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May 15, 2012

Re: Distributed Antenna Systems mounted on existing utility poles located within Wellesley, MA.

PURPOSE

I have reviewed the information pertinent to the existing and the possibility of future Distributed Antenna Systems (DAS) installed within Wellesley, MA. To determine regulatory compliance, theoretical calculations and actual field measurements of maximal radio-frequency (RF) fields have been prepared. The physical conditions are that personal wireless services (PWS) antennas are mounted on the existing utility poles at 15 Dukes Road, and 3 Vista Road (See Figures 1 and 2, respectively), in addition to their associated radio equipment. The antennas are mounted at a centerline height of 34 feet above ground level (AGL). In the future, the Wellesley Municipal Light Plant (WMLP) may allow for future DAS sites to be utilized at additional locations. This report considers the contributions of the PWS services on the DAS sites as if they were operating at the full technologically achievable capacity. The calculated and measured values of power density are presented as a percent of current Maximum Permissible Exposures (%MPE) as adopted by the Federal Communications Commission (FCC) [1,2], and those established by the Massachusetts Department of Public Health (MDPH) [3].

SUMMARY

The measured existing ambient RF field levels indicate the maximum to be less than one-half of one percent of the current exposure guidelines. These RF measurements are accurate and were obtained according to guidelines as set forth by the FCC and MDPH. Theoretical RF field calculations data for PWS services on similar DAS sites operating at full technologically achievable capacity indicate a maximal potential RF field level at ground level to be well within the RF exposure guidelines. In fact, there could be more than 100 similar installations at each location, and still be within the guidelines for RF exposure.

Based on my extensive experience with personal wireless services facilities, and the theoretical RF fields I have calculated and measured, it is my expert opinion that the existing DAS sites comply with regulatory guidelines for RF exposure to members of the public, as would any future DAS site similarly constructed.

Note: The analyses, conclusions and professional opinions are based upon the precise parameters and conditions of these particular sites; **15 Dukes Road & 3 Vista Road, and/or similarly constructed sites in Wellesley, 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.

Figure 1: Utility pole with DAS facility; 15 Dukes Road, Wellesley, MA (Inset: Antenna)

