AECOM Environment

Prepared for:
Montgomery County Public Schools
Rockville, MD

Prepared by:
AECOM
Milwaukee, WI
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RADIOFREQUENCY (RF) MONITORING SUMMARY REPORT

Montgomery County Public Schools

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This Radiofrequency (RF) Monitoring Summary Report was prepared by AECOM Company (AECOM) for the Montgomery County Public Schools (MCPS). This report presents a series of evaluations of Radiofrequency (RF) exposures associated with existing WiFi installations. This report includes results of a variety of RF exposure scenarios, as summarized in the table below:

School	Access Point	ChromeBook	Charging Station
Gaithersburg High School	X	X	
Wootton High School	X	X	
Carbin John Middle School	X	X	
Churchill High School	X	X	
Bells Mill Elementary School	X	X	
Beverly Farms Elementary School	X	X	
Fallsmead Elementary School	X	X	
Little Bennett Elementary School		X	
William Wims Elementary School			X
Arcola Elementary School	X	X	
Goshen Elementary School	X		
Strawberry Knoll Elementary School	X	X	

Results of the RF monitoring study showed all of the average power density results were well below the FCC, IEEE, and ICNIRP level of 10,000 $\mu W/cm^2$ for time-averaged, whole body exposure. All values were also below the Bioinitiative Report 2007 precautionary level of 0.1 $\mu W/cm^2$.

All the measured field strengths were collected while students were actively using their Chromebook devices. Based upon the results of this study, AECOM predicts that similar results below the FCC, ICNIRP, IEEE and Bioinitiative Report 2007 recommended levels would be expected in all classroom settings using similar equipment and WiFi configurations.

The following presents a description of the monitoring protocol and results of the RF monitoring study.

2.1 WIRELESS BASICS

All wireless technologies, including cell phones, WLANs (i.e., WiFi), and Smart Meters, work in essentially the same way. For the purposes of this project, the report will focus on WLAN systems. The device used to connect a wireless end device (e.g., laptop, iPad) to the wireless computer network is called an access point (AP). An antenna installed within the AP generates EMFs in the RF portion of the electromagnetic spectrum. The EMFs are transmitted in two instances:

1. A basic broadcast signal is transmitted sporadically (approximately every 10 seconds) to allow any device that may be attempting to connect to the network to "see" the AP.

2. A transmission signal containing data based on the type of information that the end user is attempting to download or upload.

Note that some AP devices may have two or three antennae. The number of antenna depends on the number of different frequency bands an AP supports. Two-antenna APs usually support a single frequency range, while three-antenna APs typically support two simultaneously-active frequency ranges. IEEE 802.11 is a set of standards for implementing WLAN computer communication in the 2.4, 3.6, and 5 GHz frequency bands. IEEE 802.11b and 802.11g use the same frequency range (2.4 GHz) while 802.11a operates in the 5GHz band, and 802.11n operates in both the 2.4GHz and 5GHz band. Most of the time, only one antenna is transmitting a signal at a time. In a two-antenna AP, usually one antenna transmits and the other antenna receives. In a three-antenna AP, usually one antenna transmits, while two antennae are dedicated to receiving under the different 802.11 protocols. However, under extreme demand, which is typically when 80% of capacity has been reached (based on either 11 megabytes per second [Mbps] for 802.11b or 54 Mbps for 802.11a or g), the AP may switch one of the antennae to operate partially as a transmitter. Note that this would be a relatively rare occurrence.

In order to receive the signal from the AP, the end device must have an antenna as well. The antenna is located within the body of the end device, in back of the screen in newer models. The antenna within the end device generates RF EMFs as well. The end device emits RF EMFs attempting to perform the following functions:

1. Communicate with the AP, either downloading or uploading information, called operating in infrastructure mode.

2. Communicating with other wireless devices, called operating in *ad hoc* mode.

3. Detection of other end devices in the area.

Figure 2-1 illustrates the general set up of a wireless network and the EMF emissions of the devices.

Figure 2-1: *General setup of a wireless network, illustrating that both the AP and the end devices emit RF EMFs.*

2.2 WIRELESS AND EMF

RF EMFs from the end device and the AP are not continuous, nor are these EMFs of the same power (or strength). Rather, the strength and frequency of the EMFs generated are based on several factors, including the following:

1. **Proximity of the end device to the AP.** The closer the end device is to the AP, the lower the signal strength necessary to transmit the information between the two devices. Similarly, the farther away the end device is from the AP, the stronger the signal that must be employed for the AP to accurately receive and transmit. Note that in general, wireless devices normally operate at lower power levels than regulatory limits to conserve battery power.

2. **Antenna gain and directionality.** Normal wireless APs have an antenna gain of less than 6 dB, but commercial APs can have custom antennas with gains up to 21 dB (or higher). Omnidirectional antennas can be upgraded to gains of 8 to 12 dB, while directional (i.e., panels, sectors) antennas can be upgraded to much higher gains.

3. **Number of end devices.** When few end users are present, the likelihood that several end devices would attempt to receive or transmit at the same time is small. Thus, every time that the end device attempts to transmit to the AP, the signal would succeed and the frequency of EMF transmission would be relatively low. However, as the number of end users increases, congestion on the wireless system increases as multiple end devices attempt to communicate with the AP at the same time. However, the AP can only service one end user at a time. In this situation, multiple end users could transmit at the same time, generating EMFs, without successfully connecting to the AP, which would result in the end device having to re-attempt the connection, and thus generating additional EMFs.

4. **Amount of data transferred.** Small files logically take less time to transmit and receive than large files. For example, downloading a webpage to read content would take less time and, thus, less EMF exposure than downloading a streaming video.

5. **Interference/Signal attenuation.** While EMFs can in theory be transmitted unchanged through solid medium, like a wall, in reality, the EMFs can be attenuated by transmission through solid media. This attenuation lowers the signal strength so that the receiving device may have difficulty receiving the signal. In addition, other wireless devices operating within the area can cause interference with the wireless system of interest. In both of these cases, the wireless system can attempt to adjust for the interference. The wireless system may take the following actions to adjust the RF signal and transmit the data:

    a. Increase the signal strength, which will increase the strength of the EMF being emitted from the device and may increase the field strength that the user is exposed to.

    b. Slow down the rate of transfer, which increases the time that the user is exposed to the EMF.

6. **Regulatory maximums.** The Federal Communications Commission (FCC) has set forth maximum power strengths that a device may emit. While manufacturers may make devices with strengths lower than these maximums, devices that exceed these power requirements cannot be produced. The FCC guidelines equate to a power density of 1 mW/cm^2. All wireless devices sold in the US go through a formal FCC approval process to ensure that the maximum allowable level when operating at the device's highest possible power level is not exceeded (FCC 2012).

2.3 UNITS

Various units are used to express the strength of EMFs and wireless devices. **Table 2-1** summarizes the units and their applicability.

Table 2-1
Summary of Units Used

Name	Unit Abbreviation Unit Name	Comment
Duty Factor	-unitless-	Measure of the time that a wireless device is actually transmitting.
Electric Field Strength (E)	V/m Volts per meter	
Frequency	Hz	Cycles per second. How many

Table 2-1 Summary of Units Used		
Name	**Unit Abbreviation** **Unit Name**	**Comment**
	Hertz	times per second a wave goes through its maximum value.
Magnetic Field Strength (H)	A/m Amperes per meter	
Magnetic Flux Density (B)	T (or G) Tesla (or Gauss)	
Power Density	W/m^2 Watts per square meter	The rate of energy flow through a given surface area. Can also be expressed in milliwatts per square centimeter (mW/cm^2) or microwatts per square centimeter ($\mu W/cm^2$).
Specific Absorption Rate (SAR)	W/kg Watts per kilogram	Measure of the rate that RF energy is absorbed by the body

2.4 DUTY FACTOR

As stated above, wireless devices are not emitting EMFs all the time. Because regulations for EMF exposure are based on exposure over time, the duty factor of the device is important. The duty factor quantifies the amount of time that the wireless device is actually transmitting and, therefore, emitting EMFs. The duty factor is the ratio of the amount of time that the device spends transmitting divided by the total amount of time monitored. The duty factor cannot exceed "1" (which would represent transmitting all of the time). Sometimes the duty factor is expressed as a percentage.

Logically, the duty factor for an AP is larger than for an end device, as the AP needs to service the needs of all end users (and their end devices) within a given time frame. Duty factors for some wireless devices have been reported, but reliable duty factor reporting for laptop or tablet type devices is limited.

2.5 WIRELESS DEVICES

Cell phones, smart meters, and WLANs emit EMFs in the RF area of the electromagnetic spectrum. While their frequencies are similar, each frequency is dedicated to a specific use. However, because each emits in the RF band, some similarities exist between the wireless technologies. Because of these similarities, often these devices are lumped together as "RF

emitting devices." While it is important to note that each technology operates at a different frequency and power density within the RF spectrum, the basic concepts behind how the devices operate is similar. **Table 2-2** provides a comparison of the power density of these devices.

Table 2-2

Comparison of Power Density for Wireless Devices

Source	Power Density («W /cm^2)
Cell phone, held close to ear, during call	1,000 - 5,000
Cell phone base station, at typical distances of 10-1000 meters	0.5 – 3
Microwave oven, producing maximum permitted leakage radiation, 30 centimeters from door	1,000
WiFi computer, 1 meter away, when transmitting	0.005 – 0.2
radio and TV broadcast signals	0.005 - 1
Smart Meter, transmitting data in mesh mode to other local meters	10 - 40 (1 meter away) 1 - 4 (3 meter away)
Smart Meter, transmitting data in mesh mode to other local meters, average over 1% duty cycle	.1 - .4 (1 meter away) 0.01 - 0.04 (3 meter away)

Source: National Grid, http://www.emfs.info/Sources+of+EMFs/meters/smart/

2.5.1 WLAN

WLANs can service a number of end devices, including wireless-enabled laptops and tablets. Although laptops and tablets look different, the operation of the antennae within the devices is essentially the same. Therefore, published data on the duty factor and power density of laptops may be applied to tablet devices as well. While little research has been performed explicitly on tablets, a few studies have been performed on laptops, as discussed below.

Findlay and Dimbylow (2012) in the United Kingdom (UK) have reported calculating the SAR of a 10-year-old child in a school setting using a WLAN. They reported a SAR of 0.057 mW/kg,

which is less than 0.01% of the SAR experienced in the head from cell phone usage. For this calculation, they used a duty factor of 0.01 (or 1%), based on the work of Khalid, *et al*. (2011).

The Khalid, *et al*. (2011) study investigated the duty factor of laptops in various school settings in the UK and reported a range of duty factors for both APs and end devices, as summarized in **Table 2-3**. The study was ground-breaking, as it was the only study to investigate the duty factor of wireless devices used by children in a school setting.

Table 2-3
Summary Duty Factors from Khalid *et al.* (2011)

Device	Duty Factor	
	Minimum Observed	**Maximum Observed**
AP	0.0006 (0.06%)	0.1167 (11.67%)
Laptop	0.0002 (0.02%)	0.0096 (0.96%)

In 2007, Foster measured the RF signal from wireless devices in multiple settings (academic, commercial, health care) and multiple countries (USA and Europe). Foster found a number of interesting results, including the following:

- The RF signal from most of the networks surveyed was usable by the laptop, but the signal was too small to be measured by the highly-sensitive EMF meter employed in this study.
- "In nearly all cases, the field intensities within the band used by WLANs were exceeded by other RF sources."
- RF energy measured in this study (2007) was comparable to RF measurements made in 1980, when the primary RF source was UHF television broadcasting facilities. Note that UHF broadcasting facilities are still present. Thus, this study concluded that wireless technology is not significantly contributing to overall RF exposure given that UHF remains the major contributor.
- "…the peak power output of APs and client cards is comparable to or somewhat below those of mobile telephone handsets."

2.6 SUMMARY

Comparing the statements and conclusions of the various reports, the following points can be made:

- Duty factors for all wireless end devices are reported to be quite low, ranging from 0.01% to 5%, with a typical duty factor for all applications (except APs) around 1%.
- WLAN devices, including laptops and tablets, operate at lower power densities than cell phones because the functional distance that the wireless devices operate over is much

lower. Thus, RF exposure from WLAN devices is expected to be lower than for cell phone use.

This section summarizes the various EMF limits that organizations around the world have proposed or have used. **Table 3-1** is a summary of these limits. For a thorough summary of power density limits by country, consult Stam (2011).

3.1 STATE AND NATIONAL

Several organizations have developed guidelines for EMF exposure, including individual states, the Federal Communications Commission (FCC), the Occupational Safety and Health Administration (OSHA), the Institute of Electrical and Electronics Engineers (IEEE), and the American National Standards Institute (ANSI).

Neither the Maryland government nor the United States government has regulations limiting EMF exposure to residences.

At the national level, the IEEE standard C95.1, which has been formally adopted by ANSI, specifies Maximum Permissible Exposure (MPE) levels for the general public and for occupational exposure to RF EMFs. Note that the IEEE C95.1 (2005) levels are recommendations only, not regulations.

In 2006, ANSI adopted IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, as its C95.1 Standard for safe human exposure to non-ionizing electromagnetic radiation. The standards are frequency dependent. MPEs are strictest at 100 to 300 MHz because the human body absorbs the greatest percentage of incident energy at these frequencies. The MPE standards become progressively higher at frequencies above 400 MHz because the human body absorbs less energy at these higher frequencies. The C95.1 standards specify different safety levels for occupational and general-public exposure. The general-public exposure safety levels are stricter because workers are assumed to have knowledge of occupational risks and are better equipped to protect themselves (e.g., through use of personal safety equipment). The safety levels are intended to protect all members of the public, including pregnant women, infants, the unborn, and the infirm from short-term and long-term exposure to electromagnetic fields. The safety levels are also set at 10 to 50 times below the levels at which scientific research has shown harmful effects may occur, thereby incorporating a large safety factor (ANSI/IEEE, 2006).

FCC Regulations at Title 47 CFR §1.1310 are based on the 1992 version of the ANSI/IEEE C95.1 safety standard. The FCC (1999) has developed a series of MPE limits based on the frequency of the EMF. The NCRP and ANSI/IEEE exposure criteria and most other standards specify "time-averaged" MPE limits. This means that exceeding the recommended limits is permissible for given periods of time if the average exposure (over the appropriate period specified) does not exceed the MPE limit. FCC MPEs are based on an averaging time of 30 minutes for exposure of the general public.

Table 4
Summary of EMF Limits

Organization	Type	B Field	Power Density «W/cm^2	E Field	Notes	Source
ANSI	Public		1,000		same as IEEE	
Bioinitiative Report 2007	Public: near power lines; pregnant women; children	1 mG				Carpenter, D.; Sage, S. (2007). Bioinitiative Report. Available at http://www.bioinitiative.org/.
	Public: new construction	2 mG				
	Cautionary level		0.1	0.614 V/m		
Salzburg Resolution	Public: cell phone tower		0.1	0.614 V/m		Salzburg Resolution on Mobile Telecommunication Base Stations. International Conference on Cell Tower Siting, Linking Science & Public Health, Salzburg, June 7-8, 2000.
ICNIRP	Public		1,000		6 minute averaging time	International Commission on Non-Ionizing Radiation Protection (2012). Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz).
	Occupational		5,000			
IEEE	Public: 2,000 MHz to 100 GHz		1,000			http://www-group.slac.stanford.edu/esh/eshmanual/references/nirreqexplimits.pdf

Table 4
Summary of EMF Limits

Organization	Type	B Field	Power Density «W/cm^2	E Field	Notes	Source
OSHA	Occupational		10,000		6 minute averaging time	29 CFR §1910.97
US FCC	Public: Frequency Range from 300 to 1,500 MHz		f/1.5		30 minute averaging time	http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet56/oet56e4.pdf
	Public: Frequency range from 1,500 to 100,000 MHz		1,000			
China	Public		10			Foster, K. R. Exposure Limits for Radiofrequency Energy: Three Models. World Health Organization, Conference on Criteria for EMF Standards Harmonization. Available at http://www.who.int/peh-emf/meetings/day2Varna_Foster.pdf.
Russia	Public		10			
Switzerland	Public		10			

Notes:
1. E and B field values are only provided when power density values are not available.

Abbreviations:
B=Magnetic
E=Electric
f=frequency in MHz
For a thorough summary of power density limits by country, consult Stam (2011).

The OSHA safety standards for occupational exposure to RF emissions are found at 29 CFR §1910.97. Per OSHA: "For normal environmental conditions and for incident electromagnetic energy of frequencies from 10 MHz to 100 GHz, the radiation protection guide is 10 mW/cm^2 (milliwatt per square centimeter) as averaged over any possible 0.1-hour period." This means that the power density cannot exceed 10 mW/cm^2 during any 6 minute period. In most cases, the OSHA levels do not vary with frequency and are less stringent than the equivalent ANSI/IEEE and FCC MPEs. However, for occupational exposure to fields with frequencies above 5,000 MHz, the OSHA MPE is equal to the C95.1 MPE and is, therefore, two times higher than the FCC MPE.

