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Radiation Safety Specialist

MA Radiation Control Program Health Physics Services Provider Registration #65-0017

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April 1, 2017

RE: Proposed installations of radio base station antennas and associated equipment for the Verizon Wireless Small Cell Personal Wireless Services facilities to be located on 12 different utility poles in Needham, MA.

PURPOSE

I have reviewed the information pertinent to the Verizon Wireless proposed installation of a total of 12 small cell (SC) personal wireless services (PWS) facilities at 12 different locations within Needham, MA. To determine regulatory compliance, theoretical calculations of maximal radio-frequency (RF) fields have been prepared for each site. The physical conditions are that Verizon Wireless proposes to install PWS omni-directional canister type antennas on 12 different utility poles. The antenna arrangement will include a single canister antenna on the utility pole along with two remote radio head (RRH) units. The mounting centerline height of the antennas varies according to the physical attributes of the individual host pole. This report provides written proof that the proposed facilities would comply with the all regulatory RF exposure guidelines.

This report considers the contributions of the Verizon Wireless PWS transmitters operating at their proposed 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,ii] and those established by the Massachusetts Department of Public Health (MDPH).[iii]

SUMMARY

Theoretical RF field calculations data indicate the summation of the proposed Verizon Wireless RF contributions would be within the established RF exposure guidelines at each proposed site; see Figures 4A – 4L. This report provides written proof that the proposed facilities would comply with the FCC and MDPH RF exposure guidelines, including residential areas and in the surrounding neighborhoods.

Based on the theoretical RF fields I have calculated, it is my expert opinion that these facilities would comply with all regulatory guidelines for RF exposure to members of the public.

Note: The analyses, conclusions and professional opinions are based upon the precise parameters and conditions of **these specific 12 utility poles within Needham, 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/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

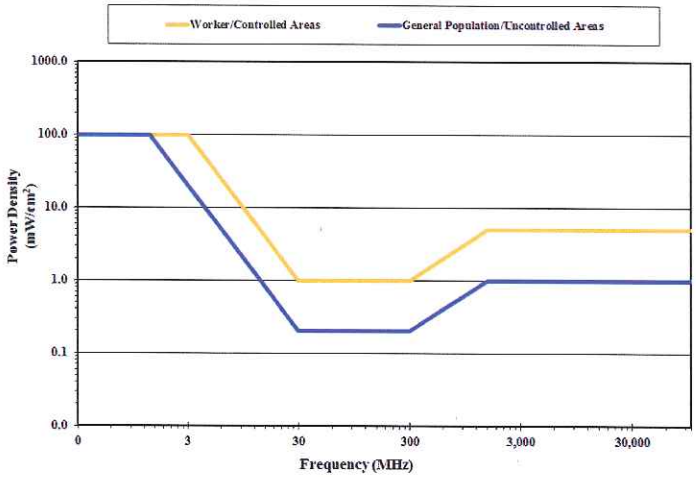


Figure 1: FCC Limits for Maximum Permissible Exposure (MPE)

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.

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 for VERIZON WIRELESS:

1. Effective Radiated Power (ERP): See Table 2 inventory.
2. Antenna height (centerline, above ground level (AGL) See Table 2 inventory.
3. Antenna vertical radiation patterns; the source of the negative gain (G) values. "Omni directional" antennas are designed to focus the RF signal, resulting in "patterns" of signal loss and gain. These patterns (see **APPENDIX A**) display the loss of signal strength relative to the direction of propagation due to elevation angle changes.
   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: [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 = (Height)^2 + (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; 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:

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

To calculate the % MPE, use the formula:

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

Observations in Consideration with FCC Rules §1.1307(b) & §1.1310

Is it physically possible to stand next to or touch any omni-directional antenna? No, access to the utility poles is restricted, and the utility companies will adhere to RF safety guidelines regarding potential access to the proposed PWS antennas mounted on the poles.

Antenna Installation Locations

The location of each proposed utility pole which would host a Verizon Wireless SC antenna is shown below in Figure 2.

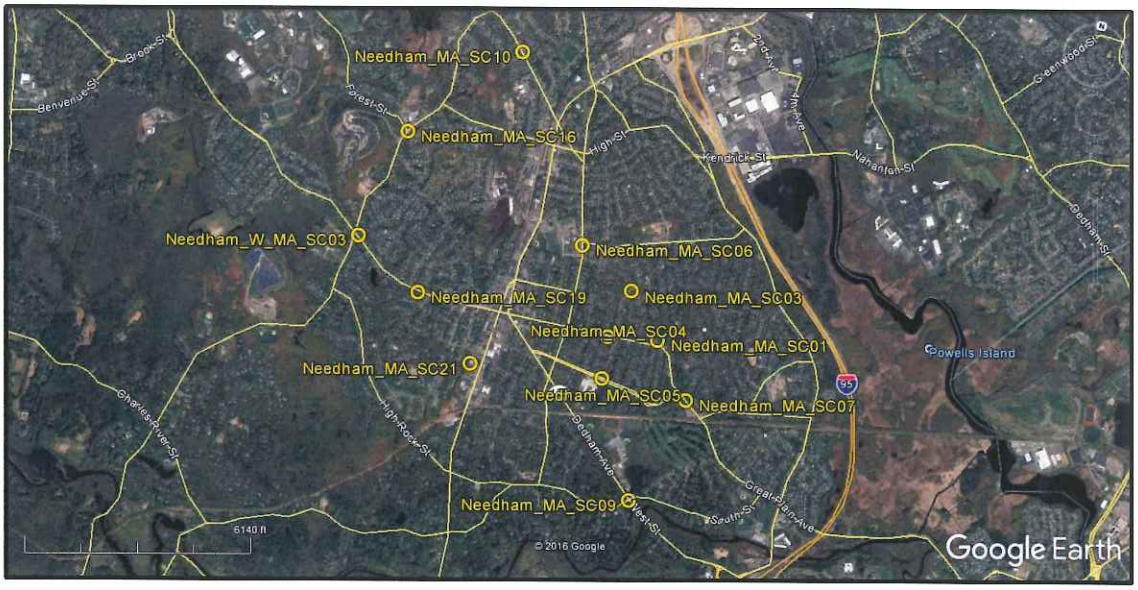


Figure 2: Proposed Location of 12 Utility Poles Which Would Host a Verizon Wireless SC Antenna within Needham, MA.