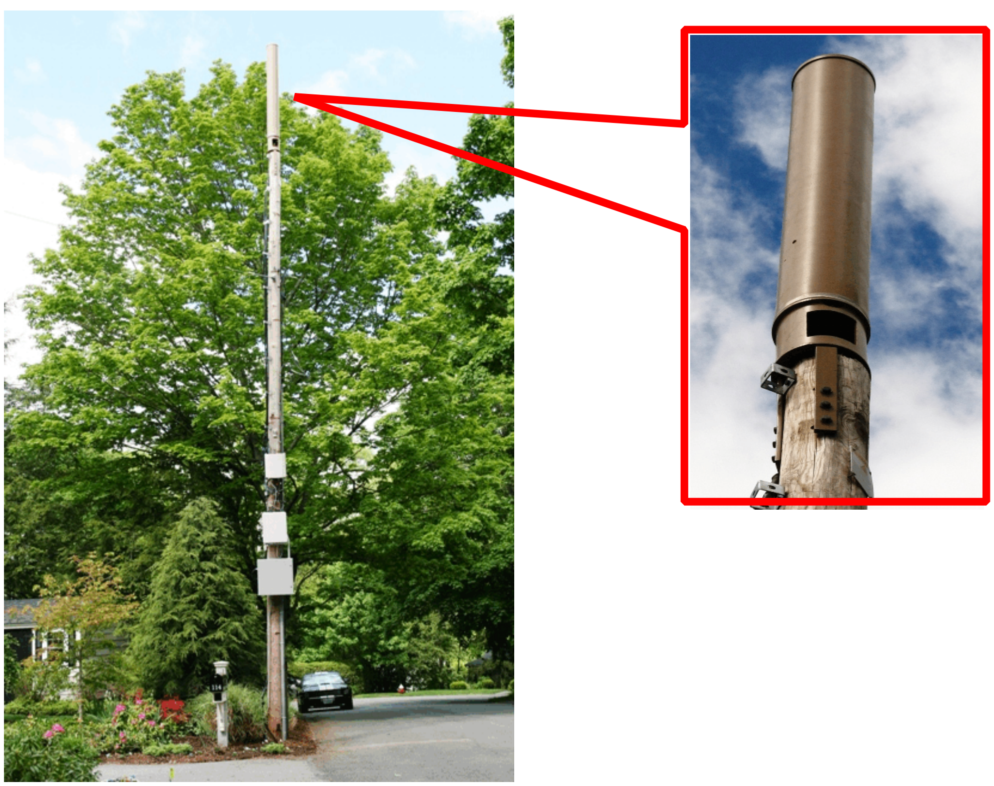


Figure 2: Utility pole with DAS facility; 3 Vista Road, Wellesley, MA (Inset: Antenna)

RF EXPOSURE LIMITS AND GUIDELINES

The RF exposure guidelines adopted by the FCC are a combination of the standards published by the American National Standards Institute (ANSI) [4] and the National Council on Radiation Protection and Measurement (NCRP) [5]. Also applicable are those published by the MDPH [3]. The RF exposure guidelines are divided into two categories: "Controlled/Occupational areas" (those areas restricted to access by RF workers only) and "Uncontrolled/Public Areas" (those areas unrestricted for public access). Listed in Table 1 below are the applicable RF exposure guidelines for uncontrolled areas as they pertain to the operating frequency band of DAS facilities.

Table 1: Maximum Permissible Exposure Values for Uncontrolled/Public Areas

Frequency Band:	Maximum Permissible Exposure:
1500 - 100,000 MHz	1000 $\mu W/cm^2$ *

Note: 1 μW = 0.000001 Watt

* For equivalent plane-wave power density, where *f* is the frequency in MHz (10^6 Hz).

DAS (Distributed Antenna System; Excerpt from From *Wikipedia*, the free encyclopedia**)**

DAS is a network of spatially separated antenna nodes connected to a common source via a transport medium that provides wireless service within a geographic area or structure. DAS antenna elevations are generally at or below the clutter level and node installations are compact.

The idea is to split the transmitted power among several antenna elements, separated in space so as to provide coverage over the same area as a single antenna but with reduced total power and improved reliability. A single antenna radiating at high power is replaced by a group of low-power antennas to cover the same area. These antennas have recently been employed by several service providers in many areas around the United States. The idea works because less power is wasted in overcoming penetration and shadowing losses, and because a line-of-sight channel is present more frequently, leading to reduced fade depths and reduced delay spread.

DAS is used in scenarios where alternate technologies are infeasible due to - terrain, zoning challenges for cell towers, infeasible cell tower placements, etc.

MEASUREMENT PROTOCOL

RF field measurements were obtained on May 11, 2012, using accepted scientific procedures.[6, 7] The temperature was 52-54˚F with mostly sunny skies. The measuring equipment included a Narda model 8715 Electromagnetic Radiation Meter with model B8742D Broadband Isotropic Probe. The probe of choice in a mixed-frequency environment is the broadband type - that is, it responds to a wide range of frequencies.

The Narda model B8742D probe provides a meter read-out in %MPE (percent FCC 1997 Maximum Permissible Exposure) for members of the general public within the frequency band of 300 kHz to 3 GHz (NOTE: 1 kHz = 1,000 cycles per second,1 MHz = 1,000,000 cycles per second, and 1 GHz = 1,000,000,000 cycles per second).

The RF field measurements were obtained at several locations in the general vicinity of the existing DAS installations (See maps, Figures 3 & 4). At each location, measurements were obtained by continuously scanning an area from the ground plane up to a height of six feet above ground level, referred to as the "Spatial Average". The spatial average readings at each location were recorded as %MPE. In addition, the highest readings during the spatial average were recorded as the "peak" reading. The results are listed in Table 2. NOTE: The readings in this report were compared with MPE values for members of the public.

The accuracy of the measurement system is a combination of the following : instrument accuracy, ± 1.0%; calibration uncertainty, + 0.5 dB (1.122), - 0.5 dB (0.891); and probe isotropy error, + 0.75 dB (1.189), - 0.75 dB (0.841). A conservative approach is to obtain the root-sum square (RSS) of the three factors as follows:

- If the meter reads high, RSS = [(0.01)2 + (0.122)2 + (0.189)2]½, or 22.5 % higher than true value; the correction factor is 1/1+RSS = 0.816.

