

Living Near Broadcast Towers is Hazardous to your Health: Implications for Cell Sites

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16th May 2000

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Abstract

When measured or realistic radial radiation patterns from FM/TV broadcast towers are matched with cancer rates in people living in the vicinity of high-powered radio and television towers they produce consistent significant dose response relationships. These prove that chronic exposure to very low level RF radiation causes cancer in many part of the human body. With the consistency between the biological effects of studies involving powerlines, electrical occupations, diathermy, radio, radar and cell phone electromagnetic radiation exposure, it is highly probable that these adverse health effects will be found in the vicinity of cell sites. Because of the small population numbers around single sites, these effects will only be detectable by studying populations around hundreds of cell sites.

Introduction:

Goldsmith (1997) reported elevated mutagenesis and carcinogenesis among the employees and dependents that were chronically exposed to a very low intensity radar signal the U.S. Embassy in Moscow in the 1960's and 1970's. For most of the time the external signal strength was measured at $5 \mu\text{W}/\text{cm}^2$ for 9 hours/day on the West Facade of the building where the radar was pointed, Lilienfeld et al. (1978). To get the full strength of the signal a person would have to stand at an open window on the west side of the building at the 6th floor, Pollack (1979). Hence allowing for the internal signal strengths to be between 20 and 100 times lower, the occupants of the embassy were exposed to a long-term average radar signal in the range of 0.02 to $0.1 \mu\text{W}/\text{cm}^2$. Blood tests showed significantly elevated chromosome aberrations in more than half of the people sampled. Leukaemia rates were elevated for adults and children.

Goldsmith (1997) also reports that the Korean War Study, Robinette et al. (1980), showed elevated leukaemia in radar exposed military personnel. An exposure gradient was identified using a job matrix exposure assessment. This revealed a significant dose response for all mortality ($p=0.03$) and for respiratory cancer ($p<0.05$). By comparing the low exposure ET group with the very high exposure FT group mortality for All Cancer was significantly elevated, $RR = 1.66$, $95\%CI: 1.06-2.60$, as was mortality for leukaemia and lymphoma, $RR = 2.22$, $95\%CI: 1.02-4.81$. For low, intermediate and high exposure occupational groups the cancer rates/1000 people are 4.44, 4.95 and 8.25, and for leukaemia are 1.03, 1.16 and 3.06, respectively, Figure 1. Figure 1 also shows a dose response for all mortality and death from all disease. For occupational groups where the low exposure group has a mixture of generally low exposures and the high exposure

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group has a mixture or generally higher exposures, this is a typical dose response relationship.

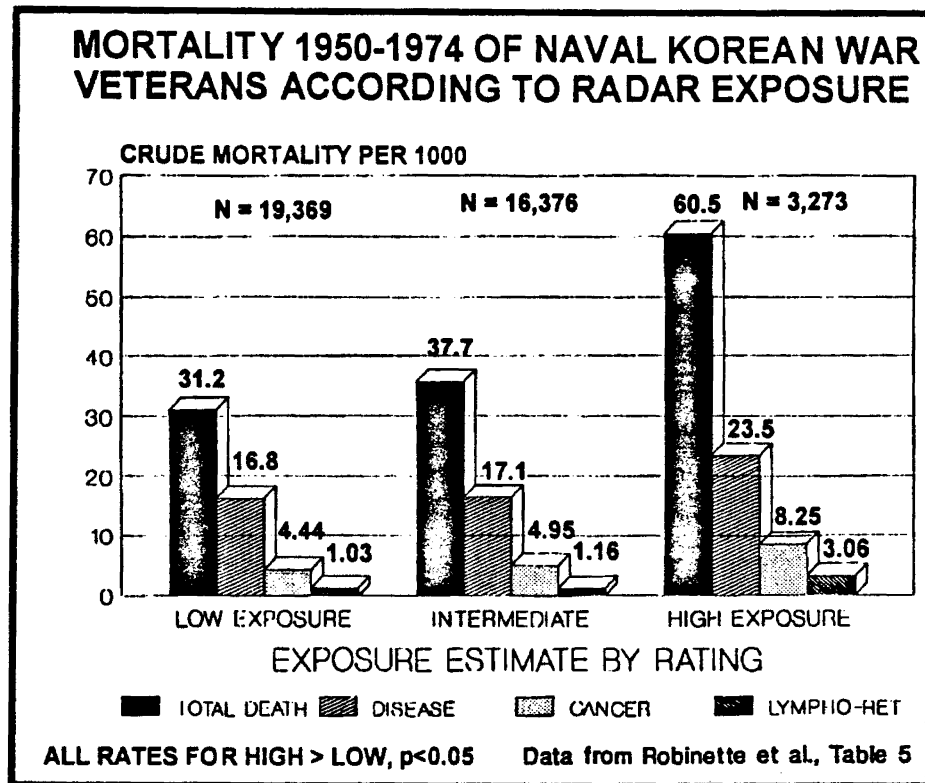


Figure 1: Naval occupations grouped by exposure category, showing dose response increases in mortality for all mortality, all disease, cancer and Lymphatic/Leukaemia. Low exposure (RM+RD), Intermediate exposure ET+FT), High exposure (AT).

Grouping occupational groups according to exposure levels also reveals dose-response increases for Total Death, All Disease, All Cancer and Lymphatic/hematopoietic Cancer, Figure 1. Hence it is shown that these are not "no effects" studies. Rather they show significant dose response increases in death, cancer and a wide range of diseases. They also show significant increases of many mortality and morbidity health effects.

Leukaemia was also significantly elevated for amateur radio operators, Milham (1988), SMR = 162. In a very large and well conducted study, Szmigielski (1996), Polish Military Personnel exposed to RF/MW radiation from radio and radar showed very highly significant elevations of leukaemia incidence and other cancers. For Leukaemia/Lymphoma RR = 6.31, 95%CI: 3.12-14.32, $p < 0.001$. For Chronic Myelocytic Leukaemia, RR = 13.9, 95%CI: 6.72-22.12, $p < 0.001$.

Global Leukaemia dose response for RF/MW exposure:

Epidemiological studies reveal significant elevations of All Cancer and Leukaemia for military occupations exposed to radar and radio, for amateur radio operators and electrical workers exposed to RF signals. As a class of studies military exposures produce high Rate Ratios (RRs), recreational and occupational exposures are intermediate and residential exposures are low. Table 1 summarizes several studies that are ranked in

response relationship for increased adult leukaemia and RF/MW exposure with a dose-response threshold close to zero.

Table 1: A summary of epidemiological studies involving adult leukaemia mortality or incidence, ranked by probable RF/MW exposure category.

Study	Reference	Exposure Category	Leukaemia Type	Risk Ratio	95% Confidence Interval
Polish Military (Mortality)	Szmigielski (1996)	High	ALL	5.75	1.22-18.16
			CML	13.90	6.72-22.12
			CLL	3.68	1.45-5.18
			AML	8.62	3.54-13.67
			All Leuk.	6.31	3.12-14.32
Korean War Radar Exposure (Mortality)	Robinette et al. (1980)	High AT/ET	Leuk/Lymp	2.22	1.02-4.81
Radio and TV Repairmen	Milham (1985)	Moderate	Acute Leuk. Leuk.	3.44 1.76	
Amateur Radio (Mortality)	Milham (1988)	Moderate	AML	1.79	1.03-2.85
UK Sutton Coldfield <=2km	Dolk et al. (1997a)	Moderate	Leuk	1.83	1.22-2.74
North Sydney TV/FM towers (Mortality)	Hocking et al. (1996)	Low	All Leuk.	1.17	0.96-1.43
			ALL+CLL	1.39	1.00-1.92
			AML+CML	1.01	0.82-1.24
			Other Leuk	1.57	1.01-2.46
UK TV/FM (Incidence)	Dolk et al. (1997b)	Low	Adult Leuk.	1.03	1.00-1.07

Note: ALL : Acute Lymphatic Leukemia; CLL: Chronic Lymphatic Leukaemia; AML Acute Myeloid Leukaemia; CML: Chronic Myeloid Leukaemia; and All Leuk.: All Adult Leukaemia.

When actual residential exposures are considered in detail, comparing actual radial radiation patterns with cancer patterns, dose responses for residential cancer are also shown by Selvin et al. (1992), Hocking et al. (1996), Dolk et al. (1997 a,b) and Michelozzi et al. (1998). These show a causal effect of adult and childhood leukaemia at levels of residential exposure involving exposure levels produced by cell sites out to over 500m.

The Special case of Broadcast Tower Epidemiological Studies:

Broadcast towers provide a unique opportunity for determining whether or not RF/MW

large populations that may be exposed and the second is the particular shape of the radial RF patterns. The ground level radial RF radiation patterns are complex undulating functions of the carrier frequency, the height of the tower and the antenna horizontal and vertical radiation patterns. When rates of disease follow these patterns it excludes all other factors, removing all possible confounders.

Around broadcast towers the ground level exposure patterns are a function of the power of the source signal and the antenna gain. The gain, is expressed as a function of the Equivalent Isotropic Radiated Power (EIRP) is a function of the technology used to focus the signal. Antennae are complex elements that attempt to efficiently focus the main beam and minimize the side-lobes. The ability to do this to some extent is a function of the carrier frequency. Because of these side-lobes a complex antenna pattern is formed with undulating peaks in the 'near field' towers, which extends out to 5 to 6 km typically. Figures 2 to 5.

Figure 2 shows the measured radial pattern near ground level around the Empire State Building in the 1930's, formed by the VHF stations installed on it tower.

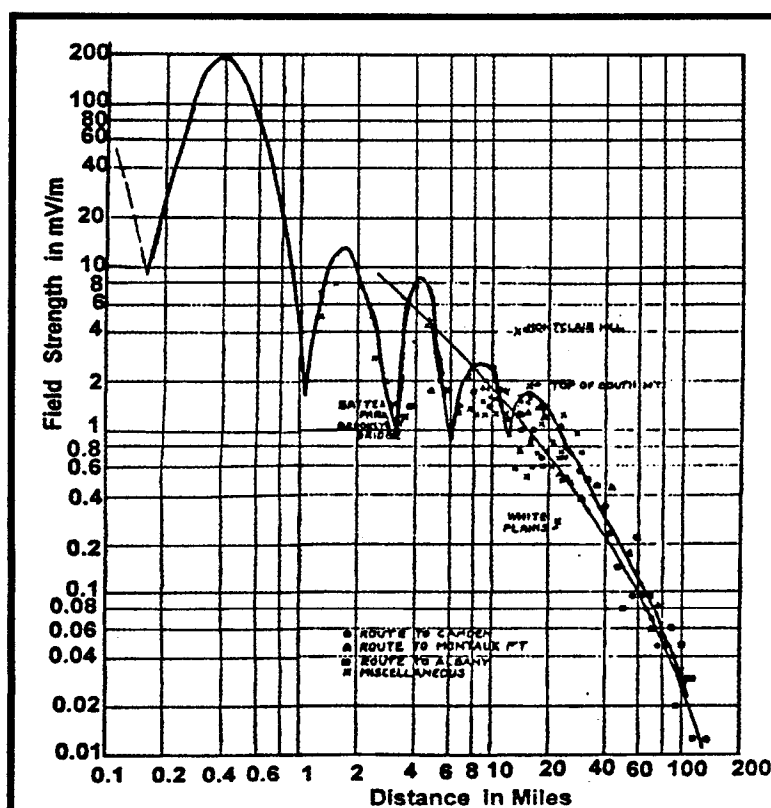


Figure 2: Ground level radiation pattern for (a) the 44 MHz (VHF) signal from the Empire State Building in New York City, from Jones (1933) by merging his figures 6 and 8,

Figure 3, from 'Reference data for Engineers', Jordon (1985), shows the dependence on the distance of the peaks and troughs as a function of the carrier frequency. The higher frequencies, 300 MHz, have higher relative peaks further out and lower relative peaks closer in than the 50 and 100 MHz signals. Note that the closest part of Figure 3, is 1 mile (1.6 km) from the tower. Figure 2 shows for a 44 MHz signal, a peak at 0.4 miles, 640m.

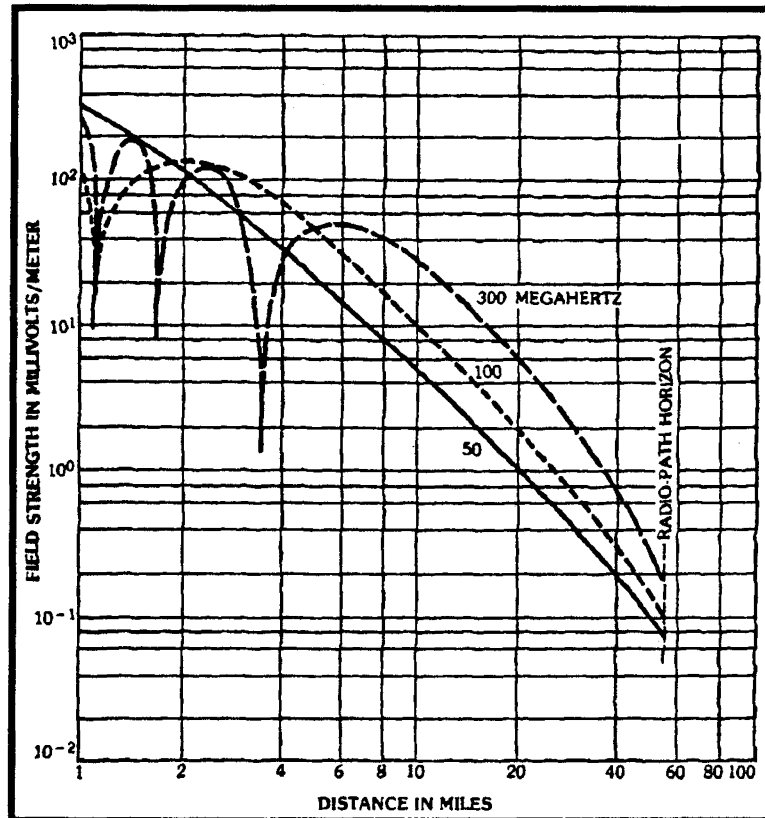


Figure 3: A theoretical set of radial VHF antennae patterns, Antenna height 1000', receiver height 30', power 1 kW, Reference data for Engineers, Jordon (1985).

Once the horizontal and vertical antenna patterns are known, the ground level exposure is a function of the gain for the particular elevation angle involved and the distance from the antenna, since the inverse square law operates along the ray of the beam. There are also signal strength variations caused by positive and negative reinforcement of the direct beam and the reflected beam at any point.

Vertical Antenna Patterns:

The vertical antenna pattern is a function of the antenna type and the carrier frequency. Figure 4 shows the vertical antenna pattern of an 8-dipole array for a 98 MHz FM station.

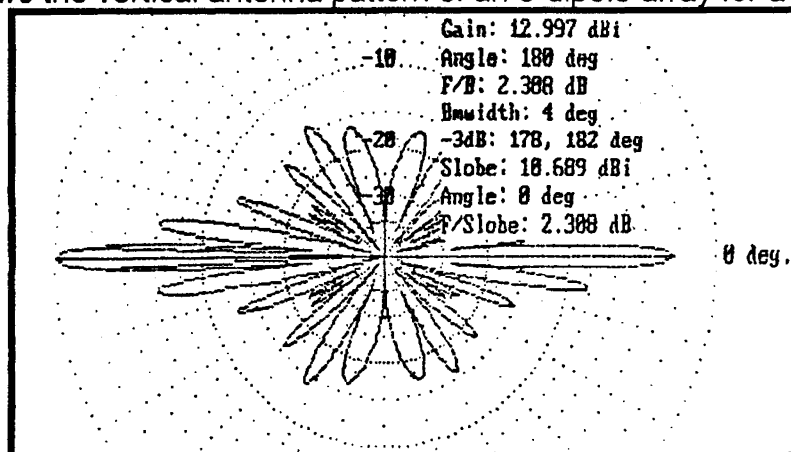


Figure 4: A typical vertical antenna pattern for a 4-element dipole array at about 98

The radial scale in Figure 4 is in dB that vary logarithmically with intensity. There is a very large difference between the intensity in the main horizontal beam (0 deg), the first minimum and the first side-lobe. These three points are -2.3, -28 and -8.1 dB respectively. These correspond to gains of 0.588, 0.00016 and 0.155, or relative gains of 1.0, 0.00027 and 0.2 respectively. The side-lobes have elevation angles of 8, 15, 40, 57 and 72 degrees. For an antenna at 500 m above ground level, the ground level side-lobe peaks occur at 160, 390, 600, 1870 and 3560 m from the base of the tower, with significant troughs of low exposure between them. The amplitudes of the peaks and troughs are very large because of the logarithmic nature of the dB units. It is common to tilt the antenna pattern slightly downwards so that the main beam is directed towards major population centres in the listening and viewing area rather than towards the far horizon.

The elevation angle of the antenna is usually slightly tilted downwards to point the main beam at the more remote listening or viewing audience. Figure 5 shows the relative antenna pattern for a UHF antenna with a down tilt of 0.5°.

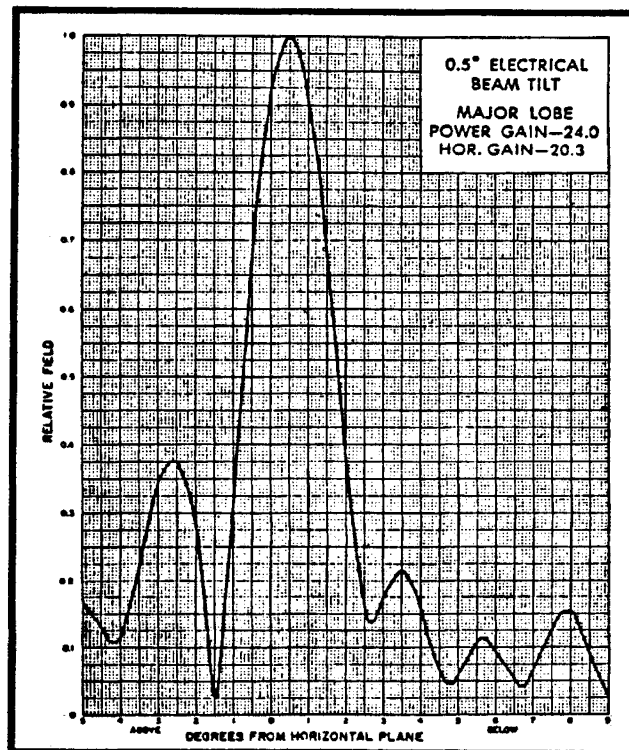


Figure 5: A UHF relative field factor (RFF) for the vertical antenna pattern from Hammett and Edison (1998).

The strength of the signal is proportional to the square of RFF. Figure 5 shows the main beam and side lobes at 0.5, 3.5, 5.7 and 8.9°, with RFF of 1.0, 0.22, 0.12 and 0.15. There are low points at 2.7, 4.8 and 6.7°, with RFF of 0.14, 0.046 and 0.044. For a signal with an Equivalent Isotropic Radiation Power (EIRP) of 10 MW this pattern produces the ground level exposure pattern in Figure 6.

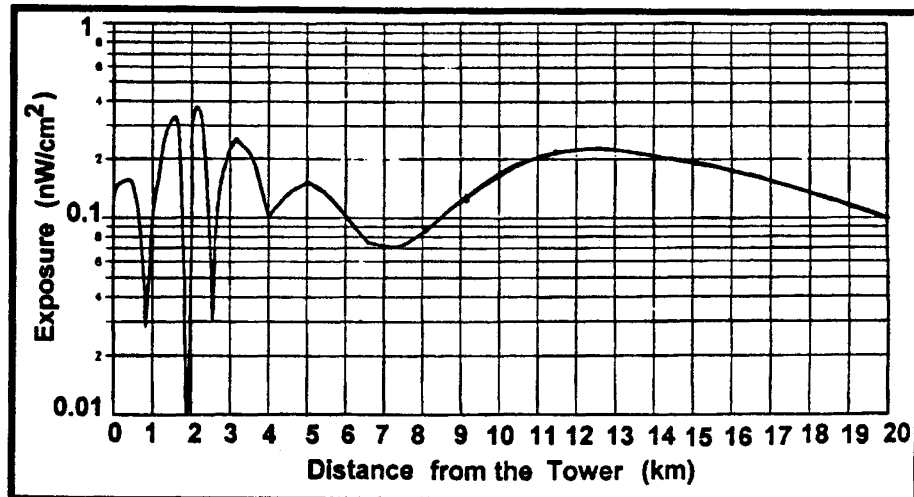


Figure 6: Ground level exposure for a typical UHF TV broadcast signal, from an antenna pattern from Hammett and Edison (1997), for a 2.4 MW EIRP transmitter at 400m AGL, for a flat surface.