ANTENNA INVENTORIES

Table 2: Proposed Verizon Wireless Antenna Inventory Utility Poles in Needham, MA
Parameters: 560 watts ERP* of PCS @ 1970 MHz; 1173 watts ERP* of AWS @ 2145 MHz

Site Name	Address (See Figures 3A-3L)	Antenna Centerline (AGL)	Antenna Model
Needham MA SC01	20 Great Plain Ter	35' 5"	NH360QM-DG-2XR
Needham MA SC06	609 Webster St	41' 0"	NH360QM-DG-2XR
Needham MA SC10	270 Hunnewell St	41' 0"	NH360QM-DG-2XR
Needham SC03 MA	97 Melrose Ave	24' 0"	NH360QM-DG-2XR
Needham SC04 MA	7 Stevens Rd	26' 7"	NH360QM-DG-2XR
Needham SC05 MA	200 Harris Ave	28' 4"	NH360QM-DG-2XR
Needham SC07 MA	443 Great Plain Ave	39' 0"	NH360QM-DG-2XR
Needham SC09 MA	Dedham Ave & South St	24' 1"	NH360QM-DG-2XR
Needham SC16 MA	Central Ave	41' 0"	NH360QM-DG-2XR
Needham SC19 MA	1250 Great Plain Ave	24' 7"	NH360QM-DG-2XR
Needham SC21 MA	33 Chestnut Place	36' 6"	NH360QM-DG-2XR
Needham W SC03 MA	1437 Great Plain Ave	40' 6"	NH360QM-DG-2XR

Table Notes:

AWS: **A**dvanced **W**ireless **S**ervices

PCS: **P**ersonal **C**ommunication **S**ervices

* ERP = Power out per channel (CH) X # channels per remote radio head (RRH) X #RRHs X gain the antenna provides within that frequency band.

RESULTS

The results of the percent Maximum Permissible Exposure (%MPE) calculations for the summation of the proposed Verizon Wireless contributions are depicted Figures 4A – 4L as plotted against linear distance from the base of each utility pole. The values have been calculated for a height of six feet above ground level in accordance with regulatory rationale. In addition to the six-foot height, and depicted on the graphs for reference only, values have been plotted for a height of 16 feet above ground level for comparison with a typical two-story structure. A logarithmic scale was used to plot the calculated theoretical %MPE values in order to compare with the MPE of 100%, which is so much larger that it would be off the page in a linear plot. The curves in the figures resemble a straight-line on the log-linear plots at distances beyond about five hundred feet. Within that distance, the curves are variable due to the application of the vertical radiation patterns.

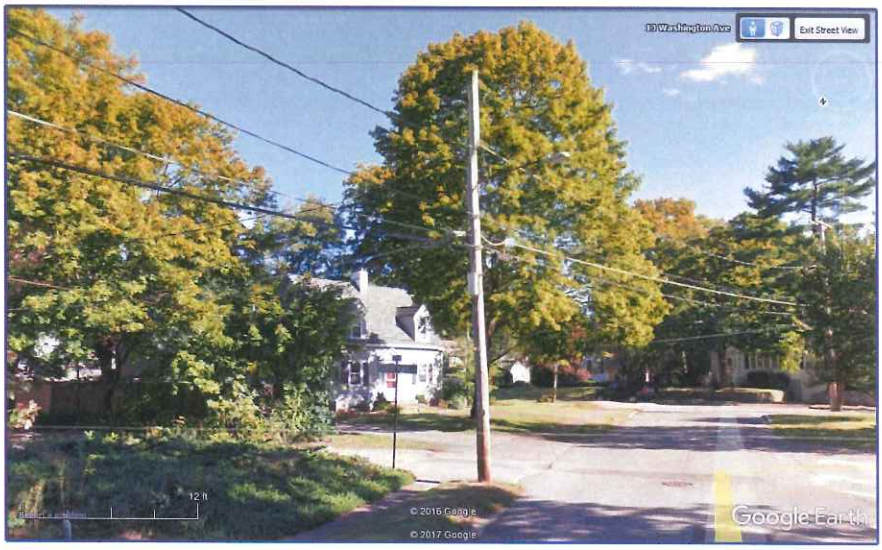


Figure 3A: Proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC01"

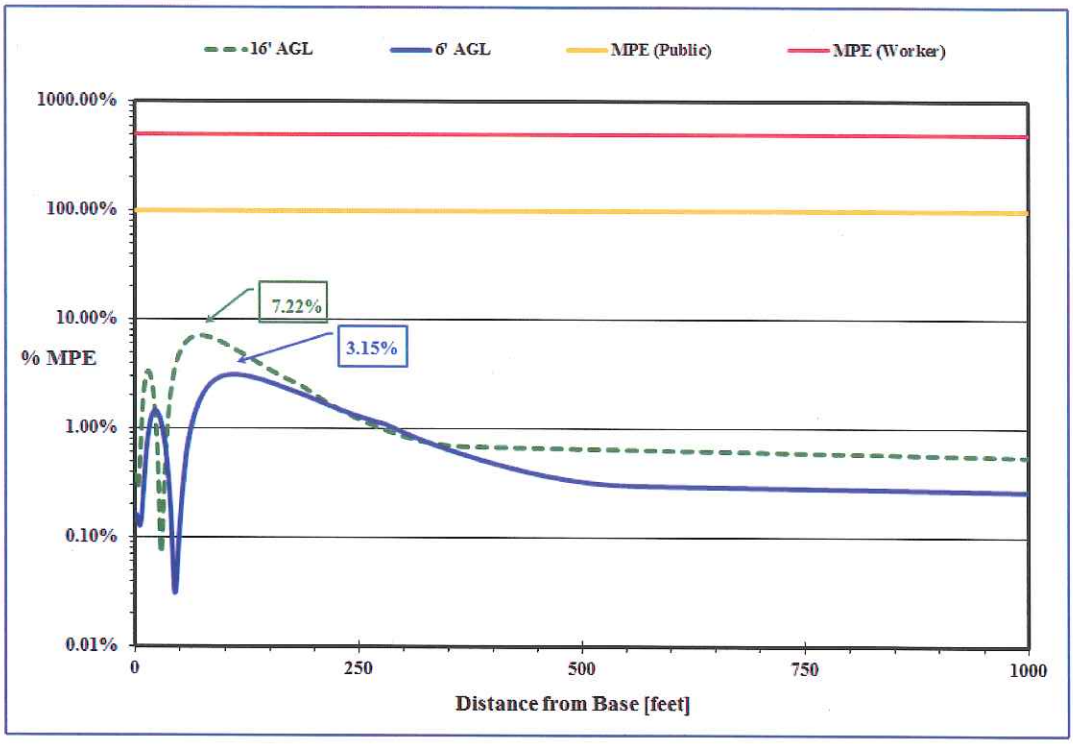


Figure 4A: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC01"

Figure 3B: Proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC03"