3.2 INDEPENDENT ORGANIZATIONS

In addition to the organizations described above, several other independent organizations have proposed EMF guidelines. Note that none of these guidelines are legally enforceable as regulations.

3.2.1 Bioinitiative Report

The Bioinitiative Report (2007) is a publication released on the internet by a group of 14 "…scientists, public health and public policy experts to document the scientific evidence on electromagnetic fields." The report claims to have evidence for the following effects of exposure to EMF:

- Modification of gene and protein expression
- Genotoxic effects
- Stress protein response
- Immune function modification
- Effects on neurology and behavior
- Brain tumors and acoustic neuromas
- Childhood cancers
- Melatonin production
- Alzheimer's disease
- Breast cancer

The group argues that current regulatory limits are set too high based on evidence presented in the report that adverse effects from EMF exposure can occur at levels of exposure approaching 2 mG. The report advocates for an EMF cautionary exposure level of 0.1 $\mu W/cm^2$, which is 10,000 times lower than the FCC limit.

The report maintains that EMF limits should be lowered not only because of the effects of exposure stated above, but also based on the fact that EMFs have been successfully used in some medical applications (i.e., bone healing) at much lower levels than the FCC limits. Thus, they

argue that health effects of EMF exposure, albeit positive, are observed below the ICNIRP limit for tissue heating.

The authors state that in light of the evidence indicating a possible link between adverse health effects and EMF exposure, the "precautionary principle" should be used to set conservative limits for EMF exposure.

3.2.2 Salzburg Resolution

In 2000, a group of scientists at the International Conference on Cell Tower Siting proposed the following limits:

- For the total of all high frequency radiation, a limit of 100 mW/m² (10 µW/cm²).
- For preventive public health protection, a preliminary guideline level for the sum of exposures from all ELF pulse modulated high-frequency facilities such as GSM base stations of 1 mW/m² (0.1 µW/cm²).

Note that these guidelines are not legally enforceable as regulations.

3.3 INTERNATIONAL

Internationally, many countries have developed their own EMF guidelines. Most of these regulations are based on the International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommendations, including the European Union (EU).

The ICNIRP exposure guidelines are based on "basic restrictions," which define the highest level of electric and magnetic field that can occur within various parts of the body without adverse health effects. The basic restrictions include reduction factors to account for uncertainties, such as variations among individuals. Because measuring the level of electric and magnetic field within the human body is difficult, the ICNIRP used dosimetry calculations. These calculations quantify the reference levels of external electric and magnetic fields to which humans could be exposed. The ICNIRP developed separate reference levels for occupational exposure and exposure of the general public. ICNIRP published references levels covered the entire frequency range in 1998. In 2010, the ICNIRP updated the reference levels for the 1 Hz to 10 MHz portion of this range, and reaffirmed the 1998 reference levels for the remainder of the frequency ranges (ICNIRP, 2010).

The ICNIRP guidelines are not intended to protect against potential electromagnetic interference with implantable medical devices (ICNIRP, 1998; 2010). In 2004, the Electric Power Research Institute (EPRI) stated that magnetic fields of 1 to 12 G could cause electromagnetic interference (EMI) with implanted medical devices (EPRI, 2004). The ACGIH recommends a maximum exposure level of 5 G for persons wearing cardiac pacemakers (ACGIH, 2008). Researchers and manufactures have been continuously working to improve the immunity of these devices to external electromagnetic fields. In 2007, The Association for Advancement of Medical Instrumentation (AAMI) developed a standard for the level of magnetic field that an implantable medical device (e.g. cardiac pacemakers, implantable cardioverter defibrillators [ICDs]) can withstand without harm to the wearer. The AAMI standard was adopted by ANSI and specifies

that cardiac pacemakers and ICDs must be tested by exposure to static magnetic fields with flux density equal to 1 mT (10 G) without malfunction or harm to the device. As a result, magnetic fields equal to or less than that level will not interfere with operation of the newer models of these devices or harm the device (ANSI/AAMI, 2007).

The International Organization for Standardization (ISO) developed a Draft Standard 14117 for electromagnetic compatibility of active implantable medical devices. Like the AAMI PC69:2007 Standard, the ISO standard is applicable to cardiac pacemakers and ICDs. The ISO standard also applies to cardiac resynchronization devices. Draft Standard 14117 requires that these medical devices operate without malfunction or harm in the presence of specified EM field levels (ISO, 2008). The safety levels prescribed in the ISO 14117 standard are identical to the safety levels contained in the ANSI/AAMI PC69:2007 standard.

The International Agency for Research on Cancer (IARC), which is a section within the World Health Organization (WHO), issued a press release in May of 2011 stating that radiofrequency electromagnetic fields are possibly carcinogenic to humans. The IARC classified RF radiation in Category 2B, which is "possibly carcinogenic to humans." The IARC maintains a list of 266 substances in this category, which includes coffee, coconut oil, pickled vegetables, gasoline exhaust, talcum powder, and nickel. The IARC definition of the 2B category (2006) states, "This category is used for agents for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals. It may also be used when there is inadequate evidence of carcinogenicity in humans but there is sufficient evidence of carcinogenicity in experimental animals."

4.1 EMFS AND THE HUMAN BODY

All EMFs have the potential to interact with the human body in three different ways, each of which will be discussed in further detail below:

- Electric field interactions
- Magnetic field interactions
- Magnetic field energy transfer

4.1.1 Electric Field Interactions

Time-varying electric fields may cause ions (either positively or negatively charged molecules or atoms within the human body) to flow, cause the reorientation of polar molecules within the body, and cause the formation of polar molecules that would otherwise be non-polar. The magnitude of the effects depends on the part of the body that is exposed (for example, the brain and blood contain a large number of ions), the frequency of the EMFs, and the magnitude of the electric field. (ICNIRP, 1997)

Certain chemical reactions within the body generate charged molecules, called free radicals, which are susceptible to electric fields. The electric fields may affect how many free radicals are generated, the orientation of the free radicals in space, or the orientation of the electrons within the free radical. These phenomena may, in turn, affect the amount or type of product that results from a chemical reaction within the body. (ICNIRP, 1993)

4.1.2 Magnetic Field Interactions

Time-varying magnetic fields couple with the human body and result in induced electric fields, which in turn result in electric currents within the body. The magnitude of the effect depends on the strength of the magnetic field, the size of the person, and the type of tissue exposed. (ICNIRP, 1997)

Certain portions of the body are more susceptible to magnetic fields. Blood, for example, is made up of many charged particles, called electrolytes, flowing through the body. These electrolytes can interact with a magnetic field, thereby causing an electric current within the body as the blood flows. The effect is compounded when human beings move within the magnetic fields, which causes more variation of the magnetic field strength, which in turn causes variations of the induced electric current. (ICNIRP, 1993)

4.1.3 Magnetic Field Energy Transfer

For stationary magnetic fields (magnetic fields that do not vary with time), the human body can absorb energy from the fields, causing an increase in body temperature. The energy is absorbed as the ions within the human body attempt to align themselves with the magnetic field, much as a compass needle attempts to orient itself with the Earth's magnetic field. (ICNIRP, 1993) This effect is only significant for EMFs with frequencies above 100 kHz. (ICNIRP, 1997)

4.2 HEALTH EFFECTS OF EMFS

Scholarly journals and the Internet are replete with studies reporting the health effects of EMFs. AECOM has attempted to supply a representative, although not exhaustive, list of articles illustrating the many research studies that have been published in the past 20 years. Because this research was focusing on the ramifications of using WLANs in public schools, the rest of the report will focus specifically on RF EMF. However, because the Bioinitiative Report (2007) maintains that divisions between different frequency regions are artificial, that exposure to multiple EMF frequencies may be additive, and that all EMFs have the potential to adversely affect the human body regardless of frequency, the following discussion includes other portions of the electromagnetic spectrum. For clarification, **Figure 4-1** illustrates the ICNIRP general public and occupational exposure limits and the frequency bands of interest. (The graph is presented based on the electric field, in volts per meter [V/m].)

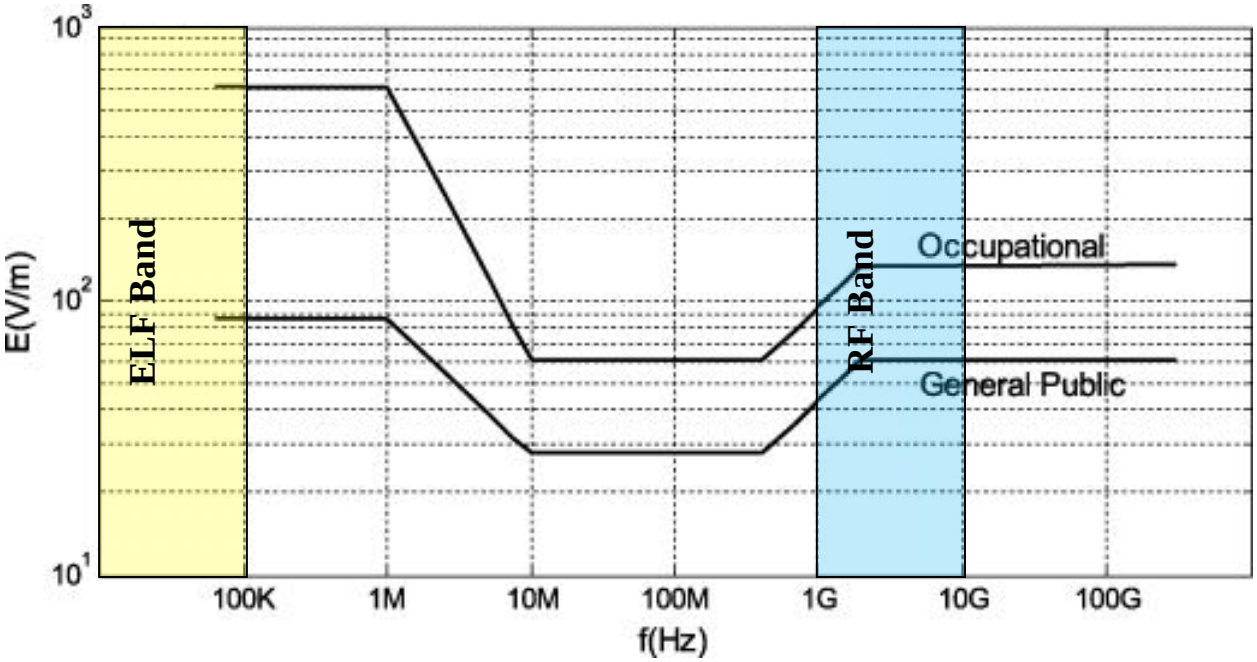

Figure 4-1: *ICNIRP EMF limits as a function of frequency.*

4.2.1 ICNIRP

The ICNIRP consulted only reliable research during their EMF research. Based on these criteria, the following adverse health effects may be suspected with EMF exposure: (ICNIRP, 2001)

(1) Childhood cancer

(2) Adult leukemia

(3) Brain tumors

(4) Breast cancer

(5) Cardiovascular disease

(6) Neurological disorders (depression and suicide)

Of those listed, childhood cancer, especially childhood leukemia, has the largest and most compelling body of research, which directly links the incidence of childhood cancer with increased ELF EMF exposure.

More recently, studies have begun to link ELF EMF exposure to adult leukemia and brain tumors. However, a new report by the ICNIRP in 2010 determined that only childhood leukemia was linked to ELF EMF exposure, and only weakly. Other studies have suggested that RF EMF exposure can cause other types of adult cancer (Bioititiative Report, 2007), however insufficient evidence is currently available to verify or refute this claim. Future research will be necessary to determine whether EMF exposure is linked to other forms of cancer. The research that studied brain tumors focused primarily on EMF exposure from cellular phones.

Breast cancer, cardiovascular disease, and neurological disorders have been implicated with increased exposure to EMFs. However, these are more recent findings that have not yet been reproduced or verified. A conservative stance would caution against undue EMF exposure in order to mitigate all potential adverse health effects.

Note: while case studies are not generally applicable to the entire population, the European Union has acknowledged that a certain portion of the population may be susceptible to a disorder called "EMF hypersensitivity." Such individuals appear to suffer adverse health effects from exposure to much smaller EMF doses than the general population. However, this disorder has not been acknowledged within the US.

4.2.2 NIH

The US National Institutes of Health (NIH) tasked the National Institute of Environmental Health Sciences (NIEHS) with studying and making recommendations on EMF and human health. NIEHS has put out a series of reports outlining their interpretations and recommendations (NIEHS 1998, 1999, 2002). The NIEHS concludes that for most health outcomes, evidence is not available to substantiate that EMF exposures have adverse health effects. The NIEHS calls for more studies and continued education on ways of reducing exposures.

4.2.3 EU

The European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN) monitors and searches for evidence of the health risks associated with exposure to EMFs. Their latest report (2010) summarized the published literature to date and concluded that, for high frequency RF exposure, insufficient evidence is available to substantiate a causal association between EMF exposure and risk of any disease. The study pointed out that results of the international analyses of glioma and meningioma risk in the Interphone study have been published, which indicated that while an association between mobile phone use and risk of these diseases has not been demonstrated, the study also does not demonstrate an absence of risk. Because most of the subjects in Interphone were light users compared to users today, especially

young people, EFHRAN called for further research to evaluate the possible association between RF exposure and risk of tumors. EFHRAN concluded that the possibility remains that long-term mobile phone use may induce symptoms, such as migraine and vertigo, and further work is required to clarify this issue.

4.2.4 Bioinitiative Report

As discussed above, the Bioinitiative Report (2007 and 2012) is a publication released on the internet by a group of 14 "…scientists, public health and public policy experts to document the scientific evidence on electromagnetic fields." The report claims to have evidence for the following effects of exposure to EMF:

- Modification of gene and protein expression
- Genotoxic effects
- Stress protein response
- Immune function modification
- Effects on neurology and behavior
- Brain tumors and acoustic neuromas
- Childhood cancers
- Melatonin production
- Alzheimer's disease
- Breast cancer

The Bioinitiative Report has garnered much attention from groups both for and against the recommendations. Discussed briefly below is a summary of both sides.

4.2.4.1 Support

Supporters of the Bioinitiative Report cite the following points:

- The Report was an international collaboration between scientists from countries in Europe, North America, and Asia.
- Countries around the globe have varying regulatory limits for EMF exposure, which vary from 1,000 $\mu W/cm^2$ to 10 $\mu W/cm^2$. Thus, no consensus has been reached regarding the issue.
- Insufficient research currently exists to draw definitive conclusions on whether a link is present between adverse health effects and EMFs.
- Current research has indicated a link between childhood leukemia and residential proximity to power lines. Thus, preliminary evidence indicates an adverse link between EMF exposure and human health.

- EMFs have been used medically to heal bone fractures at levels lower than current regulatory limits. This would argue against detractors' claims that no evidence for health effects of EMFs has been observed below regulatory limits.
- The International Agency for Research on Cancer (IARC), which is a part of the World Health Organization (WHO), has classified EMF exposure as a "possible carcinogen," indicating that EMFs may have adverse health effects.
- In light of these points, supporters argue that adoption of the "Precautionary Principle" is justified. This principle states that, until more definitive research is conducted and a link between EMFs and human health is verified or denied, human beings should assume that a negative health impact may exist and take precautions for protection from EMFs.

4.2.4.2 Criticism

The two co-editors of the report, Sage and Carpenter, have attempted to publish the salient points of the Bioinitiative Report in various sources (2009), however the paper has been listed as "in press" since 2009.

The Bioinitiative Report has come under fierce scrutiny from scientists around the world. For a comprehensive summary of the criticism, see EMF-Link (2012). An outline of salient points is presented here:

- The work is a conglomeration of 14 scientists' reports, which is a relatively small group compared to the vast amount of research conducted by hundreds of researchers around the world.
- Statements made by authors of the report have been classified as misleading, such as the suggestion by Ollie Johansson that lung cancer is not caused only by smoking, but is exacerbated by RF exposure.
- Several of the papers cited by the Bioinitiative Report have been accused of scientific fraud and have been withdrawn from publication by the authors.
- Many countries and organizations have criticized the paper, including the following:
    - EMF-NET (part of the EU)
    - IEEE
    - The Health Council of the Netherlands
    - Australian Centre of Radiofrequency Bio-effects Research
    - EPRI
    - Mobile Manufacturers Forum
    - German Federal Office for Radiation Protection
    - French Agency for Environmental and Occupational Safety
- The report fails to mention the inverse square law applicable to EMFs, which is that the intensity of the EMF decreases as a function of $1/r^2$, where "r" represents the distance

from the EMF source. Thus, for a given power density at 1 foot from an EMF source, the power density would be ¼ of this value at 2 feet from the source.

- The 2007 report make the recommendation of 0.1 μW/cm^2, while the 2012 report decreases the precautionary limit to 300 pW/cm^2 (0.0003 μW/cm^2) for children, which is larger than naturally-occurring background EMF levels.