Figure 6 clearly illustrates the nature of UHF antenna with low exposures inside 1 km, a set of side-lobe peaks out to 6 km and the main beam peaking at 12 to 13 km.

Horizontal antenna patterns:

Antennae are not only capable of focussing RF radiant power into vertical beams but can also focus the beams in the horizontal plain to send most of the broadcast signal towards most of the listeners and viewers. Two examples are given in Figures 7 and 8. The first is for the FM radio signal shown in Figure 4. The second is for the UHF antenna, the vertical pattern of which is in Figure 5.

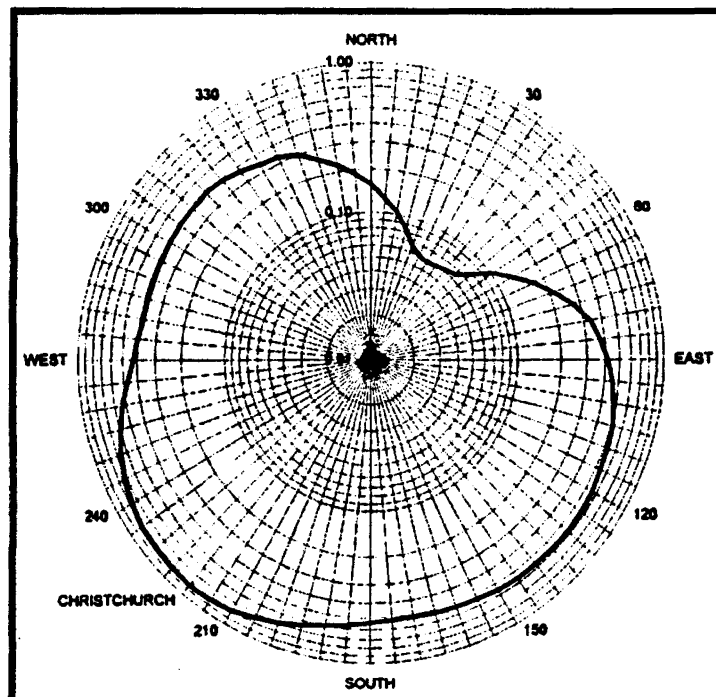


Figure 7: Horizontal antenna pattern for an 8-element dipole array for a 98 MHz FM transmission

Figure 7 shows that the signals from this antennae are horizontally focussed towards the city of Christchurch from the tower which is located to the northeast of the city.

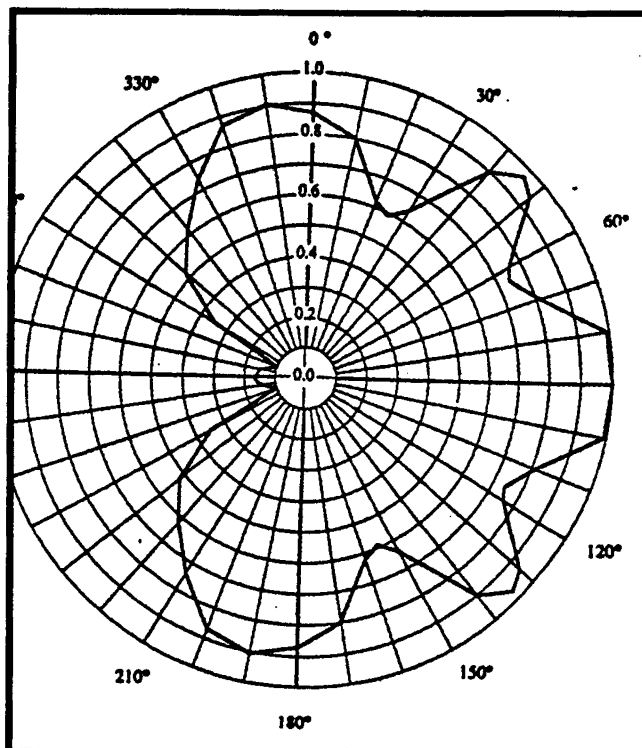


Figure 8: Horizontal antenna radiation patterns showing the relative field strength for, (a) UHF Digital TV (linear scale) from the Sutra Tower.

The Sutra tower is in the western portion of the San Francisco Peninsula, with a small number of seaside suburbs behind it, most of the City of San Francisco, plus Oakland and Berkeley to the east.

When considering epidemiological studies of health effects in association with broadcast towers it is essential that the complex radial and horizontal RF radiation patterns are understood and used. This must be carried out along with other geographic features such as the existence of shadows produced by hills on one side and elevated exposure on the hill slopes facing a tower. Lakes, ocean, Central Business Districts (CBD) and parks are not residential areas and must be incorporated into the analysis of incidence of health effects.

Personal exposures will be somewhat less than the direct peak exposure at a given location. Indoor exposures are very much lower than the outdoor exposures, Pollack (1979) and McKenzie, Yin and Morrell (1998). McKenzie et al. measured some locations around the TV/FM towers in North Sydney. They report that at one location close to the towers the measurement on the roof was $3\mu\text{W}/\text{cm}^2$, at street level $0.066\mu\text{W}/\text{cm}^2$ and inside the house $0.017\mu\text{W}/\text{cm}^2$. Hence the exposure reduction factors are 46 and 176 respectively.

A residential exposure factor is estimated using reduction factor of 1 for direct exposure, 20 for outside and away and 50 inside. The typical weekly exposed:outside:away:inside ratio is 6: 20: 12: 130 giving an overall residential exposure factor (REF) of 0.061. This is rounded up to 0.075.

Exposure dilution is an important factor in EMR health studies. Many of the health effects take decades to develop or are only able to be studied using long-term health records. Every person has a different distribution of exposure experiences. It is rare to identify a large group with a consistent high exposure to compare the health effects incidence rates in a comparative group with consistent low exposures. Within groups there can be higher average exposures compared to other groups. Hence health effects are related to mean exposures not peak exposures. 'Clean' dichotomization is very difficult to accomplish. In residential studies migration is a source of dilution. Cancer rates are reduced by exposed people leaving the study area and by previously unexposed moving into the study area.

The vast majority of factors that influence these studies reduce the apparent effects. This shows that the actual effects will be stronger than those indicated by the ratios and statistics used.

Epidemiological studies of Residential RF/MW exposure:

U.S. Embassy in Moscow:

The first residential study was the U.S. Embassy in Moscow which was irradiated by a radar for over 20 years. Typical tours of duty were 2 to 4 years. The Lilienfeld et al. (1978) report shows that peak daily exposures on the fifth floor at one end of the west facade was irradiated by one radar during working hours for most of the time with a peak exposure of $5\mu\text{W}/\text{cm}^2$. For a short period in the 1970's two radars were used and the peak measured exposure was $15\mu\text{W}/\text{cm}^2$. The chronic health effects are related to the earlier 2 decades and to mean exposures that are 50 to 100 times lower than the peak measured at one particular point, i.e. in the range 0.01 to $0.1\mu\text{W}/\text{cm}^2$.

The all cause mortality rate for Moscow males as 0.42 (0.3-0.6) and for females 1.1 (0.5-1.9). Hence males, primarily State Department employees, were much healthier and females were as healthy as the average U.S. residents. This is a good example of the "healthy worker" effect. State Department selection procedures rule out a range of unhealthy people and favour healthy people.

Table 2: Sickness rates increased in Moscow with years of service: (Table 6.18)

	Under 2 yrs	2-3 years	4 + years	p-value for trend
Number of people	316	455	45	
Person-years	3709	5570	568	
Male Conditions (%)				
Present Health Summary	5.4	9.7	16.2	0.05
Arthritis/rheumatism	4.3	6.5	8.8	0.02
Back Pain	4.0	7.7	11.8	0.04
Ear problems	3.8	5.6	14.7	0.02
Vascular system	0.8	2.7	11.8	0.004
Skin & Lymphatic	9.4	12.2	28.0	0.02
Female Conditions (%)				

Table 2 shows a number of health effects which rose in a significant dose-response manner as a function of years in Moscow.

The sickness rates increased independent of the age of arrival and faster than the influence of aging. Neurological symptoms were elevated and some were significantly elevated.

Table 3: Neurological Symptoms per 1000 p-y, Male employees: (Table 6.31)

	Moscow	Comparison	RR	p-value
Depression	1.3	0.73	1.78	0.004
Migraine	1.8	0.97	1.86	
Lassitude	1.2	0.78	1.54	
Irritability	1.3	0.66	1.97	0.009
Nervous Disorders	1.5	0.64	2.34	
Difficulty in Concentrating	1.4	0.52	2.96	0.001
Memory Loss	1.6	0.50	3.20	0.008
Dizziness	1.2	0.85	1.41	
Finger Tremor	1.3	0.71	1.83	
Insomnia	1.1	0.90	1.22	
Neurosis	1.3	0.76	1.71	

These symptoms are consistent with the "Microwave Syndrome" of the "Radiofrequency Radiation Sickness", Johnson-Liakouris (1998). Mild et al. (1998) identified significant dose-response relationships for the following symptoms from the use of mobile phones: Memory Loss, Difficulty in Concentrating, Headache and Fatigue. Hence it is now shown and known that RF/MW exposure from extremely low but chronic exposure over many years, occupational exposure and cell phone use all produces significant and consistent neurological symptoms. The Risk Ratios were quite large but they were not quite significant because of the very small sample numbers.

Table 4: Congenital Malformations of children after the first tour:

Conditions	Moscow SMBR	Comparison SMBR	RR	Number of children
Leukaemia and cancer	1.2	0.84	1.43	1
Blood Disorders	1.7	0.42	4.05	7
Mental, Nervous Cond ⁿ .	1.8	0.36	5.0	8
Behavioural Problems	1.4	0.68	2.06	7
Chronic Disease	1.1	0.88	1.25	7

Patients with mutagenic level of 3 and above were advised not to reproduce until 6 months after somatic levels had returned to 2 or 1. This warning applied to 68 % of the patients in this sample. Staff with elevated chromosome aberration rates were advised not to have children for until six months after they had returned to near normal.

A survey of cancer mortality rates is summarized in Table 6. This shows that despite the extremely small sample size and the very significant exposure dilution in the years between residence in Moscow and the survey results, there are highly elevated and

increases chromosome aberration and cancer. This was recently also found in mice, Vijayalaxmi et al. (1997).

Table 5: Blood samples showed a high proportion of the staff had significantly altered red and white blood cell counts and well above average chromosome aberrations (CA). The CA data is set out in Goldsmith (1997), i.e.

Mutagenic Level	Designator	Subjects, No.
5	Extreme	0
4	Severe	6
3.5	Intermediate	5
3	Moderate	7
2.5	Intermediate	5
2	Questionable	5
1	Normal	6

Table 6: Cancer Mortality Rates:

<u>Male employees (Table 6.37)</u>	Moscow SMBR	Comparison SMBR	RR
Skin Cancer	1.5	0.69	2.17
Benign Neoplasms	1.4	0.75	1.87
<u>Female employees (Table 6.38)</u>			
Malignant Neoplasm (Excl. skin)	1.7	0.63	2.86 (p=0.06)
<u>Adult Dependents: (Tables 7.12, 7.13)</u>			
	Obs.	Exp	SMR (95%CI)
<u>Live-in</u>			
All malignant Neoplasms	5	1.5	3.3 (1.1-7.7)
Digestive Organs Cancer	1	0.26	3.8 (0.1-21.2)
Pancreas Cancer	1	0.03	33.3 (0.8-185)
Breast Cancer	1	0.4	2.5 (0.1-13.9)
Ovarian Cancer			3.0
Multiple Myeloma			1.5
Arteriosclerotic Heart Disease	2	0.59	3.4 (0.4-12.3)
<u>Live-out</u>			
All malignant Neoplasms	7	3	2.3 (0.9-4.7)
Brain tumor	2	0.1	20.0 (2.4-72.2)
Lung cancer	1	0.44	2.3 (0.4-93)
All Accidents	4	1	4.0 (1.1-10.2)

Table 14: cont'd:				
	Obs.	Exp	SMR	(95%CI)
Suicide	1	0.36	2.8	0.1-15.6)
<u>Children Living In (Table 7.16)</u>				
All Malignant Neoplasms	2	0.5	3.8	(0.5-13.7)
Leukaemia	1	0.2	5.3	(0.1-29.5)
Suicide	1	0.29	3.4	(0.0-1.6)
<u>Children Living out</u>				
All Malignant Neoplasms	2	0.83	2.4	(0.3- 8.7)
Leukaemia	1	0.3	3.4	(0.1-18.9)
Suicide	1	0.3	3.3	(0.1-18.4)

The dominant cancers are brain tumor and leukaemia and reproductive organ cancer. But this study, like the Korean War Study, confirms that extremely low level chronic microwave exposure is associated with very significant increases in illness and mortality in organs across the whole body, consistent with widespread cellular chromosome damage. Significantly elevated chromosome aberrations were measured in this case, Table 5, as well as significant alterations in white and red blood cell counts, Jacobson (1969). This would also be the expected result from reduced melatonin.

This shows many elevated cancer rates and significantly elevated cancer for all cancer and brain tumour.

A highly remarkable result is the dose-response relationship for a range of sicknesses, Table 2. The results must be very highly significant to survive the exposure dilution effect with the disease gradient intact and statistically significant. As with Robinette et al. (1980), the data presented in the Lilienfeld contract report is contrary to that stated in the report's stated (an altered) conclusions. Despite the small numbers, the lack of long latency period and dilutionary factors, the Lilienfeld data shows significant increases in:

- Cardiac symptoms
- Neurological and psychological symptoms
- Altered blood cell counts
- Increased chromosome aberrations, and
- Elevated cancer in children and adults
- Sickness increasing in a dose-response manner with years of residence.

The data in Robinette et al. (1980) also shows significant cardiac and neurological symptoms and dose response increases in all mortality, all cancer, respiratory cancer and Leukaemia/Lymphoma. These earlier studies set the scene for residential studies that show increases in childhood and adult cancer, particularly leukaemia.

Sutra Tower Study: Selvin et al. (1992):

Professor Steve Selvin and his colleagues were interested in developing a statistical method for identifying from residential data, who was appropriately characterized as "exposed" compared with "non-exposed". They chose to use a data set for 4 childhood cancers, representing about 50 % of the total childhood cancer, for the San Francisco City area. A prominent feature of the area is the Sutra Tower. It is a very tall tower on a hill which can be seen from all over San Francisco. Since this is the primary radio and TV broadcast facility in the Bay Area, there are very high-powered outputs from the Tower. In broadcast facility in 1997 it had over 980 kW of VHF TV and FM radio, and 18,270 kW of UHF TV, expressed as EIRP, Hammett and Edison (1997). The tower is 300m high on a 276 m hill, placing the majority of the high-powered antennas at 520 m AMSL.

The locations of children with leukaemia and "all cancer" are shown in Figures 9 and 10.

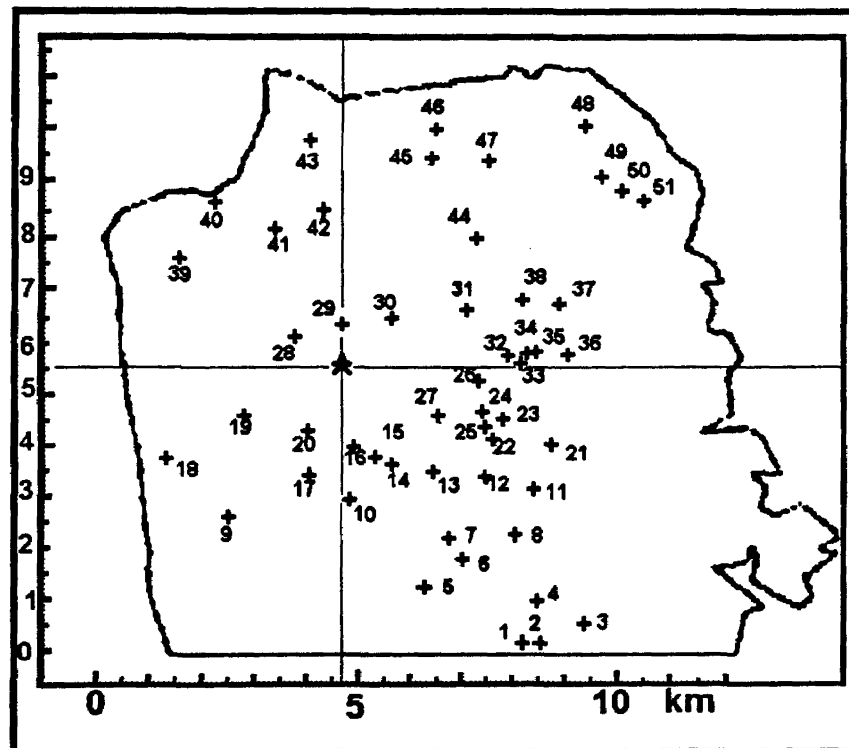


Figure 9: Spatial map of white childhood (<21 years) leukaemia for San Francisco, 1973-88, from Selvin et al. (1992).

Figure 10 reveals the lack of cancer and residence in Golden Gate Park to the WNW of the tower, the broad low density housing area of the Army Base, the Presidio to the NW, a large park area and hills to shade suburbs to the SW, the Central business district to the ENE and the port and industrial area along the eastern coastline. These were all taken into account when the residential population density was calculated below.

The cluster 48-51, to the NE are residences on a western facing hill slope, with higher exposure levels from the Sutra Tower than the radial distance implies. They contribute to the higher cancer rate in the 6-8 km ring compared with the 5-6 km ring. This explains some of the scatter about the dose response line.

there is a ring with low cancer rates and then a ring with higher cancer rates. Selvin et al. (1992) assumed a linear relationship with exposed and found a distance related peak at 1.75 km. Figure 11 shows the measured and fitted radial exposure curve.

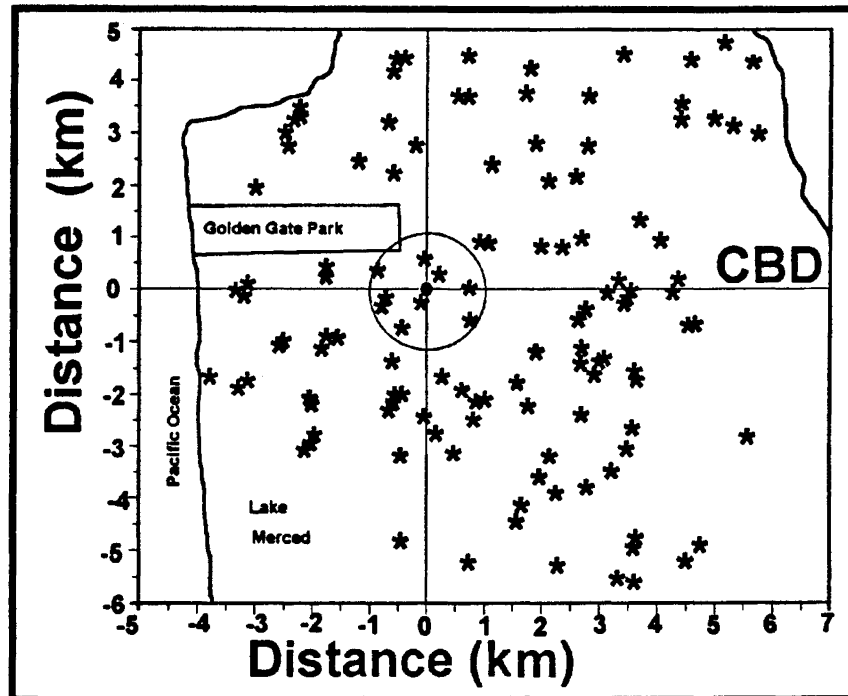


Figure 10: All cancer for children (<21 years) from 1973-88, from Selvin et al. (1992), involving 123 cases with brain tumor (35), leukaemia (51) and Lymphoma (37).