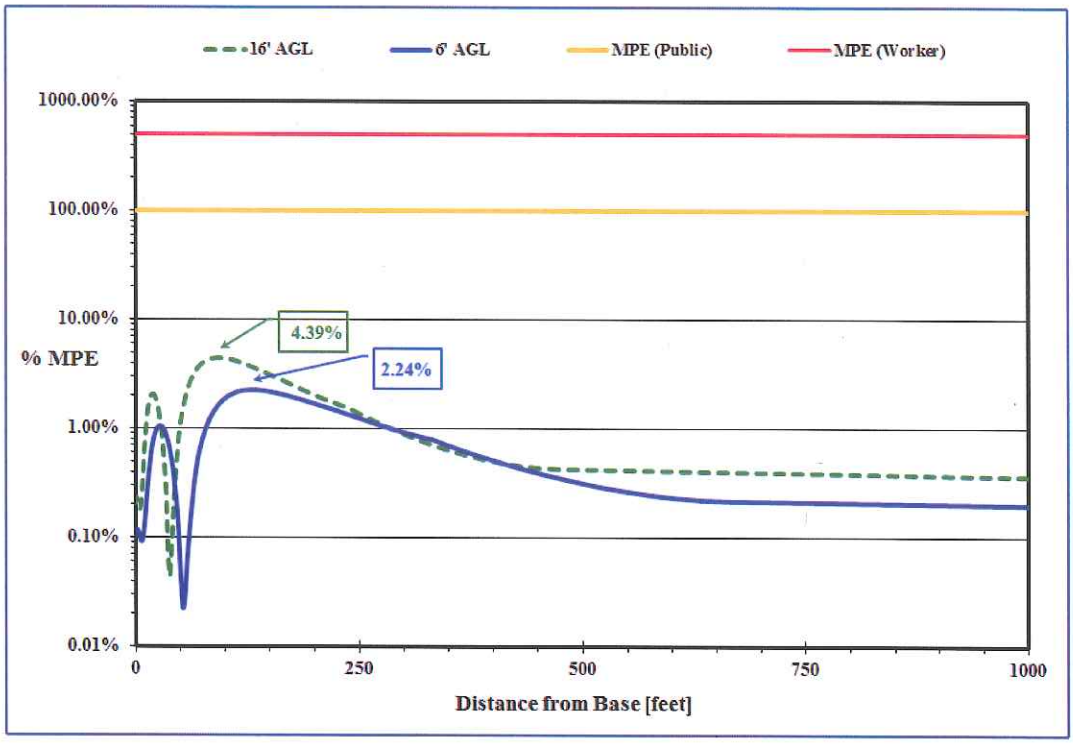


Figure 4B: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC03"

Figure 3C: Proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC04"

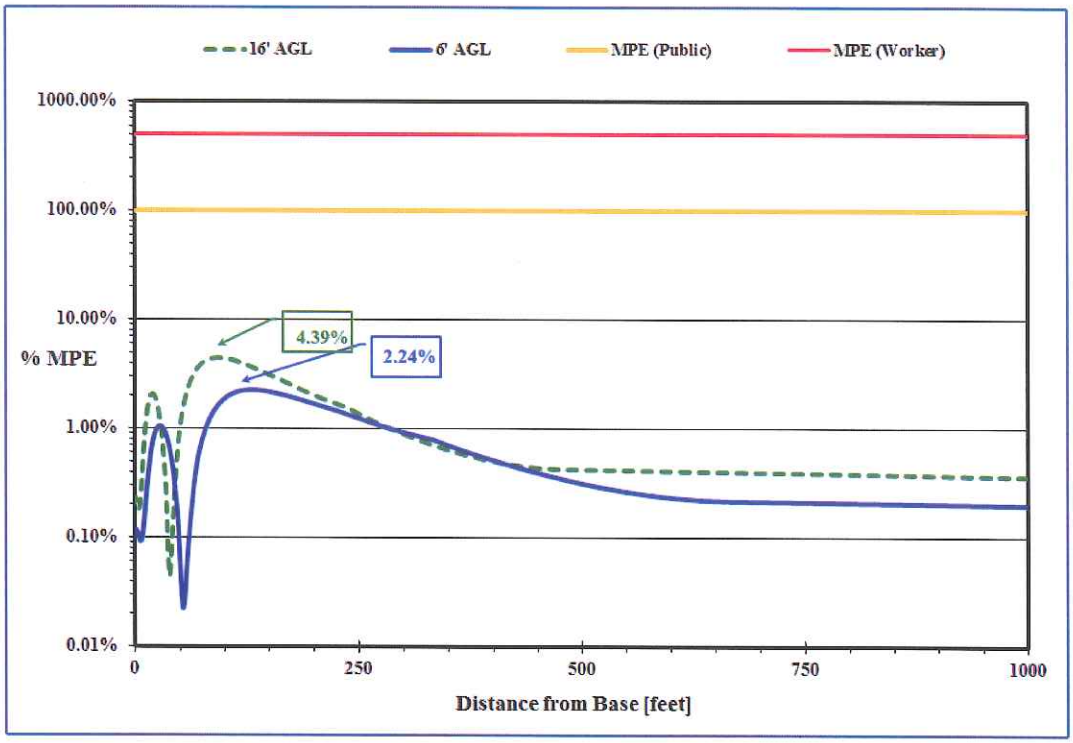


Figure 4C: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC04"

Figure 3D: Proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC05"