4.2.5 2007 Release

Based on medical applications of EMF exposure in therapeutic settings as well as on research reports that claim an adverse EMF health effect at levels lower than regulatory limits, the 2007 Bioinitiative Report advocates a markedly-lower EMF exposure limit by way of a cautionary level of 0.1 μW/cm^2. Note that this recommendation is several orders of magnitude lower than regulatory limits, making the Bioinitiative Report the first entity to make such a recommendation.

4.2.6 2012 Release

The 2012 report advocates an EMF exposure limit by way of a cautionary level of 0.0003 μW/cm^2, which is 1,000 times lower than the 2007 recommendation, and reserves the right to lower this level even farther.

However, the 2012 cautionary level is so extreme as to be unrealistic. The value of 0.0003 μW/cm^2 is below the ambient (background) power density regardless of location, as illustrated in **Table 4-1** below.

Table 4-1: Summary of Ambient Power Densities

Type	Power Density («W/cm^2)	Details	Source
Bioinitiative Report 2012	0.0003		
Ambient RF (1 GHz to 3.5 GHz)	0.0063	In an urban environment	Bouchouicha, *et al.* 2010
Ambient Indoor light	100		Vullers *et al.* 2009
Ambient Outdoor light	100,000		
Ambient RF	0.01	European residence	Bolte & Eikelboom, 2012
Cell Phone	300		Vullers *et al.* 2009
Ambient laboratory	0.001	No high-powered equipment operating	Hagerty *et al.* 2004
WLAN signal	0.001	7 meters (21 feet) from source	Vullers *et al.* 2008
	0.00001	12 meters (36 feet) from source	

In addition, the World Meteorological Organization (WMO) conducted ambient RF EMF measurements in a variety of settings across the United States, including urban, suburban, rural, and airport environments (Leck, 2006). The WMO found no difference between the magnitudes of the RF EMF power density regardless of location. This indicates that urban environments, where theoretically more RF EMF-generating equipment is in use compared to rural environments, did not have elevated RF EMF levels compared to rural environments.

Since background RF EMF levels are above the 2012 Bioinitiative Report precautionary level, this level is unrealistic and unattainable. Background sources include man-made sources, like television, cellular and radio signals, as well as natural sources, like cosmic radiation and the sun.

5.1 MCPS EQUIPMENT

MCPS currently provides Acer C720 Chromebooks for student use in classrooms. The classrooms are provided with one of two types of APs: Cisco Aironet Series 2600 or Aerohive AP230. The predominant model is the Cisco AP. Both models of APs are dual band, which follow the IEEE 802.11n standard. The IEEE 802.11n standard operates in the RF band of the EM spectrum, between 2.4 and 2.5 GHz and 5.150 and 5.950 GHz.

5.2 SCHOOLS SURVEYED

AECOM representatives conducted RF measurements at the following schools:

Table 5-1: Measurement Types

School	Access Point	ChromeBook	Charging Station
Gaithersburg High School	X	X	
Wootton High School	X	X	
Carbin John Middle School	X	X	
Churchill High School	X	X	
Bells Mill Elementary School	X	X	
Beverly Farms Elementary School	X	X	
Fallsmead Elementary School	X	X	
Little Bennett Elementary School		X	
William Wims Elementary School			X
Arcola Elementary School	X	X	
Goshen Elementary School	X		
Strawberry Knoll Elementary School	X	X	

5.3 SCHEDULE

The study was conducted over the course of several days, as summarized in the table below.

Table 5-2: Measurement Schedule

Date	School
Wednesday, June 3, 2015	Wootton High School
	Gaithersburgh High School

Table 5-2: Measurement Schedule	
Date	**School**
Thursday, June 4, 2015	Cabin John Middle School
	Churchill High School
Friday, June 5, 2015	Bells Mill Elementary School
Monday, June 8, 2015	Fallsmead Elementary School
	Beverly Farms Elementary School
Tuesday, June 9, 2015	Little Bennett Elementary School
Wednesday, June 10, 2015	William Wims Elementary School
	Arcola Elementary School
	Goshen Elementary School
Thursday, June 11, 2015	Strawberry Knoll Elementary School

6.1 DURATION OF MONITORING EVENTS

Monitoring was conducted while Chromebooks and access points were in use. Data were collected for six minutes while students were actively engaged in using their Chromebook devices. Monitoring involved approximately 550 millisecond sweeps, resulting in approximately 650 data sets being collected within the 6-minute monitoring time. Data were collected in 6-minute increments at set distances from the APs and Chromebook devices.

6.2 MONITORING EQUIPMENT

The monitoring was conducted using the Narda Selective Radiation Meter Model 3006 (SRM 3006). The SRM 3006 was used to perform narrowband spectral analysis of application and individual classroom RF transmissions associated with the use of Chromebooks and access points (APs) across designated frequencies of 2 to 5 gigahertz (GHz). Two different Narda probes were used to measure the electric field, and one probe was used to measure the magnetic field, as summarized in the table below. Calibration certificates for all equipment used in this study is provided in **Appendix A**.

Table 6-1: Probes Used

Probe Model	Type of Field	Frequency Range
3501/03	Electric Field	27 MHz to 3 GHz
3502/01	Electric Field	420 MHz to 6 GHz
3531/02	Magnetic Field	9 KHz to 300 MHz

6.3 MONITORING DISTANCES

Measurements were taken for both Chromebooks and APs at distances of one inch, one foot, two feet, and, if noticeable levels were present, three feet. Classroom measurements were taken predominantly at the user's interface (desk level). Measurements are summarized in the table below.

Table 6-2:
Measurement Distances from APs and Chromebooks

Distance (in)	Electric Field	Magnetic Field
1	X	X
6	X	X

Table 6-2: Measurement Distances from APs and Chromebooks		
Distance (in)	**Electric Field**	**Magnetic Field**
12	X	X
24	X	X
36	X (if needed)	

6.4 MONITORING PROTOCOL

A discrete monitoring protocol was developed by AECOM for use during the classroom RF studies, as detailed below.

6.4.1 Preparation

6.4.1.1 Day Before

- Receive the SRM unit for studies from shipped location or reconfirm the unit is available
- Test the SRM base unit and probes in office with 5 GHz enabled router
- Perform a test of data download routine with assigned laptop preloaded with SRM software
- Keep unit plugged into the wall to charge the battery and charge the second battery

Note: Use the three-axis antenna isotropically to measure all axis (three spacial components) at once. The isotropic measurement will be set by default, do not change this setting.

6.4.1.2 Day of Empirical (In-School) Study

- Unpack SRM and three-axis antenna, assemble in pre-established set-up location
- Establish an initial baseline to determine that the SRM is operating as assigned (parameter selection).
- Plug in the SRM to an electrical outlet and turn the SRM on with on/off button
- Activate the laptop and specifically the SRM software
- Hook the SRM to the laptop using the USB cable
- Determine that the three-axis antenna is being read by the SRM. The three-axis antenna should be used in the isotropic mode. The upper left hand corner of the laptop screen will show the type of three-axis antenna and cable in use.

6.4.1.3 One hour before a Study

- Confirm the following settings on the display: from upper left corner clockwise:

- Battery: will show charge level or Ext. Power if plugged into the wall. If plugged into the wall unplug to confirm battery is fully charged.
- Clock and Time
- GPS: ---
- Ant: 3AX 0.4-6 G
- Cable: 1.5 m
- SrvTbl: Ex-W-LAN Over
- Stnd: IEEE GP
- Progress: Not adjustable
- No. of Runs: changes as collecting data
- AVG: 4
- Sweep time in ms, varies depending on other settings
- Fmax: Adjustable depending on field conditions
- RBW: Adjustable depending on field conditions
- MR: Adjustable depending on field conditions
- VBW: Off
- Fmin: Adjustable depending on field condition
- MR: Adjustable depending on field condition

6.4.2 Perform the Study – Adjust Settings

- Go to the study location
- Turn the SRM on.
- From Main Menu: Select the SRM to Spectrum (analyis mode).
- Select the Result type using the result type soft key. Select ACT for actual, AVE for average (average of the actual), MAX for Maximum, and MxA for Maximum Average (average of the maximum).
- If the display is not reading out in the correct display units, change the units displayed, use the Display and then Unit soft keys. In general select V/m (for E-field) is selected; then the X axis soft key should be toggled so that the optimum display units are shown.
- Set the time setting for 6 minutes.
- Determine and adjust if necessary the a) resolution bandwidth RBW to the lowest option (highest resolution), b) measurement range (Meas. Range) for the study, and c) frequency ranges (Fmin and Fmax)

6.4.2.1 Resolution band width (RBW)

- The RBW determines the ability of the SRM to distinguish between signals having the same bandwidth and different frequencies
- See section 6.2 from the owners manual

6.4.2.2 Measurement Range (MR)

- Begin MR automatic selection by selecmting the MR Search soft key. However, make adjustments if the MR automatically set shows an overdriven warning.

Overdriven indicates that the signal range is higher than that which can be measured. If this is the case, manually set the MR to the next higher using the Meas Range softkey. In some cases, you may also need to switch to a conservative rather than the normal measurement search type by using the MR Search soft key. The intent is to avoid over saturation (often caused by interferring and other than iPAD signals operating outside the SRM frequency measurement range) while still having appropriate input attenuator settings (aks sensitivity). See Owners Manual Insert 6.3.1 through 6.3.3 for details on setting the Measurement Range.

6.4.2.3 Frequency

- Select the full scan frequency range from the upper right hand softkey panel.
- Set frequency minimum and maximum using the upper right SRM soft keys to capture the full spectrum of the probe for magnetic fields and the frequency ranges of the WiFi for the electric fields (2.4 GHz to 6 GHz). See manual insert 8.2.1 for details on selecting frequency minimum and maximum.

6.4.3 Perform the Study—Background

- Collect background readings outside of the school, such as in a parking lot or field.
- Collect a six-minute background sample for both the electric and magnetic fields.

6.4.4 Perform the Study – Room Survey

- Keep hard copy notes that include the schools, days, and room numbers.
- Conduct a minimum of four data runs on a Chromebook holding the probe bulb at locations 1 inch, 6 inches, one foot, and two feet from the Chromebook. If noticeable signal is still present at two feet, collect another data run at three feet.
- Conduct a minimum of four data runs on a the AP holding the probe bulb at locations 1 inch, 6 inches, one foot, and two feet from the AP. If noticeable signal is still present at two feet, collect another data run at three feet.
- Data runs should be collected using both the electric and magnetic field probes.
- Locations should include the following if possible:
  - Location representing the worst case between AP units or in front of AP units, experience has shown highest levels are found at a location that forms the corner of an isosceles triangle at the height of the AP units.
  - Location within 8 inches of the back of an individual student actively running an application.
  - Location where a table or group of students are working together.

After each study interval download the information from the SRM to the laptop computer (loaded with SRM software).

6.5 EQUIPMENT

Different equipment was available over the course of the study. While the same magnetic field probe (3531/02) was available for the duration of the study, different electric field probes were available. The electric probes used are summarized in the table below.

Table 6-3: Electric Probes Used

School	Electric Field Probe
Wootton High School	3501/03
Gaithersburg High School	
Cabin John Middle School	
Churchill High School	
Bells Mill Elementary School	
Fallsmead Elementary School	3502/01
Beverly Farms Elementary School	
Little Bennett Elementary School	
William Wims Elementary School	
Arcola Elementary School	
Goshen Elementary School	
Strawberry Knoll Elementary School	

This section presents a summary of the evaluations of near-field exposures during the operation of APs and use of selected end-devices (Chromebooks).

Each evaluation presented in this section is composed of varied measurements that were collected with the SRM 3006 operating in spectrum analysis mode. Each measurement was collected at a specific location for a six-minute interval, while students were actively engaged in activities that required them to access the AP on their Chromebooks.

The SRM 3006 can report various field strength outputs such as average (AVE), Maximum (MAX), and Minimum (MIN) for each frequency range. For this evaluation, the maximum value was recorded for each data sweep (550 milliseconds), and data analysis was performed on the set of 650 measurements taken within the 6-minute time interval to determine the average value. Calculations were performed in this manner in order to capture both the instantaneous ("worst-case") values as well as the time-averaged values.

Note that all electric field measurements were collected in V/m. These measurements were then converted into power density using the following equation:

$$P_D = (E)^2/Z_o$$

where

P_D = Power Density, in W/m^2
E = Electric field, in V/m
Z_o = Characteristic impedance of free space, 377 Ohms

Both instantaneous E-field measurements and time-averaged E-field measurements were converted into power density in the following tables.

7.1 BACKGROUND READINGS

In order to characterize the background EMF in the vicinity of the school, EMF measurements were collected outside of each school in a parking lot or athletic field at each location. The table below summarizes the magnitude of the electric field in V/m, the power density in $\mu W/cm^2$, and the magnetic field in A/m.

Table 7-1: Background Readings

School	Maximum E (V/m)	Average E (V/m)	Maximum Power Density («W/cm²)	Average Power Density («W/cm²)	Maximum H (A/m)	Average H (A/m)
Wootton High School	1.51×10^{-2}	1.1×10^{-2}	6.07×10^{-5}	3.21×10^{-5}	6.57×10^{-2}	5.98×10^{-2}
Gaithersburg	5.48×10^{-2}	1.74 x	7.96×10^{-4}	8.00×10^{-5}	5.99×10^{-2}	1.74 x

Table 7-1: Background Readings						
School	**Maximum E (V/m)**	**Average E (V/m)**	**Maximum Power Density («W/cm^2)**	**Average Power Density («W/cm^2)**	**Maximum H (A/m)**	**Average H (A/m)**
High School		10^{-2}				10^{-2}
Cabin John Middle School	2.25×10^{-2}	1.52×10^{-2}	1.34×10^{-4}	6.09×10^{-5}	5.13×10^{-2}	4.26×10^{-2}
Churchill High School	8.30×10^{-2}	1.58×10^{-2}	1.83×10^{-3}	6.60×10^{-5}	7.25×10^{-2}	6.64×10^{-2}
Bells Mill Elementary School	1.75×10^{-1}	2.69×10^{-3}	8.08×10^{-3}	1.92×10^{-6}	7.57×10^{-2}	6.76×10^{-2}
Fallsmead Elementary School	2.07×10^{-1}	1.62×10^{-2}	1.13×10^{-2}	6.94×10^{-5}	5.15×10^{-2}	4.74×10^{-2}
Beverly Farms Elementary School	6.15×10^{-2}	2.58×10^{-2}	1.00×10^{-3}	1.76×10^{-4}	6.21×10^{-2}	2.31×10^{-5}
Little Bennett Elementary School	1.24×10^{-1}	1.83×10^{-2}	4.07×10^{-3}	8.86×10^{-5}	4.60×10^{-2}	4.24×10^{-2}
William Wims Elementary School	2.74×10^{-1}	1.49×10^{-2}	1.99×10^{-2}	5.91×10^{-5}	2.74×10^{-1}	2.98×10^{-2}
Arcola Elementary School	1.10×10^{-1}	3.67×10^{-2}	3.23×10^{-3}	3.56×10^{-4}	4.74×10^{-1}	4.69×10^{-1}
Goshen Elementary School	1.81×10^{-1}	3.08×10^{-2}	8.72×10^{-3}	2.52×10^{-4}	5.66×10^{-2}	5.30×10^{-2}
Strawberry Knoll Elementary School	1.42×10^{-1}	1.80×10^{-2}	5.33×10^{-3}	8.57×10^{-5}	8.75×10^{-2}	8.38×10^{-2}

7.2 IN SCHOOL EVALUATIONS

Data from all schools is summarized below. Original, raw data is provided for reference in **Appendix B** in electronic format.

Initial data analysis was performed by collecting all 650 files—where each file represents one sweep—into one Excel file. Data for each frequency were then averaged together to generate the 6-minute time-averaged value. A graph of the time-averaged value as a function of frequency was generated. A comparison was also performed of all individual field values within the data set to identify the highest reading recorded by the meter during the 6-minute interval. This was done so that a comparison between the maximum value and the time averaged value could be performed. Finally, the maximum time-averaged value was identified.

Data analysis files are provided in **Appendix C** in electronic format. Note that **Appendix C** includes the following analysis:

- Averages as a function of frequency.
- Maximum field values – the maximum electric and magnetic instantaneous value measured during the sweeps.
- Maximum average field values – the maximum average electric and magnetic field value from all frequencies measured.
- Graphical representations of the average field values as a function of frequency.

Figure 7-1 below presents a typical graph of the average electric field for an access point measured at one foot away, while **Figure 7-2** below presents a typical graph of the average electric field for a Chromebook measured at one foot away as part of this study.