- If the meter reads low, RSS = [(0.01)2 + (1-0.891)2 + (1-0.841)2]½, or 19.3 % lower than true value; the correction factor is 1/1-RSS = 1.24.

For this RF exposure analysis, the readings were multiplied by 1.24 to be conservative.

RESULTS

Table 2: Results of RF Field Measurements
Surrounding Areas, DAS on Utility Poles, Wellesley, MA

Location, See Figure 2	Spatial Average Reading	Peak Meter Reading
	Corrected (% MPE) *	Corrected (% MPE) *
15 Dukes Road		
1	0.12 %	0.17 %
2	0.10 %	0.13 %
3	0.15 %	0.20 %
4	0.11 %	0.19 %
5	0.12 %	0.17 %
6	0.19 %	0.31 %
7	0.12 %	0.19 %
8	0.12 %	0.16 %
9	0.15 %	0.28 %
10	0.12 %	0.24 %
3 Vista Road		
1	0.15 %	0.24 %
2	0.15 %	0.17 %
3	0.19 %	0.31 %
4	0.19 %	0.32 %
5	0.12 %	0.19 %
6	0.12 %	0.13 %
7	0.12 %	0.23 %
8	0.17 %	0.32 %
9	0.12 %	0.24 %
10	0.19 %	0.29 %

Table Notes:
* Readings multiplied by 1.24 to correct for instrument uncertainty.
"MPE" refers to (percent FCC 1997 Maximum Permissible Exposure) for members of the general public

Figure 3: Locations of RF Field Measurements
DAS Facility and Surrounding Area, 15 Dukes Road, Wellesley, MA
(Picture courtesy Google Earth™ and may not represent current conditions)