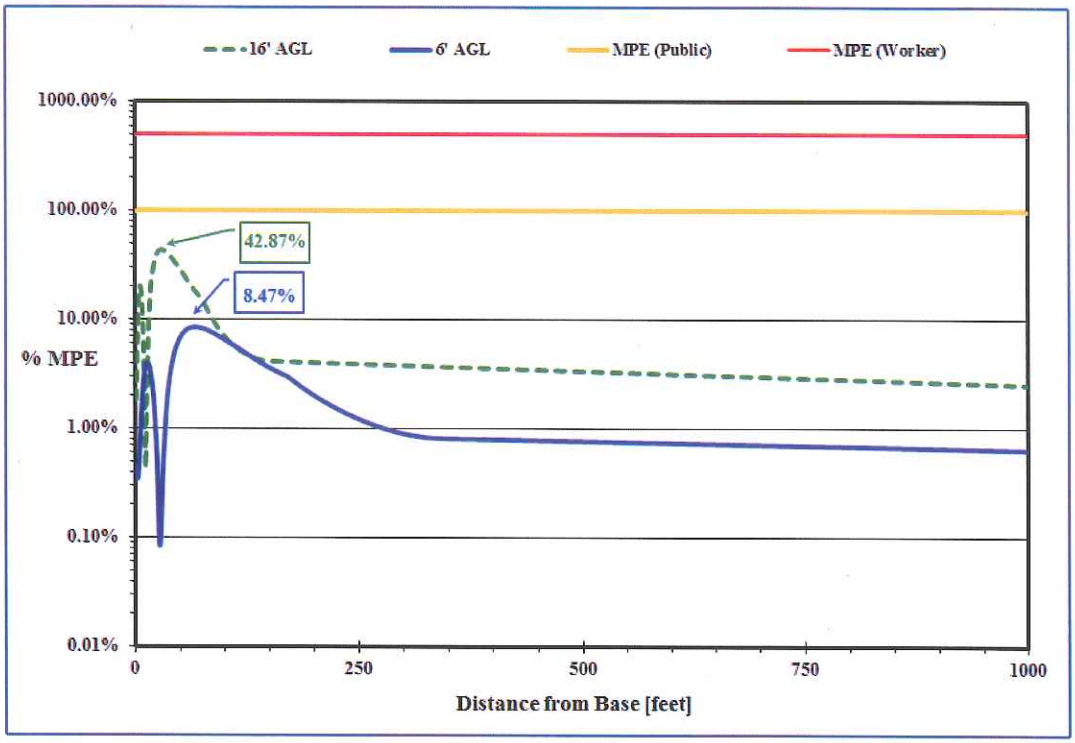


Figure 4D: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC05"

Figure 3E: Proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC06"

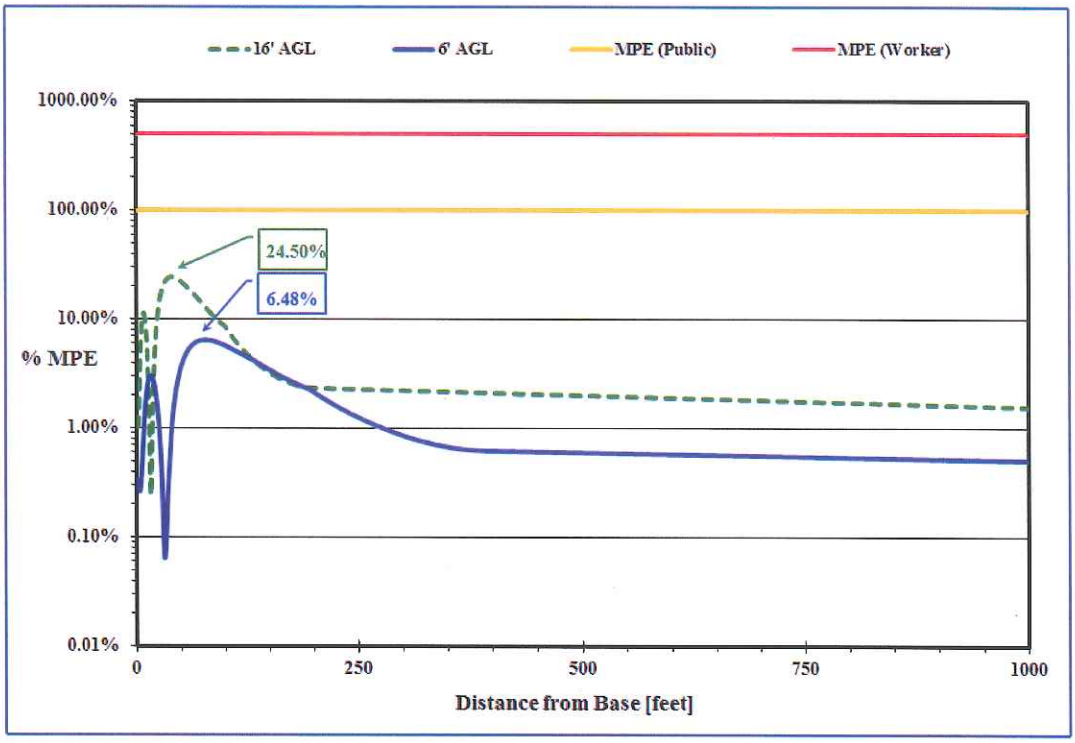


Figure 4E: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC06"

Figure 3F: Proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC07"

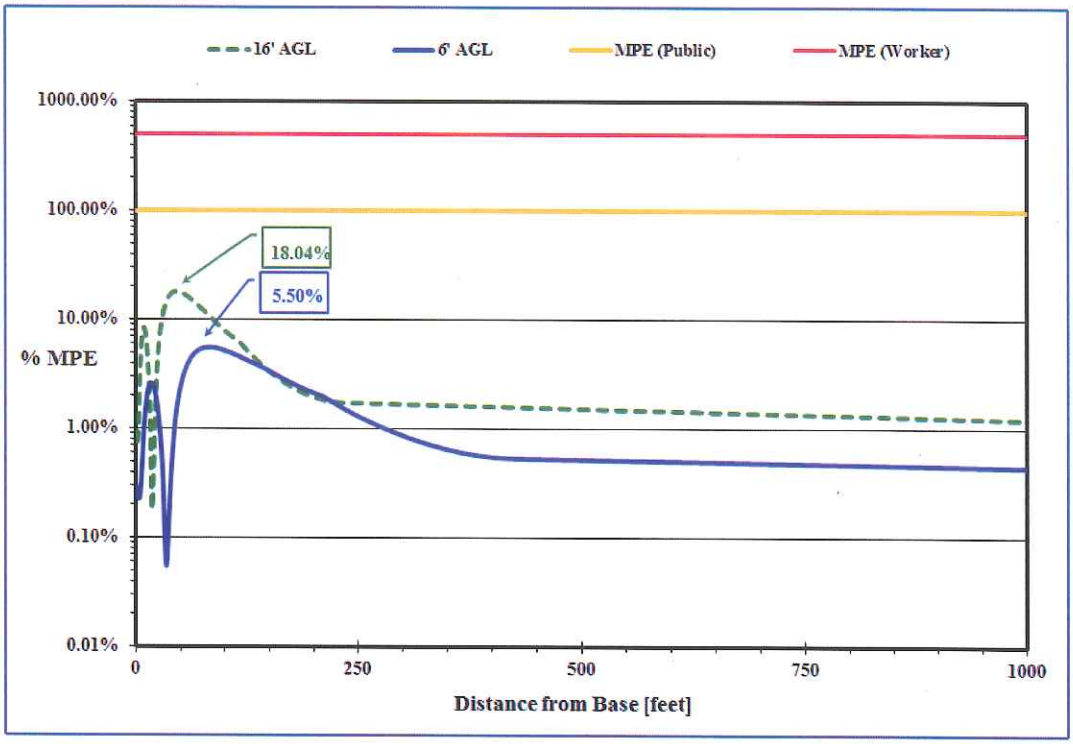


Figure 4F: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC07"

Figure 3G: Proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC09"

