RF field calculations data indicate the summation of the existing PWS and proposed Verizon Wireless PWS RF contributions would be within the established RF exposure guidelines; see Figure 4. This includes all publicly accessible areas, and the surrounding neighborhood in general. The results support compliance with the pertinent sections of the Massachusetts Department of Public Health regulations regarding PWS facilities.

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 installation of the proposed Verizon Wireless antenna and transmitter equipment.

Feel free to contact me if you have any questions.

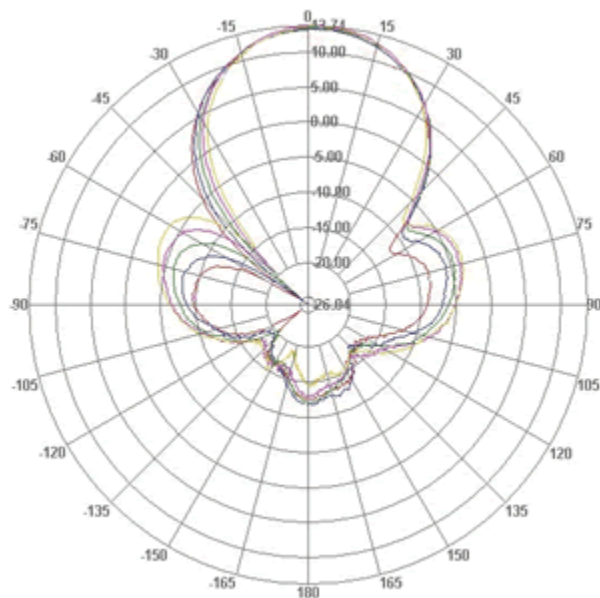
Sincerely,



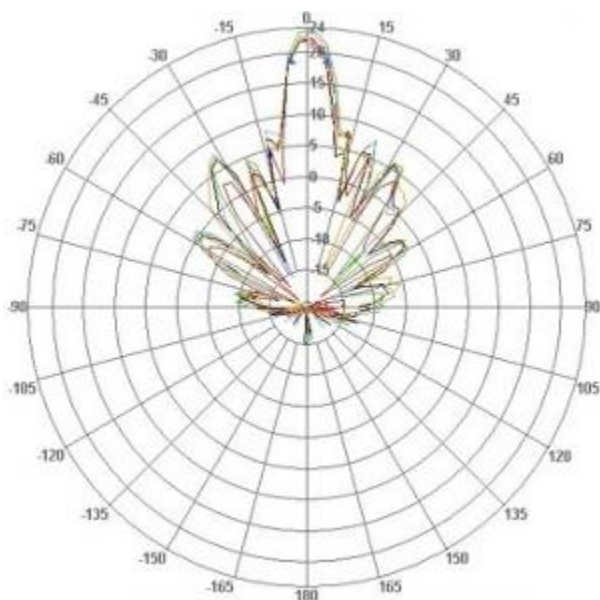
Donald L. Haes, Jr., Ph.D
Certified Health Physicist

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APPENDIX A



Horizontal plane radiation pattern



Vertical plane radiation pattern

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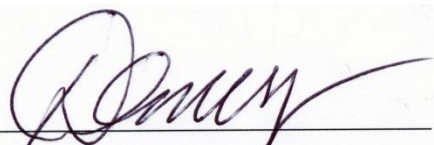
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STATEMENT OF CERTIFICATION

1. I certify to the best of my knowledge and beliefs, 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: May 29, 2017



Donald L. Haes, Jr., Ph.D

Certified Health Physicist

ENDNOTES

- i. 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).
- ii. Telecommunications Act of 1996, 47 USC; Second Session of the 104th Congress of the United States of America, January 3, 1996.
- iii. 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*.
- iv. 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)*.
- v. National Council on Radiation Protection and Measurements (NCRP); *Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields*, NCRP Report 86, 1986.
- vi. 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.