Low Power Mobile Radio Service Addendum

Introduction

The use of low power mobile radio service has increased at an astonishing rate since its introduction in the mid 1980's. An ever-increasing number of users are taking advantage of the advancement of telecommunication technology to meet their communication needs. The market for low power mobile radio service telecommunication has grown from only a few well-to-do individuals to a wide variety of users. Businesses, public safety departments, and recreational users are finding new ways to utilize the advancing technologies. Some forecasters predict as many as 100 million customers for low power mobile radio service within the next ten-years.[1]

Recent regulatory changes by the Federal Communication Commission (FCC) have opened up new portions of the radio spectrum to allow new wireless competition into the market. Now, in addition to cellular, low power low power mobile radio service communication have expanded to include Enhanced Specialized Low Power Mobile Radio (ESMR) and Personal Communication Services (PSC). These new low power mobile radio services will have physically similar facilities to the better known cellular facilities.

The current Jefferson County Telecommunications Plan was adopted in 1985 when the industry was making its debut and has since been updated in 1992. It was intended to focus on major broadcasting facilities in centralized areas within the County and does not adequately address low power mobile radio service technology. The purpose of this document is to develop an addendum to the *Telecommunications Land Use Plan* to address the land use issues brought on by the rapid growth in demand for low power mobile radio service.

Low power mobile radio service technology differs from the more traditional broadcasting technology. Traditionally most broadcasters transmit their signal from tall towers from low to high power in an attempt to reach as many people as possible in a large geographic area. In contrast, low power mobile radio service networks typically use low facilities at lower power to reach a limited number of users in a small geographic area. For several of the low power mobile radio technologies, each site is called a "cell site". The sites may be interconnected to other sites which in turn create a low power mobile radio service network. Because of these fundamental differences, low power mobile radio service facilities should not be viewed by the plan in the same way as other telecommunication facilities, but should be a separate section of the Jefferson County Telecommunications Land Use Plan.

Until the adoption of this Plan, there is no differentiation in review procedures for various types of telecommunication facilities. All are classified together as "radio, television and microwave transmission and relay towers" and dealt with similarly in the zoning regulations. A 500-foot broadcast tower, for example, was evaluated in the same manner as building-mounted panel antennas. A more refined review and evaluation procedure, based on rational siting criteria and appropriate impact mitigation, was streamlined the approval process and brought greater efficiency to benefit the public, the industry and the County. Low power mobile radio service technology and system design parameters place unique constraints upon facility placement that until recently, were not recognized in the County's regulatory framework.

This Plan distinguishes low power mobile radio service communication from other broadcasting type telecommunication technologies and establishes policies that deal with issues of demand, visual mitigation, noise, engineering, residential impacts, health, and facility siting. This Plan supersedes all the references to low power mobile radio service technology found in the current Telecommunications Plan, but it is not the intent of this Plan to override existing Community Plan's policies and recommendations.

Concurrently with the adoption, corresponding changes should be made to the Jefferson County Zoning Resolution to institute the policies and recommendations of this Plan.

Background

Low Power Mobile Radio Service Technology

Low power mobile radio Service communication works this way: A mobile or hand-held portable hand sets transmits a signal from a caller to a site antenna. The call is then relayed from the site antenna via a land based telephone line or microwave dish to a centrally located switch computer. The switch computer completes the call by tying into the Public Switched Telephone Network [PSTN (land line)] to a land line telephone or sending it back to a site to be transmitted to another low power mobile radio service handset. As a low power mobile radio service user passes through different sites, the call is switched from site to site by the switch. This process is known as hand-off. In this fashion, the caller can continue the call uninterrupted.

[1] *USA Today, 7/26/94, page 1B*

For the most part, low power mobile radio service employs a cellular-like technology. This initial network provides coverage for a FCC licensed service area. The size of the site's coverage area may vary depending on engineering and geographic constraints. Generally, sites with high antennas cover large geographic areas where demand for service is low. These site facilities are called coverage sites. In areas where demand for service is high, the site will cover a small geographic area and use lower facilities. These sites are called capacity sites. Each site has a maximum number of telephone calls that can be handled at one time. When this number is reached, the site has reached its capacity. A site at capacity must be split to cover smaller geographic areas, to cover the same area as the original site. The same number of radio channels are reused throughout the system. Since channels must be reused in the network, it is important that each site have a height and power level that does not interfere with other sites in the operating system.

To maintain maximum efficiency, low power mobile radio service sites are engineered to maintain a line of sight between the user and the low power mobile radio service antenna. To ensure the signal is transmitted unobstructed, it is necessary to elevate the antenna of the site above any topographic feature and/or tree tops found within the site's assigned geographic area.

As the low power mobile radio service industry evolves, technological changes can be expected that will impact the growth of low power mobile radio service users and the ultimate design of low power mobile radio service facilities. One such technological advance on the horizon for implementation in the near term that will help the low power mobile radio service providers meet the need for additional capacity sites is the shift from analog to digital signal processing. The industry is debating over digital technology standards - Time Division Multiple Access (TDMA), currently used by cellular and ESMR; and Code Division Multiple Access (CDMA), available in the future. These technologies promise to boost low power mobile radio service capacity by a factor of three to six, once the system is fully converted and without major additions to the existing physical systems. These and other changes in low power mobile radio service technology may require physical alteration of antenna systems on low power mobile radio service facilities.

In addition to the advances that will increase capacity without major additions to the existing physical systems, there also are changes expected in the sizes of and applications for low power mobile radio service equipment. Cellular ESMR and PCS will provide services in addition to voice transmission. They will offer data transmission, paging system, message service and fleet service capabilities. Low power mobile radio service transmitters and receivers are expected to be smaller in the future, requiring less space for the "equipment building" function of the site. "Micro-cells," linked in parallel by fiber optic cable or other means of transmitting voice and/or data from the main site will offer future designers application opportunities that do not currently exist. Although the number of sites may increase significantly in the future using the new, smaller equipment that the industry anticipates, their physical characteristics should be very different than what exists today.

Low Power Private Mobile Radio Service Technology (PMRS)

Low power private mobile radio services are separated from Commercial Mobile Radio Systems (CMRS) by the FCC primarily because this mobile radio service is for private use and not connected to the public telephone network. This type of radio service is a not-for-profit service in and of itself but it may be part of a business operation which may be for profit such as a two-way radio service used by businesses that operate a fleet of vehicles or emergency response providers. In general, PMRS utilizes a single site which may cover a larger geographic area than commercial network facilities.

Types of Facilities

There are three categories of low power mobile radio service facilities that incorporate some or all of the typical components listed below. Roof and/or Building Mounted Facilities occur when low power mobile radio service antennas are attached to or mounted on an existing structure, such as a water tank or building. Freestanding Facilities use some type of stand-alone structure for antenna support, such as a wooden pole, steel monopole, lattice tower, or light standards. Micro-cell or Repeater Facilities are used to extend low power mobile radio service coverage or capacity to dead spots or high traffic areas. These facilities are linked to a "donor" site by a donor antenna, microwave, fiber optic, or phone line connection. Required equipment is much smaller than for the other two facility types.

Depending upon its type, a low power mobile radio service telecommunications facility may include all or some of the following elements:

1. Equipment Storage

A small unmanned, single story equipment building less than 500 square feet gross floor area (GFA) in size used to house radio transmitters and related equipment. This equipment may also be placed inside an existing structure when appropriate space is available. Micro-cells do not require any accessory building.

2. Antennas

a. Omnidirectional antennas, also known as whip antennas, are used when 360 degree coverage is desired.

b. Directional antennas, such as panel antennas, are used to transmit and receive signals for situations when directional coverage is desired. Panel antennas are typically rectangular in shape.

c. Microwave antennas are used to link two technologically compatible telecommunication facilities together by line of sight. They are typically circular or parabolic in shape and can be a grid or solid materials.

3. Antenna Mounting

Structures on which antennas can be mounted include:

a. A roof, building side, or other structure such as a silo, windmill, water tank, smokestack, or existing communication tower.

b. Monopoles made of wood or metal are used for lower heights of 30 to 150 feet and when structural loads are relatively light.

c. Lattice towers (steel structures) which have 3 or 4 sides. They can be guyed or self supporting. Greater heights and larger structure loads can be accommodated using these towers.

d. A cross bar or platform is often used to provide horizontal separation of antennas on the mounting structure.

4. Fencing

The freestanding pole, tower, and/or building is usually fenced with security fencing.

Health Issues

The level of radio frequency (RF) radiation emitted from low power mobile radio service relay transmissions have been determined to be far below the level now known to cause negative health effects. The levels have been determined to be only a small fraction of the radiation the public is exposed to on a daily basis.

The Federal Communications Commission (FCC) has adopted the American National Standards Institute (ANSI) standards for RF emissions, which are recognized by Jefferson County as being acceptable In the immediate vicinity (within 50 feet) of a low power mobile radio service transmission tower, the power density has been determined to be no more than 1/150 of the ANSI exposure standards. This level is well below the most restrictive exposure standards in effect across the country, which are one-fifth of the ANSI Standards. As the distance from the antenna increases, the power level decreases by an inverse squared factor. Microwave relay antennas utilize very low levels of power. The power density emitted is typically no greater than 1/500,000 of the ANSI exposure standard, at the tower base. Therefore, based on the above, there are no expected negative health effects from exposure to a low power mobile radio service telecommunications facility.

Community Response

Despite enthusiastic response of Jefferson County citizens to low power mobile radio service, strong objections have been raised to the presence of low power mobile radio service facilities in communities and neighborhoods. These objections are based on the visual effect of these facilities and the presence of this type of activity in residential areas. This has been the case not only in zoned residential districts, but also in areas which are zoned as agricultural, but which are actually used as residential property. This document recognizes that certain types of low power mobile radio service telecommunications facilities are inappropriate in areas of single-family residential development.

1. Electromagnetic Interference

Because of the frequencies assigned to the low power mobile radio service providers by the FCC and the relatively low power output by low power mobile radio service facilities, possible interference to household appliances such as radios, television and cordless telephones for nearby residents will be minimal. The FCC has established regulations governing interference that state it is the responsibility of the carrier to promptly resolve any electromagnetic interference problems created.

2. Residential Property Values

Low power mobile radio service facilities should be located and designed to minimize any adverse effect they may have on residential property values. Strict compliance to the policies and recommendations of this Plan and adherence to the design standards and careful location of facilities should minimize any adverse effects on property values.

Federal, State, & Local Regulations

1. Federal Communications Commission

In August of 1993, when Congress enacted the Omnibus Budget Reconciliation Act of 1993, the public mobile and private radio categories were replaced with two newly defined categories - Commercial Low Power Mobile Radio Service (CMRS) and Private Mobile Radio Service (PMRS). CMRS includes all services that are for: a) profit, b) interconnected to Public Telephone Switched Network, and c) available to the public or such classes of eligible users as to be effectively available to a substantial portion of the public. At this time, this definition would include: Cellular, ESMR and Paging Services, and Personal Communications Services/ Person Communications Networks. All other forms of wireless telecommunications which are not CMRS are considered Private Low Power Mobile Radio Service (PMRS). PMRS include industrial, land transportation, special emergency, public safety and government, automatic vehicle monitoring, personal mobile (CB's), and HAM operators.

The FCC has authorized a very limited frequency band for both CMRS and PMRS.

2. Federal Aviation Administration (FAA)

Under authority granted in the Federal Aviation Act, the FAA reviews the location and height of proposed towers to prevent possible interference with nearby airport operations. The agency has jurisdiction over towers that exceed 200 feet in height, as well as smaller towers located within 20,000 feet of a major airport (commercial and military aircraft facility) and 10,000 feet of a general aviation airport (serving smaller aircraft). The FAA requires that such towers be painted and/or appropriately illuminated. The FAA also has authority to review possible interference problems with aircraft-to-ground communications caused by transmission facilities in or near flight paths. It is the responsibility of the carrier to file a notice of proposed construction when necessary and receive painting and/or lighting instructions from the FAA.

3. State and Local Regulation

Low power mobile radio service telecommunication is considered a non-regulated public service that the Colorado Public Utilities Commission has chosen not to regulate at this time. From the standpoint of local land use regulations, low power mobile radio service telecommunication companies are considered private enterprises subject to applicable local zoning controls, to the extent not otherwise preempted by state and federal laws.

c. Lattice towers (steel structures) which have 3 or 4 sides. They can be guyed or self supporting. Greater heights and larger structure loads can be accommodated using these towers.

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Future Demand

The low power mobile radio service industry has experienced rapid growth since its inception, and it is expected future technologies offered to the public will also be popular. Growth of this industry is being fueled by a number of factors such as lower cost of telephones and services, expanding areas of coverage, new advances in low power mobile radio service technologies, expanded services, and a wide variety of new users. In unincorporated Jefferson County, the number of sites will grow steadily. This trend is expected to level off once each provider has established their network and converted to the digital base technology.

Based upon the projected demand for low power mobile radio service and the engineering constraints of the network, the following are likely places for sites:

1. Population Centers

Most population centers within the unincorporated areas of the County currently have some level of low power mobile radio service. These areas are likely to require new sites as new industries are licensed by the FCC. Demand will increase and site capacity will reach its limit and must be split to increase capacity for current and future technologies.

2. Transportation Corridors

New sites are also likely along major transportation corridors within the County.

3. Areas of Variable Topography

Topography places constraints on the "ideal" line-of-sight signal path for low power mobile radio service transmissions. Additional sites may be needed in some locations to fill in the shadowing caused by topographic changes.