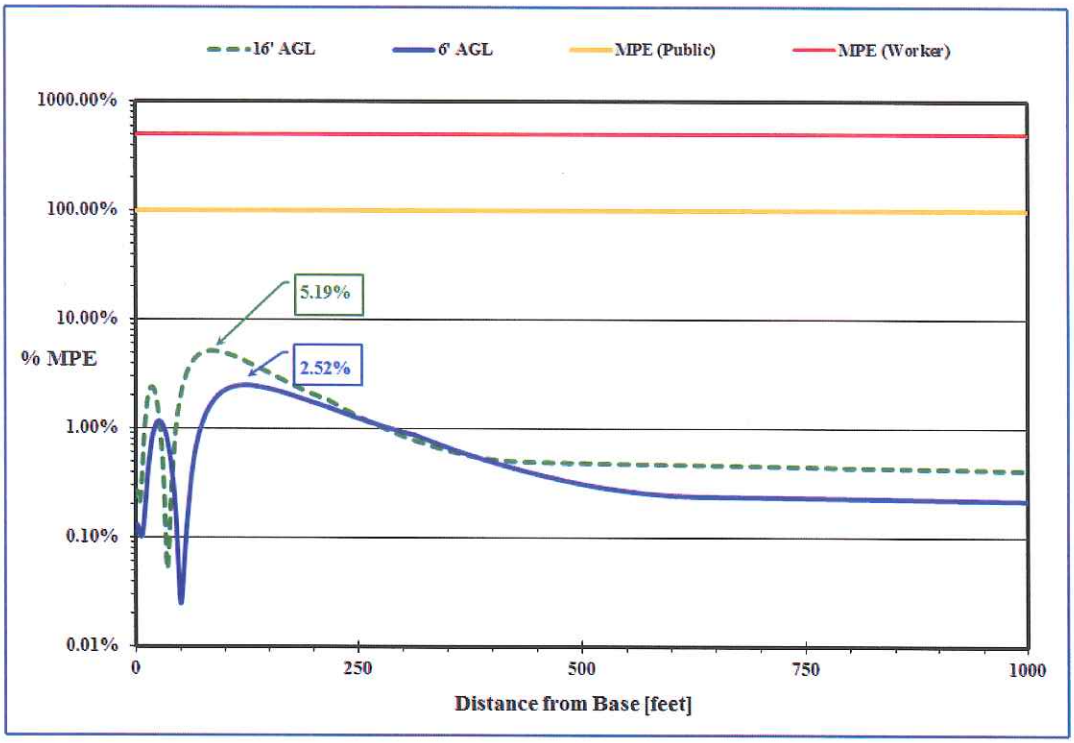


Figure 4G: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC09"

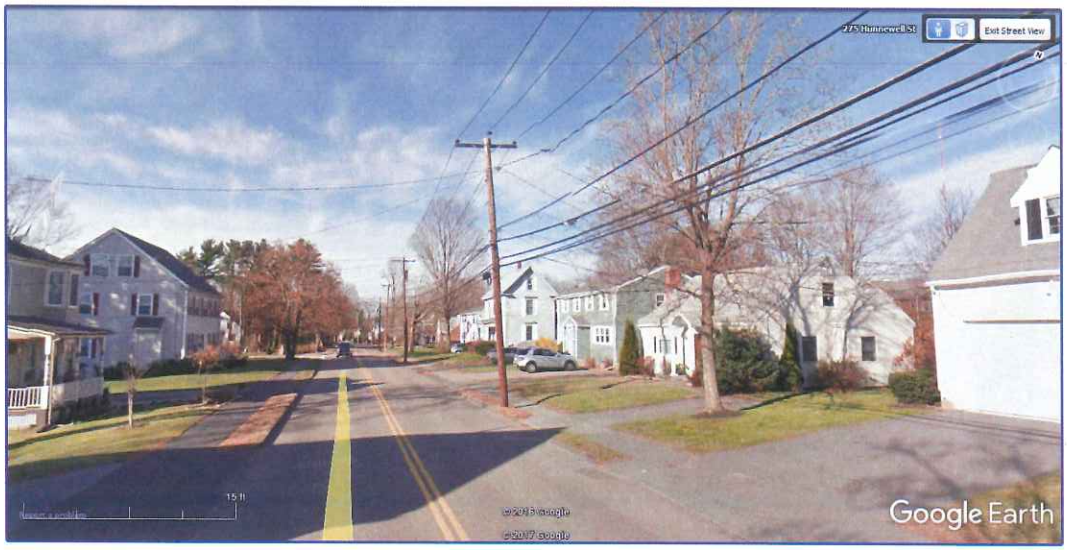


Figure 3H: Proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC10"

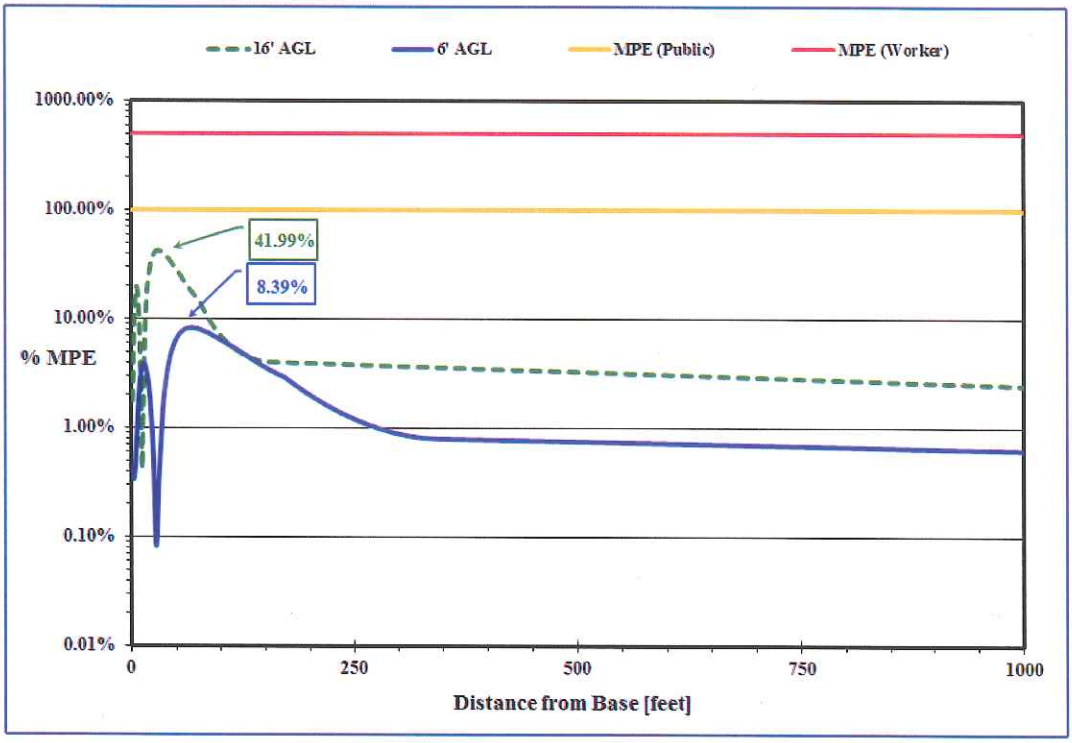


Figure 4H: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC10"

