PINNACLE TELECOM GROUP
Professional and Technical Services
Telecom Consulting

ANTENNA SITE FCC RF COMPLIANCE ASSESSMENT AND REPORT

prepared for

T-MOBILE NORTHEAST LLC

SITE VA70332A
1012 THOMAS STREET
HAMPTON, VA

NOTE: The new address is 332 Rip Rap Road and is no longer 1012 Thomas Street.

MAY 30, 2017

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Contents

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Introduction and Summary

At the request of T-Mobile Northeast LLC ("T-Mobile"), Pinnacle Telecom Group has performed an independent expert assessment of radiofrequency (RF) levels and related FCC compliance for a proposed wireless base station antenna operation on a monopole located at 1012 Thomas Street in Hampton, VA. T-Mobile refers to the antenna site by the code "VA70332A", and its proposed antenna operation involves directional panel antennas transmitting in the 700, 1900 and 2100 MHz bands.

The FCC requires all wireless antenna operators to perform an assessment of potential human exposure to radiofrequency (RF) fields emanating from all the transmitting antennas at a site whenever antenna operations are added or modified, and to ensure compliance with the Maximum Permissible Exposure (MPE) limit in the FCC's regulations. In this case, there are no other existing antenna operations at the site to include in the compliance assessment. Note that FCC regulations require any future antenna collocators to assess and assure continuing compliance based on the cumulative effects of all then-proposed and then-existing antennas at the site.

This report describes a mathematical analysis of RF levels resulting around the site in areas of unrestricted public access, that is, at ground level around the site. The compliance analysis employs a standard FCC formula for calculating the effects of the antennas in a very conservative manner, in order to overstate the RF levels and to ensure "safe-side" conclusions regarding compliance with the FCC limit for safe continuous exposure of the general public.

The results of a compliance assessment can be explained in layman's terms by describing the calculated RF levels as simple percentages of the FCC MPE limit. If the reference for that limit is 100 percent, then calculated RF levels higher than 100 percent indicate the MPE limit is exceeded, while calculated RF levels consistently lower than 100 percent serve as a clear and sufficient demonstration of compliance with the MPE limit.

The results of the FCC RF compliance assessment in this case are as follows:

- At ground level, the conservatively calculated maximum RF level from the proposed antenna operations at the site is 0.6245 percent of the FCC general population MPE limit – well below the 100-percent reference for compliance. In other words, the worst-case calculated RF level – intentionally and significantly overstated by the calculations – is still more than 160 times below the FCC limit for safe, continuous exposure of the general public.
- The results of the calculations provide a clear demonstration that the RF levels from the proposed antenna operations will be in compliance with the applicable FCC regulations and MPE limit. Moreover, because of the conservative methodology and operational assumptions incorporated in the calculations, RF levels actually caused by the antennas will be even less significant than these calculations indicate.

The remainder of this report provides the following:

- relevant technical data on the proposed T-Mobile antenna operations;
- a description of the applicable FCC mathematical model for assessing MPE compliance, and application of the relevant data to that model; and
- an analysis of the results, and a compliance conclusion for the antenna operations at this site.

In addition, Appendix A provides a list of key FCC references on MPE compliance, and Appendix B provides a summary of the qualifications of the expert certifying FCC compliance for this site.