Predicting the growth of low power mobile radio service telecommunications, and, more specifically, the number of new sites that will be required in any future time-frame by low power mobile radio service providers, is virtually impossible. Demand for low power mobile radio service relates to many factors including customer usage and economic conditions, by market sector and geographic sub-area. Increasing use of portable low power mobile radio service phones has impacted coverage requirements. Low power mobile radio service is increasingly being used for non-voice transmission, including data such as mobile fax and telemetry, Global Positioning System/Geographic Information System and Emergency Services interconnect.

Site Selection

Industry Site Selection Criteria

In siting a new site, the industry requires a location that is technically compatible with the established network. A general area is identified based upon engineering constraints and the desired area of service. Specific locations within that general area are evaluated using the following criteria (not listed in any order of priority):

1. Topography as it relates to line of sight transmission for optimum efficiency in telephone service.
2. Availability of road access.
3. Availability of electric power.
4. Availability of land based telephone lines or microwave link capability.
5. Leasable lands and willing landlords.
6. Screening potential of existing vegetation, structures and topographic features.
7. Zoning that will allow low power mobile radio service facilities.
8. Compatibility with adjacent land uses.
9. The least number of sites to cover the desired area.
10. The greatest amount of coverage, consistent with physical requirements.
11. Opportunities to mitigate possible visual impact.
12. Availability of suitable existing structures for antenna mounting.

Citizens' Site Selection Criteria

Citizens believe that the following criteria should be addressed by the site selection process (not listed in any order of priority):

1. Certain types of low power mobile radio service facilities should not be located in single-family residential areas.
2. Preservation of view corridors.
3. Potential for preservation of pre-existing character of site.
4. Minimal impact on residential areas surrounding commercial or industrial zoned sites.
5. Selection of sites which lend themselves to visual mitigation.
6. Compatibility with surrounding land uses.
7. Pre-existing zoning that allows low power mobile radio service facilities.
8. Use of existing buildings.

General Policies for Site Selection

Site selection should be made in compliance with the Low power mobile radio Service Telecommunication Facilities Zone District Use Standards, which are set forth in the chart that appears within this section. Community and neighborhood visual concerns should be considered paramount in the consideration of and selection of sites. These concerns should be evaluated by a consideration of all the policies set forth in this Plan and in relevant Community Plans.

Site Selection Policies

The accompanying Zone District Use Standards Chart contains regulations which consider the following policies applicable to low power mobile radio service telecommunications facilities.

A. Within any zone district, sites should be located in the following order of preference:

1. On existing structures such as buildings, communication towers, water towers, and smokestacks.

2. In locations where the existing topography, vegetation, buildings, or other structures provide the greatest amount of screening.

3. Sites should be located on bare ground without visual mitigation only in certain commercial and industrial zone districts, based on defined parameters (see the visual mitigation policies in the following section).

B. Certain types of low power mobile radio service facilities are more appropriate in some zone districts than others and certain facilities create a greater impact on the surrounding area than others. The Zone District Use Standards contained in the chart on the following pages provide the basis for modifications to the Zoning Resolution which have been adopted along with this Plan concerning suitability of zone districts to accommodate the various types of low power mobile radio service facilities. In addition to the chart, the Plan has established a set of uniform standards for visual mitigation applicable to the various types of facilities and zone districts. These policies balance low power mobile radio service industry and homeowner concerns and are based on the specific impacts of the different types of low power mobile radio service facilities in relation to the character of land uses found in the County's zone districts. For example, the policies recognize that freestanding low power mobile radio service facilities generate the greatest impacts and, therefore, are most suitable in commercial and industrial zone districts.

Low Power Mobile Radio Service Telecommunication Facilities: Recommended Zone District Use Standards.

	Facility Type		
Zone District..	Roof and/or Building Mount	Freestanding Facility	Micro-Cell or Repeater
SF Residential	NP	NP	NP
R-3 (Multifamily)	P	NP	SU
R-3A (Multifamily)	P	NP	SU
R-4 (Multifamily)	P	NP	P
C-1 (Convenience)	P	NP	P
C-1 (Neighborhood)	P	NP	P
C-1 (Community)	P	P	P
C-1 (Regional)	P	P	P
C-2	P	P	P
RC-1	P	P	P
I-1	P	P	P
I-2	P	P	P
I-3	P	P	P
I-4	P	P	P
PD	NP	NP	P
C-O	NP	NP	NP
A-1	SU	SU	SU
A-2	SU	SU	SU

P=Permitted (Use by Right)
NP=Not Permitted
**This plan recommends rezoning to Planned Development when seeking to locate a facility in NP zones*
SU=Special Use

C. Facilities should be located to minimize any adverse effect they may have on residential property values.

D. Facilities should be located to avoid a dominant silhouette on ridge lines, and preservation of view corridors of surrounding residential developments should be considered in the location and design of low power mobile radio service facilities.

E. Location of sites in commercial or industrial zones should consider the impact of the site on the surrounding neighborhood, particularly any adjacent residential neighborhood.

F. Facility must be architecturally and visually (color, bulk, size) compatible with surrounding existing buildings, structures, vegetation, and/or uses in the area or those likely to exist under the terms of the PD or underlying zone district. Micro-cell or repeater facilities may be considered architecturally or visually compatible if they are mounted on existing structures such as light standards, telephone poles, or otherwise camouflaged to disguise their low power mobile radio service use.

G. Less obtrusive facilities are preferred, and sites in industrial and commercial areas are preferred.

H. Co-Location: Where the result is less visual impact and the engineering of the low power mobile radio service network permits it, sites should be co-located with other low power mobile radio service facilities as well as other existing telecommunication sites and public structures. In co-location, anti-trust laws are a consideration.

I. Network Compatibility: At the time of site selection, the applicant should demonstrate how the proposed site fits into the overall network of the low power mobile radio service system within the County.

J. This plan recommends rezoning to Planned Development when seeking to locate a facility in a standard zone district which does not permit a commercial mobile radio facility.

Visual Impact & Screening Policies

The unique and diverse landscapes of Jefferson County are among its most valuable assets. Protecting these valuable assets will require that location and design of low power mobile radio service telecommunication facilities be sensitive to the setting in which they are placed. This is especially true in the mountainous parts of Jefferson County, where homes may be oriented to capture significant views and where site distance is greater. Visual concerns should include both those found on and off site. The following policies have been incorporated into the modifications to the Zoning Resolution establishing the visual impact and screening criteria of Jefferson County applicable to low power mobile radio service telecommunication facilities.

The following visual policies applicable to low power mobile radio service telecommunication facilities:

1. Low power mobile radio service facilities should be located and designed to minimize any adverse effect they may have on residential property values.

a. The use of compatible colors and facility designs should be compatible with surrounding buildings and/or uses in the area or those likely to exist in the area and should prevent the facility from dominating the surrounding area.

b. Location and design of sites in commercial or industrial zones should consider the impact of the site on the surrounding neighborhood, particularly the visual impact within the zone district.

c. Fencing should not necessarily be used to screen a site, and security fencing should be colored or should be of a design which blends into the character of the existing environment.

d. Freestanding facilities should be located to avoid a dominant silhouette on top of ridges.

2. Certain components of a site create a greater impact than other components. For example, the cross bar or other antenna mounting device and accessory building which may typically be part of a freestanding low power mobile radio service facility or a micro-cell or repeater site, may create a greater impact in a rural or mountain environment. A horizontal plane in a vertical setting can be intrusive, so the cross bar or other horizontal mounting device should be placed below the tree line to adequately mitigate its visual effect. These components should be afforded maximum screening, using existing vegetation and/or topography to minimize visual impact on the surrounding community.

3. Facilities should be architecturally compatible with surrounding buildings and land uses in the zone district or otherwise integrated, through location and design, to blend in with the existing characteristics of the site to the extent practical.

4. Site location and development shall preserve the pre-existing character of the site as much as possible. Existing vegetation should be preserved or improved, and disturbance of the existing topography of the site should be minimized, unless such disturbance would result in less visual impact of the site on the surrounding area. The effectiveness of visual mitigation techniques should be evaluated, taking into consideration the site as built.

5. At the time of rezoning or special use request, an evaluation of the visual impact should be taken into consideration if vegetation is to be removed for wildfire mitigation.

6. Innovative design should be used whenever the screening potential of the site is low. For example, by using existing light standards and telephone poles as mounting structures, or by constructing screening structures which are compatible with surrounding architecture, the visual impact of a site may be mitigated.

7. Roof and/or Building Mount Facility

Antennas on the rooftop or above a structure shall be screened, constructed and/or colored to match the structure to which they are attached. Antennas mounted on the side of a building or structure shall be painted to match the color of the building or structure or the background against which they are most commonly seen. Microwave antennas exceeding 12 inches in diameter on a roof or building-mounted facility shall not exceed the height of the structure to which they are attached, unless fully enclosed.

If an accessory equipment shelter is present, it must blend with the surrounding building(s) in architectural character or color.

8. Minimum setbacks for microcells and repeaters are those required for any accessory building or structure within the applicable standard zone district.

9. Minimum Setbacks for Freestanding Monopole and/or Lattice Towers

Minimum setback when located within 250 feet of any property zoned for residential land use: the tower height or the minimum setback for any accessory building within the applicable standard zone district, whichever is greater.

Minimum setback when not located within 250 feet of any property zoned for residential land use: the standard setback for a building or structure within the applicable standard zone district.

The structure must be architecturally and visually (color, bulk, size) compatible with surrounding existing buildings, structures, vegetation, and/or uses in the area or those likely to exist under the terms of the underlying zoning. Such facilities will be considered architecturally and visually compatible if they are mounted on or given the form of a light/sign standard or otherwise camouflaged to disguise the facility.

Implementation Policies

A. Zoning Resolution Changes

To address the policies and recommendations contained in this Plan, changes have been made to the Jefferson County Zoning Resolution as follows:

1. It distinguishes the low power mobile radio service industry from the other telecommunication industries. This is because the low power mobile radio service industry is technologically unique, rapidly expanding in the market economy, and shares few planning and land use impacts with other traditional telecommunication providers.

2. It clearly defines low power mobile radio service telephone communications and the types of facilities used by the industry.

3. The contents of the Zone District Use Standards chart and Visual Impact and Screening policies included in this Plan have been incorporated into the Jefferson County Zoning Resolution for regulation of low power mobile radio service facilities.

4. Administrative review for some types of facilities, as set forth in the Zone District Use Standards chart, have been accepted.

5. Setback requirements have been reviewed and accepted for reasonableness and flexibility, especially when evaluating visual impacts concerning the location of low power mobile radio services facilities on a particular site.

B. Community Notification

Prior to and subsequent to site application submittal for those sites where the facility is not a permitted use, the applicant should offer to meet informally with community groups and interested individuals who reside within the immediate vicinity (including adjacent landowners and registered homeowner associations) to explain the site development concept proposed in the application. The purpose of these meetings is to solicit suggestions from these groups about the applicant's proposed site design and impact mitigation measures. The industry needs to make a concerted effort to incorporate the community suggestions for impact mitigation generated by these meetings and report on their efforts in the hearings on the site application. The industry should be prepared to discuss technical and visual aspects of alternative sites as applicable at these informal meetings.

C. Third Party Review

The low power mobile radio service industry uses various methodologies and analysis tools, including geographically based computer software, to determine the specific technical parameters of a low power mobile radio service facility, such as expected coverage area, antenna configuration, topographic constraints that affect signal paths, etc. In certain instances there may be a need for expert review by a third party of the technical data submitted by the low power mobile radio service provider. The Planning Commission and/or Board of County Commissioners may require such a technical review, to be paid for by the applicant for the low power mobile radio service facility. Selection of the third party expert may be by mutual agreement among the applicant and interested parties or at the discretion of the County, with a provision for the applicant and interested parties to comment on the proposed expert(s) and review qualifications.

The expert review is intended to be a site-specific review of technical aspects of the low power mobile radio service facility and not a subjective review of the site selection. Such a review should address the accuracy and completeness of the technical data, whether the analysis techniques and methodologies are legitimate, the validity of the conclusions and any specific technical issues outlined by the Planning Commission, staff, or interested parties. Based on the results of the third party review, the County may require changes to the application for the low power mobile radio service facility that comply with the recommendations of the expert.

The expert review of technical submission shall address the following:

a. the accuracy and completeness of submissions;

b. the applicability of analysis techniques and methodologies;

c. the validity of conclusions reached; and

d. any specific technical issues designated by the Planning Commission or the Board of County Commissioners.

Abandonment

Low power mobile radio service facilities which are not in use for six months for low power mobile radio service purposes shall be removed by the low power mobile radio service facility owner. This removal shall occur within 90 days of the end of such six month period. Upon removal, the site shall be revegetated to blend with the existing surrounding vegetation.

Glossary

AM (Amplitude Modulation): Method of varying the amplitude of a radio signal while maintaining frequency; used to transmit AM radio signals and TV picture signals.

Antenna: A transmitting and/or receiving device used in telecommunications that radiates or captures radio signals. A group of electrical conductors that transmit or receive radio waves.

Band: A defined range of radio frequencies dedicated to a certain purpose (i.e., the FM band).

Broadcasting: Transmitting radio and television programming to reach the general public; contrasts with transmissions designed for a limited number of receivers.

Cellular Telecommunications: A Commercial Low Power Mobile Radio Service licensed by the Federal Communications Commission (FCC) to two providers in a specific geographical area in which the radio frequency spectrum is divided into discrete channels which are assigned in groups to geographic cells within a service area and which are capable of being reused in different cells within the service area.

Common Carrier: An organization authorized to provide telecommunication services to a third party.

Cross Bar: A structure at or near the top of the low power mobile radio service telecommunications facility which provides support and horizontal separation for the antenna(s).

Directional Antenna: An antenna or array of antennas designed to concentrate a radio signal in a particular area.

