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GUIDANCE FOR EVALUATING THE POTENTIAL FOR INTERFERENCE TO TV FROM STATIONS OF INLAND WATERWAYS COMMUNICATIONS SYSTEMS

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FOREWORD

Inland Waterways Communications Systems will occupy spectrum that until now has been underutilized. Before allocation to IWCS, the frequencies 216-220 MHz were authorized only in very limited applications because of their potential for interfering with television service. The capability of large-scale operators to suitably engineer their systems for the protection of television makes use of these frequencies feasible; the willingness of IWCS applicants to make necessary technical preparations and to remain responsible for correcting interference which may result is making this improved spectrum utilization a reality.

The rules established for IWCS operation require that license applications be accompanied by an engineering determination of geographical areas which may be affected by TV interference. The present document provides guidance for making suitable determinations of this kind.

CONTENTS

INTRODUCTION

The band of frequencies allocated for Inland Waterways Communications Systems (IWCS) is just above and adjacent to television channel 13, and there exists a potential for interference by IWCS to television reception on this channel and also on channel 10.

For the planning of an IWCS and the engineering design of new stations it is necessary to be able to estimate the likelihood of interference to TV. IWCS station authorizations are subject to the condition that no harmful interference to TV will be caused. In addition the present rules require that new station applications include engineering determinations of potential interference areas with an indication of the relatively unpopulated status of any such areas.

This report provides guidance for determining the area of potential interference. Such a determination requires engineering data concerning:

- Susceptibility of TV receivers, and
- Radio field strengths for various transmitting station configurations at various distances.

Also desireable is a straightforward procedure, such as the one that will be described here, for applying these data to specific cases.

SUSCEPTIBILITY OF TV RECEIVERS

Experimental data pertinent to the susceptibility of TV receivers to interference from IWCS transmissions are found in the FCC Lab Division report of Project No. 2229-71 [1]. The ratio of desired to undesired signal power for the condition of just perceptible interference is found to be strongly dependent upon the frequency separation and upon the power level of the desired signal. As would be expected, interfering signals on frequencies close to those of the TV channel cause interference even when relatively weak, while somewhat stronger signals produce no perceptible interference provided the frequency separation is greater. TV channel 13 occupies 210-216 MHz. The IWCS band extends from 216 to 220 MHz, with those frequencies near the upper limit of 220 MHz being less likely to cause interference.

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[1] L. Middlekamp, H. Davis, <u>Interference to TV Channels 11 and 13 from Transmitters Operating at 216-225 MHz</u>, FCC Lab Division Report, Project No. 2229-71, Oct. 1975. For the IWCS frequencies of 216-220 MHz, the potential interference is to channel 10 rather than 11. However, there is no difficulty in deriving the information pertinent to channel 10 from this Lab report.

Besides being dependent upon frequency separation, the susceptibility of TV receivers to interference from IWCS signals depends to a degree upon the TV signal level at the point at which the antenna is connected to the set. This level can vary greatly. In fact, in areas relatively close to the TV station where stronger than necessary signals are available the viewer may change the power input without loss of picture quality by changing his antenna orientation, for example.

Some assumption about the TV signal level is necessary in order to apply the data of reference 1, and we assume a low value typical of reception conditions at the edges of the TV service area. Higher values would lead to stronger permissible IWCS signals. The assumption made here is not necessarily the most conservative since higher values would also lead to requirements for a greater spread between the desired and undesired signal levels, that is to requiring greater protection ratios. It is difficult, however, to justify any particular high value of TV signal because residences closer to the TV station may use correspondingly poorer antenna systems. Further, the data of reference 1 are less appropriate in urban areas where radio frequency noise may mask interference effects.

To determine a value of TV signal input power suitable for use with reference 1, refer to OCE Report RS77-01 [2] which itself is based on considerations made explicit in the Third Notice [3] and in the Sixth Report and Order [4] of the series of dockets leading to the establishment of TV broadcast allocations in 1952. These documents establish the reasonableness of the following values of signal power for acceptable picture quality at VHF (channels 2-13):

Thermal Noise including Noise Figure Considerations	-96 dBm
Signal/Noise Ratio for Acceptable Picture	30 dB
Required TV Set Input Power, Rural	-66 dBm
To Overcome Urban Noise	7 dB
Required TV Set Input Power, Urban	-59 dBm

[2] G.S. Kalagian, A Review of the Technical Planning Factors for VHF Television Service, FCC, OCE, Research and Standards Division Report RS77-01, March 1, 1977.
[3] Federal Communications Commission, Third Notice of Further Proposed Rulemaking, "Television Broadcast Services", Federal Register, Vol. 16, No. 68, Page 3072, U.S. Government Printing Office, Washington, D.C., April 7, 1951.
[4] Federal Communications Commission, Sixth Report and Order, "Rules Governing Television Broadcast Stations", Federal Register, Vol. 17, No. 87 (Part II), Page 3905, Government Printing Office, Washington, D.C., May 2, 1952.

Thus it appears that the signal input power to TV sets receiving acceptable pictures is -66 dBm or greater in rural areas and -59 dBm or greater in urban environments. Accordingly, we will not be too far off if we use the data provided by reference 1 for the case of an input level of -65 dBm. Figures 8 and 29 of the reference are reproduced in Appendix A. They show sample measurements of interference susceptibility for channels 13 and 10 repectively when the TV signal input power has the -65 dBm value.