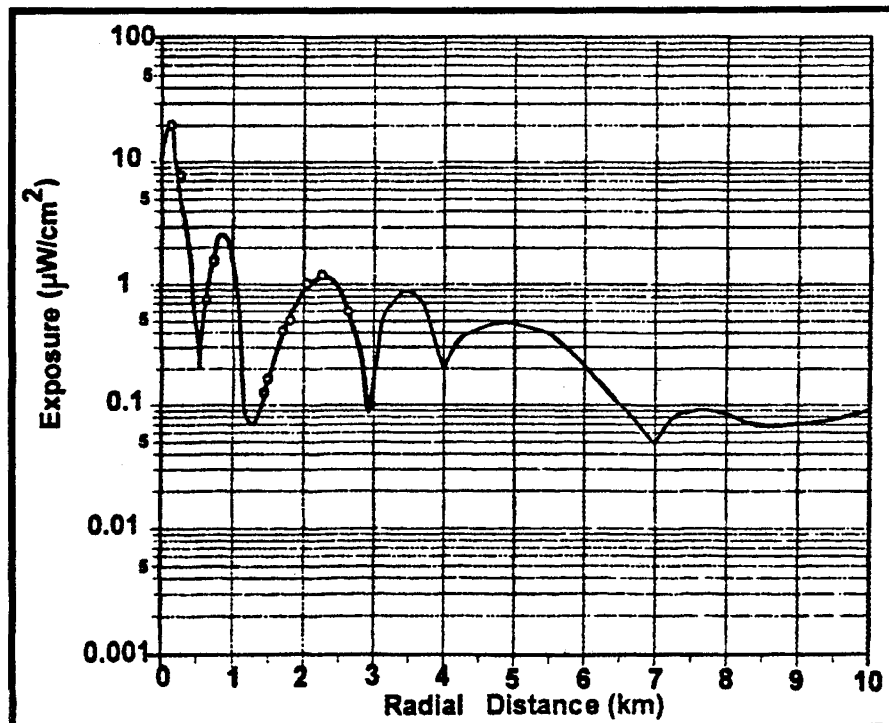


Figure 11: The measured and estimated power density (exposure in $\mu\text{W}/\text{cm}^2$) with distance from the Sutra Tower. Circles show measurements. The line follows measurement points and the radial pattern of Figure 6 beyond 3 km.

The mean radial exposure regime, for this analysis, was assumed to be isotropic and given by Figure 11. Direct exposures were reduced by a factor of 0.075 to allow for mean residential exposure. These estimates are given in Table 7. Thus the radial childhood cancer rates can be compared with a much more realistic radial radiation exposure pattern. The resulting estimates are summarized in Table 7.

Table 7: Radial rings, with estimated population, Risk Ratios and Cumulative Risk Ratios, for white childhood brain tumour, Leukaemia, Leukaemia + Lymphoma, and All Cancer, in association with RF/MW exposure from the Sutra Tower, San Francisco.

Distance (km)	<0.99	1-1.99	2-2.49	2.5-2.99	3-3.49	3.5-3.99	4-4.49	4.5-4.99	5-5.99	6-8
Est. Population	1138	4334	3558	4489	5146	5566	4939	5386	8141	7988
Estimated personal mean dose in $\mu\text{W}/\text{cm}^2$	0.25	0.05	0.08	0.06	0.06	0.05	0.03	0.04	0.015	0.007
Symptom										
Brain Tumour	11.81	2.48	3.02	1.80	2.09	1.93	1.63	1.00	0.99	1.01
Cumulative	11.81	4.42	3.87	3.18	2.88	2.66	2.49	2.26	2.02	1.86
Leukaemia	1.26	1.32	2.02	1.92	1.67	1.80	2.03	1.33	0.53	1.26
Cumulative	1.26	1.31	1.59	1.70	1.69	1.72	1.77	1.70	1.48	1.44
Leuk + Lymph	2.47	1.08	2.63	2.08	2.54	1.85	2.27	1.56	0.57	1.05
Cumulative	2.47	1.37	1.86	1.94	2.10	2.05	2.08	2.00	1.73	1.62
"All Cancer"	4.88	1.44	2.73	2.01	2.43	1.87	2.35	2.11	0.68	1.04
Cumulative	4.88	2.16	2.38	2.26	2.31	2.43	2.21	2.19	1.80	1.68

Plotting the radial All Cancer RR and mean resident RF exposure is shown in Figure 12.

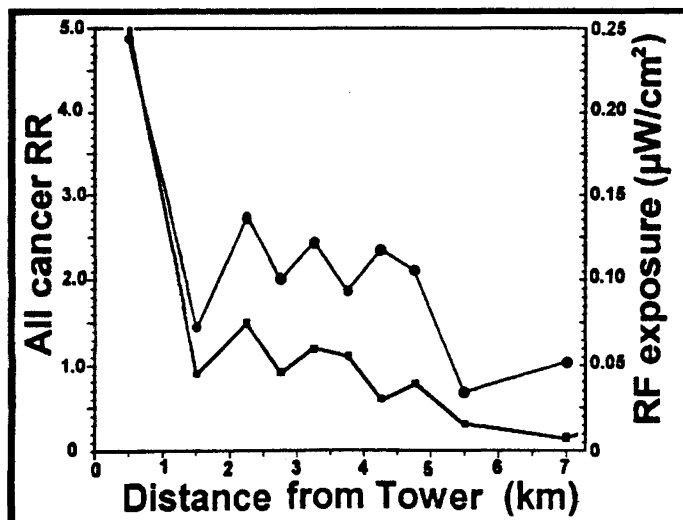


Figure 12: The radial All Cancer Risk Ratio and the mean residential RF exposure as

The dose-response trend analysis uses a least squares fit, using the Mantel-Haenszel estimate of t with a two-tailed t -test for the significance test. For All Cancer $t = 14.05$ ($p < 0.0001$) and for Brain Tumour $t = 13.70$ ($p < 0.0001$). For leukaemia ($t = 3.31$, $p < 0.01$), Leukaemia and Lymphoma combined ($t = 3.81$, $p < 0.005$), Non-Hodgkin Lymphoma ($t = 1.94$, $p < 0.05$) and Hodgkin Lymphoma ($t = 7.26$, $p < 0.001$). The dose response curves for all cancer and brain tumour are shown in Figures 13 and 14.

Contrary to the conclusion of Selvin et al. and ICNIRP (1998), who claim that this study shows no evidence of adverse effects, the spatial data when related to actual radial radiation exposure patterns forms significant linear dose-response relationships, with All Cancer and Brain Tumour having extremely significant dose-response relationships.

Figure 48 shows that the radial childhood cancer rate varies with the same pattern as the radial RF exposure. This then forms the highly significant dose-response relationship in Figure 50. No other factor varies like this. Hence this is a causal relationship.

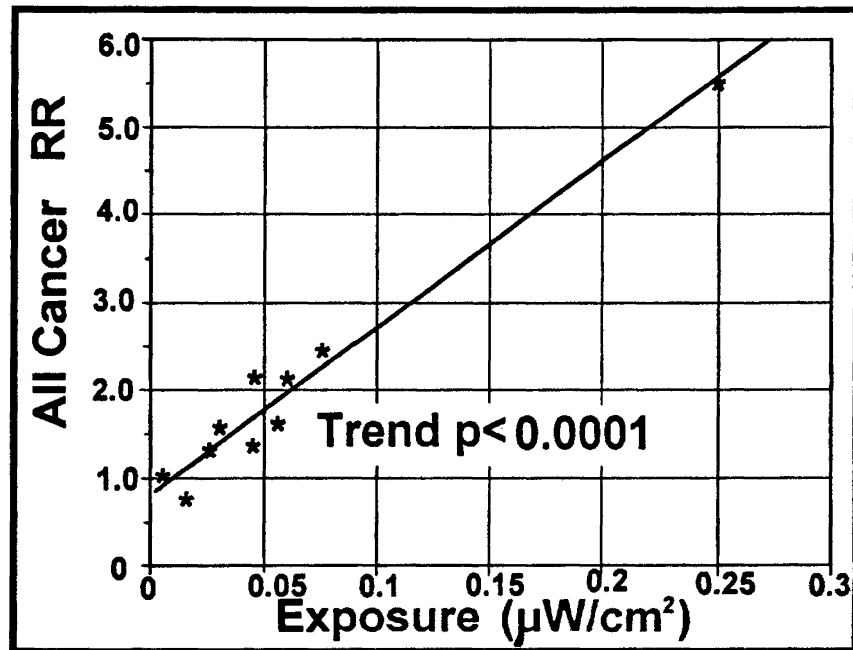


Figure 13: All Cancer Risk Ratio as a function of estimated radial group mean personal exposure to RF/MW radiation from the Sutra Tower, San Francisco, using the spatial childhood cancer data presented in Selvin et al. (1992). The dose-response relationship is extremely significant ($p < 0.0001$).

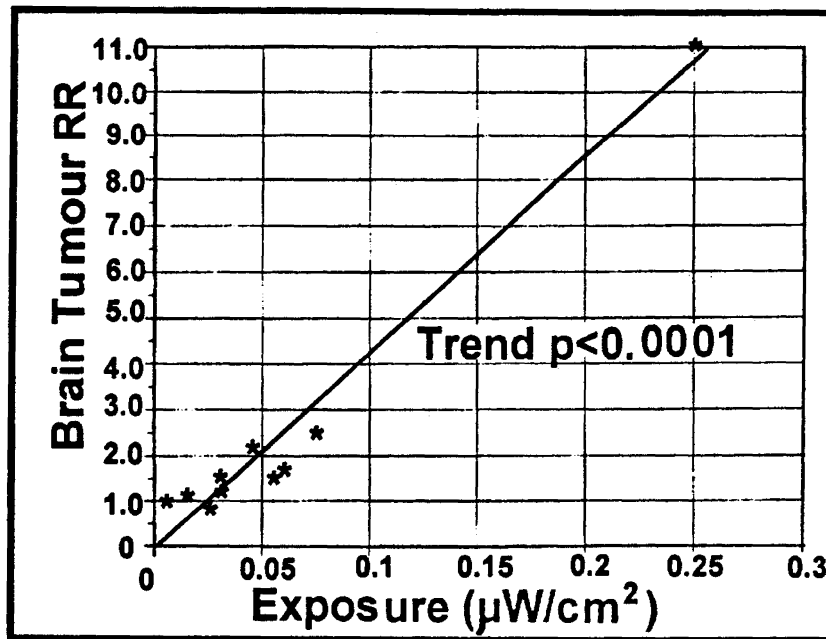


Figure 14: Brain Tumour Risk Ratio as a function of estimated radial group mean personal exposure to RF/MW radiation from the Sutra Tower, San Francisco, using the spatial childhood cancer data presented in Selvin et al. (1992). The linear dose-response relationship is extremely significant ($p < 0.0001$).

Hawaii Childhood Leukaemia Study:

Maskarinec, Cooper and Swygert (1994) report significant elevation of childhood leukaemia in the vicinity of radio towers in Hawaii, SIR = 2.09 (95%CI: 1.08-3.65), from a small sample of children.

North Sydney Leukaemia Study:

Hocking et al. (1996) reported significant elevation of childhood and adult leukaemia incidence and mortality around the TV/FM towers in North Sydney. This study was carried out to allay public fears about siting cell sites in residential properties in Australia, Hocking (pers. Comm.). The authors correctly recognized that mobile phone base stations (cell sites) have not been exposing people long enough to produce cancer because of the cancer latency periods are long. Because of the then dominance of analogue cell phones using FM radiation they decided to study the residents exposed to FM signals from FM radio and TV stations around three tall towers in North Sydney. When the study was commenced Dr Hocking was the Medical Director of the Telstra Research Laboratory. At the time of publication Dr Hocking had become an independent public health consultant and the paper was published with the support of his professional colleagues.

The population Sample:

The cancer data covered 9 municipalities in the north side of Sydney Harbour for the period 1972 to 1990, Figure 15.

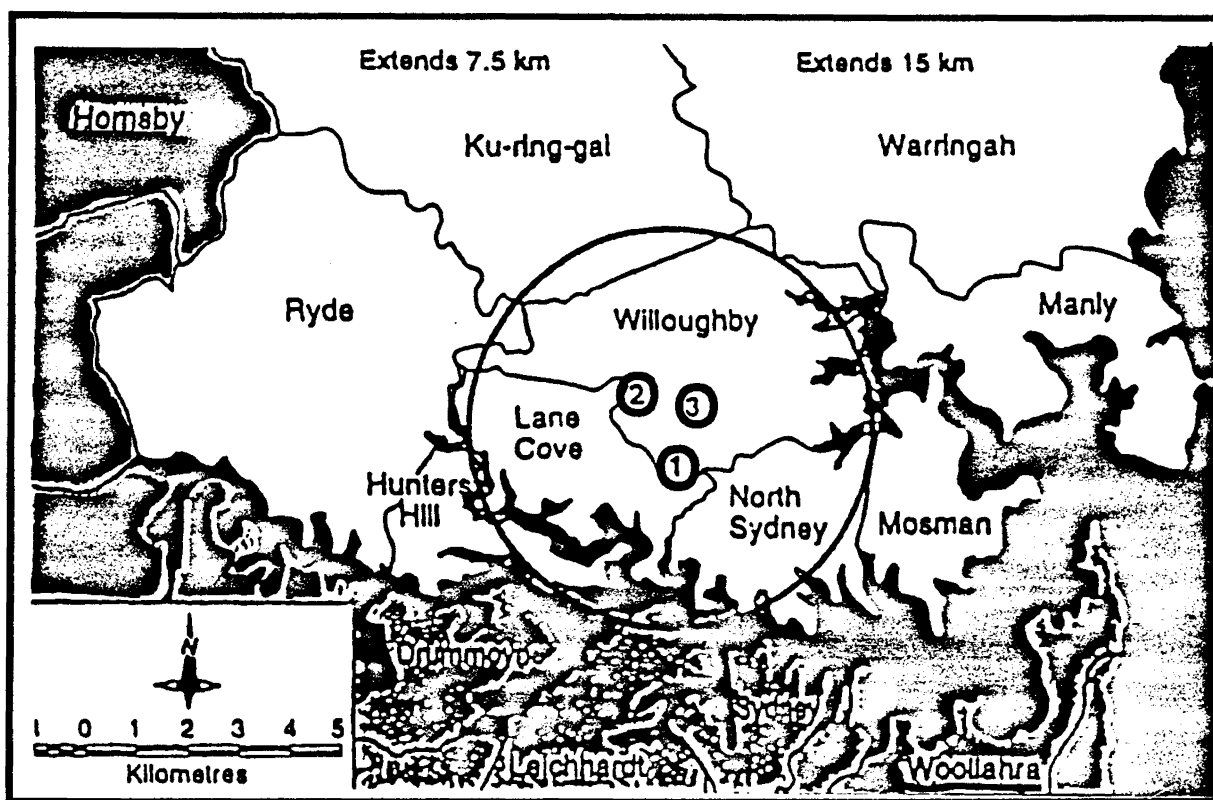


Figure 15: Municipalities in northern Sydney and the TV towers (numbered 1, 2 and 3). The circle has a 4 km radius and is for reference only. Willoughby, Lane Cove and North Sydney are the inner "exposed" municipalities, Hocking et al. (1996).

The exposed population was chosen to be the three municipalities that surrounded three large TV towers, Lane Cove, Willoughby and North Sydney. This gives an "exposed" population of 135,000. The control group came from six surrounding municipalities, Ryde, Ku-ring-gai, Warringah, Manly, Mosman and Hunters Hill, population 450,000, Figure 14.

The cancer incidence (mortality) cases were adjusted for sex, age and calendar period and resulted in 1206 (847) leukaemia cases for the total population and 134 (59) for children 0-14 years. For brain tumour the sample was 740 (606) for the total population and 64 (30) for children.

Exposure situation:

There are three towers. The frequencies involved are in the range 63 - 219 MHz and 626-633 MHz. Tower 1 has the highest TV/FM output power, 500 kW, while Tower 2 has 180 kW and Tower 3, 110 kW. The exposure of each municipality is also a function of the horizontal radiation patterns. See Figures 7 and 8, for example. One of the horizontal transmission patterns from North Sydney is given in Figure 16.

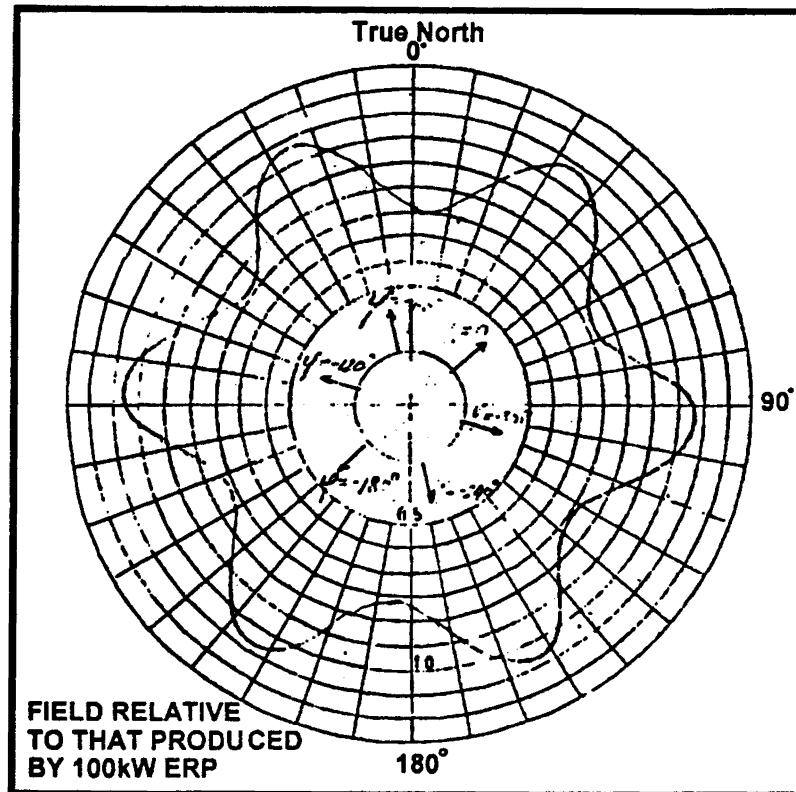


Figure 16: A horizontal radiation pattern for one North Sydney transmitter.

Figure 16 shows a 6-peak pattern with the peak rotated towards the SW. This is appropriate to reach the largest population in the viewing area, as for the patterns in Figure 6. The SW peak is over Lane Cove. Most of the Lane Cove population lives with 2.5 km of the towers, Figure 56. The centre of North Sydney is on the side of the SE peak and the centre of Willoughby is at the low point between the two northern peak which cover the sides of Willoughby. If the exposure of the centroid was assessed this would rank Lane Cove, North Sydney and Willoughby from high to low. This would then produce a dose response in the adult leukaemia rates that are 16.7 (9.7-26.8), 7.1 (2.8-14.6) and 6.1 (3.0-10.8) respectively. Adjusting the centroid estimates from McKenzie et al. (1998) by the horizontal pattern in Figure 16 gives representative direct exposure levels of 1.5, 0.5 and $0.63 \mu\text{W}/\text{cm}^2$, respectively. This indicates a probable dose response. Applying the residential exposure factor of 0.075 reduces the highest exposure to $0.11 \mu\text{W}/\text{cm}^2$. This is comparable with the higher exposure levels near the Sutra Tower.

Hocking et al. shows statistically significantly increased incidence and mortality for total leukaemia, Lymphatic Leukaemia and Other Leukaemia for the whole population, with Risk Ratios in the range 1.09 to 1.67 for leukaemia incidence and 1.01 to 1.57 for leukaemia mortality. The highest relationship is for Lymphatic Leukaemia mortality, RR = 1.39 (95% CI: 1.00-1.92), Table 8.

The strongest relationship is for childhood lymphatic leukaemia death, RR=2.74 (95%CI: 1.42-5.27). The study found that 59 children had died from having leukaemia when the expected number was 25.43, an excess of 33.6 deaths. For childhood lymphatic leukaemia 39 children died when 14.2 were expected, an excess of nearly 25 children, Table 9.