Antenna and Transmission Data

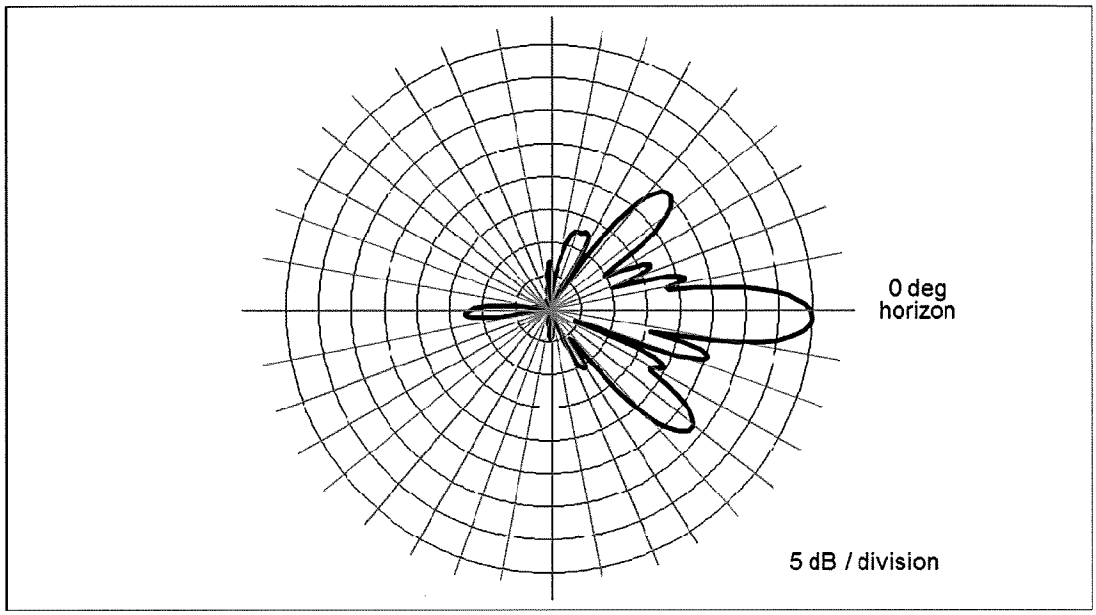
Relevant compliance-related antenna and transmission data for the proposed T-Mobile's antenna operation is provided in the table that follows.

General Data – T-Mobile	
Frequency Bands	700 MHz, 1900 MHz, and 2100 MHz
Service Coverage Type	Sectorized
Antenna Type	Directional Panel
Antenna Centerline Height AGL	117 ft.
Antenna Line Loss	Conservatively ignored (assumed 0 dB)
700 MHz Antenna Data	
Antenna Models (Max. Gain)	Commscope F-65C-R1 (15.8 dBi)
RF Channels per Sector	One 40-watt channel
1900 MHz Antenna Data	
Antenna Models (Max. Gain)	Ericsson AIR32 (18.0 dBi)
RF Channels per Sector	Two 40-watt channels
2100 MHz Antenna Data	
Antenna Model (Max. Gain)	Ericsson AIR32 (18.0 dBi)
RF Channels per Sector	One 80-watt channel

The antenna vertical-plane radiation pattern is used in the calculations of RF levels at street level around a site. By way of illustration, Figure 1 that follows shows the vertical-plane pattern of the proposed antenna model in the 700 MHz band. In this type of antenna pattern diagram, the antenna is effectively pointed at the three o'clock position (the horizon) and the pattern at different angles is described using decibel units. Note that the use of a decibel scale to describe the relative pattern at different angles actually serves to significantly understate the actual focusing effects of the antenna. Where the antenna pattern reads 20 dB the relative RF energy emitted at the corresponding downward angle is 1/100th of the maximum that occurs in the main beam (at 0 degrees); at 30 dB, the energy is only 1/1000th of the maximum.

Note that the automatic pattern-scaling feature of our internal software may skew side-by-side visual comparisons of different antenna models, or even different parties' depictions of the same antenna model.

Figure 1. Commscope F-65C-R1 - 700 MHz Vertical-plane Pattern



Compliance Analysis

FCC Office of Engineering and Technology Bulletin 65 ("OET Bulletin 65") provides guidelines for mathematical models to calculate the RF levels at various points around transmitting antennas.

At street-level around an antenna site (in what is called the "far field" of the antennas), the RF levels are directly proportional to the total antenna input power and the relative antenna gain in the downward direction of interest – and the levels are otherwise inversely proportional to the square of the straight-line distance to the antenna.