From Figures 8 and 29 of reference 1, interference protection ratios may be determined in the form presented as Table I:

Coast Station Frequencies (MHz)	IWCS Channel Group	Protection Ratios (dB) (Largest Sample Value in Tests of Desired-to-Undesired Signal Ratio for Just-Perceptible Interference) TV Channel 13	TV Channel 10
216.0 - 216.5	D	11	-29
216.5 - 217.0	C	- 2	-31
217.0 - 217.5	B	-10	-31
217.5 - 218.0	A	-17	-33

PROTECTION RATIOS DETERMINED BY BENCH TESTS OF REPRESENTATIVE RECEIVERS WITH DESIRED SIGNAL INPUT OF -65 dBm

Table I

The ratios appearing in the table resulted in just perceptible interference in only one of the five receivers tested and at only one of the sample frequencies within the indicated bands. For example, reference 1 provides eleven samples of just perceptible interference conditions with the undesired signal in the frequency range 217 to 217.5 MHz and the desired channel 13 signal at -65 dBm. The ratio given in Table I corresponds to the poorest observed TV receiver performance among these samples.

Since the number of measurements is quite small, the interference actually caused by IWCS stations may be more or less than that predicted by Table I. The table must be considered as providing a reasonable basis for proceeding to develop these systems rather than assured criteria for avoiding interference. The five receivers measured represent a wide range of RF and IF circuits now in use. However, only one receiver of each type was observed.

RADIO PROPAGATION PREDICTION METHOD APPROPRIATE FOR IWCS INTERFERENCE TO TV

The propagation curves of FCC Report R-6602 [5] are recommended for the purpose of predicting relative field strengths at various distances from TV and IWCS stations. These curves are accepted standards for determining the potential for interference between TV services, making them very appropriate for the present related application. They are incorporated in the FCC's Rules for broadcast services and are therefore familiar to engineers and operators of TV stations who may wish to review IWCS engineering plans. The curves were developed by an extensive study of propagation measurements that had been made by both industry and government agencies. For the usual propagation modes in the VHF band of concern here they still represent the most up-to-date information.

For convenience, the R-6602 curves related to channels 10 and 13 are included here as Appendix B. There are two sets, one predicting field strengths that will be medians with respect to both receiver location and to variation in time, and the other for field strength exceeded for 10% of the time at median locations. The symbols used to denote these fields are F(50,50) and F(50,10). Values of field strength exceeded for 90% of the time may be obtained by assuming that the time fading follows the normal or Gaussian type of distribution, with symmetrical variation about the median level.

FIELD STRENGTH RATIOS AFFECTING THE INTERFERENCE POTENTIAL

The potential for interference at a geographical point can be evaluated in terms of the median fields there after making allowance for likely deviations. Necessary considerations are (1) the variations in strength of the competing electromagnetic fields with respect to location, (2) similar variations with respect to time and (3) the minimum acceptable ratio between the two fields.

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[5] J. Damelin, W. Daniel, H. Fine and G. Waldo, Development of VHF and UHF Propagation Curves for TV and FM Broadcasting, FCC, Office of Chief Engineer, Research Div. Report No. R-6602, September 1966.

Location variability affects both the IWCS and the TV field. Median values of these fields can be determined at any geographical point by the propagation curves of Appendix B, and the relative strengths of these fields are a first indication of the interference potential. However, the situation will be considerably worse if the terrain of the respective propagation paths results in a stronger than average IWCS signal or a weaker TV signal or both. This variability from location to location is usually assumed to have a Gaussian probability distribution when expressed in units of decibels (a log-normal distribution). It is graphed in Fig. 1 of reference 2 and in Fig. 5 of reference 3. The standard deviation is about 8.6 dB, and there is a 90% chance that the deviation will be as high as 11 dB.

At any particular TV reception point the fields will also vary in time, and Appendix B includes information on the amount of such variations. The most reasonable method of combining the fading factors of the two fields is calculation of the square root of the sum of the squares (RSS) since both distributions are approximately log-normal and there is no apparent mechanism which would cause them to be correlated. Further, the TV reception point of concern will usually be relatively close to the IWCS station and far from the TV broadcasting tower with the consequence that the fades in the TV signal will be the dominant factor and the RSS fade will be approximately equal to that of the TV signal alone.

The minimum acceptable ratio between the two fields is analogous to the signal ratios of Table I. We will assume that the ratio of field strengths is converted into an equal ratio of input signals to the TV set. This ignores the possible advantage of polarization discrimination by the antenna. Such advantages may not be justifiable since it is known [6] that the relative response of TV receiving antennas to horizotally and vertically polarized waves is greatly dependent upon the relative bearings of the signal sources.

EVALUATION OF THE INTERFERENCE POTENTIAL

We seek criteria for identifying any geographical areas within which there is a reasonable likelihood of interference to TV. Reference 3 includes a discussion of the approach used to determine adequate separation distances between TV stations, and the same considerations are applicable here. Time and location variability are treated separately in this approach. The objective is to determine the percentage, L, of locations at which there will be interference-free reception at least T% of the time.

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[6] A.C. Wilson, Performance of VHF Receiving Antennas, National Bureau of Standards Report 6099, May 26,1960.

Quantities involved in the analysis may be denoted by the following symbols (as in reference 3):

A = Minimum Acceptable Desired-to-Undesired Ratio, in dB, between the Fields.

$R_d(T)$ = Time Distribution Factor, in dB, used to evaluate the depth of fade affecting the desired signal at most T% of the time. Defined as $F_d(50,T) - F_d(50,50)$ where the subscript d refers to the desired field.

$R_u(T)$ = Time Distribution Factor, dB, describing the amount by which the undesired field may increase during as much as T% of the time. Defined as $F_u(50,T) - F_u(50,50)$ where the subscript u refers to the undesired field.

$\sqrt{R_d^2(T)+R_u^2(T)}$ = Total Allowance, dB, for Variations with Respect to Time.