Duplex Antenna: One capable of transmitting the signals of two stations from one antenna.

Effective Radiated Power (ERP): The product of the antenna power input and the numerically equal antenna power gain.

FAA (Federal Aviation Administration): The federal agency responsible for aircraft safety.

FCC (Federal Communications Commission): The federal agency which regulates telecommunications.

FM (Frequency Modulation): Method of impressing an audio signal on a VHF frequency by varying the frequency; use to transmit FM radio, two-way radio, and television audio signals.

Frequency: The number of cycles completed each second by a sound wave; measured in hertz (Hz).

Interference: Disturbances in reception caused by intruding signals or electrical current.

Land-Mobile Systems: Two-way radio service for mobile and stationary units in which each user is assigned a particular frequency.

Lattice Tower: A guyed or self-supporting three- or four-sided, open, steel frame structure used to support telecommunications equipment.

Low Power Commercial Mobile Radio Network: A system of low power commercial telecommunications facilities which allow wireless conversation to occur from site to site.

Low Power Commercial Mobile Radio Service: a) profit, b) interconnected to Public Switch Network, c) available to the public or such classes of eligible users as to be effectively available to a substantial portion of the public, and must propose to or has develop, multiple networked sites within the County.

Low Power Mobile Radio Service Telecommunications Facility: A facility which consists of equipment for the reception, switching, and transmission of low power mobile radio service communications. Such facility may be elevated (either building-mounted or ground-mounted) transmitting and receiving antennas, low power mobile radio service base station equipment, and interconnection equipment. The categories of facility types include: 1) roof and/or building mount facilities, 2) freestanding low power mobile radio service facilities, and 3) micro-cell or repeater facilities. For purposes of district height limitations, height of freestanding low power mobile radio service telecommunications facility shall be measured from the average elevation of the finished grade of the building or structure.

Roof and/or Building Mount Facility: A low power mobile radio service telecommunications facility in which antennas are mounted to an existing structure on the roof (including rooftop appurtenances) or building face. Roof or building-mounted facilities may include micro-cell and/or repeater facilities. Such facilities must be screened, constructed or colored to match the existing structure to which

they are attached. Roof and/or building-mounted facilities shall not exceed the following maximum criteria.

1. The facility may include up to a maximum of 4 whip antennas, which may extend a maximum of 15 feet above the highest portion of the structure to which they are attached, including any rooftop appurtenances.

2. The facility may extend a maximum of 6 feet above the highest portion of the structure to which it is attached, including any rooftop appurtenances.

3. A single accessory building may be constructed provided that the building does not exceed 500 square feet gross floor area (GLA); and

4. Antennas on the rooftop or above a structure shall be screened, constructed and/or colored to match the structure to which they are attached. Antennas mounted on the side of a building or structure shall be painted to match the color of the building or structure or the background against which they are most commonly seen. Microwave antennas exceeding 12 inches in diameter on a roof or building-mounted facility shall not exceed the height of the structure to which they are attached, unless fully enclosed. If an accessory equipment shelter is present, it must blend with the surrounding building(s) in architectural character and color.

Freestanding Low Power Mobile Radio Service Facility: A low power mobile radio service telecommunications facility that consists of a stand-alone support structure, antennas and associated equipment. The support structure may be a wooden pole, steal monopole, lattice tower, light standard, or other vertical support. Whip antennas on a freestanding low power mobile radio service facility may extend a maximum of 15 feet above the highest portion of the structure to which they are attached; panel antennas may extend a maximum of 6 feet above the highest portion of the structure to which they are attached.

Micro-cell: A low power mobile radio service telecommunications facility used to provide increased capacity in high call-demand areas or to improve coverage in areas of week coverage. Micro-cells communicate with the primary low power mobile radio service facility in a coverage area via fiber optic cable or microwave. Coverage area for a micro-cell is typically a one-mile radius or less. Micro-cells shall not exceed the following maximum characteristics:

1. Pole height: not to exceed the height limit of the underlying zone district as measured from the average elevation of the finished grade of the building or structure; height is measured to the top of antennas.

2. Number of whip or panel antennas: four.

3. Number of microwave antennas: one.

4. Size of antennas whip antennas: no greater than 3" diameter and up to 24 inches long for each such antenna; for panel antennas: no greater than one square foot of surface area for each such antenna; for microwave antennas: as allowed by the applicable zone district regulations.

5. Size of accessory building: no building permitted.

6. Setback requirements: That required for any accessory building or structure within the applicable zone district.

Low Power Telecommunications Facility: An unmanned facility consisting of equipment for the reception, switching and/or receiving of wireless telecommunications operating at 1,000 watts or less effective radiated power (ERP), including but not limited to the following:

1. Point-to-point microwave signals.

2. Signals through FM radio translators.

3. Signals through FM radio boosters under 10 watts effective radiated power (ERP).

4. Cellular, Enhanced Specialized Mobile Radio (ESMR) and Personal Communications Networks (PCN).

5. Private Low Power Mobile Radio Service (PMRS).

MHZ: Megahertz or 1,000,000 Hz.

Microwave: Electromagnetic radiation with frequencies higher than 1,000 MHZ; highly directional signal used to transmit radio frequencies from point to point at a relatively low power level.

Microwave Antenna: A dish-like antenna manufactured in many sizes and shapes used to link communication sites together by wireless transmission of voice or data.

Monopole: A structure composed of a single spire used to support telecommunications equipment.

Multiplex Antenna: One capable of transmitting the signals of several stations.

MW/cm²: Milliwatts per square centimeter; a measurement of the radio frequencies hitting a given area.

Nonionizing Electromagnetic: The lower portion of the electromagnetic spectrum;

Omnidirectional Antenna: An antenna that is equally effective in all directions, and whose size varies with the frequency and gain for which is it designed.

Private Low Power Mobile Radio Service: All other forms of wireless telecommunications which have similar physical facilities as Commercial Low power mobile radio Service, but do not meet the definition of commercial mobile radio service.

RF: Radio Frequencies

Radiation: Includes household electric current, radio, television, microwave communication, radar, and visible light. It is insufficient to ionize tissue (unlike ionizing radiation created by fission of atoms); causes thermal effects at high levels; may cause nonthermal effects.

Repeater, Equipment: Contains both a receiver and transmitter; used to relay radio signals over large distances or to provide signals in an area otherwise in shadow.

Repeater, Low Power Mobile Radio Service Telecommunications Facility: Extends coverage of a cell to areas not covered by the originating cell. Repeater facilities shall not exceed the following maximum characteristics:

1. Pole height: in all zones, not to exceed the underlying zone district height limit as measured from the average elevation of the finished grade of the building or structure; height is measured to the top of antennas.

2. Number of whip or panel antennas: four.

3. Number of microwave antennas: one.

4. Size of antennas for whip antennas: no greater than 3" diameter and 12 feet long; for panel antennas: four square feet of surface area for each such antenna; for microwave antennas: as allowed by applicable zone district regulations.

5. Size of accessory building: one accessory building up to 100 square feet gross floor area (GFA) in size.

6. Setback requirements: that are required for any accessory building or structure within the applicable zone district regulations.

Shadow: Area within which a radio signal is received poorly or not at all due to manmade or natural obstructions in line of sight from the transmitter.

Translator: Equipment containing both a receiver and transmitter; used to relay TV signals over large distances or to provide signals in an area otherwise in shadow.

Transmission Tower: The structure on which transmitting and/or receiving antennas are located. An AM radio tower is its own transmitting antenna.

Transmitter: Equipment that generates radio signals for transmission via antenna.

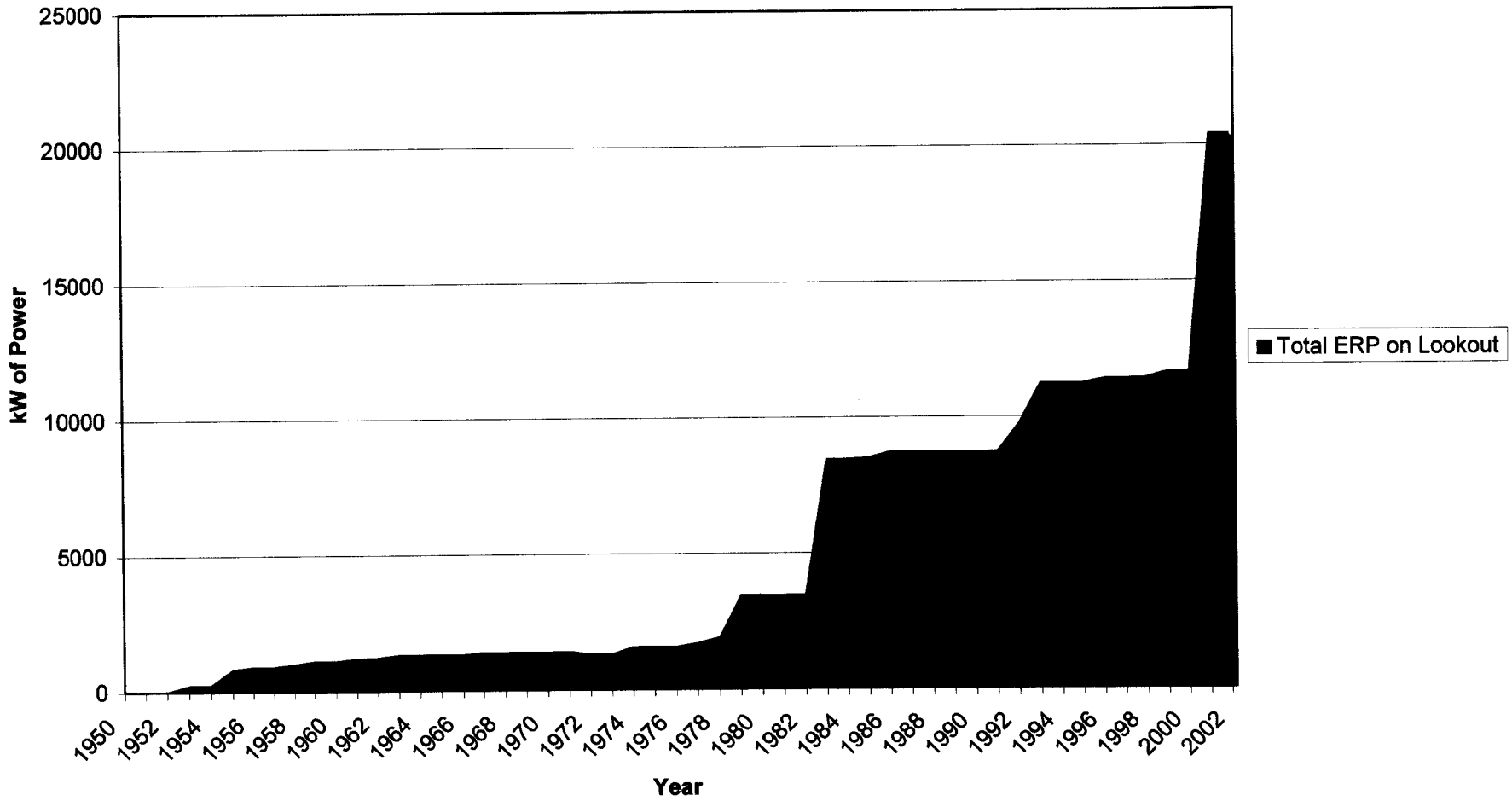
UHF: Ultra High Frequency with bands from 300 to 3,000 Mfz; includes UHF-TV (such as Channel 31), microwave, and some land mobile and common carriers.

uW/cm²: Microwatts per square centimeter; a measurement of the radio frequencies hitting a given area.

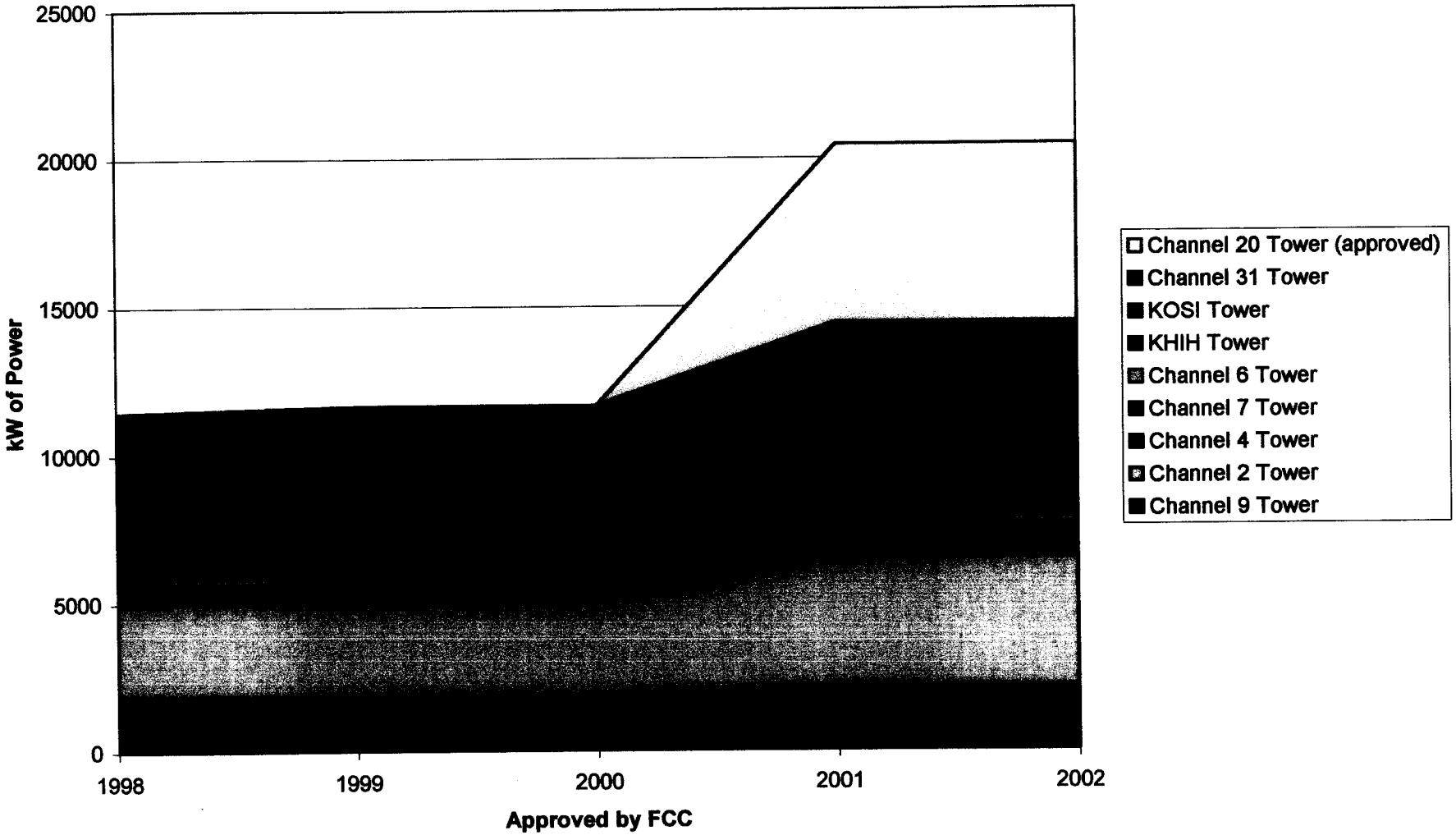
VHF: Very High Frequency with bands from 30 - 300 MHZ; includes FM radio, VHF-TV (Channels 2 to 13) and some land mobile and common carriers.