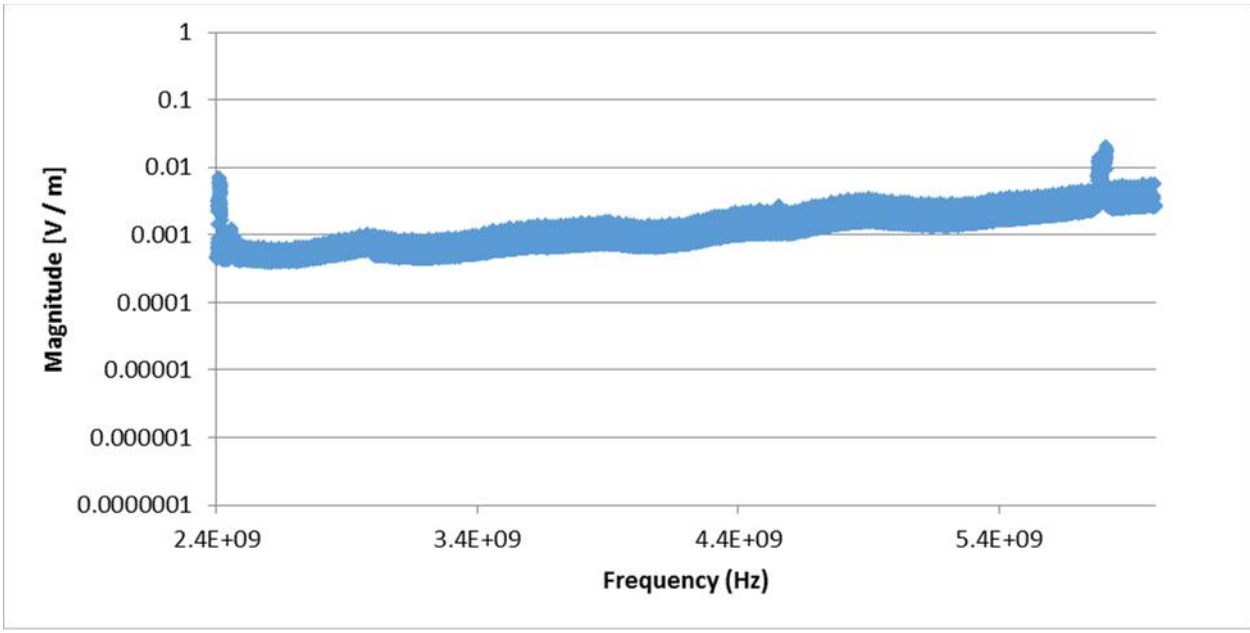

Figure 7-1: *Measurement of the average electric field generated at one foot away from an AP in use at Beverly Farms Elementary School. Note the peaks on the left and right, which are characteristic frequencies of the 802.11n protocol.*

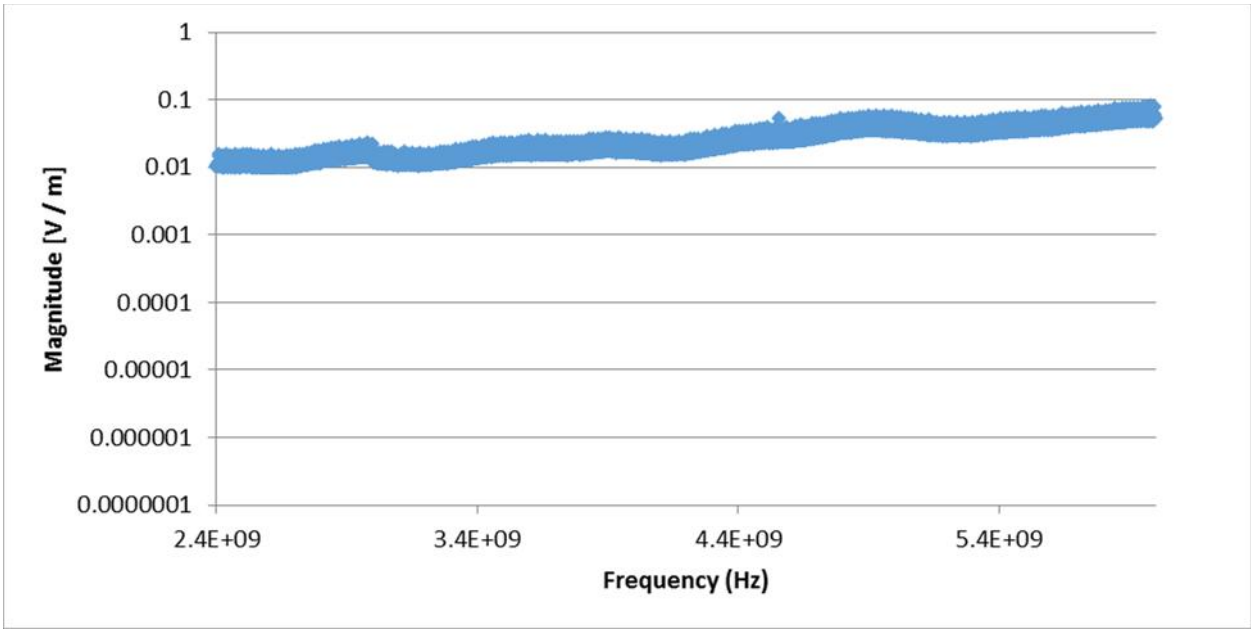

Figure 7-2: *Measurement of the average electric field generated at one foot away from a Chromebook while in use for 6 minutes. Note that the average values result in a relatively flat line, as the amount of time that the Chromebook spends interacting with the AP is actually quite low.*

Appendix D contains the next phase of the data analysis. **Appendix D** contains the maximum instantaneous magnitude of the electric field, the maximum average magnitude of the electric

field, the maximum instantaneous power density, the maximum average power density, the maximum instantaneous magnetic field and the maximum average magnetic field, all organized by school, by distance from the device, and by type of device measured. For each school and each type of measurement, the maximum value for the average power density is highlighted in yellow.

A summary of the data for each school as a function of the type of data collected is provided below.

7.2.1 Average Power Density

7.2.1.1 Access Points

The maximum value for the average power density associated with each access point and school is summarized below, along with a comparison of national and international guidelines for exposure to RF fields.

Table 7-2: Access Point Analysis

School	Maximum Average Power Density («W/cm^2)	Bioinitiative Report 2007 Precautionary Action Level («W/cm^2)	Bioinitiative Report 2012 Precautionary Action Level («W/cm^2)	IEEE MPE («W/cm^2)	ICNIRP Guidelines («W/cm^2)
Wootton High School	1.24×10^{-4}	0.1	3×10^{-4}	10,000	10,000
Gaithersburg High School	1.27×10^{-5}				
Cabin John Middle School	1.14×10^{-5}				
Churchill High School	9.72×10^{-4}				
Bells Mill Elementary School AP Rm 149	8.50×10^{-4}				
Bells Mill Elementary AP Rm 223	1.40×10^{-4}				
Fallsmead Elementary School	6.83×10^{-5}				
Beverly Farms Elementary School	2.51×10^{-4}				
Arcola Elementary	3.62×10^{-3}				

Table 7-2: Access Point Analysis					
School	Maximum Average Power Density («W/cm^2)	Bioinitiative Report 2007 Precautionary Action Level («W/cm^2)	Bioinitiative Report 2012 Precautionary Action Level («W/cm^2)	IEEE MPE («W/cm^2)	ICNIRP Guidelines («W/cm^2)
School					
Goshen Elementary School	7.37×10^{-4}				
Strawberry Knoll Elementary School	2.22×10^{-3}				

All measured values for APs are under the IEEE MPE limit, the ICNIRP guidelines, and the Bioinitiative Report 2007 precautionary action level, as illustrated in **Figure 7-3**. Most AP values were also under the Bioinitiative Report 2012 precautionary level. Note that the only regulatory agency in the United States for RF exposure is the FCC, which has adopted the IEEE MPE standard in the table above. All MCPS RF exposures from AP devices are well below the FCC regulatory limit. Original graphs are contained in **Appendix D**.

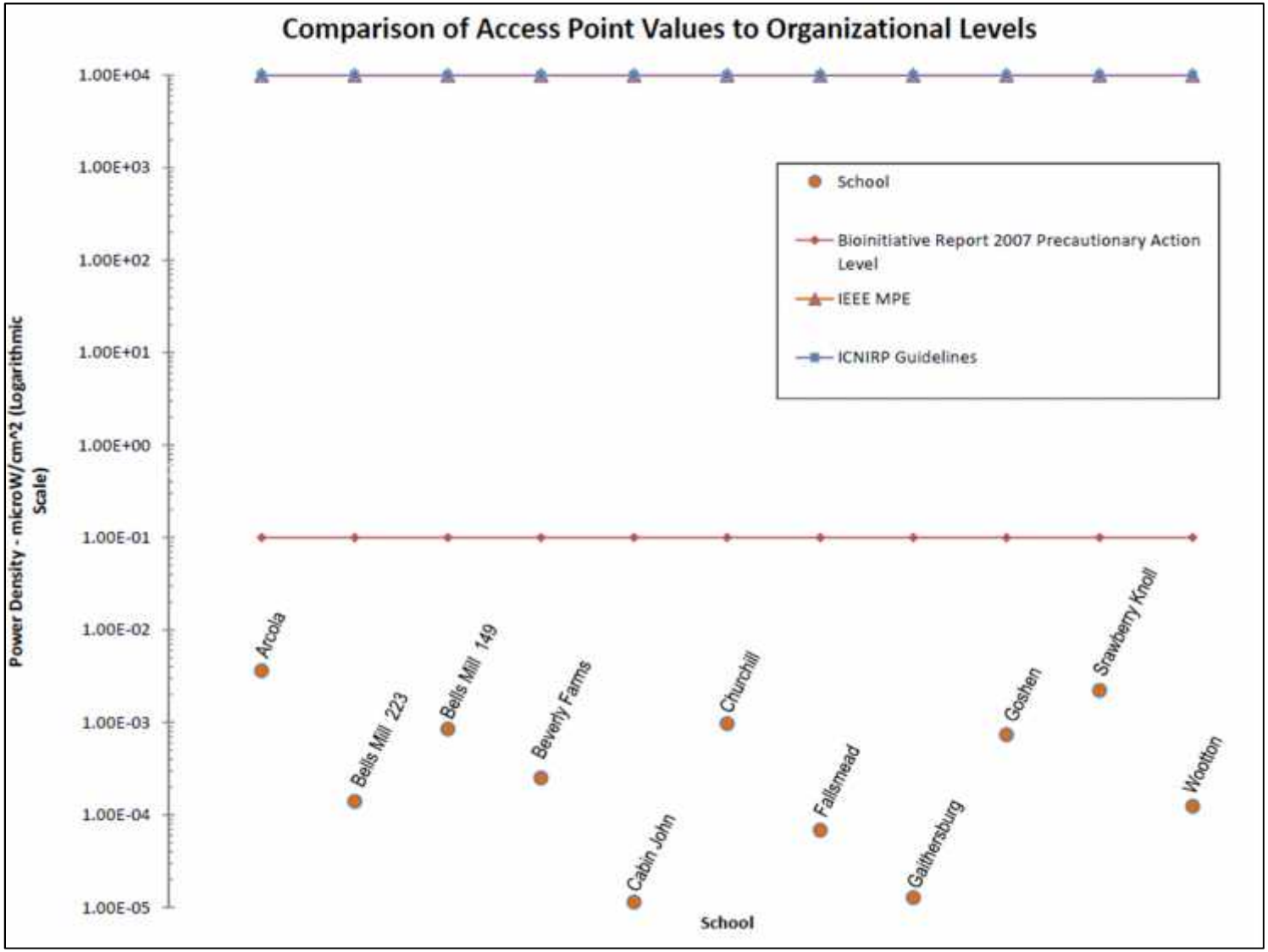

Figure 7-3: *A comparison of the AP average measurements in schools to various organizational levels.*

7.2.1.2 Chromebooks

The maximum value for the average power density associated with each Chromebook measurement and school is summarized below, along with a comparison of national and international guidelines for exposure to RF fields.

Table 7-3: Chromebook Analysis

School	Maximum Average Power Density («W/cm^2)	Bioinitiative Report 2007 Precautionary Action Level («W/cm^2)	Bioinitiative Report 2012 Precautionary Action Level («W/cm^2)	IEEE MPE («W/cm^2)	ICNIRP Guidelines («W/cm^2)
Wootton High School	1.54×10^{-3}	0.1	3×10^{-4}	10,000	10,000
Gaithersburg High School	3.45×10^{-5}				
Cabin John Middle School	7.21×10^{-5}				
Churchill High School	1.79×10^{-3}				
Bells Mill Elementary School Rm 149	1.99×10^{-4}				
Bells Mill Elementary Rm 223	3.44×10^{-3}				
Fallsmead Elementary School	7.41×10^{-4}				
Beverly Farms Elementary School	7.36×10^{-3}				
Little Bennett Elementary School	1.21×10^{-3}				
Arcola Elementary School	1.23×10^{-2}				

Table 7-3: Chromebook Analysis					
School	Maximum Average Power Density («W/cm^2)	Bioinitiative Report 2007 Precautionary Action Level («W/cm^2)	Bioinitiative Report 2012 Precautionary Action Level («W/cm^2)	IEEE MPE («W/cm^2)	ICNIRP Guidelines («W/cm^2)
Strawberry Knoll Elementary School	7.70×10^{-4}				

All values measured for Chromebooks are under the IEEE MPE limit, the ICNIRP guidelines, and the Bioinitiative Report 2007 precautionary action level, as illustrated in **Figure 7-4**. Most Chromebook values were also under the Bioinitiative Report 2012 precautionary level. Note that the only regulatory agency in the United States for RF exposure is the FCC, which has adopted the IEEE MPE standard in the table above. All MCPS RF exposures from Chromebooks are well below the FCC regulatory limit. Original graphs are contained in **Appendix D**.

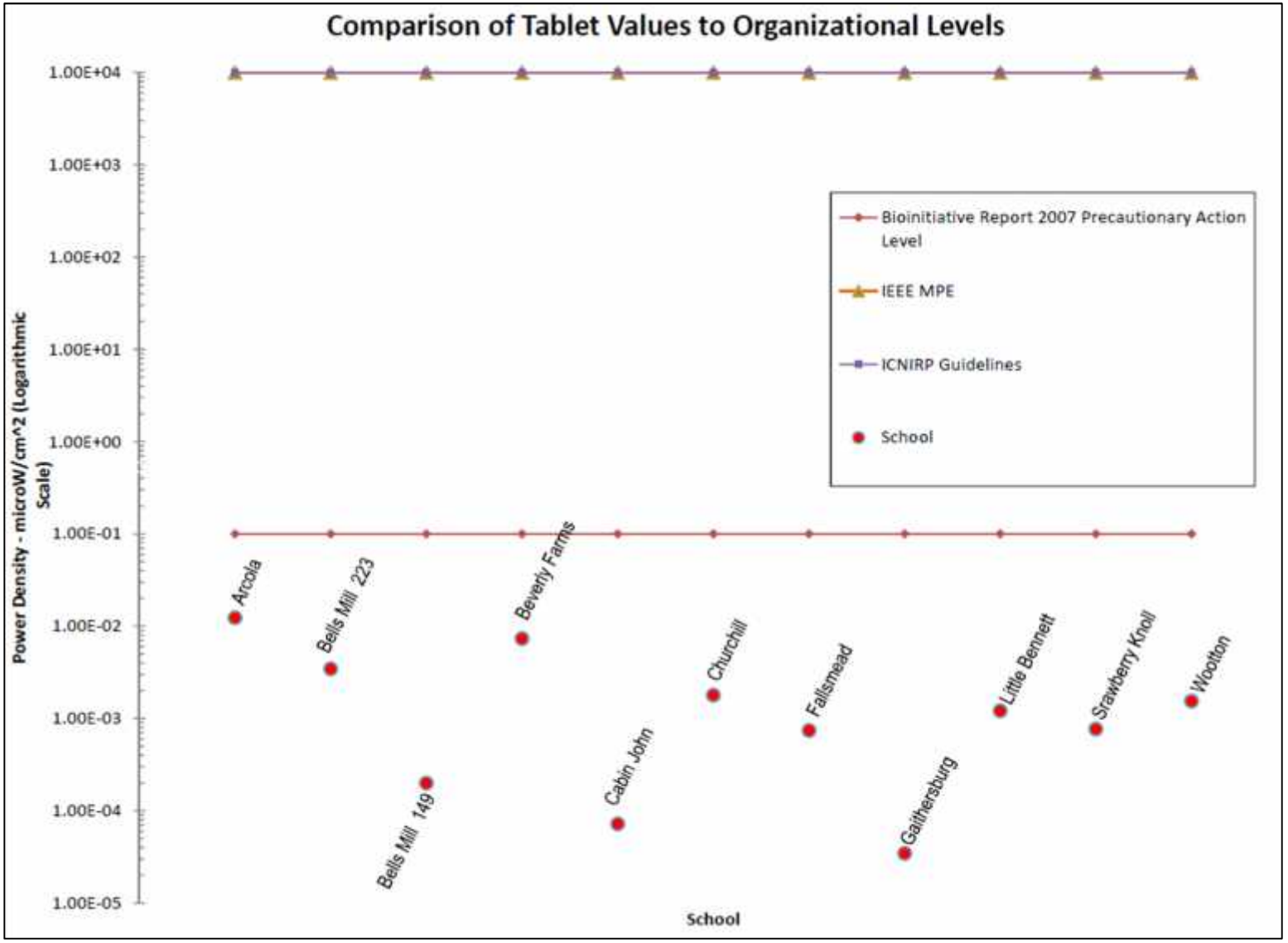

Figure 7-4: *A comparison of the Chromebook average measurements in schools to various organizational levels.*

7.2.2 Maximum, Instantaneous Power Density

For comparison, the maximum, instantaneous power density associated with the highest electric field measurement for both Chromebooks and APs is included below. These values are included only for comparison to the time-averaged power density. Note that these values are not used for regulatory compliance, but do serve as information for the maximum values that students may be exposed to during the course of normal work on the Chromebooks.