The desired condition of no interference will hold where there is a favorable margin between the TV signal and IWCS signals. In addition, there will be no interference in areas where the TV signal by itself is too weak for reception. It follows that the percentage, L, of locations without interference depends upon (1) the difference between median field strengths after the above allowances are made and also upon (2) the median field strength itself of the TV signal. The percentage L can be determined from the following equation:

$$R(L,G) = A + P_u - P_d + F_u(50,50) - F_d(50,50) + \sqrt{R_d^2(T) + R_u^2(T)} \qquad (1)$$

where

P_d = Effective Radiated Power (ERP) of TV Station, in dB above 1 kilowatt radiated from a half-wave dipole

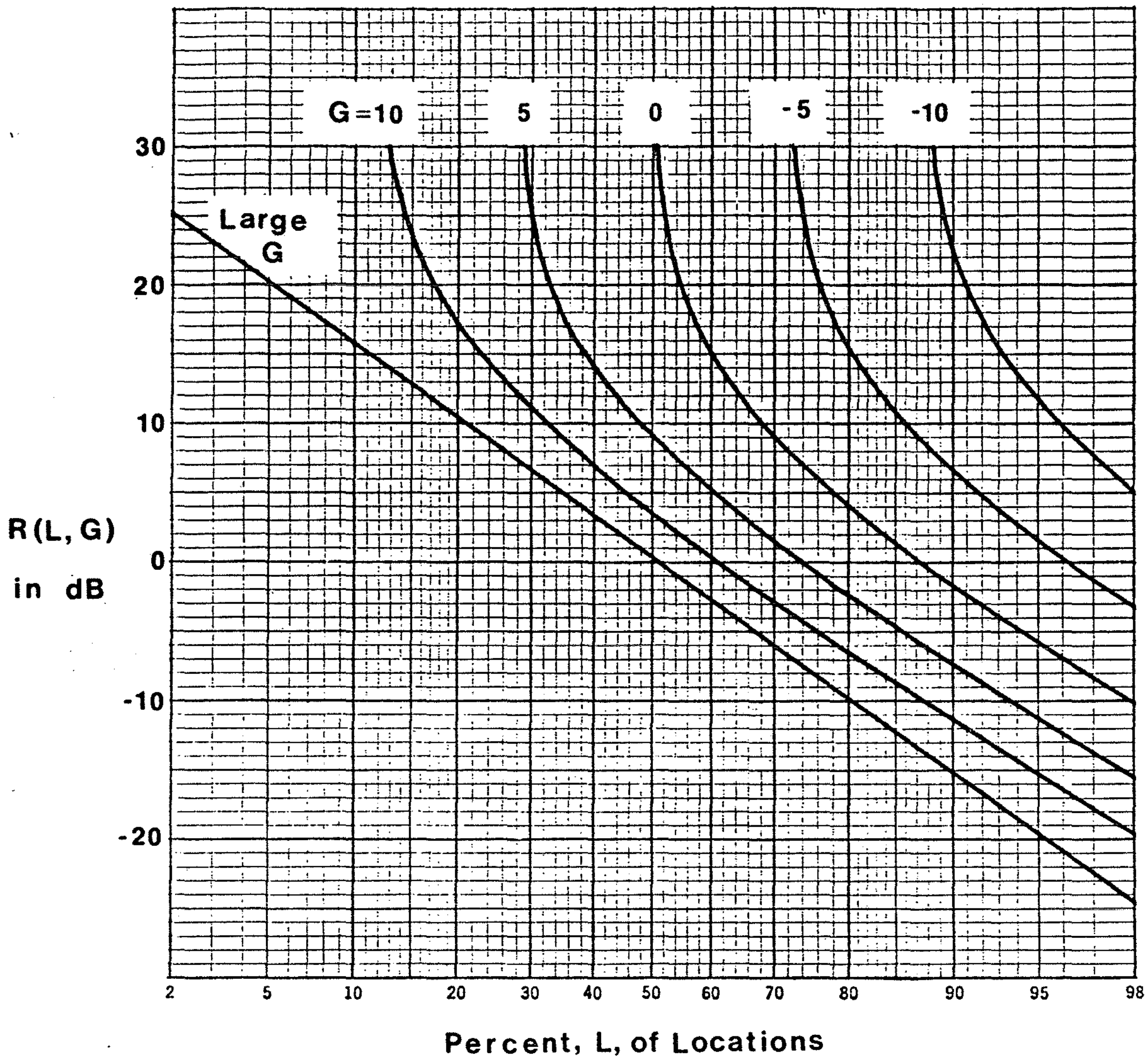
P_u = ERP of IWCS Station (same units as P_d),

$F_d(50,50)$ and $F_u(50,50)$, in units of dB(uV/m), are median field strengths that may be determined from Appendix B.

$G = F_d(50,50) - F_s$, and

F_s = Minimum TV Field Strength for Service, in dB(uV/m). For channels 10 and 13 an appropriate value is 56 dB(uV/m), the level which defines the Grade B contour.

The function R(L,G) is graphed in Figure 1. It is derived from probability considerations in Appendix C.



L is the percentage of locations at which either (1) the desired signal by itself is too weak for reception or (2) the desired-to-undesired field ratio is higher than its median by an amount at least equal to R(L,G).

For example, suppose that the median desired-to-undesired ratio in the area of interest is 6 dB higher than the value needed to avoid interference. Then R(L,G) can be as low as -6 dB. If it is also supposed that the area is near the Grade B contour where G=0, then 95% of locations will be without interference since R(95,0) = -6.

GRAPH OF FUNCTION R(L,G) WHICH MAY BE USED TO DETERMINE PERCENT OF LOCATIONS WITHOUT INTERFERENCE

Figure 1

DETERMINATION OF THE INTERFERENCE CONTOUR

At a later time it may become possible to choose the percentages T and L on the basis of actual experience with IWCS stations operating near TV service areas. At present it appears reasonable to use 90% for both values. Television grades of service are specified with reference to 90% of the time, and it is consistent to use T = 90% in evaluating interference also. There is related experience in other applications. In particular, the use of a 90% time and location reliability criterion has been successful as a practical matter in the Domestic Public Land Mobile Radio Service for establishing interference contours [7].