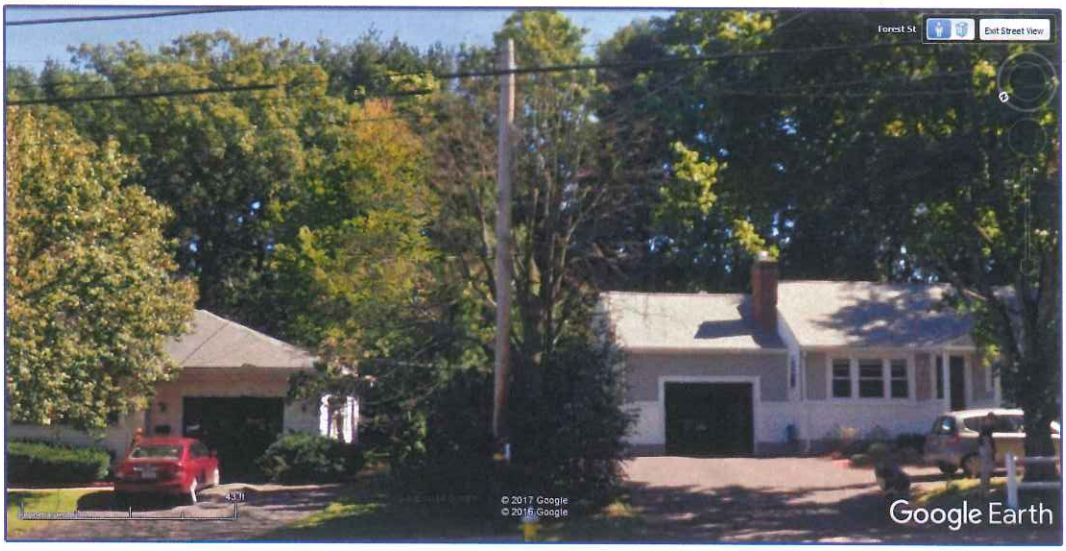


Figure 3I: Proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC16"

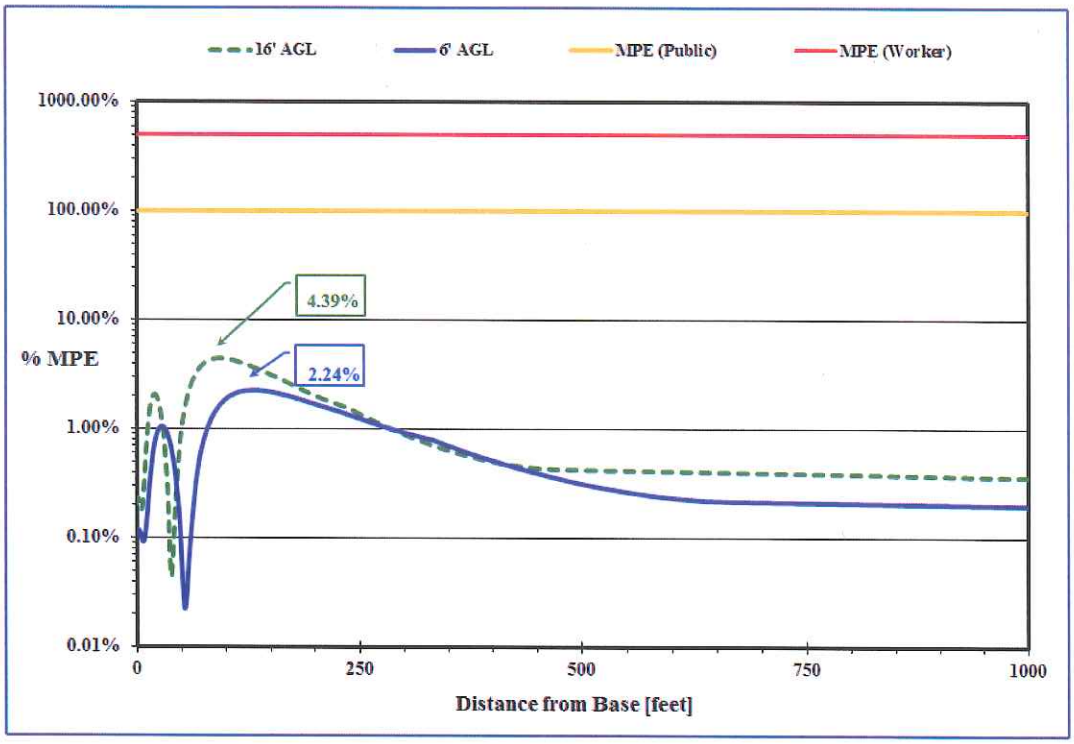


Figure 4I: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC16"

Figure 3J: Proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC19"