Table 8: Rate Ratios (RR) and 95% confidence intervals (CI) for cancer incidence and mortality in the population of the inner area compared to the outer area, adjusted for age, sex and calendar period.

Cancer Type	RR (95% CI)	Cases
Incidence		
Brain Tumour	0.89 (0.71-1.11)	740
Total Leukaemia	1.24 (1.09-1.40)	1206
Lymphatic Leukaemia	1.32 (1.09-1.59)	536
Myeloid Leukaemia	1.09 (0.91-1.32)	563
Other Leukaemia	1.67 (1.12-2.49)	107
Mortality		
Brain Tumour	0.82 (0.63-1.07)	606
Total Leukaemia	1.17 (0.96-1.43)	847
Lymphatic Leukaemia	1.39 (1.00-1.92)	267
Myeloid Leukaemia	1.01 (0.82-1.24)	493
Other Leukaemia	1.57 (1.01-2.46)	87

Table 9: Rate Ratios (RR) and 95% confidence intervals (CI) for cancer incidence and mortality in childhood (0-14 years) in the population of the inner area compared to the outer area, adjusted for age, sex and calendar period.

Cancer Type	RR (95% CI)	Cases
Incidence		
Brain Tumour	1.01 (0.59-2.06)	64
Total Leukaemia	1.58 (1.07-2.34)	134
Lymphatic Leukaemia	1.55 (1.00-2.41)	107
Myeloid Leukaemia	1.73 (0.62-14.81)	9
Other Leukaemia	1.65 (0.33-8.19)	8
Mortality		
Brain Tumour	0.73 (0.26-2.10)	30
Total Leukaemia	2.32 (1.35-4.01)	59
Lymphatic Leukaemia	2.74 (1.42-5.27)	39
Myeloid Leukaemia	1.77 (0.47-6.69)	11
Other Leukaemia	1.45 (0.30-6.99)	9

The authors searched diligently for confounding factors, including social economic factors, air pollution (benzene), ionizing radiation, migration, hospitals, high voltage power lines and local industries. None affected the relationships found. They investigated the possibility of clustering and found that no significant heterogeneity was found ($p=0.10$ for incidence and $p=0.13$ for mortality).

McKenzie et al. (1998) were critical of the Hocking study because of their analysis of

above, there are reasons why the approach of McKenzie et al. is limited in terms of appreciation of horizontal exposure patterns.

Hocking et al. (Hocking, Gordon and Hatfield (1999)) reject the substance of the criticisms of McKenzie, Yin and Morrell, concluding:

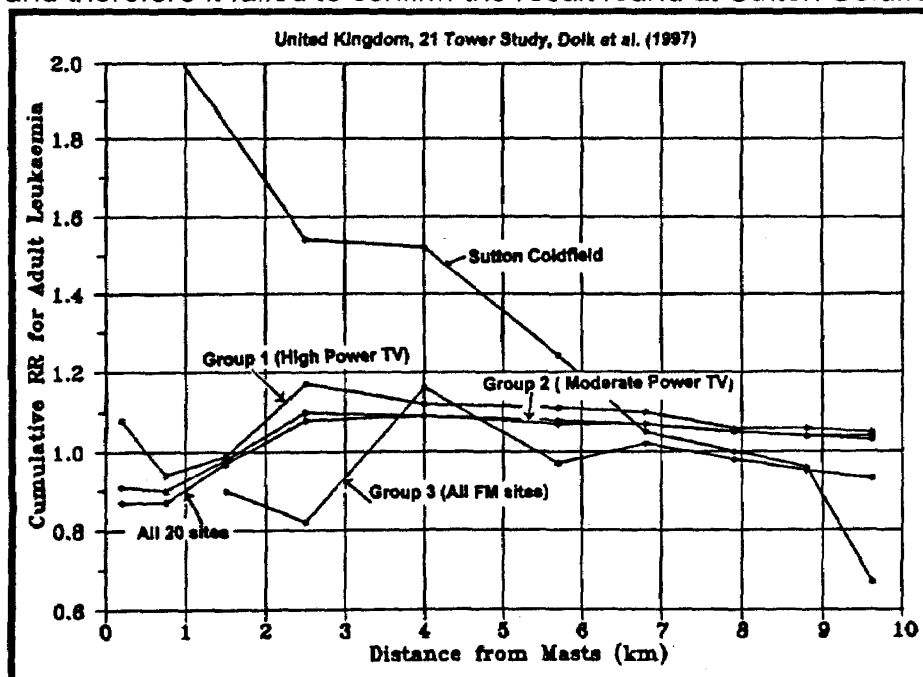
"In summary, we consider that the second look at our study had important deficiencies regarding post hoc analysis of data. Their conclusion that their analysis 'casts doubt on the apparent association between childhood incidence of acute lymphoblastic leukaemia and television RFR' is not justified. If anything, their analysis confirms our own finding of a modest association, which warrants further study."

United Kingdom Regional TV Tower Study: Dolk et al. (1997)

The Study Context:

Dr Helen Dolk and her colleagues responded to concerns about a cluster of seven cases of leukaemia and lymphoma who were patients of a Birmingham GP, Dr Mark Payne, and who lived near the Sutton Coldfield Transmitter. They obtained data from the cancer registry and found a high incidence of adult leukaemia near the tower, which declined with distance. They assumed that this was a dose-response relationship that was following an inverse square law for exposure decline with distance from the transmitter. Before they published this result they decided to extend the study to 20 other regional TV towers throughout the United Kingdom.

At these individual sites, and for all the 20 sites combined, the adult leukaemia rate was found to be low near the tower, rose to form a broad variable peak between about 1 km and 5 km, and then declined with distance. Over all distance it didn't follow an inverse square law and therefore it failed to confirm the result found at Sutton Coldfield, Figure 17.



Thus Dolk et al. (1997b) concludes that the follow-up study "at most gives very weak support to the Sutton Coldfield findings." ICNIRP accepts this conclusion and states that the results of these U.K. studies "are inconclusive".

There are two types of radial transmission signals and two types of radial cancer patterns:

Type A : UHF signals that are low near the tower, rise to a broad peak between 2 and 6 km and then decline with distance, Figure 6.

Type B: VHF signals have a peak within 1 km and decline with distance in an undulating fashion, Figure 2.

For a high cancer rate to be detectable near a tower three factors are necessary:

1. There must be a large population. This requires a high population density because there is only a small area within 1 km radius of the tower and a high proportion of this is likely to be the open field in which the tower itself is sited.
2. There needs to be a high radiation exposure for the radiation to be able to elevate the cancer rate. This occurs for the lower frequency, VHF, FM signals, Figures 2 and 11.
3. The cancer type needs to be RF-radiation sensitive to assist in raising the cancer incidence above the background level. Leukaemia and Lymphoma are very RF-sensitive cancers, Szmigielski (1996), Milham (1985, 1988), Hocking et al. (1996).

These factors completely explain these results. Sutton Coldfield is the only tower that has these three factors. All other towers lack at least one factor and therefore cannot show a high cancer rate near the tower. In fact they all follow a Type A pattern which is a dose response relationship of cancer rate as a function of mean exposure. This for all radial cancers outlined in the Tables they follow a dose response relationship appropriate to their radiation patterns.

Sutton Coldfield Cancer Study Results:

For adult cancers the results are presented in the following two tables. These tables show two radial cancer patterns:

- a. Type A: For All Cancer, Non-Hodgkin's Lymphoma, Skin Melanoma and Bladder cancer the cancer rates are low near the tower, rise to a complex broad peak between 1 km and 10 km. The skin melanoma drops faster than all the others. This is typical of UHF radiation patterns, Figure 6.
- b. Type B: Adult leukaemia has 6 people within 1 km. This gives a high O/E ratio close to the tower. In all other respects it is similar to the first group. This is typical of mixed VHF/UHF radiation patterns, Figure 2.

In following the radiation patterns appropriate for each type of site these data follow dose

powered TV and low powered FM radio sites. This is very strong evidence that there is a causal relationship between low intensity RF exposure and adult leukaemia.

Distance from transmitter (km)	All cancers*				All leukemias				Non-Hodgkin's lymphomas			
	Observed	Expected	O/E ratio	Cumulative O/E ratio	Observed	Expected	O/E ratio	Cumulative O/E ratio	Observed	Expected	O/E ratio	Cumulative O/E ratio
0-0.5	2	5.61	0.36	0.36	1	0.11	9.09	9.09	0	0.11	0.00	0.00
0.5-1.0	96	137.19	0.70	0.69	5	2.72	1.84	2.12	3	2.60	1.15	1.11
1.0-2.0	605	504.59	1.20	1.09	17	9.76	1.74	1.83	5	9.46	0.53	0.86
2.0-3.0	282	279.01	1.01	1.06	9	5.56	1.62	1.76	9	5.76	1.56	0.95
3.0-4.9	1,002	1,050.86	0.95	1.00	25	20.22	1.24	1.49	20	20.25	0.99	0.97
4.9-6.3	2,414	2,301.25	1.05	1.03	54	41.96	1.29	1.38	45	40.60	1.11	1.04
6.3-7.4	2,734	2,650.62	1.03	1.03	48	46.54	1.03	1.25	57	43.95	1.30	1.13
7.4-8.3	2,827	2,798.65	1.01	1.02	51	49.22	1.04	1.19	52	47.19	1.10	1.12
8.3-9.2	3,363	3,213.75	1.05	1.03	40	57.35	0.70	1.07	80	54.56	1.47	1.21
9.2-10	4,084	3,919.59	1.04	1.03	54	68.90	0.78	1.01	86	68.02	1.30	1.23

* All cancers excluding non-melanoma skin cancer.

Table 10: Radial adult cancer rates around the Sutton Coldfield TV Transmitter.

Distance from transmitter (km)	Skin melanoma				Bladder cancer			
	Observed	Expected	O/E ratio	Cumulative O/E ratio	Observed	Expected	O/E ratio	Cumulative O/E ratio
0-0.5	0	0.09	0.00	0.00	0	0.24	0.00	0.00
0.5-1.0	2	2.02	0.99	0.95	4	5.96	0.67	0.65
1.0-2.0	11	6.99	1.57	1.43	39	22.17	1.76	1.52
2.0-3.0	12	5.03	2.39	1.77	11	11.94	0.92	1.34
3.0-4.9	16	16.16	0.99	1.35	43	45.27	0.95	1.13
4.9-6.3	26	28.77	0.90	1.13	119	100.31	1.19	1.16
6.3-7.4	28	27.93	1.00	1.09	131	114.85	1.14	1.15
7.4-8.3	32	30.90	1.04	1.08	117	120.64	0.97	1.10
8.3-9.2	28	35.66	0.79	1.01	169	140.13	1.21	1.13
9.2-10	34	43.08	0.79	0.96	155	167.45	0.93	1.08

Table 11: Radial adult cancer rates around the Sutton Coldfield TV transmitter.

Childhood Cancer results:

This study involves a far smaller sample than the San Francisco study, less than half a million compared to several million total population, but this study considers a wide range of cancer types for adults as well as for children. However, the population of children involved is very small, especially in the "exposed" group, and therefore reaching statistical significance is unlikely. For example, at Sutton Coldfield there are 97 children with cancer with 10 km of the tower. Within 2 km of the tower there were two childhood leukaemia cases when 1.1 was expected. This gives $RR = 1.82$ which is elevated but non-significant. Hence the Sutton Coldfield study cannot reliably address the childhood cancer issue. This problem, of small numbers, also limits the reliability of relationships with individual cancer types, especially close to the towers where population numbers are necessarily small.

The 20-Site Study:

Table 12 (Table 1) shows in the course radial analysis that Skin Melanoma is higher close to the towers whereas Bladder Cancer is more broadly elevated, consistent

TABLE 1. Cancer incidence near 20 high power radio and TV transmitters in Great Britain (excluding Sutton Coldfield): observed and expected numbers of cases, observed/expected (O/E) ratios, and 95% confidence intervals (CI), for all transmitters combined, by distance of residence from transmitter, in persons aged ≥15 years, 1974–1986

Type of cancer	Distance from transmitter (km)								Stone's ρ value*	
	0-2				0-10				U	C
	Observed	Expected	O/E ratio	95% CI	Observed	Expected	O/E ratio	95% CI		
All leukemias	79	81.58	0.97	0.78-1.21	3,305	3,194.25	1.03	1.00-1.07	0.001	0.052
All acute	34	36.21	0.94	0.67-1.31	1,422	1,347.90	1.05	1.00-1.11	0.124	
Acute myeloid	20	26.06	0.77	0.50-1.19	1,022	964.48	1.06	1.00-1.13	0.152	
Acute lymphatic	5	5.54	0.90	0.39-2.11	204	202.63	1.00	0.88-1.15	0.500	
Chronic myeloid	7	11.19	0.63	0.30-1.29	449	448.67	1.00	0.91-1.10	0.315	
Chronic lymphatic	28	23.23	1.20	0.83-1.74	969	953.98	1.02	0.95-1.08	0.055	0.674
Skin melanoma	51	46.08	1.11	0.84-1.46	1,540	1,719.36	0.90	0.85-0.94	0.001	0.725
Bladder cancer	209	193.66	1.08	0.94-1.24	8,307	7,655.32	1.09	1.06-1.11	0.001	0.864

* *p* values given by Stone's unconditional (U) and conditional (C) tests

Table 12: Cancer data for the 20 site U.K. study from Dolk et al. (1997b).

TABLE 2. Cancer incidence near 20 high power radio and TV transmitters in Great Britain—all leukemias: observed (O) and expected (E) numbers of cases, O/E ratios, and cumulative O/E ratios, for all transmitters combined, for transmitter groups, and selected individual transmitters, by distance of residence from transmitter, in persons aged ≥15 years, 1974–1986

Distance from transmitter (km)	O	E	O/E ratio	Cumulative O/E ratio	O	E	O/E ratio	Cumulative O/E ratio	O	E	O/E ratio	Cumulative O/E ratio	O	E	O/E ratio	Cumulative O/E ratio
<i>All transmitters</i>					<i>Group 1*</i>				<i>Group 2*</i>				<i>Group 3*</i>			
0–0.5	2	2.3	0.87	0.87	2	1.9	1.08	1.08	2	2.2	0.91	0.91	0	0.2	0.0	0.00
0.5–1.0	12	13.8	0.87	0.87	11	12.0	0.92	0.94	12	13.4	0.90	0.90	0	0.6	0.0	0.00
1.0–2.0	85	85.5	0.99	0.97	53	52.6	1.01	0.99	83	83.2	1.00	0.98	6	5.8	1.03	0.90
2.0–3.0	155	135.3	1.15	1.08	125	97.1	1.29	1.17	155	132.0	1.17	1.10	11	13.9	0.79	0.82
3.0–4.9	539	494.1	1.09	1.09	377	342.7	1.10	1.12	516	476.1	1.08	1.09	78	61.0	1.28	1.18
4.9–6.3	623	589.7	1.06	1.07	376	341.0	1.10	1.11	607	562.6	1.08	1.08	103	123.3	0.84	0.97
6.3–7.4	547	518.0	1.05	1.07	315	297.1	1.06	1.10	503	484.8	1.04	1.07	134	120.7	1.11	1.02
7.4–8.3	434	453.4	0.96	1.05	220	245.0	0.90	1.06	414	429.2	0.96	1.05	83	100.0	0.83	0.98
8.3–9.2	497	493.5	1.01	1.04	304	296.8	1.02	1.06	465	456.1	1.02	1.04	83	97.5	0.85	0.95
9.2–10	431	427.9	1.01	1.03	259	254.1	1.02	1.05	383	398.7	0.98	1.04	80	96.0	0.83	0.93
<i>Crystal Palace</i>					<i>Wenvoe</i>				<i>Rowridge</i>				<i>Group 4*</i>			
0–0.5	1	1.6	0.62	0.62	0	0.1	0.00	0.00	0	0.02	0.00	0.00	0	0.1	0.00	0.00
0.5–1.0	11	11.7	0.94	0.90	0	0.2	0.00	0.00	0	0.02	0.00	0.00	0	0.2	0.00	0.00
1.0–2.0	50	48.5	1.03	1.00	4	2.9	1.38	1.25	0	0.1	0.00	0.00	4	3.8	1.12	1.02
2.0–3.0	116	87.4	1.33	1.19	9	9.2	0.98	1.05	1	0.5	2.08	1.54	11	10.7	1.03	1.03
3.0–4.9	343	310.4	1.10	1.13	35	27.0	1.30	1.22	12	7.9	1.52	1.52	55	42.9	1.28	1.22
4.9–6.3	348	311.2	1.11	1.12	81	54.6	1.12	1.16	17	15.6	1.09	1.24	87	98.2	0.90	1.02
6.3–7.4	273	259.2	1.06	1.11	58	51.7	1.12	1.15	3	7.2	0.42	1.05	80	88.4	1.04	1.03
7.4–8.3	184	207.1	0.89	1.07	49	48.5	1.01	1.11	1	2.8	0.35	1.00	63	75.9	0.83	0.98
8.3–9.2	244	250.4	0.97	1.05	20	36.4	0.55	1.02	2	3.4	0.58	0.96	51	62.1	0.82	0.95
9.2–10	190	185.1	1.03	1.05	16	30.3	0.53	0.97	8	10.9	0.55	0.87	42	66.8	0.63	0.91

* Group 1, highest power TV transmitters of 870–1,000 kW ERP; Group 2, all TV transmitters of 500–1,000 kW ERP; Group 3, all FM transmitters of 250 kW ERP; Group 4, all transmitters with a combination of TV (≥500 kW ERP) and FM (250 kW ERP) transmission.

Table 13: Adult leukaemia as a function of radial distance from regional TV transmission towers, for all 20 sites and for a number of individual sites throughout the United Kingdom, Dolk et al. (1997b).

All of these sites show the Type A pattern from above, with leukaemia rates being low near the tower, rising to a broad, complex peak and then declining with distance. The rate of decline is slower with the more high powered transmitters, Group 1, Group 2, Crystal Palace and Wenvoe.

The elevated cancers identified by Dolk et al. include Leukaemia, Non-Hodgkin's Lymphoma, Skin Melanoma and Brain, Bladder, Male and Female Breast, Colorectal, Stomach and Prostate Cancer. Some are elevated only in the 0–2 km ring and some in the 0–10 km zone, Table 14 (Table 5).

TABLE 5. Other cancers near the Sutton Coldfield transmitter, West Midlands, England: observed and expected numbers of cases, observed/expected (O/E) ratios, and 95% confidence intervals (CI), by distance of residence from transmitter, in persons aged ≥ 15 years, 1974–1986

Type of cancer	Distance from transmitter (km)								Stone's <i>p</i> value*	
	0-2				0-10				U	C
	Observed	Expected	O/E ratio	95% CI	Observed	Expected	O/E ratio	95% CI		
<i>Cancers possibly associated with non-ionizing radiation</i>										
Brain										
Malignant and benign	17	13.20	1.29	0.80-2.06	332	317.74	1.04	0.94-1.16	0.612	
Malignant	12	9.18	1.31	0.75-2.29	218	223.27	0.98	0.86-1.11	0.717	
Skin melanoma	13	9.10	1.43	0.83-2.44	189	196.53	0.96	0.83-1.11	0.027	0.018
Eye melanoma	0	0.71	0	0-4.22	20	17.19	1.16	0.75-1.80	0.849	
Male breast	1	0.61	1.64	0.04-9.13	15	15.08	0.99	0.60-1.64	0.889	
<i>Common cancers</i>										
Female breast	107	98.67	1.08	0.90-1.31	2,412	2,288.30	1.05	1.01-1.10	0.131	
Lung	113	112.31	1.01	0.84-1.21	3,466	3,418.60	1.01	0.98-1.05	0.875	
Colorectal	112	99.48	1.13	0.94-1.35	2,529	2,454.93	1.03	0.99-1.07	0.330	
Stomach	33	43.75	0.75	0.54-1.06	1,326	1,248.40	1.06	1.01-1.12	0.246	
Prostate	37	32.81	1.13	0.82-1.55	785	760.45	1.03	0.96-1.11	0.466	
Bladder	43	28.37	1.52	1.13-2.04	788	728.96	1.08	1.01-1.16	0.008	0.040

* *p* values given by Stone's unconditional (U) and conditional (C) tests.