The interference contour will be the set of geographical points at which equation (1) is satisfied with the suggested levels of time and location reliability. The area of potential interference may be considered as lying inside. The prediction for this area is that the following conditions will both be found at more than 10% of locations: (1) The desired TV signal by itself would be adequate at least 90% of the time, but (2) the ratio between desired and undesired fields is unacceptable more than 10% of the time.

Figure 2 will help locate the interference contour. The Figure is a graph of -R(L,G) which may be considered as a component of a margin to be imposed between desired and undesired fields. Equation (1) is satisfied wherever the desired and undesired signals differ by the total margin found by adding the appropriate value read from the figure to the margin $A + \sqrt{R_u^2(10) + R_d^2(10)}$.

For example, Grade B service of a maximum facility TV station in Zone I (1000-foot antenna, 316 kilowatts) extends 60 miles from the station and $R_d(10)$ for this distance is 7 dB (see Appendix B). The total required margin in dB is:

$$A + \sqrt{R_u^2(10) + R_d^2(10)} - R(90,0) = A + \sqrt{R_u^2(10) + 49} + 1.6$$

and the IWCS field strength may be as great as 56 dB(uV/m) (the median TV field strength at the Grade B contour) less this margin. That is, the IWCS field strength (50% of locations, 50% of time) along this contour should not exceed $54.4 - A - \sqrt{R_u^2(10) + 49}$ dB(uV/m). If the IWCS field does exceed the upper limit calculated in this way, or if the proposed station lies inside the Grade B contour, these calculations must be repeated at other TV service contours (higher median field strengths and closer to the TV station) to determine the area of potential interference. No further analysis is required for stations lying outside and providing sufficient margin at the Grade B contour.

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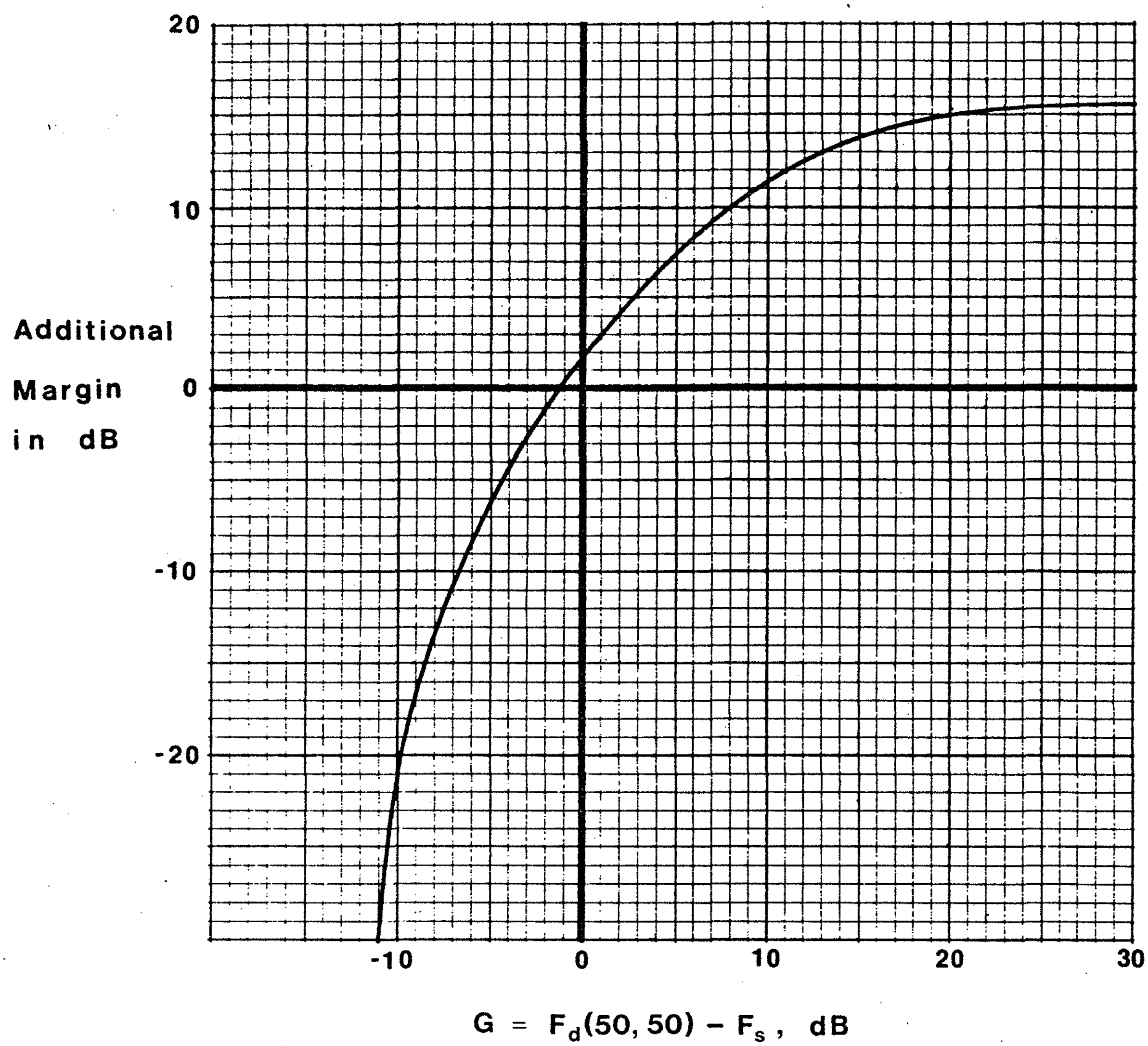
[7] R.B. Carey, Technical Factors Affecting the Assignment of Facilities in the Domestic Public Land Mobile Radio Service, FCC Report No. R-6406, Washington, D.C., June, 1964.