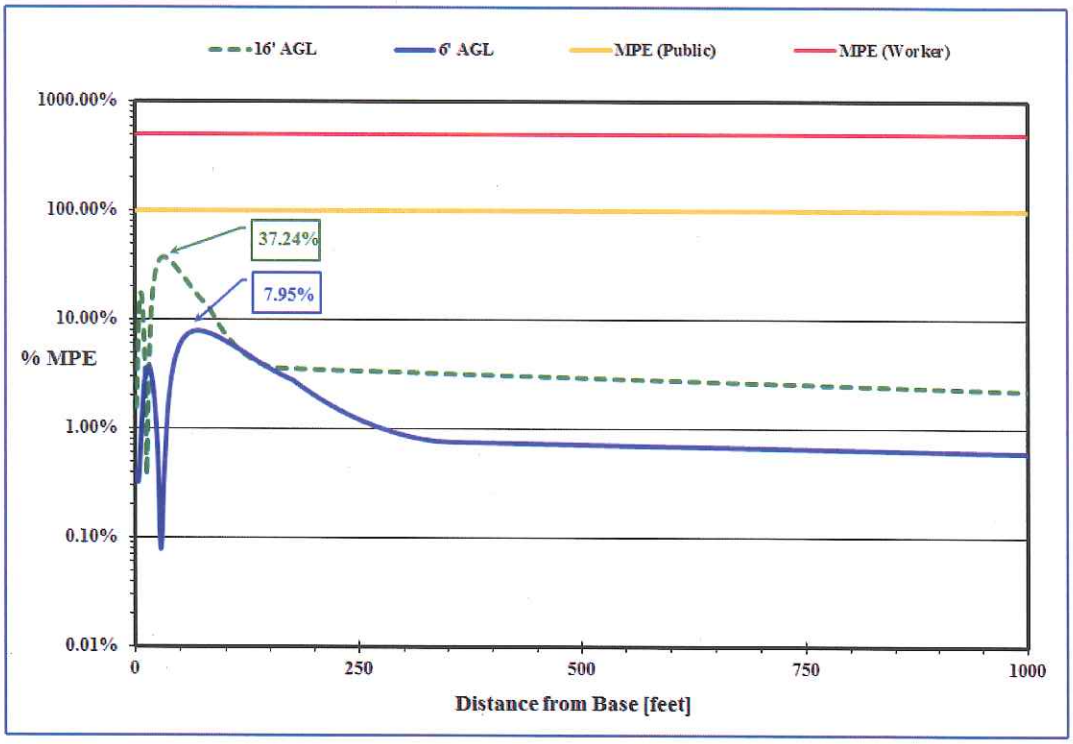


Figure 4J: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC19"

Figure 3K: Proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC21"

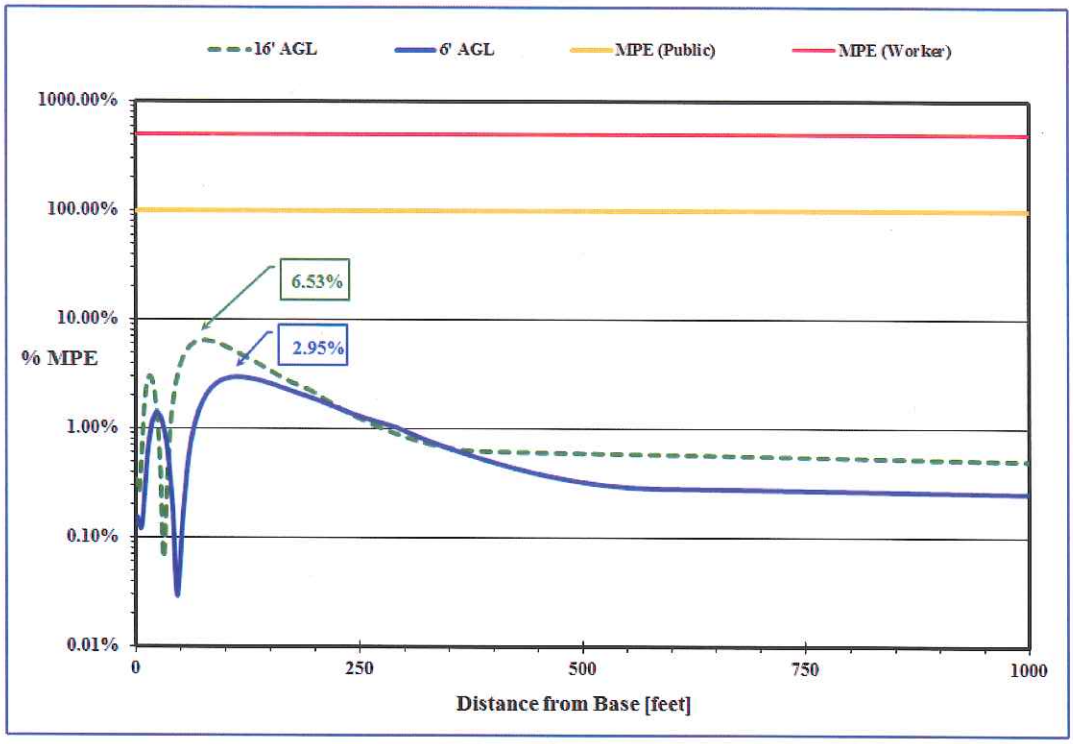


Figure 4K: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_MA_SC21"

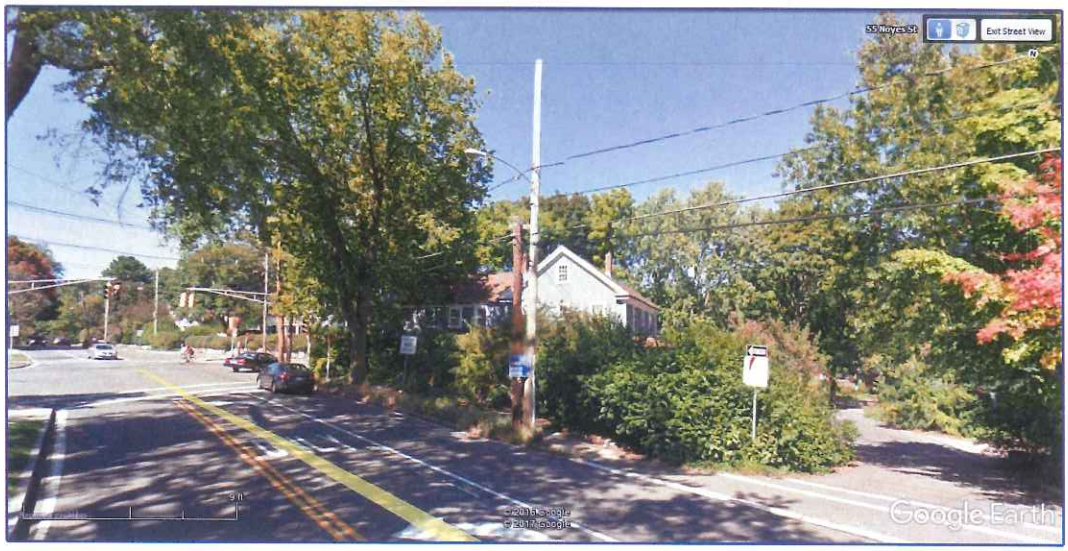


Figure 3L: Proposed Verizon Wireless Small Cell Antenna Site "Needham_W_SC03"