Whip Antenna: An antenna that is cylindrical in shape. Whip antennas can be directional or omnidirectional. Their size varies based upon the frequency and gain for which they are designed.

CURRENT FCC PERMITS
Over 20 million watts of Broadcast Radiation
Effective Radiated Power (ERP) on Lookout Mountain



Power Increases on Lookout Approved by FCC
(Supertower shown as future because not approved by Jeffco but already approved by FCC)



Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
Canyon Area Residents for the Environment	)	
Request for Review of Action Taken Under	)	DA 00-764
Delegated Authority on a Petition for	)	
An environmental Impact Statement	)	

Volume II CARE EXHIBITS

Appendix B – Letters in opposition to tower

Appendix C – Colorado Senate Joint Resolution 00-031

Appendix D – Chronology of Radio Frequency Radiation Measurements and Reports

Appendix E – Zoning Resolution of Jefferson County, Colorado October 1998

Appendix F – An Investigation of Radiofrequency Radiation Levels on Lookout Mountain

Appendix G – Letter from University of Colorado Health Sciences Center Department of Radiation Oncology opposing the tower

Appendix H – Letter from Rocky Mountain PBS

Appendix I – Affidavit of Ted Votaw

Appendix J – Rocky Mountain News article, 12/15/93 Channel 20 Sold for $7/5 million as station pulls out of Chapter 11

Appendix K – Denver Post article, 12/16/93 Chicago Broadcaster bails out Channel 20

Appendix L – Waiver of Section 73/1125

Appendix M – Combined Communications Corp Opposition to Petition to Deny

Appendix N – Jeffco BCC CC83-1089

Appendix O – Jeffco BCC CC99-427

Appendix P – Jefferson County Telecommunications Land Use Plan

Appendix Q – FCC Broadcast Permits Issued for Lookout Mountain

Appendix C

Colorado Senate Joint Resolution 00-031

Second Regular Session

Sixty-second General Assembly

LLS NO. R00-1142.01 Kate Rooney

STATE OF COLORADO

BY SENATORS Sullivant, Congrove, Evans, and Teck;
also REPRESENTATIVE Witwer.

SENATE JOINT RESOLUTION 00-031

CONCERNING URGING THE FEDERAL COMMUNICATIONS COMMISSION TO REJECT LAKE CEDAR GROUP'S PETITION TO PREEMPT LOCAL GOVERNMENT LAND USE DECISION-MAKING AUTHORITY.

WHEREAS, According to its comprehensive plan and its duly adopted zoning regulations, the Board of County Commissioners of Jefferson County, Colorado denied an application by Lake Cedar Group, LLC, to rezone land on Lookout Mountain from residential and agricultural zoning to planned development zoning in order to allow construction of an 854-foot telecommunications supertower and a 26,000 square foot support building; and

WHEREAS, Such decision was a quasi-adjudicative decision based on factual evidence presented to the Jefferson County Board of County Commissioners and application of applicable legal standards and as such can be appealed judicially to Jefferson County District Court, which court is fully empowered to grant full and appropriate relief to the appellant if appropriate under the facts of the case; and

WHEREAS, Lake Cedar Group filed an appeal of Jefferson County's decision in Jefferson County District Court, which appeal is now pending the filing of briefs by the parties; and

WHEREAS, Despite the pending judicial appeal, and after Jefferson County spent several months preparing the voluminous record of proceedings for the Jefferson County District Court action, Lake Cedar Group, without notifying the Jefferson County Board of County Commissioners or any other interested party, filed a petition with the Federal Communications Commission (FCC) requesting the FCC to "preempt" Jefferson County's decision and to declare Jefferson County's decision "prohibited and unenforceable"; and

WHEREAS, By Public Notice dated April 10, 2000, the FCC seeks public comment on Lake Cedar Group's petition; and

WHEREAS, In the United States, control over individual land use

decisions is firmly vested in local governments, through statutory delegation from state governments; and

WHEREAS, The FCC is barred by the 10th Amendment to the United States Constitution from attempting to preempt decisions made by local governments on individual land use applications because the United States Congress has not directed or authorized the FCC to preempt such local decisions; and

WHEREAS, The FCC lacks not only the authority, but also the expertise and any adopted standards to second-guess and invalidate local government land use decisions; and

WHEREAS, Any attempt by the FCC to preempt local government land use decision-making in this manner would represent an illegal, unauthorized, and unjustified attack on state- and local- government land use authority; now, therefore,

Be It Resolved by the Senate of the Sixty-second General Assembly of the State of Colorado, the House of Representatives concurring herein:

That the General Assembly of the State of Colorado hereby encourages the FCC not to preempt local government land use decision-making and state judicial processes, thus overriding local and state government authority.

Be It Further Resolved, That copies of this Joint Resolution be sent to the President of the United States Senate; the Speaker of the United States House of Representatives; each member of Colorado's Congressional delegation; each member of the House of Representatives Subcommittee on Telecommunications, Trade and Consumer Protection of the Committee on Commerce; the Governor of Colorado; and the Commissioners of the Federal Communications Commission.

Appendix D

Chronology of Radio Frequency Radiation Measurements and Reports

CHRONOLOGY OF RADIO FREQUENCY RADIATION MEASUREMENTS AND REPORTS
appendix

Overview
The Federal Government has measured RF on Lookout 3 times in the 46 years since the first broadcast off Lookout Mountain. Every time the Federal Government has measured, the measurements in publicly accessible areas documented that the Radiation limits were higher than the safety limit.
Jeffco has measured RF levels over FCC standards near every tower with FM radio. KHIH tower was brought into compliance by fencing off the public out of Jefferson County Open Space land through March 31, 2000. The TV stations try to maintain that it is they who are within the FCC limits and the FM stations that are over but all the radiation combines and three of the TV stations derive revenue from renting their tower space to the FM stations. None of these 3 TV tower owners got Jefferson County's permission to add the FM stations to their towers. Channel 2 tower- KBPI and KALC-FM. Channel 4 - KRFX, Channel 6- KUVO and KCFR.

1986

September 22, 1986

On September 22, 1986 EPA and FCC conduct extensive measurements on Lookout Mountain and document areas over ANSI Standard in a public area. The 12 page report was published 5 months later as "An Investigation of Radio-frequency Radiation Levels on Lookout Mountain, Jefferson County, Co." Electromagnetics Branch, U.S. Environmental Protection Agency, Las Vegas, NV 89114, February 1987.
Near KOSI radio measurements in public areas were as high as 580 micro watts per centimeter squared. p.6
Publicly accessible areas near KYGO had electromagnetic radiation as high as 10,000 micro watts per centimeter squared. p. 11 "The KYGO tower is located in a complex of buildings where some people live throughout the year and where seasonal, residential workshops are held to teach square dancing. " p. 7 (This is the where Beryl and Mae Elma Main and their family lived and worked with the square dance camp, The Lighted Lantern, as described by the Main's attorney Bruce DeBoskey at the May 27 hearing. Beryl Main died of lymphoma and his son was also stricken with cancer. Suit was filed against KYGO in Federal Court around 1987-1988. Mr. DeBoskey is under an obligation not to reveal the terms of the settlement.

This EPA report is revealing.
"In a mountainous area, one cannot rely on such a rapid reduction in power density with distance because the measurement locations may be moving up into the main-beam of radiation. Additional data collected near KYGO actually show an

increasing power density with distance from the antenna as the measurement location moves closer to the main beam of radiation. " p. 10 "it is interesting to note the effect of different elevations (in mountainous areas) on the power densities" Usually, tripling the distance from an antenna would reduce the power density by a factor of 9. In this case however, the effect of greater distance was overcome by moving higher into the main beam of radiation.These data illustrate the need to consider the relative elevations of areas surrounding a station in the overall RF exposure evaluation." p.8 ("An Investigation of Radio-frequency Radiation Levels on Lookout Mountain, Jefferson County, Co." Electromagnetics Branch, U.S. Environmental Protection Agency, Las Vegas, NV 89114, February 1987.)

From the Federal Government come these admissions:

".this area presented a complex electromagnetic environment" p.2 Radar, FM, TV, two-way radio and other types of antenna are present. But, "broadcasters dominate the spectrum on Lookout Mountain" p. 5 see also Tables 1 and 2.

"The number of stations and their close proximity to one another and to residential areas make the Lookout Mountain antenna farms unusual. p.1

"in a mountainous area, one cannot rely on such a rapid reduction in power density with distance because the measurement locations may be moving up into the main-beam of radiation. Additional data collected near KYGO actually show an increasing power density with distance from the antenna as the measurement location moves closer to the main beam of radiation. " p. 10 "it is interesting to note the effect of different elevations (in mountainous areas) on the power densities" Usually, tripling the distance from an antenna would reduce the power density by a factor of 9. In this case however, the effect of greater distance was overcome by moving higher into the main beam of radiation.These data illustrate the need to consider the relative elevations of areas surrounding a station in the overall RF exposure evaluation." p.8

1987

1988

1989-FCC REVEALS THAT RARELY IS RF OVER STANDARDS, LOOKOUT IS EXCEPTION

Lookout Mountain is one of the few residential areas in the country that has exceeded the FCC radiation standards according to FCC OET document published in 1989.

"Measurements made by EPA and others (References 15 and 19) have shown that RF radiation levels in inhabited areas near broadcasting facilities are generally well below levels believed to be hazardous. There have been a few situations around the country where exposure levels have been found to be higher than those recommended by applicable safety standards (e.g. Reference 20 Page 17, Reference 20 "An Investigation of Radio-frequency Radiation Levels on Lookout Mountain, Jefferson County, Co."

Electromagnetics Branch, U.S. Environmental Protection Agency, Las Vegas, NV 89114, February 1987.)
"But such cases are relatively rare, and few members of the general public are likely to be routinely exposed to excessive levels of RF radiation from broadcast towers." Page 9, Paragraph 4. 1989) FCC OET (Office of Engineering and Technology) Bulletin # 56

1990
1991
1992
1993
1994
1995

January 20, 1995

Mr. Richard Tell conducted an RF survey ordered and paid for by Andrews and Anderson, the architects for the Jefferson County Lookout Mountain Nature Center. Mr. Tell finds that the RF fields at the Nature Center are strong enough to interfere with electronic systems such as public address, intercoms and various types of audio equipment. Although shielding materials can be installed in new or existing construction to help reduce RF field strength's impact on sensitive equipment, Mr. Tell warns at page 19 of his report , "there are no reliable means for predicting whether specific electronic systems will be interfered with at certain field strengths; the only reliable approach is by trial and error." Various mitigation measures are discussed at pages 16-18 that show the expense to the landowner afflicted with electromagnetic interference.

1996

***5/9/96*- JEFFERSON COUNTY CONFIRMS RF LIMIT IS THE ANSI STANDARD**

letter from Jefferson County Manager, Dora Harrison Jefferson County Commissioners
to Carole Lomond

1. **The recent ANSI standard of 200 micro watts per square centimeter is the Jefferson County standard.** This was further confirmed by Dan Brindle of the County that this 200 standard is a zoning requirement in a letter to CARE

Jeffco trying to get an inventory of devices on Lookout from the FCC

July 12, 1996

Richard Tell, who did the 1986 NIER (non-ionizing Electromagnetic Radiation) study of the towers' emissions, takes RF measurements around community at Jeffco request

Report of Survey of Radio-frequency Fields Completed. This study documents that levels of broadcast radiation over 1 microwatt per centimeter squared are documented over a wide area of the community. Areas as far away as three miles show radiation amounts thousands of times above the national average.

1997

October 21 &22, 1997

Robert Weller of Hammett & Edison, RF engineer for Lake Cedar Group (LCG), measures RF exposure levels on Lookout Mountain. He finds "ground level areas that exceed the public limits" in the vicinity of the Channel 6 tower, and reports this to the FCC on October 28, 1997.