The ratio of median field strengths, $P_d + F_d(50,50) - P_u - F_u(50,50)$, should equal or exceed $A + \sqrt{R_u^2(10) + R_d^2(10)}$ plus the margin read from the graph above. In areas where this condition is met, 90% of locations will be without interference in the sense that either (1) the acceptance ratio, A, is exceeded 90% of the time or (2) the TV signal by itself is too weak for satisfactory reception.

The minimum field, F_s, for TV service may be considered to be 56 dB(uV/m), the value that defines the Grade B contour for channels 10 and 13. The additional margin graphed is -R(L,G), where R(L,G) is the function shown in Figure 1.

ADDITIONAL MARGIN TO SECURE ACCEPTABLE FIELD STRENGTH RATIOS WITH A RELIABILITY OF 90%

Figure 2

For example, suppose it is desired to operate an IWCS station 10 miles from the Grade B contour of a channel 13 TV station. Suppose in addition that the proposed frequency of operation is from IWCS Channel Group B so that A = -10 as determined by Table I. As far as 20 miles away it is found (Figure 10 of Appendix B) that $R_u(10)$ is less than 2 dB. As a result the precise value of $R_u(10)$ does not affect the computations except somewhat beyond 20 miles. Within this range and along the Grade B contour the IWCS field may be as large as

$$54.4 - A - \sqrt{R_u^2(10) + 49} \cong 57.4 \text{ dB(uV/m)}.$$

Now refer to Figure 19 of Appendix B and assume that the proposed station will have an antenna height of 200 feet. If the ERP is 1 kilowatt, the propagation prediction curves can be read directly. The curves predict that the IWCS field will fall to the acceptable level of 57.4 dB(uV/m) at a distance of about 12.5 miles, somewhat inside the Grade B contour. If the ERP is reduced to about 440 watts, the interference contour will just touch the Grade B leaving no overlap, which may be considered an acceptable situation.

SPECIFIC SITUATIONS REQUIRING INTERFERENCE STUDIES

Present FCC rules require that IWCS applications include an engineering plan for suitable limiting of the interference contour when any of the following conditions apply:

- The station as proposed will have an antenna height greater than 200 feet (61 meters), or
- the proposed station is located less than 105 miles (169 kilometers) from a channel 13 TV station, or
- it is located less than 80 miles (129 kilometers) from a channel 10 station.

The interference contour is defined to include only areas inside the television Grade B contour. The later lies where the TV field strength (for the channels of concern here) is 56 dB(uV/m), and this is to be determined as follows using the F(50,50) curves:

- For broadcast stations, maximum permissible TV antenna height and power are to be assumed. Appendix D, included here for convenient reference, provides information on these maximum values.
- For translators and low power TV stations, use the actually licensed antenna height and power.

ACCEPTABLE FORMATS FOR PRESENTATION

The engineering plan is to include a delineation of the interference contour, identification of the method used to determine the contour, and a statement concerning the number of residences inside. The method should be based on technical considerations equivalent to those presented in this report. When the purpose is to demonstrate the absence of potential interference problems, worst case assumptions may be used to simplify the calculations.

The following are examples of methods of presenting interference study results. They are recommended as efficient ways to make the necessary demonstrations.

Case 1.

Situation:
Proposed station is located outside the Grade B TV contour, and the proposed radiation pattern is omnidirectional.

Demonstration that Interference Potential is Minimized:
At the point where the direct line connecting the two stations intersects the Grade B, show the F(50,50)-values of the respective fields. Compare with the value of the minimum margin by which the TV field should exceed that of the IWCS signal at this point, and show how this margin has been determined. The comparison, of course, must be favorable.

Remarks:
When it can be used, this analysis is preferred because of its simplicity. If the radiation pattern is not omnidirectional, it may be convenient to make a worst-case assumption that a maximum of effective radiated power is directed at the TV station. The situation may then be treated as if this maximum were being radiated in all directions.

Case 2.

Situation:
Proposed station is located outside the Grade B contour, and the proposed radiation pattern is directional.

Demonstration that Interference Potential is Minimized:
Tabulate the F(50,50)-values of the two fields along an appropriately extensive segment of the Grade B contour. Include in the tabulation the minimum acceptable margin at each Grade B point, and identify the method used to determine these margins.

Remarks:
Tabulate as a function of azimuth around the proposed station. Use

a fine enough spacing to make it apparent approximately where the point of maximum interference lies.

Case 3.

Situation:

Proposed station is outside the Grade B, but the interference contour penetrates the TV service area.

Presentation of Interference Study Results:

In this case it will be necessary to describe the interference contour. It appears most convenient to tabulate the pertinent quantities as a function of azimuth around the proposed station, starting and ending at the points where the interference contour crosses the Grade B. At each bearing, give the distances to the Grade B and to the interference contour to indicate the size of the included area. At each bearing show also the desired and undesired F(50,50)-values of field strength and the minimum acceptable margin.

Remarks:

The increment between successive bearings tabulated should be small enough so that the general shape of the area of potential interference is described. This is more or less critical depending upon the population density of the area overlaid.

Case 4.

Situation:

Proposed station lies inside the Grade B contour.

Presentation of Interference Study Results:

Same as Case 3 except that consideration will have to be given to conditions in every direction around the proposed station.

The foregoing examples have outlined the information which is logically necessary to make the required demonstrations. Applications will presumably also provide supporting data such as geographical coordinates of the stations, antenna heights, antenna radiation pattern and the proposed ERP in the direction of maximum power.