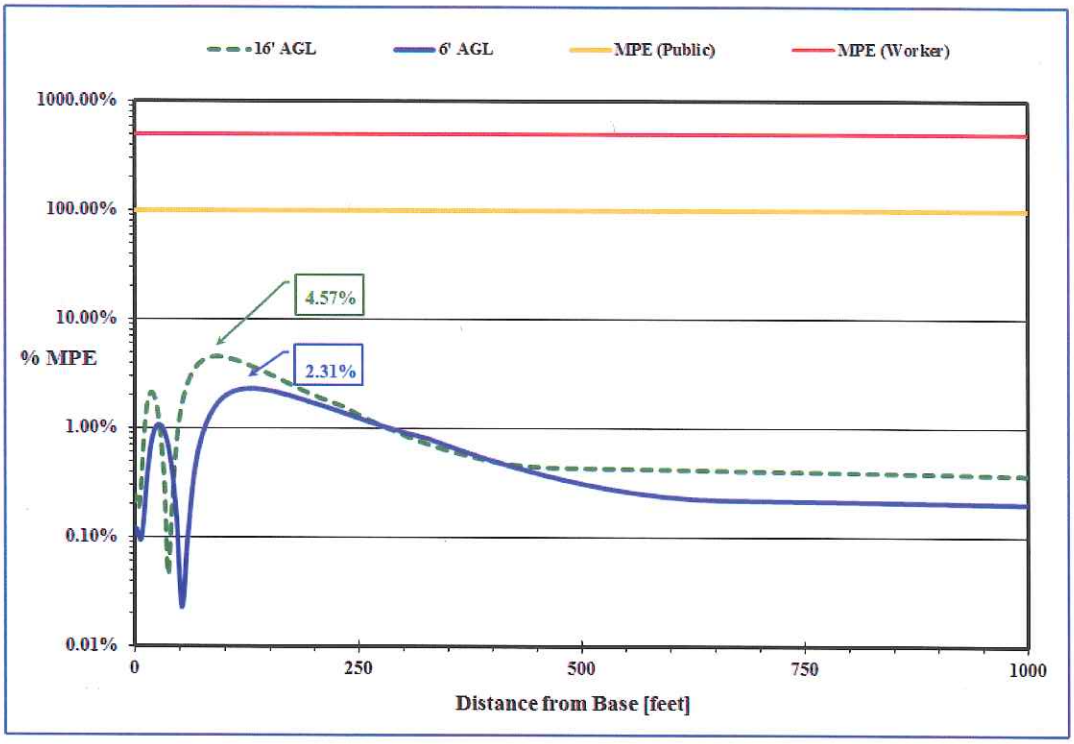


Figure 4L: Theoretical RF field calculations for the summation of the proposed Verizon Wireless Small Cell Antenna Site "Needham_W_SC03"

CONCLUSION

Theoretical RF field calculations data indicate the summation of the proposed Verizon Wireless RF contributions would be within the established RF exposure guidelines at each proposed site; see Figures 4A – 4L. This report provides written proof that the proposed facilities would comply with the FCC and MDPH RF exposure guidelines, including residential areas and in the surrounding neighborhoods.

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 theoretical RF fields I have calculated, it is my expert opinion that these facilities would comply with all regulatory guidelines for RF exposure to members of the public.

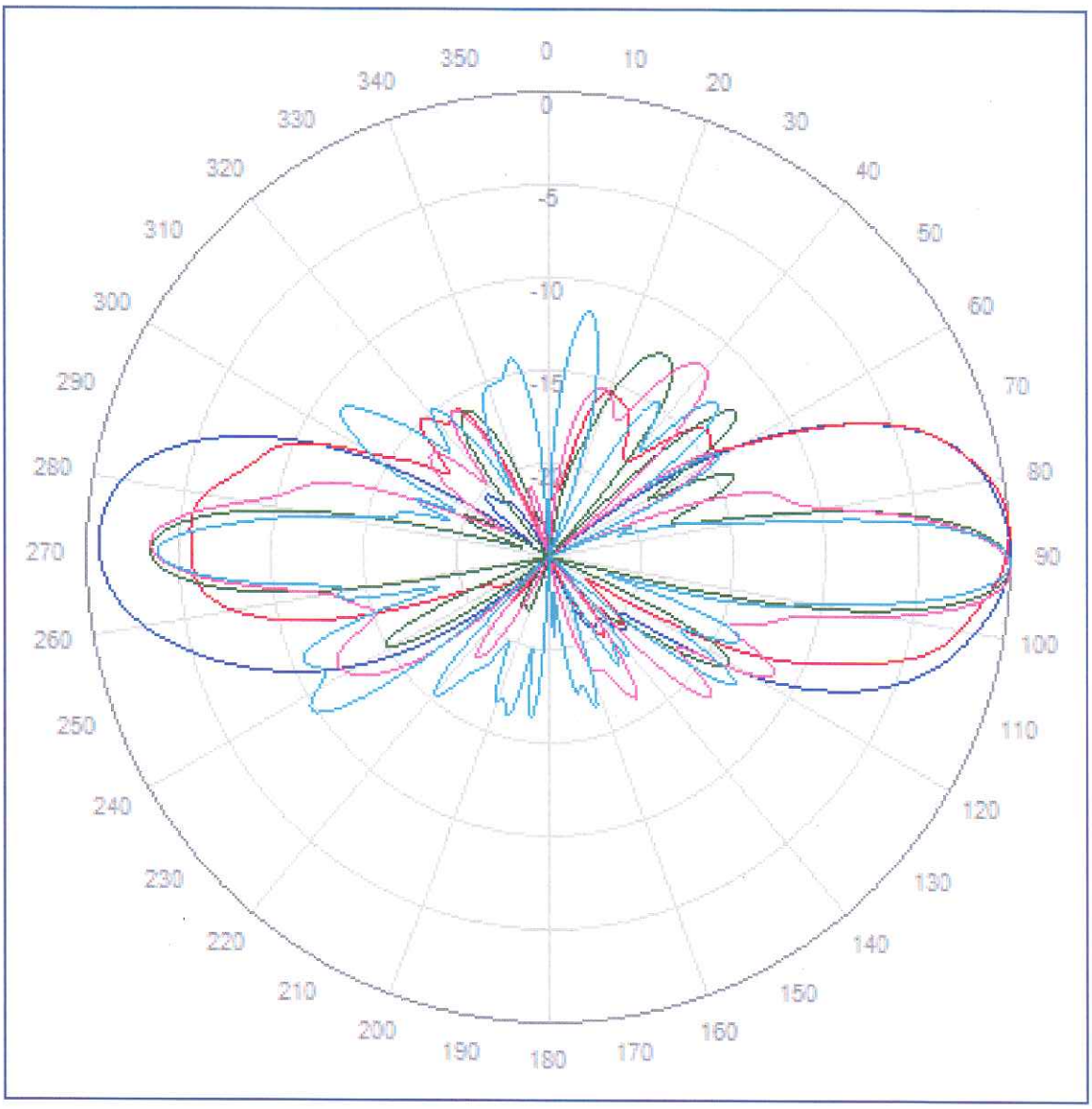
Feel free to contact me if you have any questions.

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 **these specific 12 utility poles within Needham, 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.

APPENDIX A



Composite Vertical Radiation Patterns for Proposed Small Cell Omni Antennas For Specific Verizon Wireless Proposed PWS PCS & AWS Frequencies

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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: April 1, 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.