7.2.2.1 Access Points

Table 7-4 below summarizes the maximum power density observed at each location for each AP measured.

Table 7-4: Maximum Instantaneous Power Density from APs

School	Power Density («W/cm²)
Wootton High School	1.95×10^{-2}
Gaithersburg High School	1.05×10^{-2}
Cabin John Middle School	2.67×10^{-2}
Churchill High School	2.45×10^{-1}
Bells Mill Elementary School AP Rm 149	7.50×10^{-2}
Bells Mill Elementary AP Rm 223	1.65×10^{-2}
Fallsmead Elementary School	4.20×10^{-1}
Beverly Farms Elementary School	2.38×10^{-1}
Arcola Elementary School	5.69×10^{0}
Goshen Elementary School	5.42×10^{-2}
Strawberry Knoll Elementary School	2.33×10^{0}

Note that instantaneous power density values were in the $\mu W/cm^2$ or lower range.

7.2.2.2 Chromebooks

Table 7-5 below summarizes the maximum power density observed at each location for Chromebooks.

Table 7-5: Maximum Instantaneous Power Density from Chromebooks	
School	**Power Density** («W/cm²)
Wootton High School	1.95×10^{-2}
Gaithersburg High School	1.36×10^{-1}
Cabin John Middle School	4.01×10^{-3}
Churchill High School	1.26×10^{-2}
Bells Mill Elementary School Rm 149	2.10×10^{-2}
Bells Mill Elementary Rm 223	1.18×10^{-2}
Fallsmead Elementary School	8.10×10^{-2}
Beverly Farms Elementary School	2.83×10^{-2}
Little Bennett Elementary School	3.98×10^{-2}
Arcola Elementary School	7.92×10^{-2}
Strawberry Knoll Elementary School	4.81×10^{-2}

Note that instantaneous power density values were in the $\mu W/cm^2$ or lower range.

7.2.3 Charging Station

The charging station at William Wims Elementary School is located in the Training-Conference room. AECOM personnel were specifically requested to collect data on the charging station as part of this study. **Table 7-6** below summarizes the electric, magnetic, and power density information collected during this study.

Table 7-6: Charging Station Analysis							
Measurement Type	Dis-tance (in)	Max E (V/m)	Max Power Density («W/cm^2)	Avg E (V/m)	Avg Power Density («W/cm^2)	Max H (A/m)	Avg H (A/m)
Charging Station	1	5.47x 10^{-1}	7.93x 10^{-2}	2.69x 10^{-1}	1.92x 10^{-2}	4.68x 10^{-1}	4.63x 10^{-1}
	6	3.31x 10^{-1}	2.90x 10^{-2}	5.53x 10^{-2}	8.12x 10^{-4}	8.70x 10^{-2}	8.28x 10^{-2}
	12	4.70x 10^{-1}	5.86x 10^{-2}	4.48x 10^{-2}	5.32x 10^{-4}	1.88x 10^{-1}	1.83x 10^{-1}
	24	2.96x 10^{-1}	2.33x 10^{-2}	3.87x 10^{-2}	3.98x 10^{-4}	5.52x 10^{-2}	5.17x 10^{-2}
	36	3.19x 10^{-1}	2.70x 10^{-2}	1.11x 10^{-1}	3.29x 10^{-3}		
Parking Lot	Back-ground	2.74x 10^{-1}	1.99x 10^{-2}	1.49x 10^{-2}	5.91x 10^{-5}	2.74x 10^{-1}	2.98x 10^{-2}

In general, values obtained for the electric field, power density, and magnetic field were similar to background levels, as illustrated in **Table 7-6**. This is not surprising, since charging stations generally do not emit appreciable RF EMF. Charging stations operate on 60-Hz AC from a wall outlet. Measuring EMF from 60-Hz AC was outside the scope of this study, which focused on RF EMF levels.

8.1 CONCLUSIONS

Based on the data collected in this study and the analysis of the data, AECOM makes the following conclusions:

- All of the average power density results were several orders of magnitude below FCC regulatory limits. Note that measurements and regulatory limits were for six-minute time-averaged, whole body exposure.

- Average power density results were also below recommended levels from non-regulatory agencies, including the IEEE, the ICNIRP, and the Bioinitiative Report 2007.

- The values measured in this assessment were collected while students were actively using their Chromebooks.

    - Thus, values measured represent actual and expected RF exposure during Chromebook usage.

    - Because students are not expected to be using their Chromebooks continually during the day, actual RF exposure for any given day is expected to be similar or less than the measured values.

- Given the wide variety of scenarios evaluated and that the results were all several orders of magnitude below the regulatory limit, similar results would be expected in other MCPS schools and classrooms containing the same equipment evaluated.

SECTION NINE Limitations

The opinions and judgments expressed in this RF Summary Report are based on AECOM's research and interpretations of this report. The report is limited by the amount and type of information provided to AECOM by MCPS as well as by the instruments used to collect the data. These conclusions and recommendations may be subject to change if other factors impact the organization.

ACGIH. **2008** TLVs and BEIs. Publication #0108. Available at http://www.acgih.org/store/ProductDetail.cfm?id=1975.

Bolte, J; Eikelboom, T. Personal radiofrequency electromagnetic field measurements in the Netherlands: Exposure level and variability for everyday activities, times of day and types of area. *Environ. Int*., 48, Nov 1, **2012**, p. 133-142.

Breckenkamp, J.; Blettner, M.; Schüz, J.; Bornkessel, C.; Schmeidel, S.; Schlehofer, B.; Berg-Becckhoff, G. Residential Characteristics and Radiofrequency Electromagnetic Field Exposures from Bedroom Measurements in Germany. *Radiat Environ Biophys*, 51, **2012**, p. 85–92.

Bouchouicha, D.; Dupont, F.; Latrach, M.; Ventura, L. Ambient RF Energy Harvesting. International Conference on Renewable Energies and Power Quality, European Association for the Development of Renewable Energies, Environment and Power Quality, Granada, Spain, March 23 to 25, **2010**.

Cardis, E.; Deltour, I.; Mann, S.; Moissinnier, M.; Taki, M.; Varsier, N.; Wake, K.; Wiart, J. Distribution of RF Energy Emitted by Mobile Phones in Anatomical Structures of the Brain. *Physics in Medicine and Biology*, 53, **2008**, p. 2771-2783.

Carpenter, D.; Sage, S. Bioinitiative Report: A Rational for Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF). **2007**. Available at http://www.bioinitiative.org/.

Carpenter, D.; Sage, S. BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Radiation. December 31, **2012**. Available at http://www.bioinitiative.org.

Costa, C. P.; Fontgelland, G.; Barbin, S. E. Analysis of Passive Electromagnetic Exposure to Multisource Distributed in Outdoor Places. 2012 IEEE Topical Conference on Biomedical Wireless Technolgies, Networks, and Sensing Systems (BiowireleSS), **2012**, p. 81-84.

Council Recommendation (1999/519/EC). On the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz). *Official Journal of the European Communities*, July 12, **1999**.

Electric Power Research Institute (EIRP). EPRI Comment: Sage Report on Radio-Frequency (RF) Exposures from Smart Meters. February, **2011**. Available at http://www.marbleheadelectric.com/EPRI_SageReport.pdf.

European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN). Risk Analysis of Human Exposure to Electromagnetic Fields. July **2010**. Available at http://efhran.polimi.it/docs/EFHRAN_D2_final.pdf.

EMF-Link. Information Ventures, Inc. http://infoventures.com/private/federal/q&a/qa-envn2.html. January 12, **2000**.

European directive on electromagnetic fields. *European Radiology*. Dec., **2006**, 16(12), p2886 – 2889.

FCC. Wireless Devices and Health Concerns. Available at http://www.fcc.gov/guides/wireless-devices-and-health-concerns, accessed 11/14/**2012**.

FCC. Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields. Office of Engineering & Technology, OET Bulletin 56, 4th Edition, August, **1999**.

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

Findlay, R.P.; Dimbylow, P.J. SAR in children from exposure to wireless local area networks (WLAN). 2012 Asia-Pacific Symposium on Electromagnetic Compatibility (APEMC), May 21-24, **2012**, p. 733 – 736.

Foster, K. R. Radiofrequency Exposure From Wireless LANS Utilizing Wi-Fi Technology. *Health Physics*, March **2007**, 92(3), p. 280-289.

Foster, K. R. Response to Lora Lee Martin Regarding Smart Meters and EMFs, September 23, **2010**, available at http://www.ccst.us/projects/smart/documents/foster_response.pdf.

Foster, K. R. Exposure Limits for Radiofrequency Energy: Three Models. World Health Organization, Conference on Criteria for EMF Standards Harmonization. Available at http://www.who.int/peh-emf/meetings/day2Varna_Foster.pdf.

Frei, P. Personal Exposure to Radiofrequency Electromagnetic Fields and Implications for Health. PhD Thesis, University of Basel, Germany, **2010**. Available at http://edoc.unibas.ch/1255/.

Frei, P.; Mohler, E.; Braun-Fahrländer, C.; Fröhlich, J.; Neubauer, G.; Röösli, M. Cohort study on the effects of everyday life radio frequency electromagnetic field exposure on non-specific symptoms and tinnitus, *Environment International*, 38, **2012**, p. 29–36.

Genuis, Stephen J. Fielding a current idea: exploring the public health impact of electromagnetic radiation. *Public Health*, Feb, **2008**, 122(2), p113 – 124.

Grigoriev, Y. Electromagnetic Fields and the Public: EMF Standards and Estimation of Risk. IOP Conference Series: Earth and Environmental Sciences, 10(1), **2010**. Available at http://iopscience.iop.org/1755-1315/10/1/012003.

Hand, J.W. Modeling the Interaction of Electromagnetic Fields (10 MHz-10 GHz) with in the Human Body: Methods and Applications. *Physics in Medicine and Biology*, 53, **2008**, R243–R286.

Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1-2005, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz" (IEEE Std C95.1-**2005**).

International Agency for Research on Cancer (IARC). IARC Classifies Radiofrequency Electromagnetic Fields as Possibly Carcinogenic to Humans. World Health Organization, Lyon, France, May 31, **2011**. Available at http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf.

IARC. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. World Health Organization, Lyon, France, **2006**. Available at http://monographs.iarc.fr/ENG/Preamble/CurrentPreamble.pdf.

IARC. Interphone Study Reports on Mobile Phone Use and Brain Cancer Risk, May 17, **2010**. Available at http://www.iarc.fr/en/media-centre/pr/2010/pdfs/pr200_E.pdf.

International Commission on Non-Ionizing Radiation Protection (ICNIRP), Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields, ICNIRP Guidelines, Health Physics Society, April, **1998**, 74(4), p494-522.

ICNIRP, Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 kHz), *Health Physics*, **2010**. 99(6), p. 818-836.

ICNIRP. Fact Sheet on Guidelines for Limiting Exposure to Time-Varying Electric & Magnetic Fields (1 Hz to 100 kHz), *Health Physics Society*, **2010**, 99(6), p 818-836.

IEEE. IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. IEEE Std C95.1-2005, April 19, **2006**.

Karipidis, K. K. Is the Risk Comparison Made by the Public Between EMF and Smoking or Asbestos a Valid One? *Journal of Risk Research*, 10(3), April **2007**, p. 307–322.

Khalid, M.; Mee, T.; Peyman, A.; Addison, D.; Calderon, C.; Maslanyj, M.; Mann, S. Exposure to radio frequency electromagnetic fields from wireless computer networks: Duty factors of Wi-Fi devices operating in schools. *Prog. Biophys. Mol. Biol.* 107 (3), **2011**, p. 412-20.

Leck, R. World Meteorological Organization, Results of Ambient RF Environment and Noise Floor Measurements Taken in the U.S. in 2004 and 2005, Commission for Basic Systems Steering Group on Radiofrequency Coordination, Geneva, March 16-18, **2006**.

Possible effects of Electromagnetic Fields (EMF) on Human Health - Opinion of the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). *Toxicology*, Apr, **2008**, 246(2/3), p248-250.

Sage, C.; Carpenter, D.O. (in press) Public health implications of wireless technologies, *Pathophysiology* **2009**, available at http://www.ntia.doc.gov/legacy/broadbandgrants/comments/6E05.pdf.

Salzburg Resolution on Mobile Telecommunication Base Stations. International Conference on Cell Tower Siting, Linking Science & Public Health, Salzburg, June 7-8, **2000**. Available at http://www.salzburg.gv.at/themen/gs/gesundheit/landessanitaetsdirektion-2/gesundheitsschwerpunkte/umweltmedizin/elektrosmog/celltower_e.htm#ank-salzburg.

Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE). Opinion on Possible effects of Electromagnetic Fields (EMF), Radio Frequency Fields (RF) and Microwave Radiation on human health, Expressed at the 27th CSTEE plenary meeting, Brussels, October 30, **2001**.

Selvam, R.; Ganesan, K.; Narayana R.; Gangadharan, A. C.; Manohar, B. M.; Puvanakrishnan, R. Low frequency and low intensity pulsed electromagnetic field exerts its antiinflammatory effect through restoration of plasma membrane calcium ATPase activity. *Life Sciences*, Jun, **2007**, 80(26), p2403 – 2410.

Stam. R. Comparison of International Policies on Electromagnetic Fields (Power Frequency and Radiofrequency Fields). National Institute for Public Health, the Netherlands, May, **2011**. Available at http://ec.europa.eu/health/electromagnetic_fields/docs/emf_comparision_policies_en.pdf.

US Government Accountability Office, Telecommunications: Exposure and Testing Requirements for Mobile Phones Should be Reassessed, Report to Congressional Requesters, July, **2012,** GAO-12-771.

Verschaeve, L. Evaluations of International Expert Group Reports on the Biological Effects of Radiofrequency Fields. Chapter 20, INTECH 978-953-51-0189-5, March 14, 2012, available at http://www.intechopen.com/books/wireless-communications-and-networks-recent-advances/evaluations-of-international-expert-group-reports-on-the-biological-effects-of-radiofrequency-fields.

Vullers, R.; van Schaijk, R.; Doms, I.; Van Hoof, C.; Mertens, R. Micropower Energy Harvesting. *Solid-State Electronics*, 53, **2009**, p. 684–693.

Wake, K.; Arima, T.; Watanabe, S.; Taki, M. SAR distributions in a child head phantom in the vicinity of recent mobile phones. General Assembly and Scientific Symposium, August 13-20, **2011**.

WHO. What are Electromagnetic Fields? Available at http://www.who.int/peh-emf/about/WhatisEMF/en/index4.html.

Yang, K.; Ju, M.; Myung, S.; Shin, K.; Hwang, G.; Park, J. Development of a New Personal Magnetic Field Exposure Estimation Method for Use in Epidemiological EMF Surveys Among Children Under 17 Years of Age. *Journal of Electrical Engineering & Technology*, 7(3), **2012**, p. 376-383.

Zorzi, C.; Dall'Oca, C.; Cadossi, R.; Setti, S. Effects of pulsed electromagnetic fields on patients' recovery after arthroscopic surgery: prospective, randomized and double-blind study. *Knee Surgery, Sports Traumatology, Arthroscopy*, Jul, **2007**, 15(7), p830 – 834.

Certificate of Calibration

Asset ID 13180

Work Order 16606

Certificate Number: 16606
Certificate Date: 6/1/2015

Manufacturer: Unknown
Model:
Serial Number: AB-0235
Description: RF-cable SRM, 1.5 m

Date Received: 05/04/2015
Date of Calibration: 4/15/2015
Recommended Due Date: 4/14/2017
Temperature: 23.90 °C
Relative Humidity: 39.1 %RH

Cal Procedure
Narda Manufacturer Calibration

Customer Name: AECOM - Los Angeles
Customer Address: 12420 Milestone Center Drive, Germantown, Maryland 20876
PO Number:
CRM Order Number: Return from Repair and/or Calibration

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.
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In the attached measurement results, deviation may be expressed with units, Measured Value (MV) - Nominal Value (NV) or as a proportion of the nominal value ((MV-NV)/NV), expressed without units with a scalar multiplier such as % (0.01), or as a ratio of the units (mA/A, µV/V, etc.)
Descriptions such as µA/A, µV/V, and others, where used to annotate results or column headings are the preferred replacements for what was historically labeled as "ppm" or parts-per-million and described the results in that column, unless otherwise noted by units symbols.
Where applicable, the expanded uncertainty of measurement at the time of test is given in the following pages. They are calculated in accordance with the method described in the ISO Guide to the Expression of Uncertainty in Measurement (GUM). The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k, such that the confidence level approximates 95%.
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Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Youngberg, Eric D	Technician	Javier Estrada	06/01/2015
Name	Title	Metrology Supervisor	Certificate Date

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Certificate of Conformance

The following instrument was inspected and found to be fully operational and passed all functional tests as required and/or specified by the manufacturer's inspection/test procedure or by an equivalent Advanced Test Equipment Corp. approved test procedure.