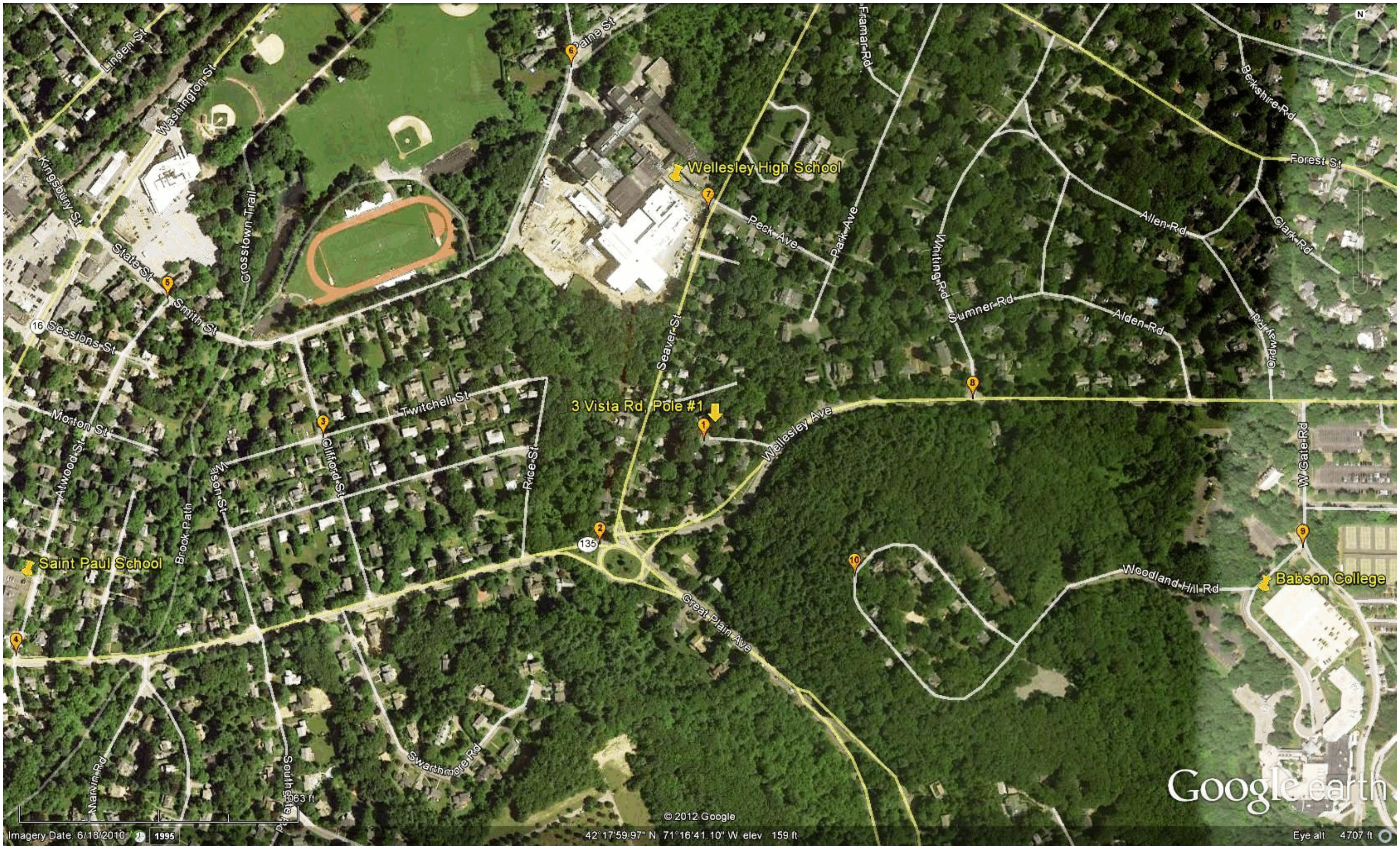


Figure 4: Locations of RF Field Measurements
DAS Facility and Surrounding Area, 3 Vista Road, Wellesley, MA
(Picture courtesy Google Earth™ and may not represent current conditions)

THEORETICAL RF FIELD CALCULATIONS - GROUND LEVELS

These calculations are based on what are called "worst-case" estimates. That is, the estimates assume 100% use of all transmitters simultaneously, at the full technologically achievable capacity. 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:

1. Effective Radiated Power (ERP). Ericsson model #2109 micro cabinets @ 41.5 dBm each, times two. NOTE: this value represents the type and number installed, but operating at the fullest technologically achievable capacity.
2. Antenna height (centerline, AGL). 34' 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 vertical radiation patterns display the loss of signal strength relative to the direction of propagation due to elevation angle changes (See Appendix 1).
   The gain here is the absolute gain and is expressed as “G^E”. Note: G^E is a unitless factor usually expressed in decibels (dB); where $G = 10^{(dB/10)}$.
   For example: for G = 3, dB = $10^{(3/10)}$ = 2; for G = -3, dB = $10^{(-3/10)}$ = 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: [8]

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

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, we need to apply the negative elevation gain value (G^E) 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 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:

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

The results of the theoretical power density calculations for a typical DAS facility, similar to what exists already in Wellesley, are listed in Table 3 for each one degree increment of depression angle (90˚ being straight down at the base of the utility pole, and 0˚ being straight out from the antenna). The values have been calculated for a height of six feet above ground level in accordance with regulatory rationale.

To calculate the % MPE, use the formula:

$$\mathbf{\%\ MPE = \frac{S}{MPE} \bullet 100}$$

The results of the theoretical percent Maximum Permissible Exposure calculations also listed in Table 3 for the same angle and height conditions, and depicted in Figure 5a as plotted against linear distance from the base of the utility pole out to a distance of 10,000 feet. I order to more closely review the data near the pole, the results are plotted for the first 1000 feet from the utility pole in Figure 5b. In both cases, a logarithmic scale is 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. 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.

NOTE: The curves in the figures resemble a straight-line on the log-linear plot at distances beyond about one thousand feet (Figure 5a). Within about one thousand feet (Figure 5ab), the curves are variable due to the application of the vertical radiation patterns.