* *p* values given by Stone's unconditional (U) and conditional (C) tests.

Table 14: Other cancer sites in the broad radial analysis from Dolk et al. (1997b).

21-Site Childhood Cancers:

The ability of these studies to detect childhood cancers was severely limited by small number of children who live within 10 km of these TV Transmission Towers. While in the 21 sites there were 3609 adults (≥ 15 years) with leukaemia, there were only 317 children (≤ 14 years). Close to the towers, i.e. inside 2 km there were 101 adults and 10 children with leukaemia. The expected incidence was 94.17 and 8.94 respectively. This gives O/E = 1.073, 95%CI: 0.81–1.42 for adults and O/E = 1.12, 95%CI: 0.61–2.06 for children.

This the childhood leukaemia rate is elevated around the 21 TV transmission towers in the United Kingdom, more so than the adult rate, but the small numbers mean the elevation is not significant.

For brain tumours, the rate is elevated within 10 km of the towers, for Malignant and Benign Brain Tumour O/E = 1.06, 95%CI: 0.93–1.20, $n=224$, and for Malignant Brain Tumours, O/E = 1.03, 95%CI: 0.90–1.18. It would have been interesting to observe the radial cancer rates for these tumours for the numbers involved are much higher than for the Sutra Tower Study. The equivalent data from the North Sydney Study is for Childhood Leukaemia O/E = 1.8, 95%CI: 1.2–2.5, $n=33$ and for Brain Tumour O/E = 1.3, 95%CI: 0.7–2.3, $n=12$. Hocking et al. use a 4 km radius whereas the UK data is for a 10 km radius. There is a different mix of TV and FM signals and signal strengths in the North Sydney Study than in the UK Study. Accepting these differences they all show elevated leukaemia and brain tumor. The very large output power of the Sutra Tower results in far higher childhood cancer rates.

U.K. Conclusion:

If the authors had known about and applied the available engineering knowledge they would have concluded that there was a significant dose-response relationship between a number of adult cancers and RF exposure from TV/FM transmission towers. There is

study also shows elevations in cancers from sites all over the body, with dose-response relationships being evident for those presented. Hence the observations are consistent with the data in Selvin et al. (1992) data and analysis of Robinette et al. (1980), Milham (1985, 1988) and Szmigielski (1996). This shows a causal relationship between RF exposure and cancer. The Dolk result has been independently replicated in Italy, Michelozzi et al. (1998).

Excesses in cancer are still seen at 10 km, where the direct exposure is 5 to 10 times less than the UHF peak of $1.3 \mu\text{W}/\text{cm}^2$, i.e. between 0.13 and $0.26 \mu\text{W}/\text{cm}^2$. Applying the lifetime mean residential exposure factor of 0.15 reduces the exposure associated with these adverse health effects to the range 0.02 to $0.034 \mu\text{W}/\text{cm}^2$.

The data in Dolk et al. is internally consistent, shows elevated childhood leukaemia and brain tumor, and a set of dose-response relationships which are likely to be highly significant, if related to realistic radial RF patterns, for cancer at a wide range of body sites including All Cancer, Leukaemia, Non-Hodgkin's Lymphoma, Brain Cancer, Bladder Cancer, Prostate Cancer, Skin Melanoma, Male and Female Breast Cancer and Colorectal Cancer. This is also consistent with Robinette et al. (1980), Szmigielski (1996) and Milham (1985, 1988).

Sleep Disturbance near a Shortwave Radio Tower, Schwarzenburg, Switzerland:

The Schwarzenburg Study, Alpeter et al. (1995) and Abelin (1999) showed a causal relationship of sleep disturbance with exposure to a short wave radio signal. The effect is assessed as causal because of the significant dose response relationship, the variation of sleep disturbance in two experiments, one involving changing the beams and one turning the transmitter off, and the identification of significant melatonin reduction. Professor Abelin told seminars in Christchurch that they had measured a significant increase in melatonin after the tower transmission was turned off permanently compared to the levels while it was on. Measurements of salivary melatonin in two herds of 5 cows revealed a significant rise in melatonin in the exposed cows when the tower was turned off for three days, Figure 18.

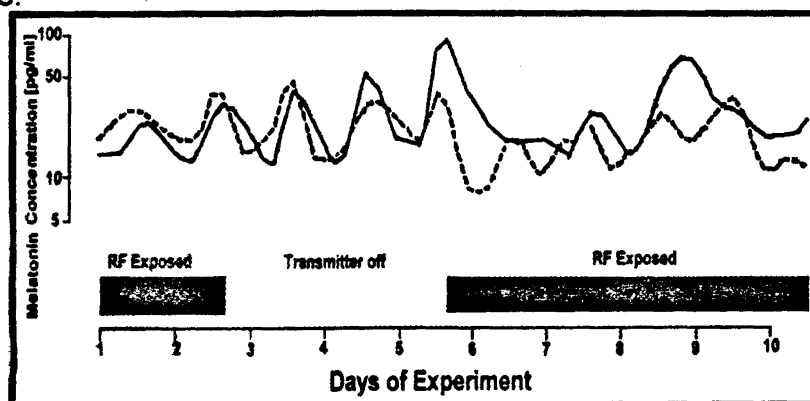


Figure 18: Salivary melatonin from two herds of 5 cows, one exposed at 500 m, $0.005 \mu\text{W}/\text{cm}^2$ (solid line) and one "unexposed" at 1000 m, $0.00022 \mu\text{W}/\text{cm}^2$ (dashed line).

On average the exposed herd had lower melatonin, but not significantly so because of the very small sample size. The same difference with about twice as many cows would have been significant.

Figure 18 also reveals that when the tower was turned on the "unexposed" herd showed a drop in melatonin. Under normal tower operation the exposed cows had a delay in their nocturnal peak by 2 to 3 hours.

When the tower was turned off the sleep quality improved significantly for the three groups being monitored at that time. Figure 19 shows the results for the highest and lowest exposed groups, Group A and Group C.

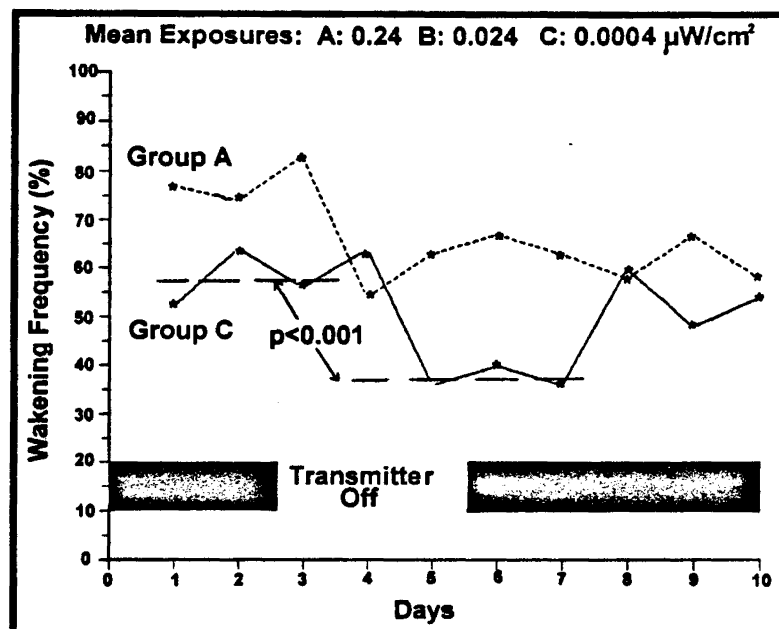


Figure 19: Sleep disturbance in people exposed to a short-wave radio stations which was turned off for three days, Altpeter et al. (1995), showing the highest exposed Group A, and lowest exposed Group C.

Both Groups show a delayed improvement in sleep of one to two days. The reduced wakening averaged over days 4 to 6 compared with days 1 to 3 are highly significantly reduced, $p < 0.001$. Thus the lowest exposed group, $0.0004 \mu\text{W}/\text{cm}^2$ also shows a significant effect of the RF exposure on sleep disturbance.

Thus turning the tower off revealed significant rises in bovine melatonin and human sleep quality. Human melatonin increased significantly when the tower was turned off permanently.

Groups B, R and C are all exposed to a mean RF signal of less than $0.1 \mu\text{W}/\text{cm}^2$ and they experienced highly significant sleep disturbance and reduced melatonin. Since sleep disturbance, Mann and Roschke (1995), and melatonin reduction, Burch et al. (1997), has been observed with cell phone exposure. Hence these observations also apply to cell phones and cell sites.

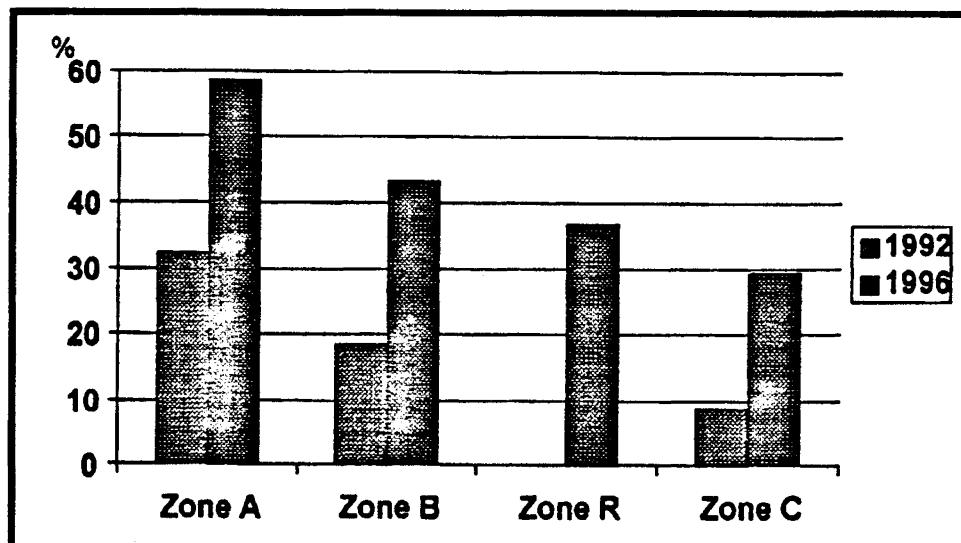


Figure 20: Adult Sleep Disturbance with RF exposure at Schwarzenburg, Switzerland, Abelin (1999).

Sleep disruption occurs in a dose-response manner with a threshold below 0.1 nW/cm^2 , i.e. very close to zero, Figure 21.

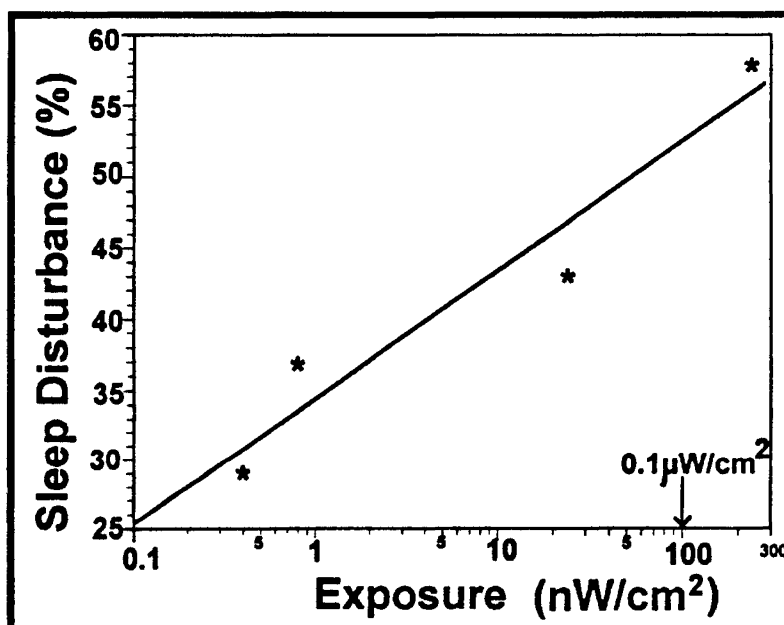


Figure 21: Dose-response relationship for Sleep Disturbance at Schwarzenburg with exposure in nW/cm^2 . Note: $1 \text{ nW/cm}^2 = 0.001 \mu\text{W/cm}^2$

Conclusions:

The Swiss researchers in the Schwarzenburg Study concluded that there was a causal relationship with sleep disruption and exposure to RF radiation. This shows the exquisite sensitivity of the brain to RF radiation, reduction in a vital neurohormone, melatonin, which is related to sleep quality, chronic fatigue and cancer. The Schwarzenburg study also identified a suite of symptoms that they referred to as Chronic Fatigue. The other residential studies above show multiple significant dose response relationships for a range of cancers, especially leukaemia and brain tumour and all cancer at residential exposure

This forms a coherent, consistent, integrated set of studies showing a causal relationship between sleep disturbance, chronic fatigue and cancer in association with extremely low mean RF exposure levels experienced in residential situations in the vicinity of radio and TV transmission towers.

The fact that cell phones are also shown to reduce melatonin, Burch et al. (1997, 1998), damage chromosomes, Tice et al. (1999) and damage DNA, Maes et al. (1994), Verschave et al. (1996) and Phillips et al. (1998), double the lymphoma in mice, Repacholi et al. (1997), and disrupt sleep, Mann and Rosche (1996), means that cell sites will produce the same adverse health effect in residential exposures out to 500 to 1000 m, depending on the power and height of the towers.

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ZONING COMMISSION ORDER NO. 587
CASE NO. 84-10
(Antennas - Text)
September 15, 1988
and
February 13, 1989

In 1984, the Zoning Commission initiated this case to address the aesthetic deficiencies of roof structures and antennas. The primary initial concern was roof structures. See Office of Planning ("OP") memoranda dated August 11, 1983 and February 3, 1984. Further, with respect to antennas, the Commission's only concern with antennas has been with their visual impact as they are viewed from sites other than the property in which they are located. See the referenced OP memorandums, and another dated May 16, 1984.

This focus is amply confirmed by the proposed text amendments applicable to antennas, and related comments, which accompanied the final OP report, dated October 12, 1984. In addition, see the October 22, 1984 letter from Wilkes, Artis, Hedrick, and Lane on behalf of that firm and three architectural firms. That letter, while citing several points for clarification and revision, stated:

Antennas are generally incompatible with building design in the city, and should be screened from view to the extent possible. The proposed antenna regulations appear to be technologically feasible, and appropriate in terms of height and setback both at the ground level and penthouse level.

Initial hearings were held in October, 1984. Comments of representatives of the telecommunications industry at those hearings persuaded the Commission and OP that the industry had legitimate technical concerns, and that it was necessary to conduct another analysis of a workable regulatory scheme. As OP phrased it in its May 8, 1985 summary abstract, "[The] attempt [is] to bridge the gap between the functional requirement for antennas and the telecommunications industry on one hand and the clear need to preserve and enhance the special physical character of Washington, D.C. on the other."

After extensive further analysis by OP and consideration by the Commission, the Commission determined to conduct further hearings to consider revised regulations. Those hearings were held in May, 1986.

Major concerns expressed at those hearings were as follows:

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1. Matter-of-right antenna dimensions would be too restrictive.
2. The special exception review process would be too frequently needed and too burdensome.
3. The Commission should not stand in the way of normal technological progress.
4. Antennas in SP zones should be governed by the rules which apply in commercial zones.

After Commission discussion of these issues at the February, 1987 meeting, OP prepared further revised text amendments to reflect the Commission's discussion. The Commission reviewed these at its meeting on September 21, 1987, and determined to propose amendments in the form published as notice of proposed rulemaking in the D.C. Register on January 8, 1988 (35 DCR 179).

The thrust of the proposed rules is to prevent antennas from having an adverse impact on the appearance of Washington as the Nation's Capital. This goal is in the District and Federal interest. This joint intent is highlighted by the following view expressed by the Director of the Office of Planning in his May 8, 1985 memorandum to the Commission:

Washington, D. C. is a unique city. As the Nation's Capital, it is woven with history and symbolic qualities. It focuses on the monumental core area with its museums and monuments (two of which afford a view out over the roofs of the city).

It is a classical city, not a space age city. It is filled with ornamental buildings, monumental buildings and classical buildings. Its low, horizontal skyline is a strong visual asset that directs attention to itself. The city is filled with trees, both Downtown and in its residential areas. Finally, it has numerous neighborhoods with small rear yards, many only 20-25 feet deep. The recently adopted Comprehensive Plan notes the unique importance of the physical appearance of the National Capital and seeks protection and enhancement of that appearance. It emphasizes the importance to that appearance of maintaining the height limit, and it calls for the use of appropriate arrangements of building materials, height, scale, massing and buffering to complement the existing environment. It also calls for the protection and enhancement of existing residential neighborhoods.

The Commission concurs with these observations.

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The general framework of the regulatory scheme is: (1) to allow as an unqualified matter of right in all zone districts those antennas which have the least potential adverse aesthetic impact; (2) to allow as a qualified matter of right, that is, with conditions for administrative review, antennas which have somewhat greater potential for such impact; and (3) to allow any other antenna as a special exception.

The rules would also require any replacement of an existing antenna to be subject to the amended regulations, and make conforming technical amendments to the Zoning Regulations, consistent with the other amendments.

The Commission is persuaded that the proposed rules are fair and reasonable, and allow ample room for technical requirements to be accommodated. The proposed rules would not completely bar any category or description of antenna from the District. Every antenna not allowed as of right could have the opportunity for consideration at a public hearing before the Board of Zoning Adjustment.

Comments on the proposed rulemaking identified the following issues:

1. Need for greater flexibility in the replacement of existing antennas serving established and ongoing functions.
2. General hostility to the concept of regulation.
3. Concern that the regulations would be subject to preemption by the Federal Communication Commission ("FCC").
4. Contentions that the different treatment of various types of antennas, including commercial broadcast antennas, which could be approved only through the special exception process, is not reasonable.
5. Various differences of opinion: "should allow more than one whip antenna"; "should accommodate taller whip antennas than the... 12 foot height"; "should delete" the different treatment of roof-mounted antennas on buildings which exceed 90 feet and those which do not; "should allow [roof-mounted] antennas... up to 20 feet in height."
6. Concern that the rules would provide overly restrictive limits on vehicle-mounted antennas as to duration and the number allowed in a square; related concerns were expressed about the

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applicability of proposed 11 DCMR 201.2(f) to a vehicle located on public space or private space.

7. A number of reasonable, albeit relatively minor, clarifying and correcting points, to which the Commission has responded by appropriate revisions.
8. Support for imposition of a time limit for the Zoning Administrator to review antenna applications.
9. Support for revisions of the proposed rules to allow Super High Frequency ("SHF") service to be established as of right.

By report dated February 4, 1988, the National Capital Planning Commission ("NCPC") found that the proposed amendments would not adversely affect the Federal Establishment or other Federal interests in the National Capital. NCPC did not report its conclusion whether the amendments would be inconsistent with the Comprehensive Plan for the National Capital. NCPC recommended that the amendments require periodic recertification of all antenna installations to review safety factors and determine whether certain installations could be removed altogether or replaced with more compact antennas.

In March, 1988, the Zoning Commission requested the advice of the Corporation Counsel about the impact of the FCC preemption policy on the authority of the Zoning Commission to adopt the proposed rule. By memorandum dated August 30, 1988, the Deputy Corporation Counsel, Community Development Division, transmitted certain advice and recommendations. The Commission has considered these recommendations, and its response is generally set forth below in its discussion of final action.

The Zoning Commission doubts that the proposed amendments would be rendered invalid by the FCC preemption rule. This Commission believes that FCC reached quite far when it assumed the task of resolving real or hypothetical jurisdictional disputes involving its authority and that of local government entities. On this point, the Commission concurs with the skeptical view of Mayor Barry, expressed in a May 7, 1985 letter to FCC, about FCC's then proposed preemption policy.

Further, both the Zoning Commission and FCC are Congressionally created entities. Congress has explicitly and unambiguously provided a means for the resolution of any conflict between the Zoning Regulations and other regulations, including those promulgated by FCC. D.C. Code Sec. 5-428 (1987) directs that the more restrictive regulations shall govern.