10/21/97-LCG takes RF measurements but does not follow Zoning Regulations
Rather than make the mandatory measurements of the NIER levels at up to 12 sites selected by mutual agreement of the applicant, the resident community and the Planning and Zoning Department, Lake Cedar Group's Engineer, Robert Weller, unilaterally substituted his own locations for his measurements of existing RF exposure conditions on October 21 and 22 of 1997. (Hammett and Edison Analysis of Ground-Level Radio Frequency Power Densities for Proposed Joint DTV Tower pg. 4

1998

July 18, 1998

CARE engineers make measurements on Lookout Mountain and confirm the excessive levels found by Weller near the Channel 6 tower. They also find RF exposure levels above the allowable standard on Cedar Lake road near KOSI FM and KKHK FM and on the hill where the towers for TV Channels 7, 9 and 31 are located. Exposure levels are found to be as high as 250% of the allowable standard.

7/28/98-Weller Report to FCC on Channel 4-Bates # 041285-88
7/28/98-Channel 4 application for Digital Channel 35 on Supertower
Q. 22 Environmental Statement-See 47 CFR Section 1.1301 et seq.
No significant environmental impact
"Grant of this application is not considered to be a major environmental action as defined in Sec. 1.1307 of the FCC rules. None of the conditions listed in Sect. 1.1307(a) are believed to apply.
(c) pursuant to OST Bulletin No. 65, the applicant must explain in an
Exhibit what steps will be taken to limit the RF radiation exposure to the
Public and to persons authorized access to the tower site. In addition,
where there are multiple contributors to radio frequency radiation,

you must certify that the established RF radiation exposure procedures
will be coordinated with all stations.
See EXHIBIT 6
Exhibit 6 is a July 14, 98 Weller report
ERP will be 1000 kw
Used computer model to calculate ground RF - Highest would be
1.5% of public limit therefore categorical exclusion claimed pursuant to Section 1.1307(b)(3) (ii) of the Rules which
states that "renewal applicants whose transmitters or facilities contribute to the power density of an accessible
are not in compliance with the limits must submit an EA if emissions from the applicant's facility results, in the area in question, in a power density that exceeds 5% of the power density exposure limit applicable to that facility.

August 5, 1998

RF exposure measurements are made on Lookout Mountain as part of the proposal by FOX TV to obtain a permit from Jefferson County to add a digital antenna on its existing tower

August 25, 1998

As part of the LCG (Lake Cedar Group Supertower) proposal, Hammett & Edison presents to Jefferson County an analysis of RF exposure levels on Lookout Mountain, based on the measurements made by Weller on October 21 & 22, 1997. This report states that the maximum RF exposure levels on Lookout Mountain are 66% of the maximum allowable. The report also states that the levels near the Channel 6 tower are only 57% of the maximum allowable, even though Weller's earlier statement to the FCC admitted the levels were over 100%.

September 29, 1998

Hammett & Edison, on behalf of LCG, submits to the FCC a report claiming that RF exposure levels on Lookout Mountain are below the maximum permissible exposure (MPE).

October 29, 1998

The FCC makes measurements on Lookout Mountain and confirms the excessive RF exposure levels measured by CARE engineers. Exposure levels of 250% MPE are found

on the Channel 7 driveway, and 140% MPE is found on the public roadway in front of the Channel 7 driveway. Exposure levels as high as 220% MPE are found on Jefferson County Open Space property between the KHIH FM tower and the Channel 2 tower.
Actual footage of the measurements taken that date and the dialog with the FCC's Engineer, Dr. Robert Cleveland, Lake Cedar Group's Engineer, Bob Weller and CARE's volunteer resident engineer, Al Hislop is included in the Documentary film, "Broadcast Blues," by independent Emmy award winning filmmaker, Len Aitken. The comments of Dr. Cleveland at the beginning of the measurement session starting on Cedar Lake Road near the proposed supertower are attached as an additional exhibit.

November 12, 1998

The FCC issues a report summarizing the results of the measurements of October 29, 1998, and recommending remedial actions to bring Lookout Mountain into compliance with RF exposure standards. The remedial actions include fencing of hot spots on public and private property where possible, and power reductions by certain stations to reduce exposure levels in public areas. The power reductions recommended for KOSI and KKHK can mathematically be shown to be insufficient to reduce the 140% MPE hot spot on the public roadway to a compliant level.

December 15, 1998

Jefferson County grants a one-year fence permit to surround hot spots on the public right-of-way on Colorow Road, near the Channel 6 tower. Representatives of KCFR and KUVO promise to resolve the RF radiation problem "one way or another" by December 31, 1999.

December 16, 1998

The FCC again visits Lookout Mountain to measure exposure levels and confirm that the requested remedial actions have resulted in a compliant situation. Instead, the FCC again finds excessive levels at all three sites as the FCC begins their measurements. Further power reductions are requested of KCFR FM, KUVO FM and KHIH FM. KHIH is reduced to transmitting at 39% of its licensed power. (KHIH subsequently obtained a permit to block access to Jefferson County Open Space with a fence, and resumed transmitting at full power.) The FCC also requires an expansion of the fences on the Channel 7 property.

1999

January 4, 1999

The FCC issues a report summarizing the results of the measurements taken on December 16, 1998. The report does not explain how the 17% reduction in total power output from stations KOSI and KKHK resulted in a reduction in the exposure level of a known hot spot on the public roadway near the channel 7 driveway from 140%MPE to 70% MPE. CARE measurements at the hot spot show exposure levels greater than 100% MPE. The

FCC report concludes that Lookout Mountain is now in compliance with RF exposure standards.

February 23, 1999

Jefferson County issues a permit for FOX TV to add a digital TV transmitting antenna on FOX's existing tower. The county relies on the FCC's assertions that the mountain is in compliance with the standards.

June, 1999

Jefferson County obtains RF survey meter and begins to make RF exposure measurements.

June 12, 1999

KOSI FM and KKHK FM further reduce transmitted power after Russell Clark of Jefferson County confirms CARE's claim that RF exposure levels exceed county and federal standards on the roadway near the Channel 7 driveway. This location is between the Channel 7 and Channel 31 (FOX) towers. (This was the point now affectionately called "Pericle Rock.")

July 1, 1999

Representatives of Jefferson County, CARE and Tribune Broadcasting have a joint measurement session at Peric le Rock. With the power reductions implemented June 12 still in effect, measurements by Jefferson County and CARE indicate RF exposure levels exceeding 100% MPE, but Tribune Broadcasting measurements are lower. Measurement results are given to the FCC. The FCC discards Jefferson County's maximum readings, averages the remaining Jefferson County readings with Tribune's lower readings, and declares the level to be 98.6% MPE.

December 14, 1999

Jefferson County grants a two-year extension for the one-year permit to fence the public right-of-way on Colorow road near the Channel 6 tower. KUVO and KCFR have made no attempt to remedy the RF excesses.

December 23, 1999

Russell Clark of Jefferson County, Jim Hart, independent consulting engineer for Jefferson County and FOX, Jim Hollinger and their engineer, Bob Bonner, measured areas around the FOX tower. Each had a meter. CARE representatives, Dr. Ron Larson and Deb Carney observed. Russell Clark said that FOX must do required county measurements within 90 days of turning on the Channel 32 Antenna (turned on Nov. 1, 99)
Location I-Between Channel 7 and Channel 31 Tower. Jeffco measured over the RF limits but FOX did not. Road leading up to several different towers, near turnoff for Channel 7 Tower. There are 3 wooden stakes, the stake closest to Denver says Pericle and has

orange paint Measurements were taken 3 ft from this N.E. stake. This is the site referred to earlier as Pericle rock.
Due to major inconsistency between the readings of the FOX meter and the JEFFCO meter and the fact that the JEFFCO meter consistently showed that the RF limits for uncontrolled areas were exceeded, the measurements were discontinued after 1 hour with the plan to come back with a third meter next Tues or Wed. Only 2 locations were measured

2000

January 8, 2000

With newly calibrated RF survey meter CARE engineer makes RF exposure measurements at Pericle Rock. Measurements indicate 106% MPE.

January 24, 2000

CARE engineer makes measurements of RF exposure levels near the Channel 6 tower on Colorow Road. RF levels on the public right-of-way on both sides of Colorow road now appear higher than before the power reductions required by the FCC in 1998.

January 25, 2000

Jefferson County and CARE have a joint measurement session at several places on Lookout Mountain. With good agreement between the two meters, RF exposure levels are found to exceed county and federal standards near the Channel 6 tower on Colorow road, with levels typically 125% MPE.
Exposure levels at Pericle Rock also exceed 100% MPE.
Levels near the KHIH tower are as high as 240% MPE. This portion of Jefferson County open space is now fenced off, but the gate is missing.
Many newly discovered hot spots are found to the south, east and north sides of the Channel 2 tower site on open space property belonging to Jefferson County and the City and County of Denver.

That same day, FOX took their RF measurements without Jefferson County or CARE representatives present and then turned these measurements over to the County. FOX did not remeasure the hot spot previously found by Jeffco at the pericle rock location between the FOX and Channel 7 Towers.

February 10, 2000

Jefferson County, Tribune Broadcasting and CARE to measure RF. Tribune issues press release that advises that the previous day they had KALC-FM (on the Channel 2 tower) turn down their power. Tribune verbally admits they turned it down 30%. Russell Clark and Jim Hart are present for Jeffco. Don Mooney, Andy Bader and a number of others are present for Channel 2. Leo Servo attends with another person from the FCC. Dave

Venetti tapes measurement techniques and Al measures. Al finds one spot that had been 147.9 % of MPE was now 101% of MPE. Kieran Nicholson and a photographer from the Post attend.
Both Russell and Al found readings in excess of 100% MPE. Bob Hensler of KCFR almost always found levels lower than ours. When he and Russell traded meters, Russell was still able to find some readings higher than 100%, with the "Lake Cedar Group" meter, as Bob Hensler called it. The Channel 2 area was right at the ragged edge,
and that the Channel 6 area was still slightly over. Russell Clark agreed. Jeffco and CARE will
measure again Tuesday, with representatives of KRMA, KCFR and KUVO all present

3/2/2000- Measurements

Channel 6 Tower
Russell Clark, Bob Hensler and Al Hislop again made measurements at the Channel 6 tower. Al and Russell's showed higher than Bob Hensler's. Jim Hart averaged the averages of the readings from the three meters, and the result was that levels across the street from the tower were found to be 105.8% MPE. Near the power pole on the same side of the street as the tower, the average of averages was 112.44%.
Pericle Rock
Russell and Al then made measurements at Pericle Rock, across from the green building near the FOX tower. The average of the averages was 115.15% MPE.

3/9/2000- Report by Al Hislop on measurements with Russell Clark

This morning KCFR and KUVO reduced power and we measured approximately 100% near the power pole by the Channel 6 tower. Russell Clark said he would periodically make measurements because it is so close. KUVO is now down to 42.5% and KCFR is down to 62%. Some adjustments may be made, increasing KUVO and decreasing KCFR, but keeping the total RF transmitted power constant.

4/3/2000-KHIH Fence Taken Down

KHIH estimated to be operating and 50% power. Russell: Al Hislop made measurements at the known hot spot on publicly accessible Jefferson County Open Space near KHIH. four spatially averaged
measurements: (uncorrected)

133.3% MPE
118.3% MPE
133.7% MPE
123.1% MPE

Taking into account the .93 calibration factor of Al Hislop's probe, the average of these measurements is 118.2% MPE.

Appendix E

Zoning Resolution of Jefferson County Colorado
October 1998

Z O N I N G

RESOLUTION

this edition printed October 1998

i. A final operational mine plan consistent with the Official Development Plan depicting method of mining, bench orientation, direction of mining and concurrent reclamation plans. (orig. 6-1-93)

j. Detailed plans for all monitoring required by the Official Development Plan, including the location of monitoring stations, frequency of monitoring and criteria for monitoring. (orig. 6-1-93)

k. All state and federal permits required for the mining operation. (orig. 6-1-93)

3. The site plan shall be reviewed by the Planning Director for conformance with the Official Development Plan and other County regulations. (orig. 6-1-93)

a. Upon receipt of a site plan, the Planning Director shall cause notice of filing of the site plan to be posted on the property, which shall indicate that there is a 60 day period commencing on the date of posting to submit written comments to the Planning Director concerning the site plan. (orig. 6-1-93)

b. The applicant shall deposit 10 copies of the site plan with the Planning Department. Five copies of the site plan shall remain at the Planning Department. Five copies shall be deposited at public libraries in the area of the proposal. The copies shall be available to the public to check out for a two week period. (orig. 6-1-93)

c. After the close of the comment period, the Planning Director shall determine whether the site plan conforms to the requirements herein and may request such changes as are deemed necessary to render the plan in conformance. (orig. 6-1-93)

4. The Planning Director's decision on the site plan may be appealed to the Board of Adjustment under the provisions set forth in Section 13 of this Zoning Resolution. (orig. 6-1-93)

5. After approval of a site plan, the Planning Director may approve minor modifications to the site plan so long as such modifications are consistent with the overall intent of the Official Development Plan and do not result in adverse impacts that were not considered at the time of zoning approval. (orig. 6-1-93)

F. PLANNED DEVELOPMENT FOR TELECOMMUNICATION TOWERS:

The purpose of the Planned Development is to minimize adverse visual effects of towers through careful design, siting, and vegetative screening; to maximize the use of any transmission tower in order to reduce the total number of towers needed to serve the telecommunications needs of the area; and to site and design towers so that electromagnetic radiation emissions to which the public will be exposed do not exceed safe levels. (orig. 5-11-93)