Conservative calculations also assume the potential RF exposure is enhanced by reflection of the RF energy from the intervening ground. Our calculations will assume a 100% "perfect" mirror-like reflection, the worst-case approach.

The formula for street-level compliance assessment for any given wireless antenna operation is as follows:

$$MPE\% = (100 * Chans * TxPower * 10^{(Gmax-Vdisc/10)} * 4) / (MPE * 4\pi * R^2)$$

where

MPE%	=	RF level, expressed as a percentage of the MPE limit applicable to continuous exposure of the general public
100	=	factor to convert the raw result to a percentage
Chans	=	maximum number of RF channels per sector
TxPower	=	maximum transmitter power per channel, in milliwatts
$10^{(Gmax-Vdisc/10)}$	=	numeric equivalent of the relative antenna gain in the downward direction of interest; data on the antenna vertical-plane pattern is taken from manufacturer specifications
4	=	factor to account for a 100-percent-efficient energy reflection from the ground, and the squared relationship between RF field strength and power density ($2^2 = 4$)
MPE	=	FCC general population MPE limit
R	=	straight-line distance from the RF source to the point of interest, centimeters

The MPE% calculations are performed out to a distance of 500 feet from the facility to points 6.5 feet (approximately two meters, the FCC-recommended standing height) off the ground, as illustrated in Figure 2 on the next page.

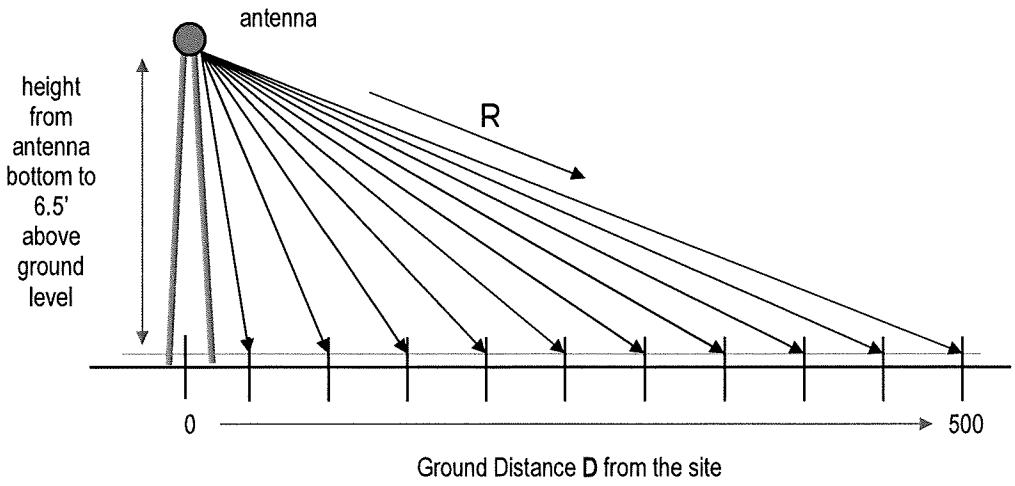


Figure 2. MPE% Calculation Geometry

It is popularly understood that the farther away one is from an antenna, the lower the RF level – which is generally but not universally correct. The results of MPE% calculations fairly close to the site will reflect the variations in the vertical-plane antenna pattern as well as the variation in straight-line distance to the antennas. Therefore, RF levels may actually increase slightly with increasing distance within the range of zero to 500 feet from the site. As the distance approaches 500 feet and beyond, though, the antenna pattern factor becomes less significant, the RF levels become primarily distance-controlled, and as a result the RF levels generally decrease with increasing distance, and are well understood to be in compliance.