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Finally, this Commission has concluded that the proposed rules are in conformity with the FCC policy: the rules have an aesthetic objective; they do not distinguish among antennas on the basis of the functional category of antennas; the different treatment that is established has a reasonable and clearly defined objective, that is the aesthetic one; and the different treatment imposes no unreasonable limits or costs.

In consideration of the comments on the proposed rule and the OP advice in those comments, dated March 4, 1988 and July 5, 1988, the Commission has revised the final rules to respond to reasonable concerns which were expressed in the comments. In particular, the final rules allow super high frequency antennas as a matter of right; increase the number and diameter of whip antennas which are allowed as a matter of right; delete the proposed requirement that any nonconforming antennas be removed when a new conforming antenna is erected on a lot; clarify the status of non-profit broadcasters; allow the Zoning Administrator flexibility to administer the new rules as they would apply to new classes of antennas; provide in Section 212 for preliminary historic preservation review of antennas; allow ground-mounted antennas in the CR and W zones under the same provisions that apply in the C-3 zone, delete the proposed restriction on the repair of nonconforming antennas; and allow the temporary, emergency replacement of a nonconforming antenna which could not be replaced as a matter-of-right.

The Commission is not persuaded that it is confusing or incorrect to characterize the installation of antennas as being a matter of right when it is subject to administrative review, on the basis of objective criteria, by the Zoning Administrator, with the advice of the Director of the Office of Planning on the basis of objective criteria. Each applicable provision refers explicitly to the procedure for administrative review.

As to the recommendation that the rules include a time limit for the Zoning Administrator to review an antenna application, the Commission does not believe that the record provides a sound basis for it to establish such a time limit.

As to the concern about the Commission's authority to regulate an antenna mounted on a vehicle, the Commission does not understand the basis for the concern. The operators of such antennas plainly are using the land on which the antennas are located. The physical presence of a vehicle does not alter this fact. The restrictive rule by its terms applies only when the antenna is mounted on a vehicle which is located in a square, that is to say, not

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located in public space. The Commission has authority to regulate such use of land.

In consideration of NCPC's recommendation, the Zoning Commission has determined that the NCPC recommendation is beyond the scope of the proposed rulemaking. In addition, the Commission is not persuaded to open the case record for consideration of the issue.

The Commission has determined to adopt rules for matter-of-right, ground-mounted antennas in the CR and W zones which reference the rules which apply in residential zones. Notwithstanding the commercial uses and height of buildings which are allowed in CR and W zones, the Zoning Regulations explicitly encourage residential uses in the CR and W zones. The residential uses require the protection which the special exception process would provide to ensure the compatibility of taller antennas with the use of neighboring property.

The Zoning Commission believes that the proposed amendments to the Zoning Regulations are in the best interest of the District of Columbia, are consistent with the intent and purpose of the Zoning Regulations and Zoning Act, and are not inconsistent with the Comprehensive Plan for the National Capital.

In consideration of the reasons set further herein, the Zoning Commission hereby orders APPROVAL of amendments to the Zoning Regulations regarding antennas. The specific amendments to DCMR Title 11 (the Zoning Regulations) are set forth in a notice of final rulemaking which appears elsewhere in this edition of the D.C. Register.

Vote of the Zoning Commission at the public meeting on September 21, 1987: 4-0 (Patricia N. Mathews, John G. Parsons, Lindsley Williams, and Maybelle Taylor Bennett, to approve; George M. White, not present, not voting).

This Order was modified and substantially approved by the Zoning Commission at the public meeting on September 15, 1988, by a vote of 5-0: Maybelle Taylor Bennett, Lindsley Williams, Patricia N. Mathews, George M. White, and John G. Parsons to approve this order and adopt the foregoing amendments to the Zoning Regulations.

This Order was further revised, and finally approved by the Zoning Commission at the public meeting on February 13, 1989, by a vote of 4-0: (Maybelle Taylor Bennett, Lindsley Williams, and John G. Parsons to approve the order as revised, and to adopt the foregoing amendments to the Zoning Regulations; George M. White to approve the order and adopt the amendments, by proxy vote; and Lloyd Smith not voting, not having heard the case.

In accordance with 11 DCMR 3028, this order is final and effective upon publication in the D.C. Register, that is, on

ZONING COMMISSION FOR THE DISTRICT OF COLUMBIA
NOTICE OF FINAL RULEMAKING
CASE NO. 84-10
(Antennas - Text Amendment)

The Zoning Commission for the District of Columbia, pursuant to the authority set forth in the Zoning Act (D.C. Code, Section 5-413, et seq.), having held a public hearing as required, hereby gives notice of adoption of amendments to the District of Columbia Municipal Regulations (DCMR), Title 11, Zoning. The amendments relate to the location of antennas. Notice of proposed rulemaking was published in the D.C. Register on January 8, 1988. (35 DCR 179). These amendments were adopted by the Zoning Commission as a final action at public meetings held on September 15, 1988, and February 13, 1989. The specific amendments to the Zoning Regulations are as follows:

1. Add a new definition for antennas in Section 199 and new definitions for specific types of antennas, to read as follows:

Antenna - a device used to transmit or receive communications signals. This term encompasses transmitting and receiving elements, and any tower and immediately related support and stabilizing elements, and rotating or other directional mechanism.

Antenna, commercial broadcast - antenna used for television and commercial radio broadcasting by a profit or non-profit entity. The transmitting antenna may be affixed to a tower or to the top of a building. In amplitude modulation (AM) radio service, the tower also acts as the antenna.

Antenna, microwave terrestrial - dish, horn, or other type antenna used for point-to-point microwave communication of sound, visual images or data from one terrestrial point to another.

Antenna, satellite earth station - antenna used to transmit or receive sound, visual images or data from one or more space stations or from one or more stations of the same kind by means of satellites or other objects in space.

Antenna, super high frequency - an antenna which serves a super high frequency channel and requires a line of sight to the transmitting antenna, and which generally

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consists of a metal grid or a sheet of bent metal, and is mounted on the pole of a UHF or VHF antenna or on a roof structure.

Antenna, whip - antenna generally consisting of a single pole or mast, also called a broomstick antenna, sometimes including irregularly shaped prongs or attachments at its extremity, including an antenna used for citizens band or two-way radio communications.

Antenna, yagi - a very high frequency (VHF) or ultrahigh frequency (UHF) directional antenna array in which a basic whip or dipole antenna is supplemented by one or more parallel reflector and director elements.

2. Add new Section 2519 to provide a clear purpose for the regulation of antennas. That purpose is supportive of the FCC declaratory rulings that do not disallow reasonable differences in regulations dealing with essentially different antennas.

2519 REGULATION OF ANTENNAS

2519.1 The purposes for the regulation of antennas as a particular type of structure are as follows:

- (a) The Zoning Commission has determined that certain antennas, because of their size, shape, design, construction or location, may affect the health, welfare or safety of the population and may detract from the streetscape, landscape, skyline, scenic beauty or aesthetic interests of Washington, D.C., and its role as the Nation's Capital;
- (b) The Zoning Regulations therefore regulate the size, height, construction, design, and location of antennas and antenna structures which have the greatest potential for adverse impact on the health, safety and welfare of the population, and on neighborhood quality, and those which have the greatest potential for adverse impact on the scenic beauty of the Nation's Capital; and
- (c) The principal types of antennas regulated are those that, because of their shape and relatively large mass, potentially have the greatest visual impact and include, by example, large

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satellite earth station antennas and
certain microwave terrestrial antennas.

- 2519.2 If the Zoning Administrator determines that an antenna does not meet the definition of any specific class of an antenna as set forth in section 199 of this title, the Zoning Administrator shall determine the class of antenna to which it is closest, and treat the antenna accordingly.
3. Permit antennas having the least potential adverse impact on the aesthetic qualities of Washington, D.C., the Nation's Capital, as a matter-of-right in the R-1 and less restrictive districts by adding new sub-sections 201.2 and 201.3, to read as follows:
- 201.2 The following classes of antennas shall be permitted as a matter of right in an R-1 district, subject to the requirements for each class of antenna:
- (a) No more than two (2) residential type UHF/VHF television and frequency modulation (FM) radio receiving Yagi antenna not to exceed 8 feet horizontally;
 - (b) No more than two (2) whip antennas not exceeding two and one-half (2½) inches in diameter, with a mounted dimension no longer than twelve (12) feet in any direction, and located on a principal building;
 - (c) No more than one (1) residential type super high frequency antenna, not to exceed three (3) feet in any dimension, excluding the support element;
 - (d) One (1) or more antennas entirely enclosed on all sides within a building or by the penthouse walls or extensions of the penthouse walls. Those walls may include an opaque membrane covering a port in front of an antenna;
 - (e) One (1) or more antennas located entirely behind and no taller than the parapet walls; provided, that the parapet wall may include an opaque membrane covering a port in front of an antenna;

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- (f) One (1) satellite earth station or one microwave terrestrial antenna with a diameter of no more than four (4) feet, not taller than eight (8) feet, located on the roof of a principal building, and set back from the edge of the roof a distance at least equal to its height above the roof. The principal building must have a height of no less than fifty (50) feet;
- (g) A whip antenna mounted on a vehicle; and
- (h) Antenna, other than a whip antenna, mounted on a vehicle located in a given square for not longer than one hundred and twenty (120) hours.

201.3 An antenna which is listed in sub-section 201.2, but which does not comply with the requirements that apply to its class of antennas, shall be permitted as a matter of right in an R-1 district, by administrative review, subject to the requirements of sub-section 201.7.

4. Other than antennas permitted as of right under sub-sections 201.2 and 201.3, permit ground-mounted antennas with a mounted height no greater than 12 feet to be erected as of right, but with conditions, in the R-1 and less restrictive districts. Review by the Office of Planning and approval by the Zoning Administrator is provided. Add new sub-section 201.4, to read as follows:

201.4 Subject to the procedure of sub-section 201.7, one ground-mounted antenna, not to exceed a mounted height of 12 feet at its highest point above the ground, shall be permitted as a matter of right in an R-1 district, provided that:

- (a) The antenna is located in either the rear yard or the side yard of the principal building on the lot;
- (b) The antenna is not visible from any public park which is within the Central Employment Area or from any street which the lot abuts;
- (c) Each part of the antenna is removed from all lot lines by a minimum distance of ten (10) feet;

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- (d) To the maximum practical extent, the antenna shall be black mesh construction or of materials and colors that blend with the surroundings;
 - (e) The installation shall include screening treatments necessary to ensure compliance with paragraph (b) of this sub-section, and, to the maximum practical extent, to reduce the adverse impact of the antenna as viewed from adjacent property; and
 - (f) The antenna installation shall be as small as is practical for its intended use.
5. Other than antennas permitted as of right under sub-section 201.2, permit roof-mounted antennas with a mounted height no greater than 12 feet above the roof to be erected as of right, but with conditions, in the R-1 and less restrictive districts. Review by the Office of Planning and approval by the Zoning Administrator is provided. Add new sub-section 201.5, to read as follows:
- 201.5 Subject to the procedure of sub-section 201.7, one roof-mounted antenna, not to exceed a mounted height of 12 feet at its highest point above the roof, shall be permitted as a matter of right in an R-1 district, provided that:
- (a) Each part of the antenna is removed from each edge of the roof a minimum distance equal at least to its height above the roof;
 - (b) To the maximum practical extent, the antenna shall be of black mesh construction, or of materials and colors that blend with the surroundings;
 - (c) Each installation must be so located and screened as to minimize the view of the antenna from the ground; and
 - (d) If the antenna is located on the roof of a building which has a height of fifty (50) feet or less, the antenna shall not be visible from the ground.
6. Permit antenna additions to an existing broadcast tower with certain conditions. Review by the Office of

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Planning and approval by the Zoning Administrator is provided.

201.6 Subject to the procedure of sub-section 201.7, an addition of an antenna to an existing broadcast tower shall be permitted as a matter of right in an R-1 district, provided that:

(a) The size of the tower is not increased; and

(b) The appearance of the tower is not changed in a manner which causes an adverse impact on the surrounding area.

7. Provide for antennas in sub-sections 201.3 through 201.6 to be reviewed and approved by the Zoning Administrator, with the report and recommendation by the Office of Planning, by adding new sub-section 201.7, to read as follows:

201.7 The following procedure shall apply to an application which is filed for the approval of an antenna under sub-section 201.3 through 201.6 of this section:

(a) Before taking final action on the application, the Zoning Administrator shall submit the application to the Director of the Office of Planning for review and report; and

(b) The Director shall report to the Zoning Administrator either within thirty (30) days of the date of submission of the application to the Director, or within such longer or shorter period as the applicant, the Zoning Administrator, and the Director may agree to establish for the report of the Director.

8. Provide for special exceptions to the regulations for commercial broadcast antennas, by deleting the existing Section 211 and substituting the following:

211 ANTENNA, COMMERCIAL BROADCAST (R-1)

211.1 Use as an antenna for commercial television and frequency modulation broadcasting to any height and in conjunction with the erection, alteration, or use of buildings for transmission or reception equipment on the same lot or elsewhere, shall be permitted in

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an R-1 District if approved by the Board of Zoning Adjustment in accordance with the conditions specified in §3108 of of this title, and subject to the provisions of this section.

- 211.2 The proposed location, height, and other characteristics of the antenna shall not adversely affect the use of neighboring property.
- 211.3 The antenna shall be mounted in a location which minimizes to the greatest practical degree its visibility from neighboring property and from adjacent public space, or is appropriately screened by landscaping or other techniques so as to soften or minimize the visibility of the antenna.
- 211.4 Each part of a ground-mounted commercial broadcast antenna, including support system and guy wires, shall be removed a minimum of ten (10) feet from each lot line, or a distance of at least one-sixth of the mounted height of the antenna, whichever is greater.
- 211.5 The proposed height of the tower shall not exceed that which is reasonably necessary to render satisfactory service to all parts of its service area.
- 211.6 No transmission equipment shall be located in a residential district, unless location in the district is necessary for technically satisfactory and reasonably economical transmission.
- 211.7 If review by the Historic Preservation Review Board or Commission of Fine Arts is required, concept review and approval should occur before review by the Board of Zoning Adjustment.
- 211.8 No height of an antenna tower in excess of that permitted by the Act of June 1, 1910 (36 Stat. 452), as amended, shall be permitted, unless the height is approved by the Mayor.
- 211.9 Before taking final action on an application for use as an antenna tower, the Board shall have submitted the application to the D.C. Office of Planning for review and report.
- 211.10 The applicant shall have the burden of

demonstrating the need for the proposed height, and that full compliance with the matter of right standards would be unduly restrictive, prohibitively costly, or unreasonable.

9. Permit an antenna other than a commercial broadcast antenna to be located in an R-1 district by special exception, by adding the following new section 212:

212 ANTENNA, OTHER THAN COMMERCIAL BROADCAST ANTENNA
(R-1)

212.1 An antenna, other than a commercial broadcast antenna, which is not permitted or approved pursuant to section 201 of this title may be permitted as a special exception by the Board of Zoning Adjustment, provided that the following requirements are met:

- (a) The proposed use, location, and conditions related thereto shall be consistent with the purposes set forth in section 2519 of this title;
- (b) If review by the Historic Preservation Review Board or Commission of Fine Arts is required, concept review and approval should occur before review by the Board of Zoning Adjustment;
- (c) The Board may impose conditions relating to operation, location, screening, or other requirements as it shall deem necessary to protect adjacent and nearby property, consistent with the general purpose and intent of this section;
- (d) The Board may require the removal of any nonconforming antenna as a condition to the approval of an antenna;
- (e) The location and other characteristics of the antenna shall be reasonably necessary for the intended use of the antenna;
- (f) The present character and future development of the neighborhood shall not be adversely affected; and
- (g) Before taking final action on an application for use and location of an antenna, the Board shall have referred

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the application to the Office of
Planning for review and report.

10. Renumber existing sections 212 through 220, and all references thereto in Title 11, as sections 213 through 221, respectively.
11. Delete existing Section 511 that permits antenna towers as of right in SP and less restrictive zone districts.
12. Permit ground-mounted antennas with a mounted height no greater than 20 feet to be erected as of right, but with conditions, in the C-1 and less restrictive districts. Review by the Office of Planning and approval by the Zoning Administrator is provided. Add new sub-section 701.7, to read as follows:

- 701.7 Subject to the procedure of sub-section 701.9, one ground-mounted antenna, not to exceed a mounted height of 20 feet at its highest point above the ground, shall be permitted as a matter of right in a C-1 district, provided that:
- (a) The antenna is located in either the rear yard or the side yard of the principal building or the lot;
 - (b) The antenna is not visible from any street which the lot abuts, or from any public park which is within the Central Employment Area;
 - (c) Each part of the antenna is removed from all lot lines by a minimum distance of ten (10) feet;
 - (d) To the maximum practical extent, the antenna shall be of black mesh construction, or of materials and colors that blend with the surroundings; and
 - (e) The installation shall include screening treatments as necessary to ensure compliance with paragraph (b) of this sub-section, and, to the maximum practical extent, to reduce the adverse impact of the visibility of the antenna from adjacent property.

13. Permit roof-mounted antennas with a mounted height no greater than 12 feet above a roof up to 90 feet above the ground to be erected as of right but with conditions in the C-1 and less restrictive districts.

Director of the Office of Planning for review and report; and

- (b) The Director shall report to the Zoning Administrator either within thirty (30) days of the date of submission of the application to the Director, or within such longer or shorter period as the applicant, the Zoning Administrator, and the Director may agree to establish for the report of the Director.

- 15. Permit ground-mounted antennas with a mounted height no greater than 20 feet to be erected as of right, but with conditions, in the C-3 and less restrictive Districts. Review by the Office of Planning and approval by the Zoning Administrator is provided. Add new sub-section 741.6, to read as follows:

741.6 Subject to the procedure of sub-section 741.7, one ground-mounted antenna, not to exceed a mounted height of 20 feet at its highest point above the ground, shall be permitted as a matter of right in a C-3 district, provided that:

- (a) The antenna is located in either the rear yard or the side yard of the principal building on the lot;
- (b) The antenna is not visible from any street which the lot abuts, or from any public park which is within the Central Employment Area;
- (c) Each part of the antenna is removed from all lot lines by a minimum distance of 10 feet;
- (d) To the maximum practical extent, the antenna shall be of black mesh construction, or of materials and colors that blend with the surroundings; and
- (e) The installation shall include screening treatments necessary to insure compliance with paragraph (b) of this sub-section.

- 16. Provide for antennas in sub-section 741.6 to be reviewed and approved by the Zoning Administrator, with report and recommendation by the Office of Planning, by adding new sub-section 741.7, to read as follows:

- 741.7 The following procedure shall apply for an application for the approval of an antenna under sub-section 741.6 of this section:
- (a) Before taking final action on the application, the Zoning Administrator shall submit the application to the Director of the Office of Planning for review and report; and
 - (b) The Director shall report to the Zoning Administrator either within thirty (30) days of the date of submission of the application to the Director, or within such longer or shorter period as the applicant, the Zoning Administrator, and the Director may agree to establish for the report of the Director.
17. Provide for antennas as a matter-of-right in the CR district under the same standards and procedure as apply in residential and commercial districts, by adding paragraph 601.1(s), to read as follows:
- 601.1(s) Antenna, subject to the standards and procedure which apply to particular class of antenna pursuant to sub-sections 201.2 through 201.7.
18. Provide for antennas as special exceptions in the CR districts under the same standards and procedure as apply in the residential and commercial districts, by adding a new section 617, to read as follows:
- 617 ANTENNAS
- 617.1 An antenna shall be permitted as a special exception in the CR district, if approved by the Board of Zoning Adjustment subject to the standards and procedures which apply to the particular class of antenna under section 211 or section 212.
19. Renumber existing section 617 and all references thereto in Title 11 as 618.
20. Provide for antennas as a matter-of-right in the W district under the same standards and procedure as apply in residential and commercial districts, by adding paragraph 901.1(u), to read as follows:
- 901.1(u) Antenna, subject to the standards and

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procedure which apply to the particular class of antenna pursuant to sub-sections 201.2 through 201.7.