1. Application Requirements:

All rezoning applications must contain the following materials, however failure to submit a complete application shall not deprive the Planning Commission or the Board of County Commissioners of jurisdiction to consider the application. These application requirements are not intended to specify criteria for decision. (orig. 5-11-93)

a. Site plan(s) drawn to scale identifying the site boundary; tower(s); guy wire anchors; existing and proposed structures, including accessory structures; existing and proposed ground-mounted equipment; vehicular parking and access; and uses,

(6) Existing easements or rights-of-way (e.g., utility, irrigation, access, etc.) on or contiguous to the site. (orig. 5-11-93)

(7) Identified mineral resource areas. (orig. 5-11-93)

(8) Where the area in which construction will occur contains slopes greater than 10 percent, a slope analysis of the area affected by construction depicting locations and direction of slope faces for slopes within the following categories: 0-8 percent, 8-15 percent, 15-22 percent, 22-30 percent, greater than 30 percent. (orig. 5-11-93)

(9) Floodplains, as designated by the Urban Drainage and Flood Control District or other agency, and overlay zoned floodplain (FPS) areas. (orig. 5-11-93)

(10) Areas within the Geologic Hazard (GH) Overlay Zone. (orig. 5-11-93)

(11) Location of other potential hazards such as wildfire, geologic, airport or radiological hazards. (orig. 5-11-93)

(12) Location of special resources such as wildlife, historic structures, and archaeologically significant remains. (orig. 5-11-93)

j. Elevations of the proposed tower and accessory building generally depicting all proposed antennas, platforms, finish materials, and all other accessory equipment. (orig. 5-11-93)

k. The Board of County Commissioners and/or the Planning Commission may require the applicant to submit funds in escrow up to a maximum of $10,000 to pay for expert review of technical submissions by the applicant, including expert review of engineering data and financial data concerning costs of modifying existing towers and costs of ameliorating interference. The Planning Department shall recommend the amount of funds to be deposited up to $10,000 based on the nature of the application and the anticipated complexity of review. Selection of the expert(s) shall be within the sole discretion of the County, however the applicant and interested parties shall have an opportunity to comment on the proposed expert(s). Any funds not utilized for expert review shall be returned to the applicant at the completion of the rezoning case. (orig. 5-11-93).

2. Review and Approval:

a. General Criteria:

(1) In reviewing a proposal under this Section, the Planning Commission and the Board of County Commissioners shall consider the compatibility of the proposal with existing and allowed land uses in the surrounding area; the County's Comprehensive Plan including but not limited to the applicable community plan or the General Land Use Plan and the Telecommunications Land Use Plan, according to the priorities set forth in the plans; the Local Government Land Use Control Enabling Act; the provisions of section 30-28-115, C.R.S., and any other applicable law, adopted public policies or plans, or studies presented as part of the zoning case. The Board has the sole discretion to determine what weight, if any, to give each of these factors. (orig. 5-11-93)

(2) If the Board of County Commissioners approves a rezoning to Planned Development pursuant to this Section, the Board may impose such conditions on access, accessory structures, landscaping, tower coloring, lighting, design, size and siting as it deems necessary to render the proposal compatible with existing and allowed land uses in the surrounding area, to comply with the policies in the Jefferson County Comprehensive Plan or applicable land use plan, the telecommunications Land Use Plan, its land use enabling authority, the laws, policies, plans and studies referenced above, except where such conditions are preempted by and conflict with regulations promulgated by the Federal Communications Commission or the Federal Aviation Administration, or where the Board of County Commissioners determines, based on evidence presented at the hearing, that such conditions would contravene sound engineering practices. (orig. 5-11-93)

b. Minimum Standards:

(1) The applicant must provide expert testimony that demonstrates to the satisfaction of the Board of County Commissioners that no existing telecommunications site is available to accommodate the equipment or purpose for which the tower or increase in height is proposed at a reasonable cost or other business terms. The need for structural or equipment modifications shall not alone be sufficient to demonstrate nonavailability. Any one or more of the following shall be considered to demonstrate nonavailability. (orig. 5-11-93)

(a) Evidence with reference to EIA-RS 222, in its then current adopted revision, that the structural capacity of existing and approved towers cannot accommodate the planned equipment and cannot be reinforced to accommodate the planned equipment at a reasonable costs, or the owner of the site is unwilling to rezone if necessary to accommodate a new user. The applicant shall be required to calculate the capacity of existing or approved towers based on information on file with the County or requested from the tower owner, if supplied. (orig. 5-11-93)

(b) Evidence that the planned equipment may or will cause objectionable radio frequency interference with other existing or planned equipment on that tower, which cannot be ameliorated at a reasonable cost. (orig. 5-11-93)

(c) Evidence that existing or approved towers do not have space to locate the planned equipment where it can function effectively and at the strength of signal required by the FCC. (orig. 5-11-93)

(d) Evidence that the addition of the planned equipment to existing or approved towers would result in NIER levels in excess of those permitted by OST-65 and ANSI C95.1 or any revisions thereto, or any adopted local standard. (orig. 5-11-93)

(e) Evidence that the fees and/or costs for shared use, including the cost to adapt existing facilities to the proposed use, exceed the cost of the proposed tower, or that the parties have not been able to reach agreement on reasonable business terms or other issues associated with locating on the tower. (orig. 5-11-93)

(2) All new structures must be set back from the property line sufficient to prevent all ice-fall materials and debris from tower failure or collapse from falling onto occupied dwellings other than those occupied by the tower owner, and protect the public from NIER in excess of that allowed herein. Where more than one tower is located on a site, the set back between such towers shall be sufficient to prevent multiple failures in the event one tower fails. (orig. 5-11-93)

(3) The tower must be designed to accommodate structurally multiple antennas if recommended by the Telecommunications Plan. (orig. 5-11-93)

(4) NIER emissions from the tower facility, when operating with maximum power output from all proposed antennas and transmitting facilities, may not exceed the level set forth in this Zoning Resolution, as measured in accordance with methods published by the United States Office of Science and Technology or any other applicable federal agency by qualified experts. (orig. 5-11-93)

(5) The written restrictions must state that at such time as there have not been any antennas on a tower or the use of the tower has been abandoned for 6 consecutive months, it will be removed within 180 days of the end of said six month period. (orig. 5-11-93)

(6) Satisfaction of the minimum standards set forth above shall not entitle an applicant to approval of the rezoning if the Board of County Commissioners determines that rezoning should not be allowed pursuant to the General criteria for review. (orig. 5-11-93)

G. GENERAL REQUIREMENTS

1. Multiple buildings per lot, except for single-family detached structures, are allowed only for property platted pursuant to the Jefferson County Land Development Regulation. (orig. 3-8-82)

2 The "General Requirements" portion of each of the standard zone districts of this Zoning Resolution as amended at the time an applicable permit is issued, together with their parking, fencing, signage, and other regulations and requirements shall be applicable to all comparable areas in the Planned Development Districts unless otherwise specified in the particular Official Development Plan. (orig. 1-17-84; am. 6-1-93)

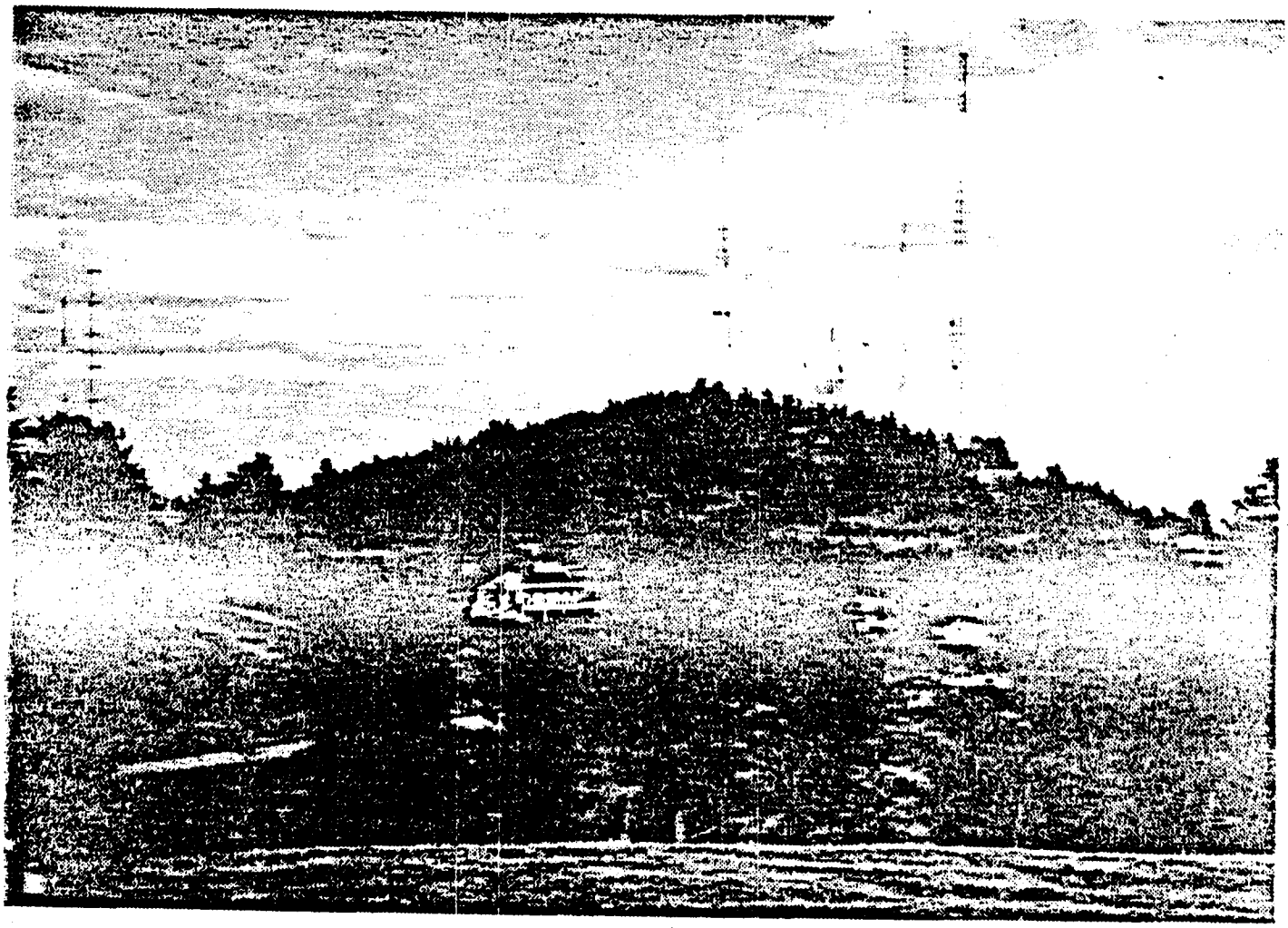
3. No Official Development Plan shall be approved which contains restrictive or protective covenants which limit the transfer, rental, or lease of any housing because of race, creed, religion, color, sex, marital status, national origin or ancestry or handicap as prohibited by C.R.S. 1973, 24-34-502 and Title VIII of the Fair Housing Act of 1968, 42 U.S.C. § 3604(c). (orig. 5-12-81; am. 6-1-93)

4. Upon approval of any planned development by the Board of County Commissioners, the written conditions or restrictions and the appropriate accompanying graphic documentation shall be filed with the Jefferson County Clerk and Recorder as an Official Development Plan as set forth in Section 1 of this Zoning Resolution. (orig. 6-1-93)

Appendix F

An Investigation of Radiofrequency Radiation Levels on Lookout Mountain

An Investigation of Radiofrequency Radiation Levels on Lookout Mountain, Jefferson County, Colorado September 22 - 26, 1986



Electromagnetics Branch
Office of Radiation Programs
U.S. Environmental Protection Agency
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February 1987

An Investigation of Radiofrequency Radiation Levels on Lookout Mountain, Jefferson County, Colorado September 22 - 26, 1986

Prepared for the
Office of Engineering and Technology
Federal Communications Commission
through Interagency Agreement RW27931344-01-0

Electromagnetics Branch
Office of Radiation Programs
U.S. Environmental Protection Agency
P.O. Box 18416
Las Vegas, Nevada 89114-8416

February 1987

EXECUTIVE SUMMARY

During the week of September 22, 1986, Environmental Protection Agency and Federal Communications Commission personnel investigated radiofrequency radiation intensities near the Lookout Mountain antenna farms, west of Denver, Colorado. Typical power densities near several area residences did not exceed 100 $\mu W/cm^2$. The highest value found near the towers along Cedar Lake Road was 580 $\mu W/cm^2$, which is below the 1000 $\mu W/cm^2$ FCC guidelines. However, near the base of the KYGO-FM tower, a 10,000 $\mu W/cm^2$ value was found and power densities exceeding 1,000 $\mu W/cm^2$ were measured over a large area. The areas exceeding the FCC guidelines are in a residential area and are accessible to the public. EPA urges the FCC to order KYGO to correct the problem as soon as possible.