Table 3: Theoretical RF Field Calculations for Typical DAS facility in Wellesley, MA
At Locations in Listed Distance (Column 3) from the Utility Pole; Reference 6' AGL

ERP = 41.5 dBm (~ 14 watts, maximum) @ *f* ~ 1900+ MHz
Jaybeam Wireless W85-13-R010 Antenna (typical), Height = 34 feet (AGL, centerline)
General Population MPE = 1000 μW/cm² @ *f* > 1500 MHz

Depression Angle (degrees)	Absolute Gain (dB)	Distance from base (feet)	Power Density (μW/cm²)	Percent MPE
-90	-20.8	0	0.084	0.008%
-89	-20.5	0	0.090	0.009%
-88	-22.4	1	0.058	0.006%
-87	-21.9	1	0.065	0.007%
-86	-20.5	2	0.090	0.009%
-85	-19.4	2	0.115	0.012%
-84	-17.9	3	0.162	0.016%
-83	-17.9	3	0.162	0.016%
-82	-17.0	4	0.198	0.020%
-81	-17.2	4	0.188	0.019%
-80	-17.6	5	0.171	0.017%
-79	-18.0	5	0.155	0.015%
-78	-18.5	6	0.137	0.014%
-77	-21.4	6	0.070	0.007%
-76	-23.4	7	0.044	0.004%
-75	-24.6	8	0.033	0.003%
-74	-25.9	8	0.024	0.002%
-73	-26.0	9	0.023	0.002%
-72	-25.7	9	0.025	0.002%
-71	-24.9	10	0.029	0.003%
-70	-24.1	10	0.035	0.003%
-69	-24.4	11	0.032	0.003%
-68	-23.5	11	0.039	0.004%
-67	-24.0	12	0.034	0.003%
-66	-24.0	12	0.034	0.003%
-65	-21.9	13	0.054	0.005%
-64	-24.5	14	0.029	0.003%
-63	-23.9	14	0.033	0.003%
-62	-23.8	15	0.033	0.003%
-61	-25.8	16	0.020	0.002%
-60	-29.1	16	0.009	0.001%
-59	-37.2	17	0.001	0.000%
-58	-31.8	17	0.005	0.000%
-57	-26.5	18	0.016	0.002%

Table 3: Theoretical RF Field Calculations for Typical DAS facility in Wellesley, MA
At Locations in Listed Distance (Column 3) from the Utility Pole; Reference 6' AGL

-56	-26.1	19	0.017	0.002%
-55	-26.0	20	0.017	0.002%
-54	-28.3	20	0.010	0.001%
-53	-31.3	21	0.005	0.000%
-52	-31.7	22	0.004	0.000%
-51	-24.3	23	0.023	0.002%
-50	-20.9	23	0.048	0.005%
-49	-18.7	24	0.078	0.008%
-48	-15.7	25	0.150	0.015%
-47	-13.1	26	0.265	0.027%
-46	-10.4	27	0.478	0.048%
-45	-8.0	28	0.802	0.080%
-44	-5.3	29	1.442	0.144%
-43	-3.9	30	1.918	0.192%
-42	-2.4	31	2.608	0.261%
-41	-1.5	32	3.085	0.308%
-40	-0.8	33	3.479	0.348%
-39	-0.5	35	3.573	0.357%
-38	-0.4	36	3.500	0.350%
-37	-0.8	37	3.050	0.305%
-36	-1.5	39	2.476	0.248%
-35	-2.8	40	1.748	0.175%
-34	-4.8	42	1.048	0.105%
-33	-7.7	43	0.510	0.051%
-32	-11.8	45	0.188	0.019%
-31	-15.5	47	0.076	0.008%
-30	-12.6	48	0.139	0.014%
-29	-8.2	51	0.360	0.036%
-28	-6.4	53	0.511	0.051%
-27	-5.7	55	0.562	0.056%
-26	-5.1	57	0.601	0.060%
-25	-4.6	60	0.627	0.063%
-24	-3.6	63	0.731	0.073%
-23	-2.2	66	0.931	0.093%
-22	-0.6	69	1.237	0.124%
-21	0.9	73	1.600	0.160%
-20	1.9	77	1.834	0.183%
-19	2.6	81	1.953	0.195%
-18	2.7	86	1.800	0.180%
-17	2.2	92	1.436	0.144%
-16	1.3	98	1.038	0.104%

Table 3: Theoretical RF Field Calculations for Typical DAS facility in Wellesley, MA
At Locations in Listed Distance (Column 3) from the Utility Pole; Reference 6' AGL