FCC compliance for a multiple-band antenna operation is assessed in the following manner. At each distance point along the ground, an MPE% calculation is made for the RF effect in each frequency band, and the sum of the individual MPE% contributions at each point is compared to 100 percent, which serves as the normalized reference for the FCC MPE limit. We refer to the sum of the individual MPE% contributions as "total MPE%", and any calculated MPE% total MPE% result exceeding 100 percent is, by definition, higher than the FCC

limit and represents non-compliance and a need to mitigate the RF levels. If, on the other hand, all results are below 100 percent, that set of results serves as a demonstration of compliance with the MPE limit.

Note that according to the FCC, when directional antennas (e.g., panels or dishes) are involved, the compliance assessments are based on the RF effect of a single (facing) sector or antenna, as the RF effects of directional antennas facing generally away from the point of interest are insignificant.

The following conservative methodology and assumptions are incorporated into the MPE% calculations on a general basis:

1. The antennas are assumed to be operating continuously at maximum power and maximum channel capacity. In addition, the effects of antenna line loss are ignored wherever possible.
2. The power-attenuation effects of shadowing or other obstructions to the line-of-sight path from the antenna to the point of interest are ignored.
3. The calculations intentionally minimize the distance factor (R) by assuming a 6'6" human and performing the calculations from the bottom (rather than the centerline) of each operator's lowest-mounted antenna, as applicable.
4. The RF exposure at ground level is assumed to be 100-percent enhanced (increased) via a "perfect" field reflection from the intervening ground.
5. The calculations take into account the different technical characteristics and related RF effects associated with a carrier's use of multiple antenna models for transmission in the same frequency band.

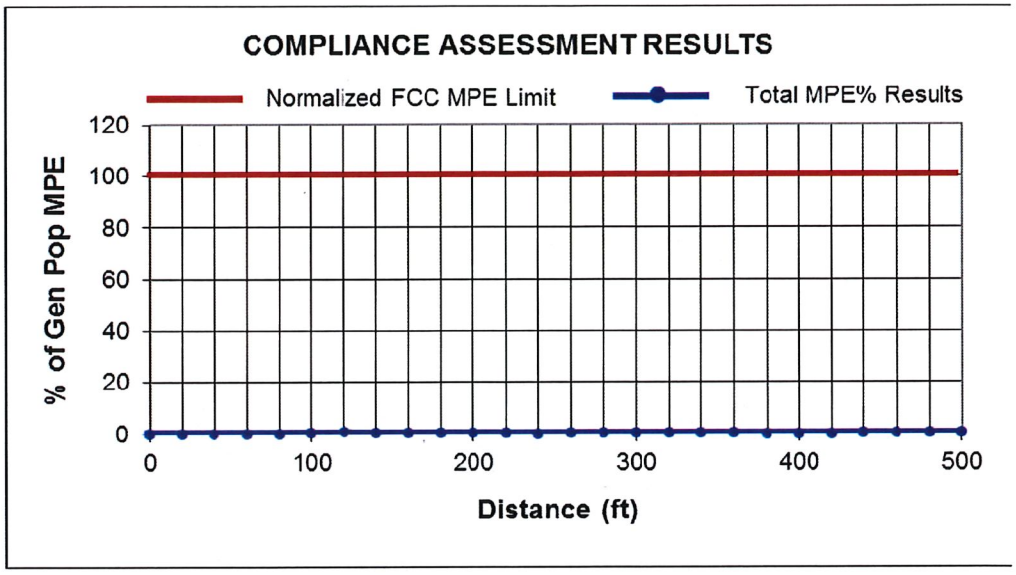
The net result of these assumptions is to significantly overstate the calculated RF exposure levels relative to the levels that will actually occur – and the purpose of this conservatism is to allow very "safe-side" conclusions about compliance.

The table that follows provides the results of the MPE% calculations for each operator, with the maximum (worst-case) overall result highlighted in bold in the last column.