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PARTICIPANTS

Environmental Protection Agency
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  - Richard A. Tell, Chief, Electromagnetics Branch
  - Edwin D. Mantiply
  - Paul Wagner
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Federal Communications Commission
- Office of Engineering and Technology
  - Robert F. Cleveland, Jr., Physical Scientist
- Denver Field Office
  - Dennis P. Carlton, Engineer in Charge

BACKGROUND

Lookout Mountain is the location for broadcast antennas for many of the television and FM radio stations that serve the Denver area. The number of stations and their close proximity to one another and to residential areas make the Lookout Mountain antenna farms unusual. Table 1 lists these stations and their frequencies. Figure 1 shows the location of stations on a map of the Lookout Mountain area. Interference to consumer electronic devices and subsequent concern over possible health effects led the residents and the Jefferson County Planning Commission to request a survey of radiofrequency (RF) radiation levels on Lookout Mountain in 1983. That survey was conducted in 1983 and 1984 and found no locations where the RF intensity exceeded the American National Standards Institute RF protection guide of 1,000 $\mu W/cm^2$ (1). However the study was limited by the fact that permission was not obtained to investigate the RF levels on private property near some broadcast antennas. In 1986, residents contacted the Federal Communications Commission (FCC) seeking a more comprehensive study. The FCC consulted EPA, and EPA found that modeled power densities near the base of the KYGO-FM tower approached 10,000 $\mu W/cm^2$. The earlier study could not corroborate or refute this prediction since the owners of the property surrounding the KYGO tower (KYGO does not own the property) had not been reached to grant EPA permission to conduct measurements on their land in 1983 and 1984. Because the projected power density near KYGO was so high and because the accuracy of the calculational model had been verified with measurements in other locations, EPA Electromagnetics Branch personnel traveled to the Denver area to conduct a study on Lookout Mountain during the period September 22 to 26, 1986. This study was conducted at the request of the FCC under the provisions of an interagency agreement between the FCC and the EPA. Accordingly, FCC personnel were present and assisted in the study.

EQUIPMENT

RF field strength is usually measured using broadband isotropic electric or magnetic field strength meters, or tunable field strength meters connected to appropriate antennas. Broadband equipment is used to determine the total RF field at a point while narrowband equipment provides details of the RF field intensity at any particular frequency. This study employed both types of equipment.

For automated, narrowband measurements, two antennas were used. A NanoFast Fiber Optic Isolated Spherical Dipole (FOISD) was used for frequencies from 10 kHz to 700 MHz. A Watkins Johnson omnidirectional biconical antenna (OMNI) was used for frequencies above 500 MHz. Both detect electric fields and both are linearly polarized antennas. The axis of each antenna was oriented at 55° from the axis of its support mast. With this orientation, one can place the antenna in each of three orthogonal positions by rotating the support mast to three azimuths, 120° apart. Each OMNI and FOISD data value presented in this report is the result of three orthogonal measurements. All OMNI measurements were made with the antenna on a fiberglass mast above the roof of the measurement vehicle at a height of about 12 feet. Some of the FOISD measurements were also made at this height, but others were made at various heights between 1 and 8 feet above ground.

RF power directly proportional to the electromagnetic wave power density was conveyed via coaxial cable from the OMNI to a Hewlett Packard 8566A spectrum analyzer and from there to a Hewlett Packard 9845B computer. The computer applies antenna factors, combines the three orthogonal spectra and stores the results on disk.

In contrast to the Watkins Johnson OMNI antenna, the NanoFast FOISD does not conduct RF power directly to the analyzer. The conventional RF coaxial cable would act as part of the antenna itself and decrease the accuracy of the information collected by the FOISD at lower frequencies - particularly in the AM radio band. To avoid this source of error the FOISD does not use electrically conductive coaxial cable but rather a fiber optic cable which conducts light instead of RF power. The voltage that the electric field induces across the two halves of the FOISD is used to amplitude modulate a light signal. This light is conducted to the inside of the measurement vehicle via a fiber optic cable. The light signal is demodulated back to an RF signal, and fed to the spectrum analyzer via coaxial cable. Then, as with the OMNI antenna, the analyzer delivers frequency specific information to the computer for processing and storage.

Two computer programs were used to process the information supplied by the spectrum analyzer. The first, DRIVER, has been used for several years by the Electromagnetics Branch for similar field studies. It is especially useful for measuring peak spectra like those associated with radar and paging systems. Those measurements that were processed with the DRIVER system are identified with file names beginning with "I". The second program, ZOOM, was developed recently to allow more rapid and accurate measurements at predetermined frequencies. The measurements made using ZOOM are identified in the report with file names beginning with "Z". ZOOM was tailored before the study began to look only at the eight FM and six TV frequencies that are broadcasting from antennas on Lookout Mountain. These frequencies are the main consideration in this study (see Procedures and Results). The data collected with ZOOM are listed in Appendix A by file name.

Several different broadband instruments were brought for the Lookout Mountain study because this area presented a complex electromagnetic environment that could affect broadband instruments to extents that were not simple to predict. Bringing a variety of meters whose responses could be evaluated on Lookout Mountain would allow the study to be completed even if the limitations of some of the instruments made their use impractical for the Lookout Mountain measurements. Three Holaday Industries field strength meters with electric field probes, one Narda magnetic field probe/meter system, two Narda electric field probe/meter systems, and one Instruments for Industry (IFI) electric field meter were used. The Holaday and Narda probes are isotropic. The IFI unit detects only one polarization at a time and must be reoriented if three orthogonal measurements are necessary. These systems were calibrated at the Electromagnetics Branch laboratory during the summer of 1986. In addition, a Holaday Industries data logger was used to store and reduce large amounts of data for spatial averaging of RF levels. Appendix B contains more detailed information on the equipment and calibrations.

Although all the antennas used in the Denver study sense either electric or magnetic fields, the data presented here have been converted to conventional units of plane-wave equivalent power density.

PROCEDURE AND RESULTS

The Denver area measurements can be sorted into four categories: those conducted around the Cedar Lake Road circle near the Lookout Mountain towers, those near KYGO-FM, those at other nearby towers, and those near residences or public attractions. Each will be addressed in turn.

Cedar Lake Road

Spectrum Survey

The top of the access road leading from Cedar Lake Road to most of the Lookout Mountain towers is the highest point topographically in the area. Its elevation allows the best line of sight to the nearby antennas, and therefore measurements were made at this location in several frequency ranges in order to establish which bands were major contributors to power density on Lookout Mountain. These data are listed in Table 2. All these data were obtained with the antenna (FOISD or OMNI) mounted above the measurement vehicle. All values for broadcast frequencies represent average power densities. Values for land mobile, two-way radio, and radar frequencies are peak power densities. The peak radar value should be multiplied by the duty cycle of the pulse (determined from repetition rate and width) and the rotational duty cycle to obtain true average values for comparison to RF exposure guidelines. Typically these duty cycles are 0.001 and 0.01 respectively so the peak value would be multiplied by 0.00001 to obtain a typical average power density for the radar beam. Once this factor is applied, the radar power density is among the lowest in Table 2. Similarly, the power densities for land mobile and two-way radio would be reduced if the duty cycles for signals in these bands were incorporated; however, because even the peak values in these bands were relatively low and because determining duty cycle would be very time consuming, these peak power densities were not adjusted to reflect the lower, average values.

The power densities in Table 2 confirmed expectations that broadcast band sources, particularly FM radio, dominate the RF environment on Lookout Mountain. FM radio accounts for over twice the power density caused by VHF and UHF TV on Lookout Mountain. This information justified deleting all bands but radio and TV from further detailed investigation.

The data in Table 2 also provide quality assurance checks between antennas and between data reduction programs. Four bands were evaluated using both the DRIVER and ZOOM programs. The difference between the reported power densities in each band using the different programs ranged from 1 to about 2.5 dB, a reasonably good comparison for programs developed for different purposes. The ZOOM program was developed recently to increase the speed and accuracy with which measurements could be made at a set of predetermined FM and TV frequencies. The primary reason for greater accuracy in the ZOOM program is its use of narrow frequency ranges and the more accurate 1 dB per division display mode on the spectrum analyzer, rather than wide frequency

ranges and the 10 dB per division display mode as used in DRIVER. ZOOM is designed to provide high accuracy in predetermined narrow frequency bands. DRIVER is better suited to studying unknown RF environments with widely disparate field intensities using the analyzer's wide dynamic range (10 dB/division) and its broad frequency range display. The ZOOM program was used for the remainder of the narrowband measurements in the Denver study.

A comparison between the data collected for UHF-TV Channel 31 using the DRIVER program shows a difference of less than 2 dB, between values obtained with the FOISD and OMNI antennas. This is probably due to the difference in the heights of the two antennas, causing them to intercept different electric field intensities along the short wavelength standing waves.

Cedar Lake Road Measurements

Narrowband measurements provide useful information concerning the particular frequencies that contribute to the power density at any location. However, narrowband antennas remain cumbersome to use, requiring a heavy base for support and three orientations for every measurement. They are not practical for investigating large areas to find locations of elevated power densities. The lightweight, isotropic, broadband instruments meet this need. Broadband instruments are not ideal, however, suffering from limitations that may be important in the presence of low frequency fields such as AM broadcasts, and multiple frequency, strong fields such as the FM and TV spectra on Lookout Mountain. Nevertheless, broadband equipment is used in order to help evaluate the RF environment in a timely manner. The question is how much faith, if any, should the investigator place in the data obtained with broadband equipment. To answer this question, six comparisons were made between the values obtained with the FOISD and the data collected with a few broadband survey instruments. The FOISD was considered the reference standard for these comparison measurements.

The comparison procedure consisted of the following steps. A Holaday was used to probe the area around a measurement site to locate the maximum electric field (E-field) value. The FOISD was then placed at the point of the highest E-field value to obtain the reference field value at that point. After measuring the field with the FOISD, the FOISD was removed from its supporting mast and the electric field probe of a broadband instrument was placed where the FOISD had been. These comparisons were made using the moveable FOISD base which allows measurements to be made close to the ground.

One of the survey instruments used in this comparison was a Narda magnetic field probe. The team did not have a magnetic field narrowband antenna system that could serve as a reference standard for this instrument as the FOISD had for the broadband electric field meters. Instead, the team used the FOISD as the reference as follows. Once the maximum electric field had been quantified and the FOISD had been removed, the area directly above and below the E-field maximum location was probed with the Narda 8616 meter and 8631 magnetic field (H-field) probe to find the H-field maximum associated with the standing wave. The E- and H-field maxima were then converted to units of plane wave equivalent power density for comparison.

Table 3 presents these comparison data for locations around Cedar Lake Road as well as for one additional location near the KYGO-FM tower, about one-third of a mile from Cedar Lake Road. The data collected near KYGO will be discussed later. The third column of Table 3 shows the power densities measured with the FOISD at six locations around Cedar Lake Road. None of the values approaches the 1000 $\mu W/cm^2$ American National Standards Institute Radiofrequency Radiation Protection Guide. This standard has been adopted by the Federal Communications Commission (FCC) for administrative use as a guide in the processing of license applications (2). However, near the KOSI tower, the power density exceeds the most stringent value (100 $\mu W/cm^2$) being considered by EPA (3) as it evaluates options for the protection of the general public from RF radiation exposure.

The data in Table 3 are listed in three categories defined by the frequency responses of the broadband instruments of interest. The first category includes all the frequencies used by broadcasters on Lookout Mountain (55 MHz to 578 MHz) including UHF Channel 31. Because broadcasters dominate the spectrum on Lookout Mountain, the FOISD values listed here are, for practical purposes, the total power density that one would find at these locations. The Holaday meters are designed to measure electric fields at all these FM and TV broadcast frequencies, so the Holaday data can be compared with the total power density FOISD values listed in the third column. With one exception, all the differences between the Holaday and FOISD values are less than 2 dB. The average deviation is less than 1 dB, showing good agreement for broadband meters in field measurements.

The second category, described on page 2 of Table 3, consists of data for frequencies below 200 MHz. This includes FM and VHF-TV. Two Narda probes and the IFI meter operate in this range. The FOISD value listed in this category includes the power density from all the Lookout Mountain broadcasters except Channel 31, which at 575 MHz is beyond the recommended range of these IFI and Narda broadband instruments. Comparisons between the FOISD values and the numbers reported by the Narda and IFI meters show good agreement in most cases. However the use of the Narda and IFI meters was limited by other considerations. When the IFI meter was used at Location B, it responded erratically, making an accurate reading impossible. The cause of this problem may have been a sensitivity to frequencies outside the design range for the meter such as the 575 MHz Channel 31 signal. Like the IFI, both Narda probes in category two responded accurately, but the Narda probes suffered from a zero-drift problem. This drift makes it difficult or impossible to obtain reliable data at relatively weak RF field levels. These problems led the team to abandon these instruments for routine measurements throughout the remainder of the study.

The third category in Table 3 includes data for frequencies only above 300 MHz. The only broadcast source on Lookout Mountain that operates above 300 MHz is KDVR-TV, Channel 31. The FOISD column in this category therefore lists only KDVR's power density. The only broadband instrument that the investigators had for which the operating range extends from 300 MHz upward, was the Narda 8621 E-field probe and meter. The sensitivity of the Narda 8621 is such that the relatively low power densities in the area could not be read reliably on the 8621 meter. Hence no Narda 8621 broadband meter data are included in Table 3.

The narrowband measurements made along Cedar Lake Road were useful for identifying the sources of the RF exposure and for evaluating the response of the broadband instruments. Based on this information, the team decided to use the Holaday meters to study typical exposure levels and to search for localized areas of elevated intensity.

The Holaday HI-3320 data logger was used with the Holaday HI-3001 meter (S/N 26046) to evaluate typical power densities along Cedar Lake Road. The data logger stores information from the meter at a rate of four values per second. At the conclusion of the sampling period, the logger reports the maximum, minimum, and average values that it recorded. For this part of the study, the Cedar Lake Road circle was divided into eleven segments of approximately 300 feet each. The endpoints of these segments are identified as locations A through K on Figure 1. The data were obtained as one of the investigators walked each of the segments, while continuously scanning with the Holaday probe from near ground level to a height of about eight feet. The data gathered in this way represent the spatially averaged power densities along Cedar Lake Road. Table 4 presents these data. None of the average values exceeds the FCC guideline or any standard that has been officially adopted or is being considered in the United States. Two of the maximum power densities exceed one of the proposed EPA guidance options (100 $\mu W/cm^2$), and one exceeds other standards (200 $\mu W/cm^2$) published by the National Council on Radiation Protection and Measurements (NCRP) (4) or the International Radiation Protection Association (IRPA) (5).