-15	-0.4	104	0.618	0.062%
-14	-2.2	112	0.357	0.036%
-13	-3.2	121	0.245	0.025%
-12	-3.4	132	0.200	0.020%
-11	-3.8	144	0.154	0.015%
-10	-5.6	159	0.084	0.008%
-9	-10.8	177	0.021	0.002%
-8	-7.1	199	0.038	0.004%
-7	0.7	228	0.177	0.018%
-6	5.5	266	0.392	0.039%
-5	9.0	320	0.611	0.061%
-4	11.6	400	0.712	0.071%
-3	13.6	534	0.635	0.064%
-2	14.8	802	0.372	0.037%
-1	15.9	1604	0.120	0.012%
0	16.2	∞	< 0.001	< 0.000%

Figure 5a: Theoretical Cumulative Maximum Percent MPE - vs. - Distance
Proposed PWS Contributions

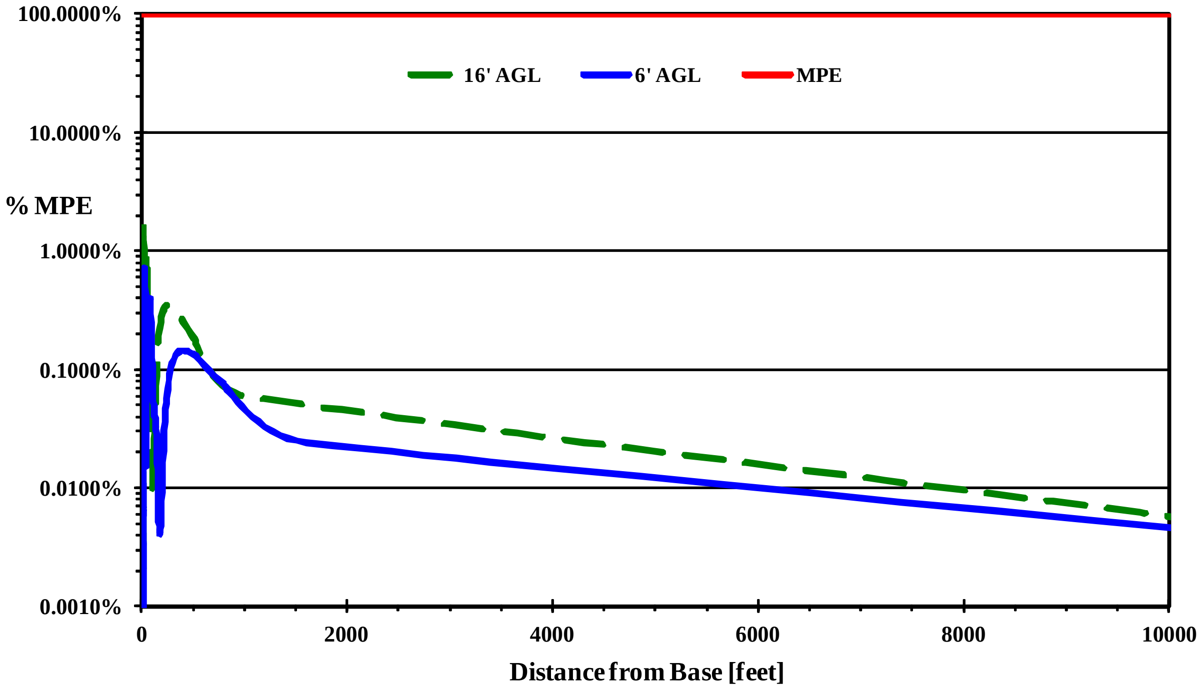
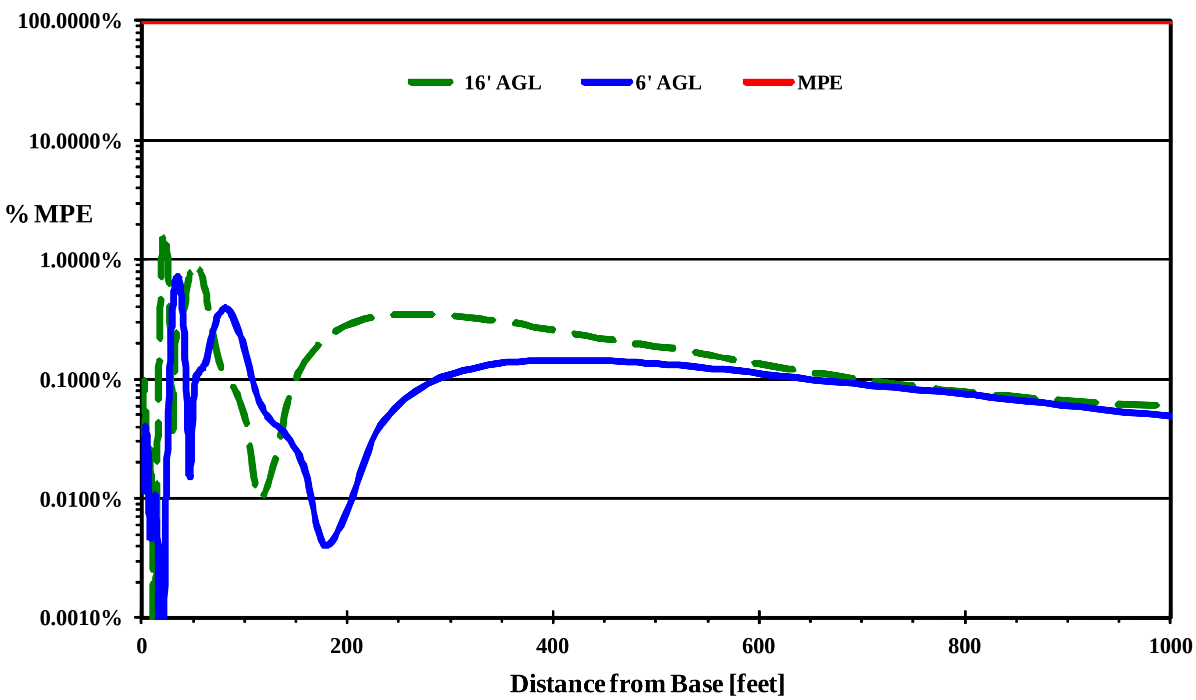