Manufacturer: NARDA

Model: NARD-3602/01

Serial number: AB-0235

Issued by:

Date: 6/1/2015

QF40/051107

Certificate of Calibration

Asset ID 9196

Work Order 16607

Certificate Number: 16607
Certificate Date: 6/1/2015

Manufacturer: Unknown
Model:
Serial Number: K-0323
Description: 27MHz-3GHz Three-Axis E-Field Antenna for

Date Received: 05/04/2015
Date of Calibration: 4/16/2015
Recommended Due Date: 4/14/2017
Temperature: 23.90 °C
Relative Humidity: 39.2 %RH

Cal Procedure
Narda Manufacturer Calibration

Customer Name: AECOM - Los Angeles
Customer Address: 12420 Milestone Center Drive, Germantown, Maryland 20876
PO Number:
CRM Order Number: Return from Repair and/or Calibration

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Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Youngberg, Eric D	Technician	Javier Estrada	06/01/2015
Name	Title	Metrology Supervisor	Certificate Date

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Certificate of Conformance

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Manufacturer: NARDA

Model: NARD-3501/03

Serial number: K-0323

Issued by: _____

Date: 6/1/2015

QF40/051107

Certificate of Calibration

Asset ID 15744

Work Order 14822

Certificate Number: 14822
Certificate Date: 6/1/2015

Manufacturer: Narda
Model: 3581/02
Serial Number: AA-0249
Description: 9kHz-250MHz Three Axis Antenna H-Field fo

Date Received: 11/20/2014
Date of Calibration: 10/27/2014
Recommended Due Date: 10/27/2016
Temperature: 23.00 °C
Relative Humidity: 38.0 %RH

Cal Procedure
H3D 3581/02

Customer Name: AECOM - Los Angeles
Customer Address: 12420 Milestone Center Drive, Germantown, Maryland 20876
PO Number:
CRM Order Number: New Item

Comments:
Operational checkout of new item caled by Narda and entering cal info into mudcats system.

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Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Christensen, Rick	Technician	Javier Estrada	06/01/2015
Name	Title	Metrology Supervisor	Certificate Date

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Manufacturer: NARDA

Model: NARD-3581/02-P

Serial number: AA-0249

Issued by: _____

Date: 6/1/2015

QF40/051107

Certificate of Calibration

Asset ID 9195

Work Order 16605

Certificate Number: 16605
Certificate Date: 6/1/2015

Manufacturer: Narda
Model: SRM-3006/127/USA
Serial Number: D-0151
Description: 9kHz-6GHz Selective Radiation Meter w/27M

Date Received: 05/04/2015
Date of Calibration: 4/16/2015
Recommended Due Date: 4/14/2017
Temperature: 23.90 °C
Relative Humidity: 39.2 %RH

Cal Procedure
Narda Manufacturer Calibration

Customer Name: AECOM - Los Angeles
Customer Address: 12420 Milestone Center Drive, Germantown, Maryland 20876
PO Number:
CRM Order Number: Return from Repair and/or Calibration

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.
This calibration conforms to the requirements of ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994 (R2002).
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Descriptions such as µA/A, µV/V, and others, where used to annotate results or column headings are the preferred replacements for what was historically labeled as "ppm" or parts-per-million and described the results in that column, unless otherwise noted by units symbols.
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Calibration Performed By:		Authorized by:	
Youngberg, Eric D	Technician	Javier Estrada	06/01/2015
Name	Title	Metrology Supervisor	Certificate Date

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The following instrument was inspected and found to be fully operational and passed all functional tests as required and/or specified by the manufacturer's inspection/test procedure or by an equivalent Advanced Test Equipment Corp. approved test procedure.

Manufacturer: NARDA

Model: NARD-SRM-3006-107

Serial number: D-0151

Issued by: _____

Date: 6/1/2015

QF40/051107

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OUTGOING ORDER QA CHECKLIST

CRM: 58113
Customer No.: URC0005
Lab QA Inspection By: KB

Date: 6/1/15
Time: 12:48pm

EQUIPMENT INFORMATION

Part Number: NARD-SRM-3006/107
Description: NARD-3581/02-P: AA-0249
Serial Number: 0-0151

- [x] Saved Data Cleared from Memory ☐ N/A
- [x] Verify that Firmware & Software are up to date
  - Software Version: 1.3.3 ☐ N/A
  - Firmware Version: 1.4.0 ☐ N/A
- [x] Verify that the battery is at least 75% charged ☐ N/A
  - Charge Level: 100 %
- [x] Verify that correct quality paper work is enclosed in envelope (includes data for amps, antennas, and probes)

ATEC ASSURANCE

ACCESSORIES

- [x] Correct power cord supplied for destination country.
  - Ship To Country: USA
- [x] Verify that all accessories are present.
- [x] All leads and cables are neatly wrapped
- [x] Interconnect cables/adapters supplied ☐ N/A

LABELS

- [x] Instrument and accessories have been properly labeled (QF42/QF43)
- [x] Instrument has cal/void warranty labels (QF44)
- [x] Instrument has correct inspection label

CALIBRATION

- [x] Verify that due date on calibration label is >90 days away from end of minimum rental term ☐ N/A
  - Calibration Due Date: 4/14/17
- [ ] Customer approved due date <90 days

CONDITION

- [x] Instrument is clean
- [x] All screws present and correctly fastened
- [x] Instrument is not missing any feet
- [x] Conduct motion test to check for loose internal components

Note physical or cosmetic damage:

Certificate of Calibration

Asset ID 16380

Work Order 15667

Certificate Number: 15667
Certificate Date: 5/28/2015

Manufacturer: Narda
Model: 3581/02
Serial Number: AA-0244
Description: 9kHz-250MHz Three Axis Antenna H-Field fo

Date Received: 02/06/2015
Date of Calibration: 7/28/2014
Recommended Due Date: 7/28/2016
Temperature: 22.00 °C
Relative Humidity: 43.0 %RH

Cal Procedure
H3D 3581/02

Customer Name: URS Corporation
Customer Address: 12420 Milestone Center Dr, Suite 150 Germantown, Maryland 20876
PO Number:
CRM Order Number: New Item

Comments:
Operational checkout of new item caled by Narda and entering cal info into mudcats system.

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.
This calibration conforms to the requirements of ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994 (R2002).
In the attached measurement results, deviation may be expressed with units, Measured Value (MV) - Nominal Value (NV) or as a proportion of the nominal value ((MV-NV)/NV), expressed without units with a scalar multiplier such as % (0.01), or as a ratio of the units (mA/A, µV/V, etc.)
Descriptions such as µA/A, µV/V, and others, where used to annotate results or column headings are the preferred replacements for what was historically labeled as "ppm" or parts-per-million and described the results in that column, unless otherwise noted by units symbols.
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This Calibration certificate may contain data that is not covered by the A2LA Scope of Accreditation. Unaccredited material, where applicable is indicated by an asterisk (*), or confined to clearly marked sections. Functional (Pass / Fail) tests are not accredited.
No statement of compliance with specifications is made or implied on this certificate. However, measurement results are reviewed, where applicable, to establish where any measurement result exceeded the manufacturer's specifications.
Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Christensen, Rick	Technician	Javier Estrada	05/28/2015
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications

Advanced Test Equipment

10401 Roselle St. San Diego, CA 92121
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www.atecorp.com

Certificate of Conformance

The following instrument was inspected and found to be fully operational and passed all functional tests as required and/or specified by the manufacturer's inspection/test procedure or by an equivalent Advanced Test Equipment Corp. approved test procedure.

Manufacturer: NARDA

Model: 3581/02

Serial number: AA-0244

Issued by:

Date: 5/28/2015

QF40/051107

Certificate of Calibration

Asset ID 15960

Work Order 15090

Certificate Number: 15090
Certificate Date: 5/28/2015

Manufacturer: Narda
Model: SRM-3006/127/USA
Serial Number: K-0098
Description: 9kHz-6GHz Selective Radiation Meter w/27M

Date Received: 12/17/2014
Date of Calibration: 11/10/2014
Recommended Due Date: 11/10/2016
Temperature: 22.00 °C
Relative Humidity: 42.0 %RH

Cal Procedure
3000-8703-00A

Customer Name: URS Corporation
Customer Address: 12420 Milestone Center Dr, Suite 150 Germantown, Maryland 20876
PO Number:
CRM Order Number: End of Rental

Comments:
Updating cal info in mudcats with corrected serial number for meter.

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.
This calibration conforms to the requirements of ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994 (R2002).
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Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Christensen, Rick	Technician	Javier Estrada	05/28/2015
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications

Advanced
Test Equipment

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Certificate of Conformance

The following instrument was inspected and found to be fully operational and passed all functional tests as required and/or specified by the manufacturer's inspection/test procedure or by an equivalent Advanced Test Equipment Corp. approved test procedure.

Manufacturer: NARDA

Model: SRM-3006/127/USA

Serial number: K-0098

Issued by:

Date: 5/28/2015

QF40/051107

Certificate of Calibration

Asset ID 15948

Work Order 15085

Certificate Number: 15085
Certificate Date: 5/28/2015

Manufacturer: Unknown
Model:
Serial Number: AB-0555
Description: RF-cable SRM, 1.5 m

Date Received: 12/17/2014
Date of Calibration: 11/10/2014
Recommended Due Date: 11/10/2016
Temperature: 23.00 °C
Relative Humidity: 41.0 %RH

Cal Procedure
3000-8703-00A

Customer Name: URS Corporation
Customer Address: 12420 Milestone Center Dr, Suite 150 Germantown, Maryland 20876
PO Number:
CRM Order Number: End of Rental

Comments:
Operational checkout after return from rent and adding Narda cal info into mudcats system.

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.
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Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Christensen, Rick	Technician	Javier Estrada	05/28/2015
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications

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San Diego, CA 92121

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Certificate of Conformance

The following instrument was inspected and found to be fully operational and passed all functional tests as required and/or specified by the manufacturer's inspection/test procedure or by an equivalent Advanced Test Equipment Corp. approved test procedure.

Manufacturer: NARDA

Model: 3602/01

Serial number: AB-0555

Issued by: _____

Date: 5/28/2015

QF40/051107

Certificate of Calibration

Asset ID 15947

Work Order 15086

Certificate Number: 15086
Certificate Date: 5/28/2015

Manufacturer: Unknown
Model:
Serial Number: K-1141
Description: 27MHz-3GHz Three-Axis E-Field Antenna for

Date Received: 12/17/2014
Date of Calibration: 11/14/2014
Recommended Due Date: 11/14/2016
Temperature: 22.00 °C
Relative Humidity: 42.0 %RH

Cal Procedure
3000-8702-00A

Customer Name: URS Corporation
Customer Address: 12420 Milestone Center Dr, Suite 150 Germantown, Maryland 20876
PO Number:
CRM Order Number: End of Rental

Comments:
Operational checkout after return from rent and adding Narda cal info into mudcats system.

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.
This calibration conforms to the requirements of ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994 (R2002).
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Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Christensen, Rick	Technician	Javier Estrada	05/28/2015
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications

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Certificate of Conformance

The following instrument was inspected and found to be fully operational and passed all functional tests as required and/or specified by the manufacturer's inspection/test procedure or by an equivalent Advanced Test Equipment Corp. approved test procedure.

Manufacturer: NARDA

Model: 3501/03

Serial number: K-1141

Issued by: _____

Date: 5/28/2015

QF40/051107

Certificate of Calibration

Asset ID 16101

Work Order 15460

Certificate Number: 15460
Certificate Date: 6/4/2015

Manufacturer: Narda
Model: 3502/01
Serial Number: F-0066
Description: 420MHz-6GHz Tri-Axial E-Field Antenna for

Date Received: 01/23/2015
Date of Calibration: 11/28/2014
Recommended Due Date: 11/28/2016
Temperature: 23.00 °C
Relative Humidity: 37.0 %RH

Cal Procedure
3000-8702-00A

Customer Name: AECOM - Los Angeles
Customer Address: 12420 Milestone Center Drive, Germantown, Maryland, 20870
PO Number:
CRM Order Number: CRM00000000054243

Comments:
Operational checkout of new item caled by Narda and entering cal info into mudcats system.

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.
This calibration conforms to the requirements of ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994 (R2002).
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Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Christensen, Rick	Technician	Javier Estrada	06/04/2015
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications

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Certificate of Calibration

Asset ID 13181

Work Order 15953

Certificate Number: 15953
Certificate Date: 6/4/2015

Manufacturer: Narda
Model: 3502/01
Serial Number: E-0101
Description: 420MHz-6GHz Tri-Axial E-Field Antenna for

Date Received: 03/02/2015
Date of Calibration: 8/23/2013
Recommended Due Date: 8/23/2015
Temperature: 22.00 °C
Relative Humidity: 43.0 %RH

Cal Procedure
3000-8702-00A

Customer Name: AECOM - Los Angeles
Customer Address: 12420 Milestone Center Drive, Germantown, Maryland, 20870
PO Number:
CRM Order Number: Stock Calibration

Comments:
Putting cal info from Narda into mudcats system.

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.
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Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Christensen, Rick	Technician	Javier Estrada	06/04/2015
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications

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Certificate of Conformance

The following instrument was inspected and found to be fully operational and passed all functional tests as required and/or specified by the manufacturer's inspection/test procedure or by an equivalent Advanced Test Equipment Corp. approved test procedure.

Manufacturer: NARDA

Model: 3502/01

Serial number: F-0066, E-0101

Issued by:

Date: 6/4/2015

QF40/051107

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OUTGOING ORDER QA CHECKLIST

CRM: 58777 Date: 6/4/15

Customer No.: URC0005 Time: 4:02 pm

Lab QA Inspection By: MH

EQUIPMENT INFORMATION

Part Number: NARD-3502/01 Description: Tri Axial E-Field Antenna

Serial Number: F-0066/E-0101

- [x] Saved Data Cleared from Memory [x] N/A
- [x] Verify that Firmware & Software are up to date
  - Software Version: _____ [x] N/A
  - Firmware Version: _____ [x] N/A
- [x] Verify that the battery is at least 75% charged [x] N/A
  - Charge Level: _____%
- [x] Verify that correct quality paper work is enclosed in envelope (includes data for amps, antennas, and probes)

ATEC ✓ ASSURANCE

ACCESSORIES

- [x] Correct power cord supplied for destination country.
  - Ship To Country: USA
- [x] Verify that all accessories are present.
- [x] All leads and cables are neatly wrapped
- [ ] Interconnect cables/adapters supplied [x] N/A

LABELS

- [x] Instrument and accessories have been properly labeled (QF42/QF43)
- [x] Instrument has cal/void warranty labels (QF44)
- [x] Instrument has correct inspection label

CALIBRATION

- [x] Verify that due date on calibration label is >90 days away from end of minimum rental term [ ] N/A
  - Calibration Due Date: 11/28/16, 8/23/15
- [ ] Customer approved due date <90 days

CONDITION

- [x] Instrument is clean
- [x] All screws present and correctly fastened
- [x] Instrument is not missing any feet
- [x] Conduct motion test to check for loose internal components

Note physical or cosmetic damage: _____

Certificate of Calibration

Asset ID 13178

Work Order 15230

Certificate Number: 15230
Certificate Date: 6/9/2015

Manufacturer: Narda
Model: SRM-3006/127/USA
Serial Number: G-0138
Description: 9kHz-6GHz Selective Radiation Meter w/27M

Date Received: 01/08/2015
Date of Calibration: 2/9/2015
Recommended Due Date: 2/9/2017
Temperature: 21.40 °C
Relative Humidity: 41.3 %RH

Cal Procedure
Narda Manufacturer Calibration

Customer Name: AECOM - Los Angeles
Customer Address: 12420 Milestone Center Drive, Germantown, MD 20876
PO Number:
CRM Order Number: Returned from Calibration

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.
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Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Youngberg, Eric D	Technician	Javier Estrada	06/09/2015
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications

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Advanced Test Equipment

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www.atecorp.com

Certificate of Conformance

The following instrument was inspected and found to be fully operational and passed all functional tests as required and/or specified by the manufacturer's inspection/test procedure or by an equivalent Advanced Test Equipment Corp. approved test procedure.