APPENDIX A

MEASUREMENTS OF TV RECEIVER SUSCEPTIBILITY

Figures 8 and 29 are reproduced here from an FCC Lab Division report*. These data are the experimental basis for the protection ratios appearing in Table I of the text.

The data given for channel 11 in Figure 29 apply to channel 10 if the frequency axis is shifted by 6 MHz. The shift should be made in such a way that the values on the horizontal scale will run from 210 MHz to 219 MHz.

* L. Middlekamp, H. Davis, Interference to TV Channels 11 and 13 from Transmitters Operating at 216-225 MHz, FCC Lab Division Report, Project No. 2229-71, Oct. 1975.

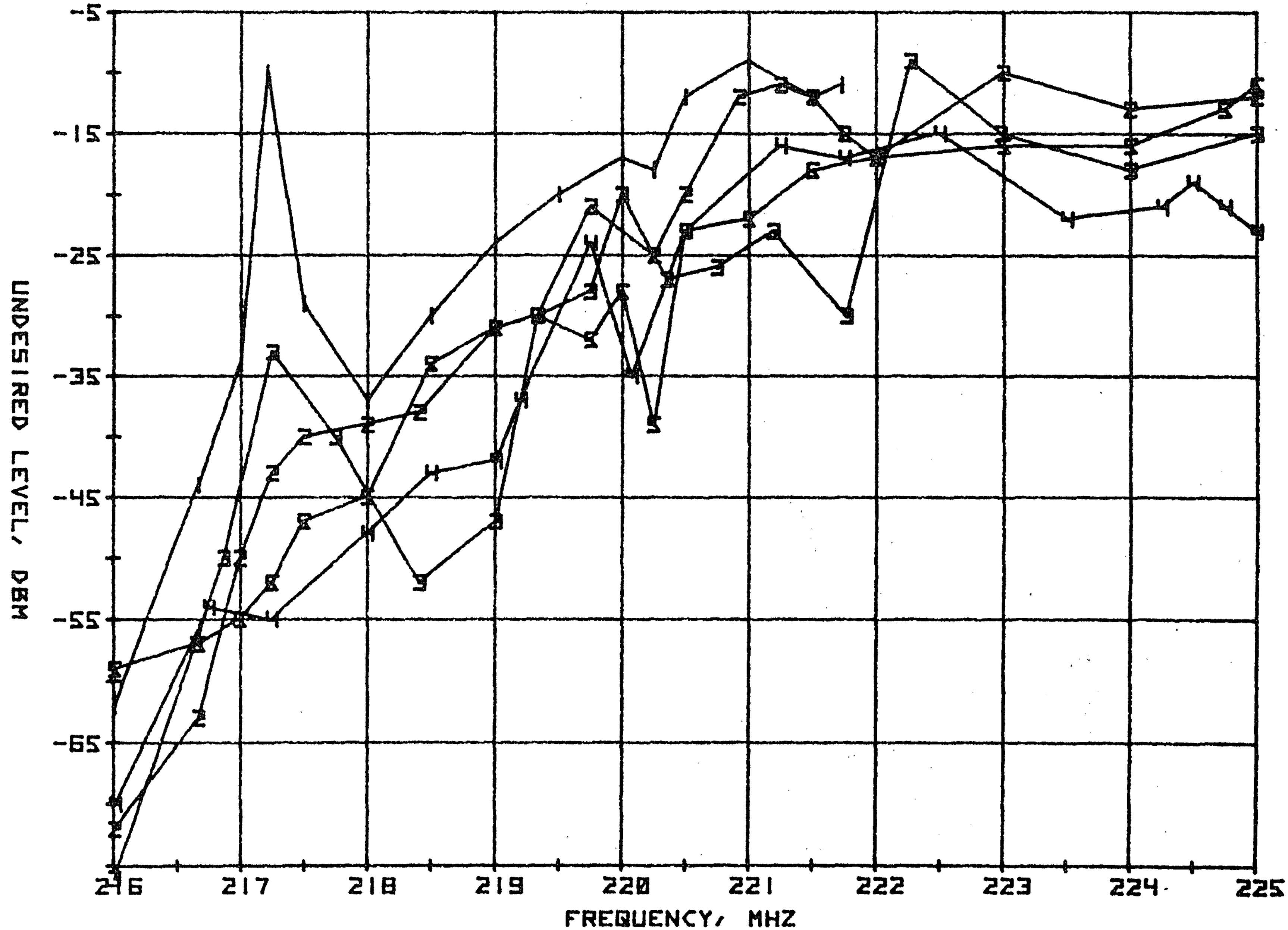