21. Provide for antennas as special exceptions in the W district under the same standards and procedure as apply in the residential and commercial districts, by adding a new section 914 to read as follows:

914 ANTENNAS

914.1 If the Board considers that it is appropriate in furthering the objections of the Waterfront Districts, an antenna shall be permitted as a special exception in the CR district, if approved by the Board of Zoning Adjustment subject to the standards and procedures which apply to the particular class of antenna under section 211 or section 212.
22. Renumber existing section 914 and all references thereto in Title 11 as 915.
23. Provide that the replacement of an existing antenna shall be subject to the regulations which apply to the location of a new antenna, by amending sub-section 2001.2, and adding new sub-section 2001.11, to read as follows:

2001.2 Except as is provided in sub-sections 2001.11 and 2001.12 of this title, ordinary repairs, alterations, and modernizations to the structure, including structural alterations, shall be permitted.

2001.11 A nonconforming antenna shall not be altered, modernized, or otherwise replaced, except in conformity with all provisions of this title.
24. Provide for an immediate, temporary replacement of a nonconforming antenna which stops functioning and can not be replaced as a matter-of-right, by adopting a new sub-section 2001.12, to read as follows:

2001.12 If a nonconforming antenna stops functioning, a temporary replacement antenna may be installed, subject to the following conditions:

 (a) A permanent replacement antenna cannot be installed as a matter-of-right;

- (b) The temporary installation shall be removed no later than one year after the nonconforming antenna stops functioning;
 - (c) Within three months after the nonconforming antenna stops functioning, the owner or occupant of the land or structure on which the antenna is installed shall apply for a special exception to install a longer term replacement; and
 - (d) If the owner or occupant elects to install an immediate replacement antenna, the cost of the temporary replacement shall not be considered by the Board of Zoning Adjustment as a basis for approval of a special exception to install a longer term replacement.
- 25. Enable antennas to exceed the normal four-foot height limit for accessory structures located in any required yard by adding new sub-section 2503.5, to read as follows:
 - 2503.5 An antenna which complies with all other requirements of this title may occupy any side or rear yard which is required by any provision of this title.
- 26. Revise the table of special exceptions under Sub-section 3108.1, by adding the following thereto:
 - Type of Special Exception:
 - Exceptions to location, density, and height regulations for antennas.
 - District:
 - Any district
 - Section in Which Conditions are Specified:
 - sub-sections 211, 212
- 27. Modify existing sub-section 400.3 to include "antenna", as follows:
 - 400.3 A spire, tower, dome, pinnacle, or minaret serving as an architectural embellishment, or an antenna may be erected to a height in excess of that which this section otherwise

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authorizes in the district in which it is
located.

28. Delete existing sub-section 400.5 and renumber existing sub-sections 400.6 through 400.13 and all references thereto in Title 11, as 400.5 through 400.12, respectively.
29. Revise existing sub-sections 530.3, 630.5, 770.3, 840.2, and 930.3 to read as follows:

Spires, towers, domes, pinnacles or minarets serving as architectural embellishments, penthouse over elevator shaft, ventilator shaft, antennas, chimneys, smokestacks or fire sprinkler tanks may be erected to a height in excess of that which this section otherwise authorizes.
30. Delete existing sub-sections 530.4 and 770.4, and renumber subsequent sub-sections consistently.

Cleveland Park Citizens Association

3404 Rodman Street, NW
Washington, DC 20008
February 26, 2001

RECEIVED
D.C. DEPT. OF ZONING
2001 FEB 28 PM 4:32

Ms. Carol J. Mitten
Chairperson
Zoning Commission of the District of Columbia
441 4th Street, NW Suite 210 South
Washington, DC 20001

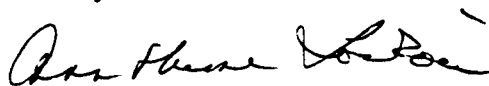
Re: Case No. 00-29-TA (Antenna Towers) &
March 5 Public Roundtable

Dear Chairperson Mitten:

In response to the Commission's request at the February 5, 2001 hearing for background information on the issues involved in antenna tower siting, I am submitting for the record with this letter copies of two videotapes (both recorded on one tape) regarding the issues raised by the siting of antenna towers. The first video is titled "*Broadcast Blues*" and was produced by Len Aitken Productions. It follows the efforts of the citizens of Golden, Colorado to defeat the rezoning of part of Lookout Mountain for a large new high definition television broadcast tower to serve the greater Denver region and explains many of the zoning, health, interference and related tower siting issues. The second video, "*Public Exposure: DNA, Democracy and the Wireless Revolution*," was produced by the Council on Wireless Technology Impacts in Novato, CA, and explores some of the latest research on the potential health risks and consequences of wireless devices and base stations (cell towers). Both videos are approximately 57-58 minutes long.

I have also attached several documents regarding health hazards of radiofrequency electromagnetic fields: (a) Neil Cherry, Lincoln University, Canterbury, New Zealand, "Living Near Broadcast Towers is Hazardous to your Health: Implications for Cell Sites," May 16, 2000, which summarizes a number of major studies on the effects of RF radiation; (b) Cindy Sage, Sage Associates, October 15, 1999 report to the Scottish Parliament on the possible health effects of wireless communications; (c) Cindy Sage, Sage Associates, study matrix on "Reported Biological Effects from Radiofrequency Non-Ionizing Radiation, published at www.wave-guide.org/library/studies.html. All three documents contain extensive bibliographies of related scientific studies.

Sincerely,



Ann Hume Loikow
Cleveland Park Citizens Association

00-29TA
Exhibit 4X-C
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ZONING COMMISSION
01-02TA
Exhibit 17-C

Len Aitken's Description of "Broadcast Blues"

Responding to a mandate from the Federal Communications Commission to begin broadcasting digital television signals by the fall of 1999, the affiliates of ABC, CBS, NBC and PBS plan to put up a new HDTV tower on residential Lookout Mountain, 2000 feet above the city of Denver, Colorado.

Residents on Lookout Mountain strongly protest the new tower claiming there is evidence that the electromagnetic radiation (EMR) levels on Lookout Mountain are too high and pose a health threat.

Lookout Mountain

already hosts 18 towers and more than 450 transmission devices, making it the most complex electromagnetic environment of any residential area in the United States. "No problem," says the FCC, "the standards are acceptable and the broadcasters are in compliance."

The stage is set and the battle lines drawn. Armed with studies suggesting that American EMR standards are unrealistically low and evidence that the Denver broadcasters on Lookout Mountain are out of compliance with FCC standards, residents take on an alliance of corporate and government giants. What's more, the battle is waged in Colorado's Jefferson County, where minimal government meddling in business affairs is the way things are done.

At every crossroad, the homeowners' umbrella group, Canyon Area Residents for the Environment (CARE), meets strong opposition. A study completed in the summer of 1998 by the Colorado Department of Health finds that brain cancer rates on Lookout Mountain are unusually high but cannot determine the cause without further study.

Months later, the Jefferson County Planning Commission ignores well-documented evidence that broadcasters routinely exceed the FCC's maximum allowable EMR levels, and recommends approval of the new tower. The case now goes to the County Commissioners.

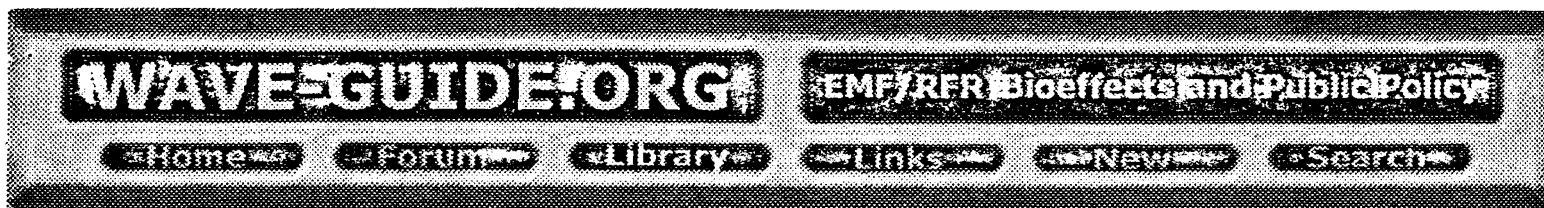
CARE is dealt another blow when broadcasters successfully lobby Colorado legislators to prevent a new more detailed health study by the Colorado Department of Health. For reasons hard to understand, the setbacks, defeats, inconclusive studies and reassurances by government authorities don't quiet the community. In fact, they have the opposite effect. The stakes for Lookout Mountain residents are high. If the HDTV tower goes in, their exposure to EMR will increase dramatically; EMR levels at the elementary school will increase by a factor of fifteen and real-estate values will plummet. Additionally, residents suspect that the FCC and the local government are not there to protect them.

From the efforts of a few individuals, the movement spreads. This is a story about a community who tackles a maze of conflicting studies, an indifferent bureaucracy and an entrenched coalition of corporate giants in an effort to save their community.

Across the country, broadcasters are meeting resistance to their proposed new HDTV transmitters from citizens concerned about the health hazards of excessive EMR. How much is enough? How much is too much? At one time, we asked the same questions about asbestos, radon and tobacco.

Len Aitken Productions 1053 Red Moon Rd. Golden CO 80401 (303) 526-1896

Canyon Area Residents for the Environment (the citizens organization involved in this case) have a website with many related documents at www.c-a-r-e.org



Reported Biological Effects From Radiofrequency Non-Ionizing Radiation

The following studies indicate biological effects at exposure levels *far below* what would be explained by "thermal effects", and well within the range people are commonly exposed to every day.

NOTE: Most of these exposures lie FAR BELOW the current advisory exposure standards in the US, which are based on thermal effects only.

- Studies by Increasing Power Density
- Studies by Increasing Specific Absorption Rate
- Standards and Background Levels
- Listing of Full Citations

Studies by Increasing Power Density

Power Density	Reported Biological Effects	References
0.1 $\mu\text{W}/\text{cm}^2$ (0.001 W/Kg SAR)	EEG brain waves are altered when exposed to cell phone signal	Von Klitzing, 1995
0.16 $\mu\text{W}/\text{cm}^2$	Motor function, memory and attention of school children affected (Latvia)	Kolodynski, 1996
0.168 - 1.053 $\mu\text{W}/\text{cm}^2$	Irreversible infertility in mice after 5 generations of exposure to cell phone signals from antenna park	Magras & Xenos, 1997
0.2 - 8 $\mu\text{W}/\text{cm}^2$	Two-fold increase in childhood leukemia from AM-FM exposure	Hocking, 1996
1.3 - 5.7 $\mu\text{W}/\text{cm}^2$	Two-fold increase in leukemia in adults from AM RF exposure	Dolk, 1997
2.4 $\mu\text{W}/\text{cm}^2$	Interference with medical devices at least up to 1000 MHz	Joyner, 1996
2 - 4 $\mu\text{W}/\text{cm}^2$	Direct effect of RFR on ion channels in cells/opening of acetylcholine channels	D'Inzeo, 1988
4 - 10 $\mu\text{W}/\text{cm}^2$	Visual reaction time in children is slowed//lower memory function in tests	Chiang, 1989
5 - 10 $\mu\text{W}/\text{cm}^2$	Impaired nervous system activity	Dumanski, 1974
10 $\mu\text{W}/\text{cm}^2$	Significant differences in visual reaction time and reduced memory function	Chiang, 1989
10 - 25 $\mu\text{W}/\text{cm}^2$	Changes in the hippocampus of the brain	Belokrinitskiy, 1982
30 $\mu\text{W}/\text{cm}^2$ (0.015 W/Kg SAR)	Immune system effects - elevation of PFC count (antibody producing cells)	Veyret, 1991
50 $\mu\text{W}/\text{cm}^2$	An 18% reduction in REM sleep (important to memory and learning functions)	Mann, 1996
100 $\mu\text{W}/\text{cm}^2$	Changes in immune system function	Elekes, 1996
100 $\mu\text{W}/\text{cm}^2$	A 26% drop in Insulin	Navakatikian, 1994
120 $\mu\text{W}/\text{cm}^2$	A pathological change in the blood brain barrier (915 MHz)	Salford, 1993

Studies by Increasing Specific Absorption Rate

SAR	Reported Biological Effects	References
0.000021 - .0021 W/Kg	Changes in cell cycle and cell proliferation (960 MHz GSM cell phone signal)	Kwee, 1997
0.0004 W/Kg	Pulsed cell phone RF caused changes in blood-brain barrier that protects brain from outside harmful chemicals and toxins (915 MHz GSM cell phone)	Salford, 1997
0.001 W/Kg	EEG brain waves are altered when exposed to cell phone signal at $0.1 \mu\text{W}/\text{cm}^2$	Von Klitzing, 1995
0.0317 W/Kg	Decrease in eating and drinking	Ray & Behari, 1990
.005 to .05 W/Kg	Calcium efflux	Dutta et al, 1989
0.14 W/Kg	Elevation of immune response at $100 \mu\text{W}/\text{cm}^2$	Elekes, 1996
0.13 - 1.4 W/Kg	Lymphoma cancer rate is 2.4 times normal with two 1/2 hour exposures per day of cell phone exposure (pulsed digital mobile phone signal 900 MHz)	Repacholi, 1997
0.26 W/Kg	Harmful effects to the eyes/ certain drugs can sensitize eyes to RFR	Kues, 1992
0.4 W/Kg	Statistically significant increase in malignant tumors at $480 \mu\text{W}/\text{cm}^2$	Guy, 1984
0.58 - 0.75 W/Kg	Biological effect on the development of brain tumors at 18% of standard (836 MHz TDMA digital cell phone signal)	Adey, 1996
0.6 and 1.2 W/Kg	DNA single and double strand breaks from RF exposure (2450 MHz)	Lai, 1995
2.4 mW/Kg to 24 mW/Kg	Digital cell phone (836 TDMA) at very low intensities cause DNA effects in human cells. DNA effects are direct DNA damage and the rate at which DNA is repaired. Is equal to about $800 \mu\text{W}/\text{cm}^2$ power density	Phillips, 1998
2-3 W/Kg	Cancer acceleration in skin and breast tumors at 50 - 75% of standard	Szmigielski, 1982

Standards and Background Levels

SAR	Standards	
0.2 W/Kg	IEEE standard for whole body SAR for general public (1/6 of an hour)	IEEE
1.6 W/Kg	FCC (IEEE) SAR limit over 1 gram of tissue (cell phone to ear)	FCC, 1996
Power Density	Standards	
$579 \mu\text{W}/\text{cm}^2$	800-900 MHz Cell Phone Signal Standard	ANSI/IEEE
$1000 \mu\text{W}/\text{cm}^2$	PCS STANDARD for public exposure (as of September 1, 1997)	FCC, 1996
$5000 \mu\text{W}/\text{cm}^2$	PCS STANDARD for occupational exposure (as of September 1 1997)	FCC, 1996
	Background Levels	
$0.003 \mu\text{W}/\text{cm}^2$	Ambient background RF exposure in cities and suburbs in the 1990's	Mantiply, 1997
1 - $10 \mu\text{W}/\text{cm}^2$	Ambient RF exposure within 100-200 feet of cell/PCS antenna array (or roughly 0.2 to 0.5 mW/Kg SAR in the human body')	Sage, 1998, unpublished

Listing of Full Citations Refrenced Above

Study	Description
Adey, WR., et. al., 1996.	Brain tumor incidence in rats chronically exposed to digital cellular telephone fields in an initiation-promotion model. Bioelectromagnetics Society 18th Annual Meeting, Proceedings, Abstract A-7-3.
Belokrinitskiy, VS., 1982.	"Destructive and reparative processes in hippocampus with long-term exposure to nonionizing radiation." In U.S.S.R. Report, Effects of Nonionizing Microwave Radiation, No. 7, JPRS 81865, pp. 15-20.
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cancer. The Committee should require the wireless industry to provide complete, honest and factual information to consumers, to independently monitor any health effects of mobile phone use, and to strongly urge public-member participation in the global policy-making and regulation-making processes on RFR exposures and technologies.

The United States has a de facto policy of "post-sales surveillance" with respect to cell phones. That means cell phones can be sold to the public, and only after years of use will there be studies to characterize what health consequences, if any, have arisen as a result. In shorter terms, "we are the experiment" for health effects. The Committee should reject "post-sales surveillance" as inadequate to protect existing users.

While the scientific community continues to study and understand the physical (and quantum mechanic) basis for electromagnetic effects on living systems, there is little to protect or inform the public about consequences of unlimited reliance on these new technologies. For all the potential good which such inventions bring to us, including the immeasurable benefit of the telecommunications/internet revolution, we must be vigilant about what consequences may come uninvited.

Appendix A: Significant Scientific Papers That the Committee Should Consider

The evidence for an association between RFR and bioeffects in living systems spans the entire range from effects on individual atoms (calcium) and molecules (DNA or the genetic code in each living cell) to humans and other mammalian species. In the past 50 years, experimentation across the electromagnetic spectrum of frequencies has found replicable bioeffects on everything from mice to men. The cascade of biological, chemical and physical events that occur in living systems in response to RFR is better understood as the multi-disciplinary scientific community and its science matures. Disease is not the only endpoint of this research. The potential medicinal applications of RFR treatment offer an unparalleled opportunities for healing and wellness.

Effects on DNA

Lai and Singh (1995) first reported DNA strand breaks from microwave RFR at low intensity levels. A dose-dependent increase in DNA single- and double-strand breaks in brain cells exposed at 0.6 W/Kg and 1.2 W/Kg whole body specific absorption rate (SAR) was found after two hours of exposure to 2450 MHz RFR. Using the sensitive comet assay for DNA breakage developed by NP Singh, it was reported that exposure to both continuous-wave and pulsed RFR produced DNA damage. Published results appeared in two peer-reviewed scientific journals: *The International Journal of Radiation Biology* (1996;69-4:513-521) and *Bioelectromagnetics* (1995; 16:207-210)

A year later in 1998, Jerry Phillips et al reported DNA single-strand DNA breaks exposed to cellular telephone frequencies 813.5 MHz and 836.5 MHz at low SAR (average 2.4 and 24 μ W/g-1). Phillips used the same comet assay techniques used by Lai and Singh. This assay is widely used by researchers to detect DNA damage produced by ionizing radiation. Phillips postulated that DNA-repair rates may be affected by exposure to RFR (Phillips et al, 1998). Of related interest, Phillips reported that 60 Hz ELF exposure caused a significant increase in DNA single-strand breaks at 1 G in Molt-4 lymphoblastoid cells (Department of Energy Contractors Conference, Tucson, Arizona, Abstract A-8, November 1998). He postulates that ELF magnetic field exposure can affect both DNA damage and repair processes, and lead to cell death (apoptosis).

Conventional wisdom has traditionally held that microwaves are not genotoxic (directly damaging to the genome or DNA) unless high temperatures are created (thermal effect of microwaves on genome).

Blank and Goodman (1997) postulate that the mechanism of EM signal transduction in the cell membrane may be explained by direct interaction of electric and magnetic fields with mobile charges within enzymes. Recent studies on DNA show that large electron flows are possible within the stacked base pairs of the double helix of DNA molecules. Therefore gene activation by magnetic fields could be due to a direct interaction with moving electrons within DNA. Electric fields as well as magnetic fields stimulate gene transcription and both fields could interact with DNA directly. Prior work on heat shock proteins by Goodman and Blank is referenced in this paper showing that cellular response to EM fields is activation of the same stress response system seen in heating, but at very much lower energy than the response to heat shock (see Gene Transcription and Induction).

Chromosome Aberrations and Micronuclei

Maes et al (1993) exposed human peripheral blood lymphocytes to microwaves at 2450 MHz. A marked increase in the frequency of chromosome aberrations and micronuclei (the formation of abnormal chromosome fragments) was reported at nonthermal levels. Chromosome aberrations increased with increasing time exposure (a dose-response). One type of damage seen (the creation of dicentric chromosomes) is considered to be the "hallmark" of ionizing radiation exposure. These results are consistent with results of microwave radiation damage at other frequencies and power densities reported by other researchers (Leonard et al, 1983; Garaj-Vrhovac et al, 1990, 1991; d'Ambrosio et al, 1992).