Ground Distance (ft)	T-Mobile 700 MHz MPE%	T-Mobile 1900 MHz MPE%	T-Mobile 2100 MHz MPE%	Total MPE%
0	0.0020	0.0006	0.0001	0.0027
20	0.0013	0.0011	0.0005	0.0028
40	0.0001	0.0038	0.0164	0.0203
60	0.0080	0.0024	0.0016	0.0120
80	0.0025	0.0050	0.0078	0.0154
100	0.1335	0.1420	0.0002	0.2757
120	0.2748	0.2833	0.0664	**0.6245**
140	0.1889	0.0697	0.1672	0.4258
160	0.0441	0.0102	0.0487	0.1029
180	0.0150	0.0206	0.0013	0.0369
200	0.0183	0.0328	0.0025	0.0535
220	0.0102	0.0195	0.0071	0.0368
240	0.0004	0.0008	0.0067	0.0080
260	0.0008	0.0257	0.0016	0.0281
280	0.0143	0.0472	0.0073	0.0688
300	0.0226	0.0694	0.0348	0.1268
320	0.0282	0.0515	0.0373	0.1169
340	0.0290	0.0259	0.0272	0.0821
360	0.0248	0.0061	0.0112	0.0421
380	0.0168	0.0014	0.0014	0.0197
400	0.0079	0.0013	0.0013	0.0105
420	0.0072	0.0111	0.0062	0.0245
440	0.0020	0.0261	0.0232	0.0513
460	0.0018	0.0240	0.0214	0.0472
480	0.0031	0.0320	0.0376	0.0727
500	0.0029	0.0296	0.0348	0.0672

As indicated, the maximum calculated overall RF level is 0.6245 percent of the FCC MPE limit – well below the 100-percent reference for compliance, especially given the conservatism in the analysis.

A graph of the overall calculation results, shown on the next page, perhaps provides a clearer *visual* illustration of the relative compliance of the calculated RF levels. The line representing the overall calculation results barely rises above the graph's baseline, and shows an obviously clear, consistent margin to the FCC MPE limit.



Compliance Conclusion

According to the FCC, the MPE limit has been constructed in such a manner that continuous human exposure to RF fields up to and including 100 percent of the MPE limit is acceptable and safe.

The conservative analysis in this case shows that the maximum calculated RF level from the proposed antenna operations at the site is 0.6245 percent of the FCC general population MPE limit. In other words, the worst-case calculated RF level is more than 160 times below the FCC MPE limit,

The results of the calculations indicate clear compliance with the FCC MPE limit. Moreover, because of the conservative calculation methodology and operational assumptions applied in this compliance analysis, the RF levels actually caused by the antennas will be even less significant than the calculation results indicate.

Certification

The undersigned certifies as follows:

1. I have read and fully understand the FCC regulations concerning RF safety and the control of human exposure to RF fields (47 CFR 1.1301 *et seq*), as well as the related provisions of the State of New Jersey's *Radiation Protection Act* (N.J.S.A 26:2D *et seq*).
2. To the best of my knowledge, the statements and information disclosed in this report are true, complete and accurate.
3. The analysis of RF compliance provided herein is consistent with the applicable FCC regulations, additional guidelines issued by the FCC, and industry practice.
4. The results of the analysis demonstrate compliance with the FCC regulations concerning the control of potential human exposure to the RF emissions from antennas.

Daniel Penesso

Daniel Penesso
Director- RF Engineering

5/30/17
Date

Appendix A. Background on the FCC MPE Limit

FCC Rules and Regulations

As directed by the Telecommunications Act of 1996, the FCC has established limits for maximum continuous human exposure to RF fields.

The FCC maximum permissible exposure (MPE) limits represent the consensus of federal agencies and independent experts responsible for RF safety matters. Those agencies include the National Council on Radiation Protection and Measurements (NCRP), the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), the American National Standards Institute (ANSI), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA). In formulating its guidelines, the FCC also considered input from the public and technical community – notably the Institute of Electrical and Electronics Engineers (IEEE).

The FCC's RF exposure guidelines are incorporated in Section 1.301 *et seq* of its Rules and Regulations (47 CFR 1.1301-1.1310). Those guidelines specify MPE limits for both occupational and general population exposure.