FIG. 8: FM INTERFERENCE SUSCEPTIBILITY, RCVRS. 1 TO 5, CH. 13 AT -65 DBM

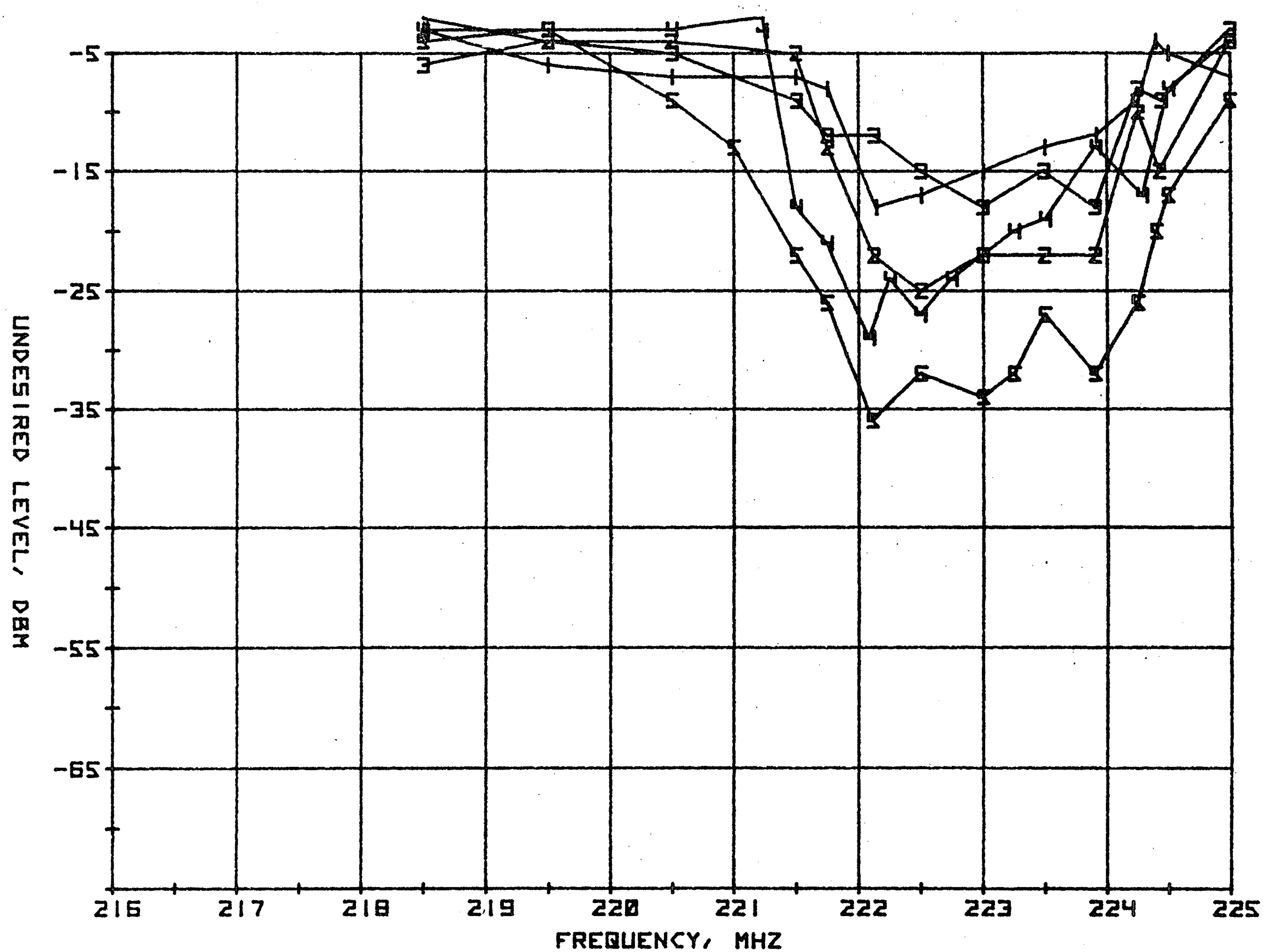


FIG.29: FM INTERFERENCE SUSCEPTIBILITY, RCVRS. 1 TO 5, CH.11 AT -65 DBM WITH 'EQUAL' LEVEL CH.13

APPENDIX B

PROPAGATION CURVES

Propagation prediction curves appropriate for evaluating the potential for IWCS interference to television are reproduced here for convenience. The curves are from FCC Report R-6602*.

The fading margin values given in Figure 10 are derived from the other two figures simply by subtraction. In the text this difference,

$$F(50,10) - F(50,50)$$

is denoted by $R_d(10)$ or $R_u(10)$ where the subscripts d and u refer to the desired and undesired signals respectively.