Maes et al (1995) reported that whole blood exposed to the radiating antenna of a GSM base station showed increased chromosome aberrations when placed within a distance of 5 cm or less with two hour exposures. Combined effects of 954 MHz radiofrequency radiation and the chemical mutagen mitomycin C were studied by the same authors using human lymphocytes. Blood samples were exposed to AM radiation from a GSM base station at an estimated SAR of 1.5 W/Kg. Microwave exposure enhanced the harmful effect of the chemical mutagen and showed a clear increase in a form of chromosome aberration (sister chromatid exchange). Single strand DNA breaks were also reported.

Effects on ornithine decarboxylase (ODC)

Litovitz et al (1993, 1997a, 1997b) and Penafiel et al (1997) tested cells for production of ornithine decarboxylase (ODC) which is an enzyme found in rapidly growing tissues, particularly tumors. They report that amplitude-modulated microwaves (but not FM or continuous wave) significantly affect ODC activity in L929 cells at an SAR of about 2.5 W/Kg at 835 MHz cellular telephone frequency. The effect was reported with several types of amplitude modulation, including a TDMA cellular telephone. The effect was notable at particular modulation frequencies from 16 Hz to 65 Hz, but no effect was reported at 6 Hz or 600 Hz. Importantly, Litovitz reported that no EMF-enhancement of ODC was observed if the field was not constant in time over intervals of longer than 1-10 seconds. If frequency was varied at intervals of 1 second or less, no enhancement of ODC was reported.

Gene Transcription and Induction

Goswami et al (1999) report that proto-oncogene mRNA levels in fibroblast cells exposed to cellular telephone frequency radiation show increased expression of the Fos mRNA levels. Exposure to 835.62 MHz (frequency modulated continuous wave) showed a 2-fold increase in Fos mRNA levels that was statistically significant. The 847.74 MHz (code division multiple access or CDMA) cellular telephone frequency exposure resulted in a 40% and 90% increase in Fos mRNA that was also statistically significant. These results indicate that specific genes (in this case proto-oncogenes) may be affected by exposure to RFR signals from cellular telephones.

Stress Response

Daniells et al (1998) found that nematodes respond to microwave radiation with a stress response that can be assayed in the same fashion as for stress related to heat and toxic chemicals. The nematode model for measuring stress response induced by microwave radiation shows that lower power levels induced larger stress responses (the opposite of a simple heating effect). Microwave radiation caused measurable stress and protein damage within cells (induction of hsp or heat shock protein) comparable to damage from metal ions which are recognized to be toxic. The authors conclude that clear biological effects of microwave radiation have been demonstrated in terms of activation of cellular stress responses (hsp gene induction).

Cellular Effects of Microwave Radiation

Calcium ion balance in living tissue is exquisitely important in the proper function of cell communication, cell growth and other fundamental life processes. Interactions of calcium at the cell membrane have been identified as the first link in bioeffects from RFR. The seminal work of W. Ross Adey and his research team, formerly at the Veterans Hospital at Loma Linda, California has detailed much of the cascade of events by which cellular processes are affected by RFR. Only selected work is presented here, but the reader is referred to the extensive scientific works and testimony on this topic (summarized in Adey, 1997).

Adey (1993) provides a comprehensive summary of microwave bioeffects at the cellular level supporting the concept of athermal responses not mediated by tissue heating. Amplitude-modulated or pulse-modulated microwave exposure is a particular focus. Adey discusses the impact of free-radicals in the brain and vascular systems and in the regulation of oxidative stress diseases including Alzheimer's and Parkinson's disease, coronary heart disease, aging and cancer. Microwave exposure at athermal levels may act as a tumor promoter, leading to tumor formation in the absence of other chemical promoters. He cautions that observed bioeffects of low intensity microwave exposure require further investigation, particularly for nonlinear, nonequilibrium cooperative processes.

Dutta et al (1989) reported that RFR caused changes in calcium ion efflux from both bird and cat brain tissues, and from human neuroblastoma cells. Significant calcium efflux was found at SAR values of 0.05 and 0.005 W/Kg (a very low energy absorption rate) with RFR at 147 MHz when amplitude-modulated at 16 Hz. Further, enhanced calcium efflux at 0.05 W/Kg peaked at 13-16 Hz and at the 57.5-60 Hz modulation ranges. According to the authors "These results confirm that amplitude-modulated RFR can induce responses in cells of nervous tissue origin from widely different animal species, including humans. The results are also consistent with the reports of similar findings in avian and feline brain tissues and indicate the general nature of the phenomenon."

Immune System Cellular Effects

Lyle et al (1983) reported that exposure to sinusoidally amplitude-modulated RFR at nonthermal levels can reduce immune function in cells. A 450 MHz radiofrequency field was modulated with a 60 Hz ELF field. Tests showed that the unmodulated carrier wave of 450 MHz by itself had no effect, and modulation frequencies of 40, 16 and 3 Hz had progressively smaller effects than 60 Hz. Peak suppression of the lymphocyte effectiveness (immune function effectiveness) was seen at 60 Hz modulation.

Veyret et al (1991) found that exposure to very low power, pulsed microwaves significantly affects the immune system (either sharp increases or decreases in immune response) at specific amplitude-modulated frequencies. Pulsed microwaves at 9.4 GHz were amplitude-modulated at modulation frequencies between 14 and 41 MHz and at power density of 30 μcm^2 , whole-body average SAR

of about 0.015 W/Kg. Importantly, in the absence of amplitude- modulation, exposure to the microwave frequency alone did not affect immune function. It was only with the addition of amplitude-modulation that effects were seen.

Elekes (1996) found that the effect of amplitude-modulated RFR and continuous- wave RFR induced moderate elevation of antibody production in male mice (but not female mice). The carrier frequency was 2.45 GHz (which is used in industry) with a modulation frequency of 50 Hz (which is similar to the frequency of some mobile phone systems like TDMA and other ELF-modulated mobile phone systems). Power density was 0.1 mW/cm², which corresponds to that allowed in the workplace for long-term exposure under Hungarian standards. Exposure was short-term, and the authors remark that the moderate increase in immune function may be related to the brevity of exposure.

Blood-brain Barrier

The blood-brain barrier has a vital role in the body to exclude toxins from the blood stream from reaching sensitive brain tissues. This barrier is known to protect the brain from toxic or other harmful compounds. It is selectively permeable, allowing some molecules like glucose to pass, but restricting others. It has a dual role in preventing the brain from damage, while stabilizing and optimizing the fluids surrounding the brain.

Salford et al (1994) showed leakage through the blood-brain barrier (or increased permeability) is caused by 915 MHz RFR. Both continuous wave (CW) and pulsed microwave RFR have the ability to open up the blood-brain barrier to leakage. Salford reported that the number of rats exposed to SARs between 0.016 and 5 W/Kg which showed leakage of the blood-brain barrier was 56 of 184 animals, compared to only 5 of 62 control animals. Whether this constitutes a health hazard demands further investigation, but the concept that the blood-brain barrier is clearly breached by both types of low power microwave radiation is concerning. At least ten other scientific papers cited in his reference list also show blood-brain barrier effects of RFR.

Cancer

From the genetic building blocks of life to the whole organism, ELF/RFR has been demonstrated to produce bioeffects, which may be deleterious to health. The basic functions of the body, which control proper cell growth, cell proliferation, immune surveillance and toxin protection is shown to be adversely affected, in many cases at environmental levels of exposure. Cancer as a disease endpoint of RFR exposure has been studied for two decades, and both animal and human studies point to a link between exposure under some conditions and cancer. The major concern with mobile telephone technology is its rapid growth around the world, putting millions of users at potential risk, and the emerging evidence for brain tumors.

Guy et al (1984) conducted studies for the US Air Force on rats in the first major research specifically designed to approximate effects of microwaves on human beings. Guy remarked there were more than 6000 articles on the biological effects of RFR by 1984, but the question of low-level exposure as a human health hazard was unanswered.

In historical perspective, this study provided the first and, to that time, the best study of potential effects from long-term exposure to RFR. John Mitchell (1992), Brooks Air Force Base Armstrong Laboratory, the sponsor of the Guy et al rat study concluded "at our request, Bill Guy took up this challenge and conducted a landmark long-term study that was longer and better conceived and conducted than anything done previously with RFR. To expose animals continuously for more than two years, as envisioned by the experimental protocol, a whole new concept of exposure facilities had to be created."

Objectives of the study were "in a population of experimental animals throughout their natural lifetimes, to simulate the chronic exposure of humans to 450 MHz RFR at an incident power density of 1 mW/cm². Our primary interest was to investigate possible cumulative effects on general health and longevity." (USAFSAM-TR-85-64).

The first publication of the Guy rat study was in the 1985 US Air Force USAFSAM-TR-85-64 report "Effects of long-term low-level radiofrequency radiation exposure on rats". It reported a four-fold statistically significant increase in primary malignancies.

Chou and Guy (1992) later reported the results of their 1984 cancer studies on rats which found a four-fold statistically significant increase in primary malignant tumors in the 1992 Bioelectromagnetics Journal honoring Dr. Guy on his retirement. The article restated the 1984-85 finding of increased cancer in rats with microwave exposure over the lifetime of the animals. Exposure conditions involved SARs of 0.15 to 0.4 W/Kg of 2450 MHz pulsed microwave (square wave modulated at 8 Hz). Note that the current standard for public exposure is 0.4 W/Kg SAR.

Although the Guy study urged immediate follow-up and verification studies, no such studies were conducted for more than a decade.

Repacholi et al (1997) conducted mice studies using 900 MHz mobile phone frequency radiation and found a statistically significant 2.4-fold increase in lymphomas. Lymphoma risk was found to be significantly higher in the exposed mice. He concluded that long-term intermittent exposure to RFR can enhance the probability that mice will develop lymphomas. It is noteworthy that the animals were exposed to normal cell phone frequency RFR for only two one-half hour periods per day for eight months. Current human use of mobile phones can exceed 2000 minutes per day for business travelers.

A second study of mice and cancer conducted by Repacholi (Harris et al, 1998) with 50 Hz magnetic fields alone did not result in increased cancer rates. The authors conclude that "in contrast, when Pim1 mice were exposed to pulse-modulated radiofrequency fields (900 MHz), a highly significant increase in lymphoma incidence from 22% to 43% occurred. Perhaps the increased incidence of cancer that in some epidemiological studies has been associated with residential proximity to high-current power-distribution wiring results from exposure to high-frequency transients rather than the primary 50/60 Hz magnetic fields. In our study, the magnetic fields to which the mice were exposed were switched on and off in a manner that minimized the production of transients."

Hardell (1999) has reported increased risk of brain tumors in humans using cellular telephones. The main type of brain tumors found to occur were malignant glioblastomas and astrocytomas and non-malignant meningiomas and acoustical neuromas. An increased risk (although statistically insignificant) was found for malignant brain tumors on the same side of the head on which the cell phone was used for analog cell phones. The increased risk was 2.45-fold for right side use, and 2.40-fold for left side. GSM users did not have adequate use over time for there to be adequate evaluation of risk. No association between RFR and acoustical neuromas was reported.

Adey (1996) found a slight protective effect of microwave mobile phone exposure with respect to brain tumors in rats, where a reduced number of the expected brain tumors resulted. The exposure was for NADC (North American digital cellular) producing a TDMA signal at 836.55 MHz. No brain tumor enhancing effect was found. Apparent "protective" effects (fewer tumors) were discussed but did not reach statistical significance. The authors conclude that TDMA field had no enhancing effect on incidence, type or location of nervous system tumors, although some protective effect may be possible and further research is warranted.

Brain Symptoms Reported Using Mobile Phones

Mild et al (1998) reported on a joint Swedish-Norwegian epidemiological study of cases using both GSM digital and analogue mobile phones. A statistically significant association between calling time/number of calls per day and the prevalence of warmth behind/around the ear, headaches and fatigue was reported. However, GSM digital phones were less associated with these symptoms than analogue phones. The Swedish data show that GSM users reported less headache and fatigue than for analogue users. Warmth sensations were also reported lower among GSM users.

Mobile phone usage was tested in humans (Hocking, 1998) to investigate whether normal use could result in immediate symptoms of the head and neck. He reported that of 40 respondents, headaches with pain radiating to the jaw, neck, shoulders or arm in a few respondents. A majority reported that sensations of head pain started in less than five minutes after commencing phone calls, and another 12 felt the sensation build up as the day progressed. All could distinguish the headaches as different in quality from typical headaches. Eleven cases reported transient effects on vision such as blurring. Fifteen cases reported feelings of nausea or dizziness or a "fuzziness" in the head, which made thinking difficult. One case had long-standing tinnitus, but after a prolonged mobile phone call developed deafness and vertigo lasting five hours. Three cases transferred the mobile phone to a belt. One reported pain in the area at nighttime and another felt a cold area over the place it was worn on the hip. A third person reported pain similar to injured muscles. Twenty eight cases reported symptoms using GSM digital mobile phones and ten with analogue mobile phones. Of the former, thirteen said they had used analogue phones without developing symptoms felt with GSM digital phones. Twenty two said they used mobile phones more than five times per day, and thirty four had changed their use of mobile phones as a result of symptoms.

Neurological Effects (Nervous System)

Neurologic effects of RFR have been examined at several levels in living organisms. At the ion and molecular levels there are many effects reported and replicated at nonthermal levels. These effects include calcium changes (essential cell communication and growth regulation), neurotransmitters (chemicals that conduct nerve signals and control such things as appetite, mood, behavior, drug responses, sleep, learning and memory), behavioral (memory and learning impairment in rats and humans), and on sleep disorders.

Lai (1994a) prepared a review of the literature on neurological effects of RFR on the central nervous system. It provides a concise overview of how the central nervous system (CNS) should normally work, and how RFR has been reported to affect functions of the CNS. The nervous system coordinates and controls an organism's response to the environment through autonomic and voluntary muscular movements and neurohumoral functions. Behavioral changes could be the most sensitive effects of RFR exposure.

The movement of calcium ions in brain tissue is changed by RFR. Calcium ions control many brain and body functions including the release and receptor function of neurotransmitters, and any change in their functioning could significantly affect health.

Psychoactive Drugs

The action of psychoactive drugs depends on proper functioning of neurotransmitters. RFR changes some neurotransmitter functions, which lead to changes in the actions of psychoactive drugs. Lai reports that RFR alters pentobarbital-induced narcosis and hypothermia at 0.6 W/Kg in rats. The nervous system becomes more sensitive to convulsions induced by drugs like pentylenetetrazol. RFR exposure makes the nervous system less susceptible to curare-like drugs that are used in anesthesia to paralyze patients during surgery. Antianxiety drugs like valium and librium may be potentiated in the body with RFR exposure. Lai has postulated that the endogenous

opioids are activated by low-level RFR exposure (Lai, 1992, 1994b). This hypothesis can explain increased alcohol consumption seen in rats during RFR exposure, and the lessening of withdrawal symptoms in morphine-dependent rats. RFR-psychoactive drug interactions can be selectively blocked by pretreating animals with narcotic antagonists (i.e., compounds that block the actions of endogenous opioids) before exposure to RFR, suggesting that the endogenous opioid system is activated by RFR (Lai et al, 1986).

Serotonin

Serotonin activity is reported to be affected by RFR. Drugs which cause a depletion of serotonin (like fenfluramine) by themselves cause a severe and long-lasting depletion of serotonin together with RFR exposure (Panksepp, 1973 in Lai, 1994). Lai (1984) reported that hyperthermic effects of RFR could be blocked by pre-treatment by serotonin antagonists suggesting that the hyperthermia was caused by activation of serotonergic activity by RFR. Drugs which decrease serotonin activity in the brain are shown to suppress aggressive behavior (Panksepp et al, 1973 in Lai, 1994). Serotonin-related functions include sleep, learning, regulation of hormone secretion, autonomic functions, responses to stress and motor functions (Lai et al, 1984). In humans, a cluster of symptoms called serotonin-irritation syndromes include anxiety, flushing, headache and migraine headache and hyperperistalsis which are related to hyperserotonergic states (Lai et al, 1984). Further work to define the relationship between RFR and serotonin has not taken place.

Eye Damage

Drugs can also enhance the adverse effect of RFR on the eyes. Kues et al (1992) reported that a drug treatment used for glaucoma could worsen the effect of RFR on corneal eye damage.

Behavioral Changes

Behavioral changes due to RFR are reported in many scientific studies (D'Andrea, 1999). The performance disruption paradigm that is based acceptable levels of RFR on thermal limits does not take into account reports of microwave effects on cognitive performance. D'Andrea (1999) discusses that "it is likely that effects on cognitive performance may occur at lower SARs than those required for elicitation of behavioral thermoregulation at levels that totally disrupt ongoing behaviors". Further, "the current literature on heat stress does not provide data or models that predict the behavioral effects of microwave absorption at low SAR levels". Finally, he notes that "the whole-body and partial-body absorption of microwaves (hotspots) is unique at each frequency in the range of 10 MHz to 100 GHz". Hotspots vary dramatically with RFR frequency, shape and size of the mammal and the animal's orientation in the field (D'Andrea, 1999). Performance of cognitively mediated tasks may be disrupted at levels of exposure lower than that required to behavioral changes due to thermal effects of RFR exposure. "Unlike the disruption of performance of a simple task, a disruption of cognitive functions could lead to profound errors in judgment due to alteration of perception, disruption of memory processes, attention, and/or learning ability, resulting in modified but not totally disrupted behavior." (D'Andrea, 1999).

Nervous and behavioral effects of RFR on humans have been reported for five decades. Silverman (1973) is an early reviewer of health effects linked to microwave exposure. She recounts that "the little experimental work that has been done on man has pointed towards possible alterations of the sensitivity of various sense organs, particularly auditory and olfactory threshold changes. There have been numerous case reports, rumors and speculations about the role of microwave radiation in a variety of disorders of the brain and nervous system, such as a causative role in severe neurotic syndrome, astrocytoma of the brain, and a protective role in multiple sclerosis. In the main, however, the nervous and behavioral effects attributed to microwave irradiation at issue are those found in clinical studies of groups occupationally exposed to various intensities and frequencies of microwaves for variable but generally long periods of time." She discusses nonthermal effects of

low-dose, long-term exposure in nine clinical studies of workers exposed to microwave-generating equipment in Czechoslovakia, Poland, the USSR and USA. All studies show nervous system effects. Silverman notes that such published studies "virtually ceased in the USA after the 1950's while considerable investigation continued to be reported from the USSR and other eastern European countries".

Raslear et al (1993) reported that significant effects on cognitive function in rats were clearly observed with RFR exposure, particularly in the decision-making process.

Learning and Memory

Lai et al (1994) found that rats exposed for 45 minutes to 2450 MHz RFR at whole-body SAR of 0.6 W/Kg showed a learning deficit in the radial-arm maze which is a behavioral task involving short-term spatial memory function. In searching for the mechanisms for this deficit in learning and memory, Lai found that a drug that enhances cholinergic activity in the brain could block this microwave-induced learning deficit in the maze. Cholinergic systems in the brain are well known to be involved in spatial learning in the radial-arm maze (Lai et al, 1994).

Cognitive Functions

Preece (1999) reported that RFR at cell phone frequencies speeded the rate at which humans responded to tasks (reaction time) but did not affect memory. Students were exposed to both analog and GSM digital phone signals for one half an hour, and then were tested for memory and speed and accuracy on cognitive tests. The higher the power from the cell phone signal, the faster the response time was reported, indicating the cell phone signal is not biologically neutral but can affect the brain's activity.

Sleep

Sleep disruption related to RFR has been reported in several scientific studies. Mann et al (1996) reported that RFR similar to digital mobile telephones reduced REM sleep in humans and altered the EEG (brain wave) signal in humans during REM sleep. REM sleep is essential for information processing in the brain, particularly with respect to learning and memory functions. It is thought to be needed for selecting, sorting and consolidating new experiences and information received during the waking state, and linking them together with old experiences.

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CASE 01-02

EXHIBIT 17D

HAS VIDEO TAPE

SEE FILE AT ZONING COMMISSION



ZONING COMMISSION
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Case ~~00-297~~ *EB*

Exhibit ~~47-D~~

ZONING COMMISSION
District of Columbia

Case 01-027A

Exhibit 17-D

HS

PREMIUM QUALITY