Manufacturer: NARDA

Model: NARD-SRM-3006/107

Serial number: G-0138

Issued by: _____

Date: 6/9/2015

QF40/051107

Certificate of Calibration

Asset ID 13179

Work Order 16011

Certificate Number: 16011
Certificate Date: 6/9/2015

Manufacturer: Unknown
Model:
Serial Number: K-0812
Description: 27MHz-3GHz Three-Axis E-Field Antenna for

Date Received: 03/09/2015
Date of Calibration: 2/17/2015
Recommended Due Date: 2/17/2017
Temperature: 21.40 °C
Relative Humidity: 41.3 %RH

Cal Procedure
Narda Manufacturer Calibration

Customer Name: AECOM - Los Angeles
Customer Address: 12420 Milestone Center Drive, Germantown, MD 20876
PO Number:
CRM Order Number: Retuned from Calibration

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.
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Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Youngberg, Eric D	Technician	Javier Estrada	06/09/2015
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications

Advanced
Test Equipment

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Certificate of Conformance

The following instrument was inspected and found to be fully operational and passed all functional tests as required and/or specified by the manufacturer's inspection/test procedure or by an equivalent Advanced Test Equipment Corp. approved test procedure.

Manufacturer: NARDA

Model: NARD-3501/03

Serial number: K-0812

Issued by: _____

Date: 6/9/2015

QF40/051107

Certificate of Calibration

Asset ID 10934

Work Order 16012

Certificate Number: 16012
Certificate Date: 6/9/2015

Manufacturer: Unknown
Model:
Serial Number: AB-0002
Description: RF-cable SRM, 1.5 m

Date Received: 03/09/2015
Date of Calibration: 2/17/2015
Recommended Due Date: 2/17/2017
Temperature: 21.40 °C
Relative Humidity: 41.3 %RH

Cal Procedure
Narda Manufacturer Calibration

Customer Name: AECOM - Los Angeles
Customer Address: 12420 Milestone Center Drive, Germantown, MD 20876
PO Number:
CRM Order Number: Retuned from Calibration

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes, ratio metric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval by ATEC Corporation Laboratory. The calibration has been completed in accordance with ATEC Corporation Quality System.
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Where applicable, the expanded uncertainty of measurement at the time of test is given in the following pages. They are calculated in accordance with the method described in the ISO Guide to the Expression of Uncertainty in Measurement (GUM). The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k, such that the confidence level approximates 95%.
This Calibration certificate may contain data that is not covered by the A2LA Scope of Accreditation. Unaccredited material, where applicable is indicated by an asterisk (*), or confined to clearly marked sections. Functional (Pass / Fail) tests are not accredited.
No statement of compliance with specifications is made or implied on this certificate. However, measurement results are reviewed, where applicable, to establish where any measurement result exceeded the manufacturer's specifications.
Measured values (MV) greater than the Manufacturer's specification (Spec) are indicated by "X".

Calibration Performed By:		Authorized by:	
Youngberg, Eric D	Technician	Javier Estrada	06/09/2015
Name	Title	Metrology Supervisor	Certificate Date

ATEC Corporation calibration documents are electronically signed utilizing MudCats Metrology Software Suite of Applications

Advanced
Test Equipment

10401 Roselle St. San Diego, CA 92121
Phone: (858) 558-6500 Fax: (858) 558-6570
www.atecorp.com

Certificate of Conformance

The following instrument was inspected and found to be fully operational and passed all functional tests as required and/or specified by the manufacturer's inspection/test procedure or by an equivalent Advanced Test Equipment Corp. approved test procedure.

Manufacturer: NARDA

Model: NARD-3602/01

Serial number: AB-0002

Issued by:

Date: 6/9/2015

QF40/051107

www.atecorp.com

Advanced Test Equipment Rentals

10401 Roselle Street San Diego, CA 92121
(800) 404-ATEC (2832)

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OUTGOING ORDER QA CHECKLIST

CRM: 58280
Customer No.: URC0005
Lab QA Inspection By: ISB

Date: 6/9/15
Time: 12:51 pm

EQUIPMENT INFORMATION

Part Number: NARD-SRM-3006/107
Description: Radiation Meter.
Serial Number: 6-0138

- [X] Saved Data Cleared from Memory ☐ N/A
- [X] Verify that Firmware & Software are up to date
  - Software Version: 1.3.3 ☐ N/A
  - Firmware Version: 1.4.0 ☐ N/A
- [X] Verify that the battery is at least 75% charged ☐ N/A
  - Charge Level: ____%
- [X] Verify that correct quality paper work is enclosed in envelope (includes data for amps, antennas, and probes)

ATEC ASSURANCE

ACCESSORIES

- [X] Correct power cord supplied for destination country.
  - Ship To Country: USA
- [X] Verify that all accessories are present.
- [X] All leads and cables are neatly wrapped
- [X] Interconnect cables/adapters supplied ☐ N/A

LABELS

- [X] Instrument and accessories have been properly labeled (QF42/QF43)
- [X] Instrument has cal/void warranty labels (QF44)
- [X] Instrument has correct inspection label

CALIBRATION

- [X] Verify that due date on calibration label is >90 days away from end of minimum rental term ☐ N/A
  - Calibration Due Date: 2-9-17
- ☐ Customer approved due date <90 days

CONDITION

- [X] Instrument is clean
- [X] All screws present and correctly fastened
- [X] Instrument is not missing any feet
- [X] Conduct motion test to check for loose internal components

Note physical or cosmetic damage: ____

Raw data is provided in electronic format only. Please see enclosed flash drive for Appendix B information.

Analyzed data is provided in electronic format only. Please see enclosed flash drive for Appendix C information.

	A	B	C	D	E	F	G	H	I
1	**Room**	**Measurement Type**	**Distance (in)**	**Max E (V/m)**	**Max Power Density (mW/cm^2)**	**Avg E (V/m)**	**Ave Power Density (mW/cm^2)**	**Max H (A/m)**	**Avg H (A/m)**
2	1118	Access Point	1	1.67E-01	7.43E-06	2.82E-03	2.11E-09	1.65E-02	7.92E-03
3	1118	Access Point	6	1.97E-01	1.03E-05	6.92E-03	1.27E-08	1.43E-02	7.13E-03
4	1118	Access Point	12	1.72E-01	7.87E-06	5.11E-03	6.94E-09	1.50E-02	6.59E-03
5	1118	Access Point	24	2.71E-01	1.95E-05	2.40E-03	1.53E-09	1.42E-02	6.30E-03
6	1118	Access Point	36	1.98E-01	1.04E-05	3.63E-03	3.49E-09		
7	1118	Chrome Book	1	1.09E-01	3.16E-06	1.14E-02	3.45E-08	1.02E-01	9.46E-02
8	1118	Chrome Book	6	1.34E-01	4.77E-06	1.10E-02	3.22E-08	1.01E-01	9.43E-02
9	1118	Chrome Book	12	1.15E-01	3.48E-06	1.13E-02	3.37E-08	1.01E-01	9.33E-02
10	1118	Chrome Book	24	9.29E-02	2.29E-06	1.12E-02	3.33E-08	9.84E-02	9.32E-02
11	1118	Chrome Book	36	8.57E-02	1.95E-06	1.15E-02	3.51E-08		
12		Parking Lot	Backgroun	5.48E-02	7.96E-07	1.74E-02	8.00E-08	5.99E-02	1.74E-02
13									
14			Maximums		1.95E-05		8.00E-08		

Room	Measurement Type	Distance (in)	Max E (V/m)	Max Power Density (mW/cm^2)	Avg E (V/m)	Ave Power Density (mW/cm^2)	Max H (A/m)	Avg H (A/m)
162	Chrome Book	1	5.40E-01	7.72E-05	7.61E-02	1.54E-06	3.81E-01	3.72E-01
162	Chrome Book	6	7.16E-01	1.36E-04	7.30E-02	1.41E-06	3.79E-01	3.70E-01
162	Chrome Book	12	2.57E-01	1.75E-05	7.47E-02	1.48E-06	3.74E-01	3.67E-01
162	Chrome Book	24	1.61E-01	6.90E-06	7.58E-02	1.52E-06	3.75E-01	3.67E-01
	Parking Lot	Background	1.51E-02	6.07E-08	1.10E-02	3.21E-08	6.57E-02	5.98E-02
154	Access Point	1	2.23E-01	1.32E-05	2.16E-02	1.24E-07	1.46E-02	6.44E-03
154	Access Point	6	2.23E-01	1.32E-05	1.27E-02	4.28E-08	2.00E-02	7.89E-03
154	Access Point	12	2.21E-01	1.30E-05	7.21E-03	1.38E-08	1.28E-02	5.93E-03
154	Access Point	24	2.03E-01	1.09E-05	5.48E-03	7.95E-09	2.44E-02	8.34E-03
154	Access Point	36	1.54E-01	6.25E-06	3.91E-03	4.05E-09		
		Maximums		1.36E-04		1.54E-06		

Room	Measurement Type	Distance (in)	Max E (V/m)	Power Density (mW/cm^	Avg E (V/m)	Power Density (mW/cm^	Max H (A/m)	Avg H (A/m)
1219	Chrome Book	1	1.06E-01	3.00E-06	1.65E-02	7.21E-08	7.36E-02	6.71E-02
1219	Chrome Book	6	1.04E-01	2.86E-06	1.47E-02	5.72E-08	7.27E-02	6.47E-02
1219	Chrome Book	12	1.14E-01	3.46E-06	1.54E-02	6.26E-08	7.22E-02	6.62E-02
1219	Chrome Book	24	1.23E-01	4.01E-06	1.45E-02	5.58E-08	7.10E-02	6.50E-02
	Parking Lot	Background	2.25E-02	1.34E-07	1.52E-02	6.09E-08	5.14E-02	4.26E-02
1219	Access Point	1	1.62E-01	6.98E-06	3.86E-03	3.96E-09	1.45E-02	7.44E-03
1219	Access Point	6	2.22E-01	1.30E-05	2.91E-03	2.25E-09	1.44E-02	7.23E-03
1219	Access Point	12	2.80E-01	2.08E-05	5.61E-03	8.34E-09	1.34E-02	7.05E-03
1219	Access Point	24	2.62E-01	1.82E-05	4.27E-03	4.84E-09	1.41E-02	7.38E-03
1219	Access Point	36	3.17E-01	2.67E-05	6.57E-03	1.14E-08		
		Maximums		2.67E-05		7.21E-08		

Room	Measurement Type	Distance (in)	Max E (V/m)	Max Power Density (mW/cm^2)	Avg E (V/m)	Power Density (mW/cm^	Max H (A/m)	Avg H (A/m)
234	Chrome Book	1	2.18E-01	1.26E-05	8.22E-02	1.79E-06	1.43E-01	1.33E-01
234	Chrome Book	6	1.51E-01	6.01E-06	3.88E-02	4.00E-07	1.12E-01	1.05E-01
234	Chrome Book	12	1.87E-01	9.30E-06	4.06E-02	4.38E-07	1.52E-01	1.47E-01
234	Chrome Book	24	1.49E-01	5.88E-06	4.17E-02	4.61E-07	9.07E-02	8.25E-02
234	Chrome Book	36	1.19E-01	3.78E-06	4.77E-02	6.04E-07		
	Parking Lot	Background	8.30E-02	1.83E-06	1.58E-02	6.60E-08	7.25E-02	6.64E-02
234	Access Point	1	2.88E-01	2.20E-05	3.46E-02	3.17E-07	1.68E-02	8.42E-03
234	Access Point	6	4.64E-01	5.71E-05	4.42E-02	5.17E-07	1.61E-02	7.92E-03
234	Access Point	12	5.99E-01	9.51E-05	5.08E-02	6.84E-07	1.61E-02	7.36E-03
234	Access Point	24	9.61E-01	2.45E-04	6.05E-02	9.72E-07	1.26E-02	6.32E-03
234	Access Point	36	5.00E-01	6.64E-05	3.88E-02	3.99E-07		
		Maximums		2.45E-04		1.79E-06		

Room	Measurement Type	Distance (in)	Max E (V/m)	Power Density (mW/cm^	Avg E (V/m)	Power Density (mW/cm^	Max H (A/m)	Avg H (A/m)
149	Chrome Book	1	1.89E-01	9.45E-06	2.14E-02	1.22E-07	7.70E-02	6.86E-02
149	Chrome Book	6	2.82E-01	2.10E-05	2.20E-02	1.29E-07	7.42E-02	6.79E-02
149	Chrome Book	12	1.16E-01	3.57E-06	1.35E-02	4.81E-08	7.41E-02	6.72E-02
149	Chrome Book	24	1.04E-01	2.87E-06	1.44E-02	5.48E-08	6.65E-02	5.83E-02
149	Chrome Book	36	1.17E-01	3.62E-06	2.74E-02	1.99E-07		
	Parking Lot	Background	1.75E-01	8.08E-06	2.69E-03	1.92E-09	7.57E-02	6.76E-02
223	Chrome Book	1	2.10E-01	1.17E-05	1.90E-02	9.57E-08	7.21E-02	6.01E-02
223	Chrome Book	6	2.11E-01	1.18E-05	1.14E-01	3.44E-06	1.93E-01	1.86E-01
223	Chrome Book	12	1.64E-01	7.09E-06	2.74E-02	2.00E-07	5.93E-01	5.84E-01
223	Chrome Book	24	1.66E-01	7.34E-06	1.06E-02	2.97E-08	6.52E-02	5.85E-02
223	Chrome Book	36	1.58E-01	6.60E-06	1.72E-02	7.85E-08		
149	Access Point	1	3.39E-01	3.05E-05	5.54E-02	8.14E-07	1.39E-02	7.35E-03
149	Access Point	6	2.87E-01	2.18E-05	1.75E-02	8.09E-08	1.50E-02	7.31E-03
149	Access Point	12	4.86E-01	6.27E-05	2.27E-02	1.37E-07	1.37E-02	6.57E-03
149	Access Point	24	5.32E-01	7.50E-05	3.48E-02	3.21E-07	1.53E-02	7.20E-03
149	Access Point	36	4.64E-01	5.71E-05	5.66E-02	8.50E-07		
223	Access Point	1	2.05E-01	1.11E-05	8.79E-03	2.05E-08	1.71E-02	7.51E-03
223	Access Point	6	2.05E-01	1.11E-05	2.29E-02	1.40E-07	1.48E-02	7.75E-03
223	Access Point	12	1.87E-01	9.28E-06	9.47E-03	2.38E-08	1.53E-02	7.39E-03
223	Access Point	24	2.50E-01	1.65E-05	1.47E-02	5.72E-08	1.60E-02	6.88E-03
223	Access Point	36	2.20E-01	1.28E-05	1.52E-02	6.17E-08		
		Maximums		7.50E-05		3.44E-06		

Room	Measurement Type	Distance (in)	Max E (V/m)	Power Density (mW/cm^	Avg E (V/m)	Power Density (mW/cm^	Max H (A/m)	Avg H (A/m)
252	Chrome Book	1	2.02E-01	1.08E-05	5.01E-02	6.65E-07	7.80E-02	2.70E-05
252	Chrome Book	6	1.51E-01	6.08E-06	8.40E-02	1.87E-06	5.57E-02	2.03E-05
252	Chrome Book	12	1.45E-01	5.61E-06	8.33E-02	1.84E-06	2.12E-01	7.20E-05
252	Chrome Book	24	3.27E-01	2.83E-05	1.67E-01	7.36E-06	4.95E-02	1.95E-05
	Parking Lot	Background	6.15E-02	1.00E-06	2.58E-02	1.76E-07	6.21E-02	2.31E-05
252	Access Point	1	3.49E-01	3.23E-05	1.32E-02	4.60E-08	9.85E-03	4.64E-03
252	Access Point	6	2.58E-01	1.76E-05	1.28E-02	4.31E-08	1.10E-02	5.00E-03
252	Access Point	12	3.17E-01	2.66E-05	2.06E-02	1.13E-07	8.42E-03	4.56E-03
252	Access Point	24	6.08E-01	9.81E-05	3.07E-02	2.51E-07	9.18E-03	5.00E-03
252	Access Point	36	9.47E-01	2.38E-04	2.98E-02	2.35E-07		
		Maximums		2.38E-04		7.36E-06		

Room	Measurement Type	Distance (in)	Max E (V/m)	Power Density (mW/cm^	Avg E (V/m)	Power Density (mW/cm^	Max H (A/m)	Avg H (A/m)
Media Center	Chrome Book	1	4.25E-01	4.78E-05	5.29E-02	7.41E-07	4.19E-01	4.12E-01
Media Center	Chrome Book	6	5.53E-01	8.10E-05	2.30E-02	1.40E-07	5.03E-02	4.61E-02
Media Center	Chrome Book	12	2.90E-01	2.23E-05	2.30E-02	1.40E-07	5.37E-02	4.61E-02
Media Center	Chrome Book	24	3.61E-01	3.45E-05	1.81E-02	8.71E-08	5.16E-02	4.62E-02
	Parking Lot	Background	2.07E-01	1.13E-05	1.62E-02	6.94E-08	5.15E-02	4.74E-02
Media Center	Access Point	1	9.25E-01	2.27E-04	1.27E-02	4.26E-08	1.10E-02	4.84E-03
Media Center	Access Point	6	5.73E-01	8.71E-05	1.11E-02	3.29E-08	1.10E-02	4.57E-03
Media Center	Access Point	12	5.62E-01	8.38E-05	1.18E-02	3.69E-08	1.25E-02	5.04E-03
Media Center	Access Point	24	9.28E-01	2.28E-04	1.47E-02	5.76E-08	8.44E-03	4.43E-03
Media Center	Access Point	36	1.26E+00	4.20E-04	1.60E-02	6.83E-08		
		Maximums		4.20E-04		7.41E-07		