Figure 5b: Theoretical Cumulative Maximum Percent MPE - vs. - Distance
Proposed PWS Contributions



CONCLUSION

The measured existing ambient RF field levels indicate the maximum to be less than one-half of one percent of the current exposure guidelines. These RF measurements are accurate and were obtained according to guidelines as set forth by the FCC and MDPH. Theoretical RF field calculations data for PWS services on similar DAS sites operating at full technologically achievable capacity indicate a maximal potential RF field level at ground level to be well within the RF exposure guidelines. In fact, there could be more than 100 similar installations at each location, and still be within the guidelines for RF exposure.

The amount and duration of data passing through personal wireless services 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 my extensive experience with personal wireless services facilities, and the theoretical RF fields I have calculated and measured, it is my expert opinion that the existing DAS sites comply with regulatory guidelines for RF exposure to members of the public, as would any future DAS site similarly constructed.

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 particular sites; **15 Dukes Road & 3 Vista Road, and/or similarly constructed sites in Wellesley, 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.

Donald L. Haes, Jr., Ph.D., CHP

Radiation Safety Specialist

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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) statement of standards of professional responsibility for Certified Health Physicist.

Donald L. Haes, Jr., Ph.D

Certified Health Physicist

May 15, 2012

Date

Appendix 1

WideBand 1710-2170 MHz

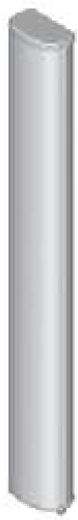
JAYBEAM Wireless

SMARTTILT

W85-13-x010

X-Pol / 85° Az / 17.0 dBi

RET Capable



Model Number Options:
W85-13-A010 - Manual Electrical Tilt Antenna
W85-13-R010 - Remote Electrical Tilt Antenna

Electrical Specifications			
Frequency:	1710 - 1880 MHz	1850 - 1990 MHz	1900 - 2170 MHz
Gain:	16.2 dBi (14.1 dBd)	16.6 dBi (14.5 dBd)	17.0 dBi (15.9 dBd)
Input Impedance:	50 ohms		
VSWR:	<1.4:1		
Polarization:	±45°		
Electrical Downtilt:	0° - 10° Variable Electrical Tilt		
Inter-Port Isolation:	>28 dB		
Azimuth Beamwidth:	85°	85°	85°
Elevation Beamwidth:	7.3°	6.8°	6.3°
1st Upper Sidelobe:	<-16 dB		
Front to Back Ratio:	>25 dB		
Intermodulation:	<-153 dBc for 2 x 20W carriers		
Input Power:	2 x 200W		
Input Connector Type / Location:	2 x 7/16-DIN Female / Bottom		
Operating Temperature:	-40°F (-40°C) to +140°F (+60°C)		