Measurements Near KOSI-FM

Both the narrowband measurement made near the base of the KOSI tower and the broadband spatially averaged survey of Cedar Lake Road indicated that the highest levels along the Cedar Lake Road loop were near the KOSI tower. Further measurements were made near the KOSI tower using the Holaday meter (S/N 26046). The highest value that could be found was about 580 $\mu W/cm^2$ in a limited area about 3 to 5 feet in front of the KOSI gate. This value does not exceed the FCC guideline, but it does exceed the nonregulatory 200 $\mu W/cm^2$ NCRP and IRPA standards. The investigators searched for the greatest distances from the KOSI tower at which 200 $\mu W/cm^2$ power densities could be measured, and found that 200 $\mu W/cm^2$ values were measurable out to a radius of about 27 feet centered on the KOSI gate. Since the surveyor searched for the greatest radius at which the 200 $\mu W/cm^2$ value could be found, even in localized areas, it follows that the power densities inside this semicircle did not always exceed 200 $\mu W/cm^2$. To estimate the typical values inside the 200 $\mu W/cm^2$ contour line, the surveyor again used the Holaday meter connected to the Holaday data logger, and made several traverses until he was confident that the power densities within the 200 $\mu W/cm^2$ contour had been thoroughly sampled. This process was repeated to evaluate its reproducibility. The average power densities for the trials were 215 $\mu W/cm^2$ and 211 $\mu W/cm^2$. The minimum values were 35 $\mu W/cm^2$ and 24 $\mu W/cm^2$. The maximum values were 494 $\mu W/cm^2$ and 430 $\mu W/cm^2$. These data indicate that the typical power density averaged over the entire area within the 200 $\mu W/cm^2$ contour does exceed 200 $\mu W/cm^2$ although the power density at any particular location could be much higher or much lower. The generality of this correlation between average value within the boundary of a contour line and the value of the contour line itself has not been established.

One additional measurement was made to evaluate KOSI. Since the KOSI antenna is mounted close to the ground on a mountain slope, structures further up the slope could be in the main beam of radiation. A cursory inspection suggested this could be the case at a house painted green along the access road to the transmitter buildings on Lookout Mountain. A survey of the deck of this house using the Holaday (S/N 26046) found power densities to be generally between 50 and 100 $\mu W/cm^2$. These levels are well below the FCC guidelines.

Measurements near KYGO-FM

The KYGO-FM antenna is about one-third mile from the Lookout Mountain antenna farm. It differs from other antennas in the area because the KYGO antenna is mounted close to the ground with its bottom element at a height of about 30 to 35 feet. This prompted the investigators to survey the area in the immediate vicinity of KYGO. Near the fence at the base of the tower, the Holaday (S/N 26046 with 103GR probe) reported 10.35 mW/cm^2 (10,350 $\mu W/cm^2$) and the Narda magnetic field system read 9.5 mW/cm^2 (9,500 $\mu W/cm^2$). A typical value around the fence was 4.5 mW/cm^2 (4,500 $\mu W/cm^2$) based on the Holaday and 4.4 mW/cm^2 (4,400 $\mu W/cm^2$) as reported by the Narda. The electric and magnetic field data corroborated one another and confirmed that power densities ten times the FCC guideline could be found in publicly accessible areas near the KYGO tower. The lower typical value remained a factor of four over the FCC guideline.

These data led the investigators to map the distances and bearings from the tower to the 1000 $\mu W/cm^2$ and 200 $\mu W/cm^2$ contours. Table 5 presents these data. The locations of the 1000 $\mu W/cm^2$ power density were identified with the Holaday (S/N 26046) electric field meter. These locations were confirmed with magnetic field measurements using the Narda 8631 probe. The 1000 $\mu W/cm^2$ locations found with the Narda were within about five feet of the locations found with the Holaday. The 200 $\mu W/cm^2$ power densities were located using only the Holaday. The 1000 $\mu W/cm^2$ power densities extended to approximately 30 feet from the tower; 200 $\mu W/cm^2$ values were usually found at 50 to 70 feet from the tower. To be certain that KYGO was responsible for the elevated power densities, a FOISD narrowband measurement was made near the KYGO transmitter building. This measurement, saved as file ZOIXJN and summarized in Table 3, showed that KYGO was responsible for 99.7% of the FM and TV power density at the location of the measurement.

The base of the KYGO tower is fenced, but most of the area within the 1000 $\mu W/cm^2$ contour is not. The KYGO tower is located in a complex of buildings where some people live throughout the year and where seasonal, residential workshops are held to teach square dancing. Many people could therefore visit areas where power densities exceed 1000 $\mu W/cm^2$. The main building of the compound is located within about 100 feet of the KYGO tower. The team found maximum power densities of 59 $\mu W/cm^2$ in the laundry room, approximately 100 $\mu W/cm^2$ in the commissary and outside the dining hall, and up to 300 $\mu W/cm^2$ on the patio/deck. Electric and magnetic field measurements made outside a dormitory (the "Tiltin' Hilton") near the tower found 40 to 50 $\mu W/cm^2$ power densities.

Finally it is interesting to note the effect of different elevations (in mountainous areas) on the power densities one records. Another narrowband FOISD measurement (file ZOIZIu) made on top of the vehicle in the parking lot at 756 Lookout Mountain Road, in the property on which the KYGO antenna is located, found a power density of 37.2 $\mu W/cm^2$. This measurement location was perhaps 100 feet from the KYGO tower and below the center of radiation. The elevation increases as one moves across Lookout Mountain Road, approaching the apparent height of the center of radiation of the KYGO antenna. Another FOISD measurement (file ZOIZJD) was made at this higher, but more distant location (perhaps 200 to 300 feet from KYGO). Usually, tripling the distance from an antenna in this way would reduce the power density by a factor of 9. In this case however, the effect of greater distance was overcome by moving higher into the main beam of radiation. The power density rose to 85.8 $\mu W/cm^2$ in the driveway of a home across Lookout Mountain Road from KYGO. Even at 1054 Colorow Road, approximately 800 feet from KYGO but still elevated with respect to the base of the KYGO tower, the power density remains greater than in the parking lot at 756 Lookout Mountain Road. The power density measured near 1054 Colorow Road was 55.8 $\mu W/cm^2$ (file ZOIYQx). These data illustrate the need to consider the relative elevations of areas surrounding a station in the overall RF exposure evaluation.

Measurements Near Other Lookout Mountain Towers

Approximately three quarters of a mile from the Lookout Mountain antenna farm are two towers which support a variety of communications antennas, two FM antennas, and one VHF-TV antenna. KRMA-TV, KCFR-FM, and KUVO-FM are located at the Colorow Hill site. Electric field measurements were made at this site using two Holaday meters (S/N 26046, 26042). At the base of the broadcast tower the power densities ranged from 2 to 124 $\mu W/cm^2$. Between the antennas and Colorow Road power densities of 350 to 425 $\mu W/cm^2$ were found. Across the road values up to 200 $\mu W/cm^2$ were found.

These data prompted the team to search for the 200 $\mu W/cm^2$ contour along Colorow Road. Power densities up to 200 $\mu W/cm^2$ were found along a 125 foot length of Colorow Road, centered approximately at the door to the transmitter building. The 200 $\mu W/cm^2$ levels extended to about 12 feet beyond the far side of Colorow Road from the transmitter building. A FOISD narrowband measurement, made near the antennas reported a power density of 204 $\mu W/cm^2$. This file, identified as ZOIZMF, found the major contributor to be KCFR-FM. KUVO-FM and KRMA-TV were the next strongest contributors but together provided only about half the power density of KCFR at that location.

At another location, one third of a mile north of the Lookout Mountain antenna farm, is a smaller group of towers supporting antennas for TV and FM stations. A survey near these towers using the Holaday (S/N 26042) found locations where the power densities reached 273 $\mu W/cm^2$. However, power densities were usually below 200 $\mu W/cm^2$, and over the entire area the levels were generally between 50 and 100 $\mu W/cm^2$, well below the FCC guidelines.

Community Measurements

The purpose of studies like this one is to evaluate the extent of human exposure to RF radiation. This was a concern of many Lookout Mountain

residents who attended an informal gathering with the EPA and FCC investigators on the evening of September 24. At that meeting, EPA agreed to make limited measurements at several homes in the area. These measurements included collection of narrowband FOISD data at each location and broadband survey data at several homes. For these measurements the FOISD was positioned on top of the vehicle, and the vehicle moved to an arbitrary point along the road or in the driveway. Because these locations were arbitrarily chosen, the FOISD power densities probably are neither maxima nor minima, but are useful because they indicate the major source(s) of the RF radiation at each location. Another measurement a few feet away would probably find a different absolute power density. The broadband data were collected with two Holadays. Table 6 presents all these data.

None of the power densities in Table 6 exceeds the FCC guideline. With only two exceptions, none of the values exceeds even the most stringent RF radiation safety guideline being considered in the United States. The two exceptions, a 200 $\mu W/cm^2$ power density near a trampoline spring and a 589 $\mu W/cm^2$ power density near a piece of metal furniture, are more representative of the concentrating effect metal objects have on electric field lines than they are representative of typical power densities. Electric field intensity can be dramatically increased near conductive objects, particularly if those objects have sharp corners. This is why lightning preferentially strikes lightning rods. However, the presence of another conductive object, such as a human, can further alter the electric field, generally lowering the intensity near pointed conductive objects. Because of this, the importance of high measured electric field intensities near conductive objects is controversial. Traditional thinking on this subject is that relatively high, localized fields, near conductive objects where the surrounding field is substantially less, do not cause energy absorption rates in tissue that would normally be associated with whole-body exposures to fields of the same high values.

In order to place these values into perspective, two measurements were made in an area that is relatively distant from the Lookout Mountain antennas. At the end of the 700 block of Chimney Creek Road in the Genesee residential area, power densities from Lookout Mountain broadcasters and from Mount Morrison broadcasters (located near Genesee) were measured with the FOISD. At this location, the power density from Lookout Mountain broadcast sources was 0.2 $\mu W/cm^2$ and that from the Mount Morrison FM broadcasters was 0.00015 $\mu W/cm^2$. These values can be compared with the 0.005 $\mu W/cm^2$ median level to which the populations of 15 major U.S. cities are exposed (6).

Holaday (S/N 26046) measurements were also made at the Buffalo Bill grave tourist attraction. At the overlook near the visitor center, the highest value found was about 2 $\mu W/cm^2$. At the grave itself, power densities up to 8 $\mu W/cm^2$ were measured. Typical values ranged from about 5 to 14 $\mu W/cm^2$ at the overlook near the grave.

DISCUSSION

The height and topographic location of the KYGO antenna make it a convenient "field laboratory" to illustrate two characteristics of FM signals. The KYGO antenna is unusually low on its tower causing excessive

power densities directly below the elements. This is the "grating lobe" which points directly down to the ground and straight up into the air from the elements. Because the antenna is so low to the ground, moving a short distance away from the tower base places one at a large angle away from vertical with respect to the elements. The 10,000 $\mu W/cm^2$ value found at the base of the tower decreases rapidly as one moves away from the base of the tower and out of the grating lobe. The power density falls to 1000 $\mu W/cm^2$ at about 30 feet, and to 200 $\mu W/cm^2$ by 50 to 70 feet from the tower. The second point illustrated by KYGO is that in a mountainous area, one cannot rely on such a rapid reduction in power density with distance because the measurement locations may be moving up into the main-beam of radiation. Additional data collected near KYGO actually show an increasing power density with distance from the antenna as the measurement location moves closer to the main beam of radiation. RF hazard investigators should be aware of this property not only in mountainous terrain but also in urban environments where the main beam of radiation may be intercepted by nearby tall buildings.

A surprising finding in Table 3 is that the Holaday electric field meter reported values that were below the actual (FOISD) value. While the Holaday data in Table 3 are not far from the FOISD data, the Holaday values are almost always low. The authors' experience, however, is that diode detectors, such as the Holaday, tend to overrespond rather than underrespond in complex RF environments. Because of this, diode detectors have been considered conservative. However, the authors' judgement in this case is that the value reported by the FOISD represented the maximum field in an area with no nearby perturbations, while the Holaday values were collected in the presence of a 6 foot tall individual, the surveyor, within a few feet of the probe. It is likely that the presence of the person would lower the field at the probe, particularly when the probe is at the location of the maximum field value in the area, thereby causing the discrepancy. Additional comparison measurements in other complex environments will help resolve the issue. The IFI meter's erratic response at location B and the Narda system's zero drift problems further underscore the fact that no single meter is adequate for all monitoring situations.

It is worthy of note that the maximum value measured at the base of the KYGO tower compares closely with that predicted by an EPA program designed for this purpose. The program calculated a maximum power density of 9,620 $\mu W/cm^2$. The maximum values measured with electric and magnetic field meters were 10,350 $\mu W/cm^2$ and 9,500 $\mu W/cm^2$ respectively for a maximum difference between theory and data of about 0.3 dB. A similar comparison between predicted and measured values in an earlier study in Oregon, also found approximately 0.3 dB difference. This correspondence is encouraging because it helps EPA and FCC decide which antennas are likely to produce ground-level power densities that exceed the FCC guidelines. Output from this modeling technique could be used to identify areas of potentially high public exposures and to select additional areas for field study. The application of the model to other FM facilities has shown that power densities as great as that predicted at KYGO are unusual but not unique.