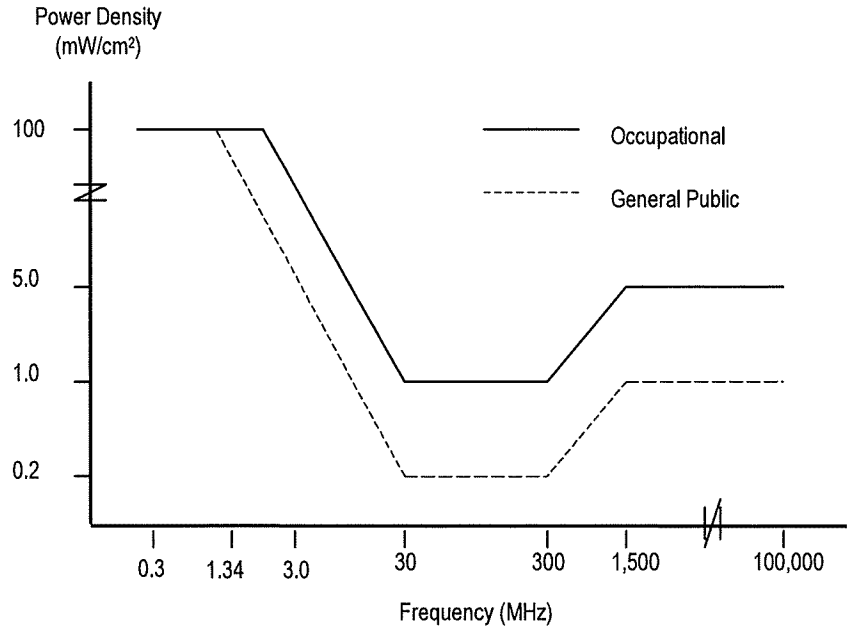
The specified continuous exposure MPE limits are based on known variation of human body susceptibility in different frequency ranges, and a Specific Absorption Rate (SAR) of 4 watts per kilogram, which is universally considered to accurately represent human capacity to dissipate incident RF energy (in the form of heat). The occupational MPE guidelines incorporate a safety factor of 10 or greater with respect to RF levels known to represent a health hazard, and an additional safety factor of five is applied to the MPE limits for general population exposure. Thus, the general population MPE limit has a built-in safety factor of more than 50. The limits were constructed to appropriately protect humans of both sexes and all ages and sizes and under all conditions – and continuous exposure at levels equal to or below the applicable MPE limits is considered to result in no adverse health effects or even health risk.

The reason for *two* tiers of MPE limits is based on an understanding and assumption that members of the general public are unlikely to have had appropriate RF safety training and may not be aware of the exposures they receive; occupational exposure in controlled environments, on the other hand, is assumed to involve individuals who have had such training, are aware of the exposures, and know how to maintain a safe personal work environment.

The FCC's RF exposure limits are expressed in two equivalent forms, using alternative units of field strength (expressed in volts per meter, or V/m), and power density (expressed in milliwatts per square centimeter, or mW/cm^2). The table on the next page lists the FCC limits for both occupational and general population exposures, using the mW/cm^2 reference, for the different radio frequency ranges.

Frequency Range (F) (MHz)	Occupational Exposure (mW/cm^2)	General Public Exposure (mW/cm^2)
0.3 - 1.34	100	100
1.34 - 3.0	100	$180 / F^2$
3.0 - 30	$900 / F^2$	$180 / F^2$
30 - 300	1.0	0.2
300 - 1,500	F / 300	F / 1500
1,500 - 100,000	5.0	1.0

The diagram below provides a graphical illustration of both the FCC's occupational and general population MPE limits.



Because the FCC's RF exposure limits are frequency-shaped, the exact MPE limits applicable to the instant situation depend on the frequency range used by the systems of interest.