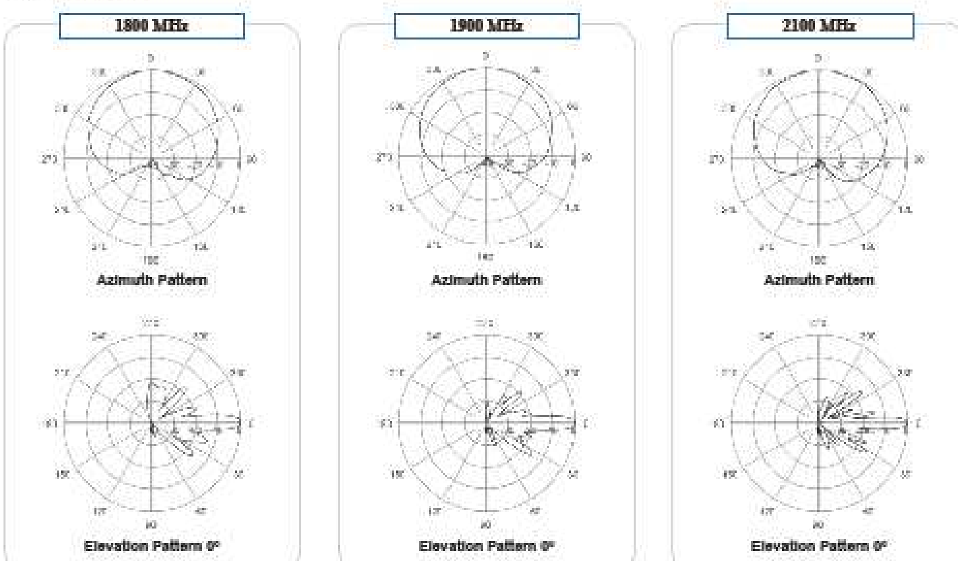
Mechanical Specifications		
Survival Wind Speed:	150 mph (241 km/h; 67 m/s)	
Wind Loads (100mph; 160km/h; 45m/s):	Front: 65 lbf (288 N)	Side: 38 lbf (167 N)
Antenna Weight and Dims (LxWxD):	15.4 lbs (7 kg)	54.5 x 6.7 x 3.9 in (1386 x 170 x 100 mm)
RET Type / Part Number:	External / RETU-EA01	

Mounting Kit Options		
Pole Mounting Kit:	MKS02P01	Weight: 6.5 lbs (2.9 kg)
Scissor Tilt Mounting Kit:	MKS02T06	Weight: 8.3 lbs (3.8 kg)
Bar Tilt Mounting Kit:	MKS02T07	Weight: 8.7 lbs (3.9 kg)

Unicell Options				
For use inside Unicell Modules:	UNX12-14 (Antenna + RET)	UNX14-13 (Antenna Only)	UNX14-14 UNX14-14LT UNX14-18 UNX14-19 (Antenna + RET)	UNX20-14 UNX20-14LT UNX20-19 (Antenna + RET)
Azimuth Swivel / Elevation Tilt:	Fixed Az / Fixed El	± 25° Az / Fixed El	± 25° Az / Fixed El	± 30° Az / Fixed El
Required Mounting Kit:	Included with Unicell	Included with Unicell	Included with Unicell	UNX20-AZ

WIDEBAND

Typical Patterns:



www.jaybeamwireless.com

ENDNOTES

1. 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).

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

3. 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*.

4. 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)**.

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

6. ANSI/IEEE C95.3-2002: American National Standard, *Recommended Practice for the Measurement of Potential Electromagnetic Fields - RF and Microwave*.

7. NCRP Report No. 119: National Council on Radiation Protection and Measurements, 1993; *A Practical Guide to the Determination of Human Exposure to Radiofrequency Fields*.

8. 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.