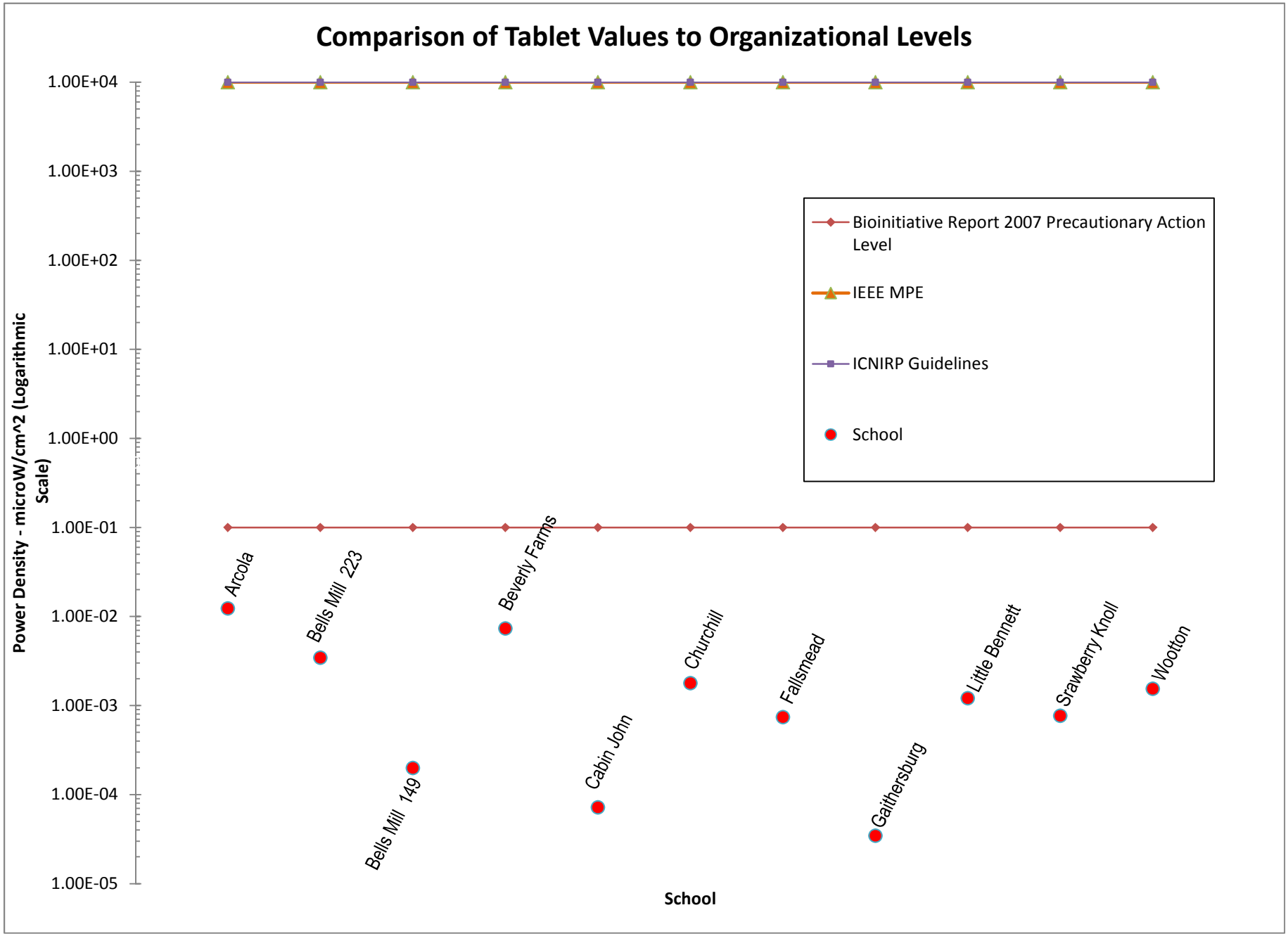
Room	Measurement Type	Distance (in)	Max E (V/m)	Power Density (mW/cm^	Avg E (V/m)	Power Density (mW/cm^	Max H (A/m)	Avg H (A/m)
141	Chrome Book	1	3.10E-01	2.54E-05	2.14E-02	1.21E-07	3.73E-01	3.69E-01
141	Chrome Book	6	3.60E-01	3.43E-05	6.75E-02	1.21E-06	9.60E-02	9.23E-02
141	Chrome Book	12	3.88E-01	3.98E-05	1.47E-02	5.74E-08	1.49E-01	1.46E-01
141	Chrome Book	24	2.95E-01	2.31E-05	1.88E-02	9.40E-08	4.64E-01	4.58E-01
	Parking Lot	Backgroun	1.24E-01	4.07E-06	1.83E-02	8.86E-08	4.60E-02	4.24E-02
		Maximums		3.98E-05		1.21E-06		

Room	Measurement Type	Distance (in)	Max E (V/m)	Power Density (mW/cm^	Avg E (V/m)	Power Density (mW/cm^	Max H (A/m)	Avg H (A/m)
Training Conference Rm	Charging Station	1	5.47E-01	7.93E-05	2.69E-01	1.92E-05	4.68E-01	4.63E-01
Training Conference Rm	Charging Station	6	3.31E-01	2.90E-05	5.53E-02	8.12E-07	8.70E-02	8.28E-02
Training Conference Rm	Charging Station	12	4.70E-01	5.86E-05	4.48E-02	5.32E-07	1.88E-01	1.83E-01
Training Conference Rm	Charging Station	24	2.96E-01	2.33E-05	3.87E-02	3.98E-07	5.52E-02	5.17E-02
Training Conference Rm	Charging Station	36	3.19E-01	2.70E-05	1.11E-01	3.29E-06		
	Parking Lot	Backgroun	2.74E-01	1.99E-05	1.49E-02	5.91E-08	2.74E-01	2.98E-02
		Maximums		7.93E-05		1.92E-05		

Room	Measurement Type	Distance (in)	Max E (V/m)	Power Density (mW/cm^	Avg E (V/m)	Power Density (mW/cm^	Max H (A/m)	Avg H (A/m)
Portable 4	Chrome Book	1	3.88E-01	4.00E-05	2.15E-01	1.23E-05	4.75E-01	4.68E-01
Portable 4	Chrome Book	6	5.47E-01	7.92E-05	4.34E-02	4.99E-07	4.73E-01	4.67E-01
Portable 4	Chrome Book	12	4.32E-01	4.95E-05	1.77E-02	8.34E-08	4.67E-01	4.62E-01
Portable 4	Chrome Book	24	4.68E-01	5.82E-05	5.38E-02	7.69E-07	4.65E-01	4.59E-01
	Parking Lot	Background	1.10E-01	3.23E-06	3.67E-02	3.56E-07	4.74E-01	4.69E-01
Portable 4	Access Point	1	4.63E+00	5.69E-03	8.08E-02	1.73E-06	4.75E-01	4.64E-01
Portable 4	Access Point	6	2.63E+00	1.84E-03	7.28E-02	1.40E-06	4.69E-01	4.62E-01
Portable 4	Access Point	12	1.83E+00	8.84E-04	6.17E-02	1.01E-06	4.72E-01	4.62E-01
Portable 4	Access Point	24	1.31E+00	4.58E-04	1.17E-01	3.62E-06	4.69E-01	4.61E-01
		Maximums		5.69E-03		1.23E-05		

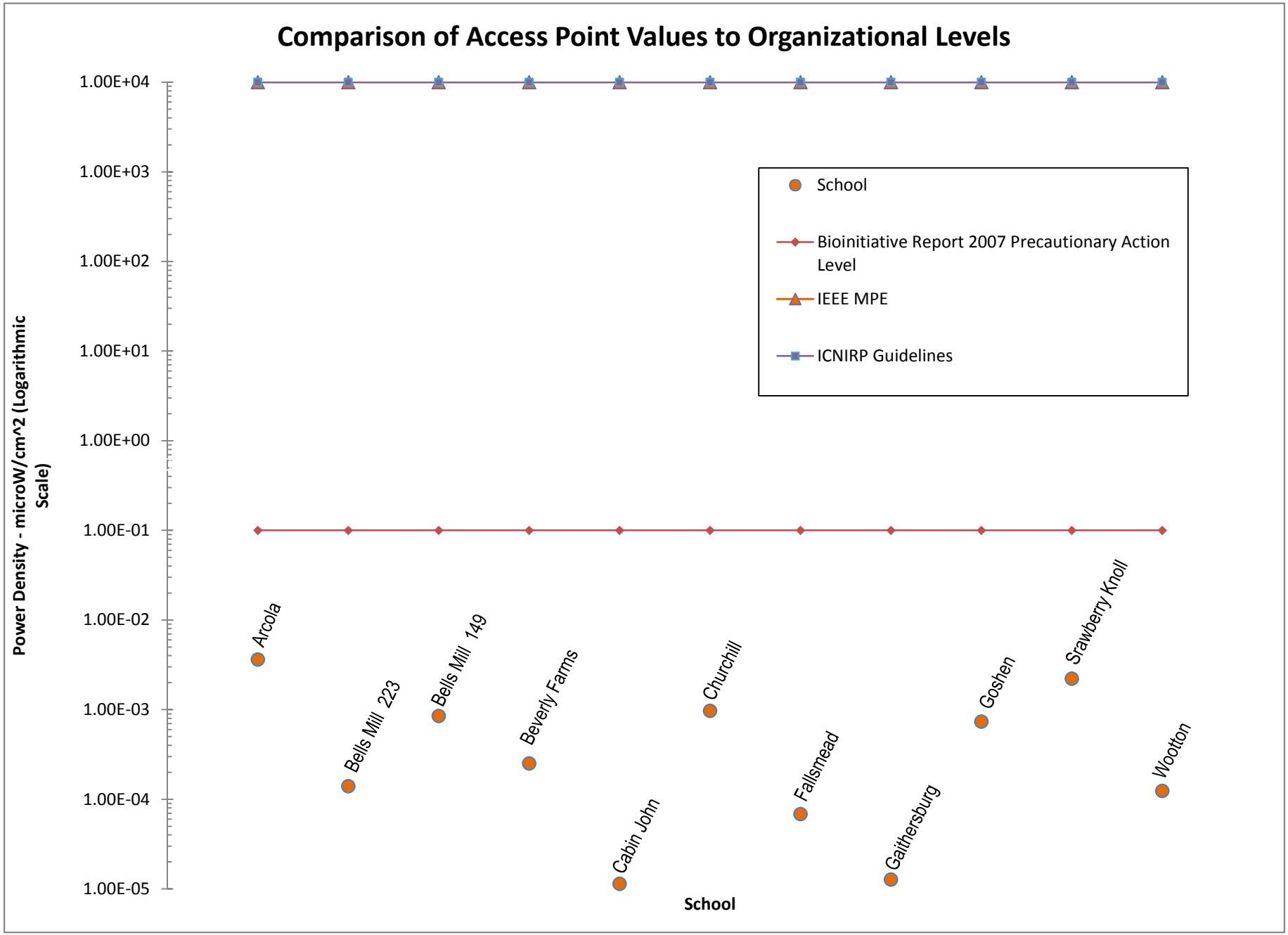
Room	Measurement Type	Distance (in)	Max E (V/m)	Power Density (mW/cm^	Avg E (V/m)	Power Density (mW/cm^	Max H (A/m)	Avg H (A/m)
19	Access Point	1	2.25E-01	1.34E-05	2.81E-02	2.10E-07	6.35E-02	5.96E-02
19	Access Point	6	3.24E-01	2.78E-05	5.20E-02	7.17E-07	6.26E-02	5.84E-02
19	Access Point	12	1.87E-01	9.25E-06	5.27E-02	7.37E-07	6.24E-02	5.80E-02
19	Access Point	24	4.52E-01	5.42E-05	2.19E-02	1.27E-07	4.52E-02	4.10E-02
	Parking Lot	Background	1.81E-01	8.72E-06	3.08E-02	2.52E-07	5.66E-02	5.30E-02
		Maximums		5.42E-05		7.37E-07		

Room	Measurement Type	Distance (in)	Max E (V/m)	Power Density (mW/cm^	Avg E (V/m)	Power Density (mW/cm^	Max H (A/m)	Avg H (A/m)
Portable 3	Chrome Book	1	4.26E-01	4.81E-05	5.39E-02	7.70E-07	7.83E-02	7.38E-02
Portable 3	Chrome Book	6	3.56E-01	3.37E-05	1.56E-02	6.49E-08	6.21E-02	5.82E-02
Portable 3	Chrome Book	12	2.25E-01	1.35E-05	1.79E-02	8.46E-08	6.20E-02	5.77E-02
Portable 3	Chrome Book	24	1.74E-01	7.98E-06	1.76E-02	8.26E-08	7.79E-02	7.33E-02
	Parking Lot	Background	1.42E-01	5.33E-06	1.80E-02	8.57E-08	8.76E-02	8.38E-02
Portable 3	Access Point	1	2.97E+00	2.33E-03	9.15E-02	2.22E-06	6.15E-02	5.80E-02
Portable 3	Access Point	6	7.38E-01	1.44E-04	2.61E-02	1.81E-07	8.56E-02	8.21E-02
Portable 3	Access Point	12	7.97E-01	1.68E-04	2.04E-02	1.11E-07	6.20E-02	5.77E-02
Portable 3	Access Point	24	3.78E-01	3.80E-05	1.20E-02	3.79E-08	9.56E-02	9.20E-02
Portable 3	Access Point	36	2.63E-01	1.84E-05	7.40E-03	1.45E-08		
		Maximums		2.33E-03		2.22E-06		


Comparison of Tablet Values to Organizational Levels
1.00E+04
1.00E+03
1.00E+02
1.00E+01
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
Power Density - microW/cm^2 (Logarithmic Scale)
Bioinitiative Report 2007 Precautionary Action Level
IEEE MPE
ICNIRP Guidelines
School
Arcola
Bells Mill 223
Bells Mill 149
Beverly Farms
Cabin John
Churchill
Fallsmead
Gaithersburg
Little Bennett
Strawberry Knoll
Wootton
School

School	School	Maximum Average Power Density	Bioinitiative Report 2007 Precautionary Action Level	IEEE MPE	ICNIRP Guidelines
1	Arcola Elementary School	1.23E-02	0.1	10,000	10,000
2	Bells Mill Elementary Rm 223	3.44E-03	0.1	10,000	10,000
3	Bells Mill Elementary School Rm 149	1.99E-04	0.1	10,000	10,000
4	Beverly Farms Elementary School	7.36E-03	0.1	10,000	10,000
5	Cabin John Middle School	7.21E-05	0.1	10,000	10,000
6	Churchill High School	1.79E-03	0.1	10,000	10,000
7	Fallsmead Elementary School	7.41E-04	0.1	10,000	10,000
8	Gaithersburg High School	3.45E-05	0.1	10,000	10,000
9	Little Bennett Elementary School	1.21E-03	0.1	10,000	10,000
10	Strawberry Knoll Elementary School	7.70E-04	0.1	10,000	10,000
11	Wootton High School	1.54E-03	0.1	10,000	10,000

**All values in microWatts/cm^2


Comparison of Access Point Values to Organizational Levels
Power Density - microW/cm^2 (Logarithmic Scale)
1.00E+04
1.00E+03
1.00E+02
1.00E+01
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
School
Bioinitiative Report 2007 Precautionary Action Level
IEEE MPE
ICNIRP Guidelines
Arcola
Bells Mill 223
Bells Mill 149
Beverly Farms
Cabin John
Churchill
Fallsmead
Gaithersburg
Goshen
Strawberry Knoll
Wootton
School

School	School	Bioinitiative Report 2007 Precautionary Action Level	IEEE MPE	ICNIRP Guidelines
Arcola Elementary School	3.62E-03	0.1	10,000	10,000
Bells Mill Elementary AP Rm 223	1.40E-04	0.1	10,000	10,000
Bells Mill Elementary School AP Rm 149	8.50E-04	0.1	10,000	10,000
Beverly Farms Elementary School	2.51E-04	0.1	10,000	10,000
Cabin John Middle School	1.14E-05	0.1	10,000	10,000
Churchill High School	9.72E-04	0.1	10,000	10,000
Fallsmead Elementary School	6.83E-05	0.1	10,000	10,000
Gaithersburg High School	1.27E-05	0.1	10,000	10,000
Goshen Elementary School	7.37E-04	0.1	10,000	10,000
Strawberry Knoll Elementary School	2.22E-03	0.1	10,000	10,000
Wootton High School	1.24E-04	0.1	10,000	10,000

**All values in microWatts/cm^2