The most appropriate method of determining RF compliance is to calculate the RF power density attributable to a particular system and compare that to the MPE limit applicable to the operating frequency in question. The result is usually expressed as a percentage of the MPE limit.

For potential exposure from multiple systems or multiple frequency bands, the respective percentage contributions of the MPE limits are added, and the overall percentage sum is compared to 100 (percent of the limit). If the result is less than 100, the total exposure is in compliance; if it is more than 100, exposure mitigation measures are necessary to achieve compliance.

Note that the FCC "categorically excludes" all "non-building-mounted" wireless antenna operations whose mounting heights are more than 10 meters (32.8 feet) from the routine requirement to demonstrate compliance with the MPE limit, because such operations "are deemed, individually and cumulatively, to have no significant effect on the human environment". The categorical exclusion also applies to *all* point-to-point antenna operations, regardless of the type of structure they're mounted on. Note that the FCC considers any facility qualifying for the categorical exclusion to be automatically in compliance.

FCC References on RF Compliance

47 CFR, FCC Rules and Regulations, Part 1 (Practice and Procedure), Section 1.1310 (Radiofrequency radiation exposure limits).

FCC Second Memorandum Opinion and Order and Notice of Proposed Rulemaking (FCC 97-303), *In the Matter of Procedures for Reviewing Requests for Relief From State and Local Regulations Pursuant to Section 332(c)(7)(B)(v) of the Communications Act of 1934 (WT Docket 97-192), Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation (ET Docket 93-62), and Petition for Rulemaking of the Cellular Telecommunications Industry Association Concerning Amendment of the Commission's Rules to Preempt State and Local Regulation of Commercial Mobile Radio Service Transmitting Facilities*, released August 25, 1997.

FCC First Memorandum Opinion and Order, ET Docket 93-62, *In the Matter of Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation*, released December 24, 1996.

FCC Report and Order, ET Docket 93-62, *In the Matter of Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation*, released August 1, 1996.

FCC Office of Engineering and Technology (OET) Bulletin 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition 97-01, August 1997.

FCC Office of Engineering and Technology (OET) Bulletin 56, "Questions and Answers About Biological Effects and Potential Hazards of RF Radiation", edition 4, August 1999.

Appendix B. Summary of Expert Qualifications

Daniel Penesso, Director – RF Engineering, Pinnacle Telecom Group, LLC

Synopsis:	• 19 years of experience in all aspects of wireless RF engineering, including network design and implementation, interference analysis, FCC and FAA regulatory matters, and antenna site compliance with FCC RF exposure regulations • Have performed RF engineering and FCC compliance work for all the major wireless carriers – AT&T, Verizon Wireless, Sprint, T-Mobile, and MetroPCS, as well as Crown Castle • Have served as an expert witness on RF engineering and/or FCC RF compliance more than 100 times before municipal boards in New Jersey and New York
Education:	• Bachelor of Science in Electrical Engineering, DeVry Institute of Technology, Chicago, IL, 1987
Current Responsibilities	• Manages PTG staff work involving FCC RF compliance for wireless antenna sites, including the provision of math- and measurements-based site compliance reports, related expert testimony in municipal hearings, and compliance-related support in client meetings with prospective site landlords and in town meetings • Provides math-based FCC compliance assessments and reports for PTG's wireless clients, including AT&T, Verizon Wireless, T-Mobile, Sprint, MetroPCS, and Crown Castle • Responsible for providing client consulting and in-house training on FCC and OSHA RF safety compliance
Prior Experience:	• Have served as senior RF engineer for four of the five national wireless carriers – AT&T, T-Mobile, Sprint, and MetroPCS – in the New York and New Jersey markets • Served as an RF engineer for Metricom, Triton PCS, Alltel Communications, and Western Wireless • Have worked as an RF engineer for several engineering services companies, including Sublime Wireless, Amirit Technologies, Celcite, and Wireless Facilities Incorporated