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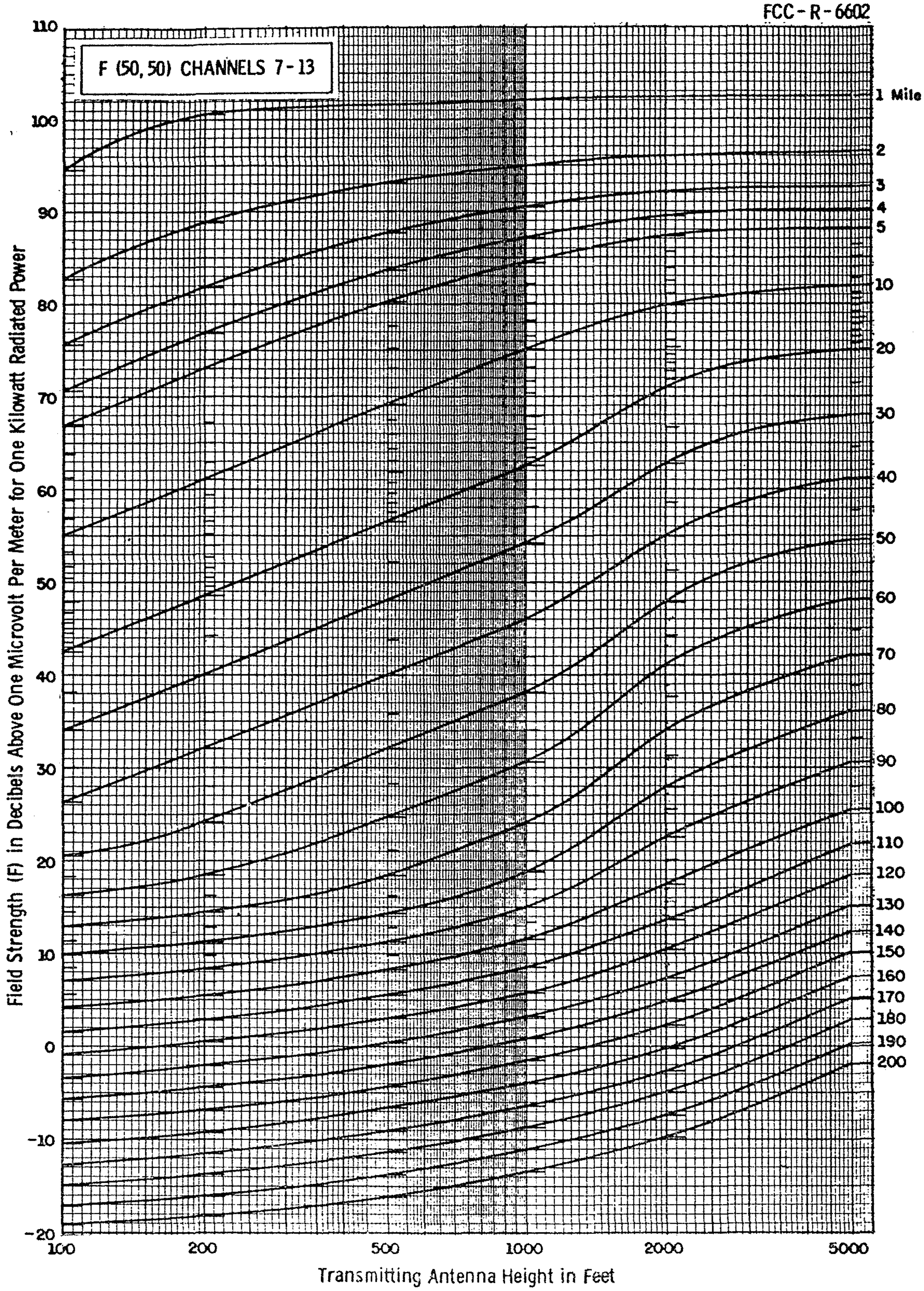
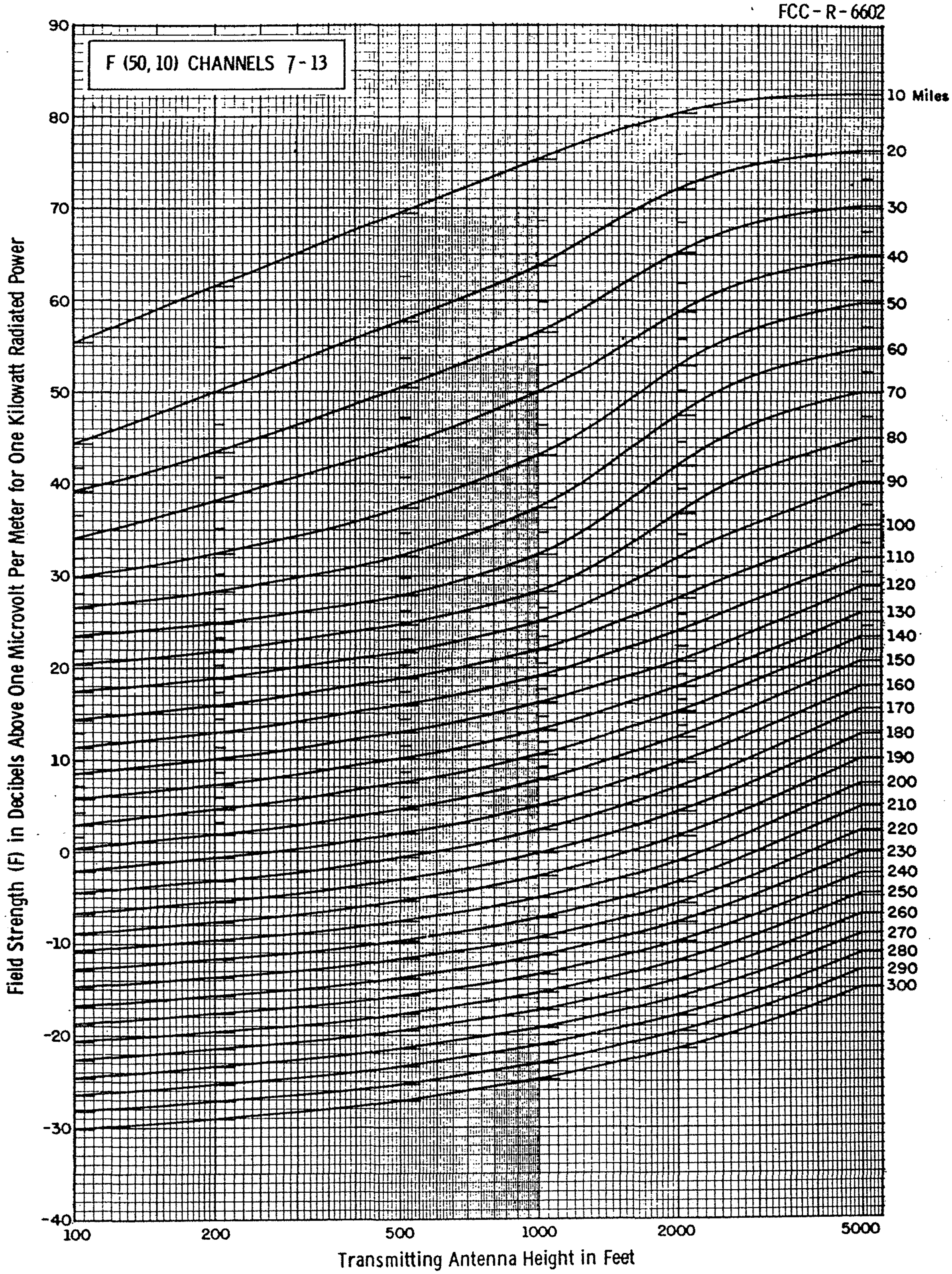
* J. Damelin, W. Daniel, H. Fine and G. Waldo, Development of VHF and UHF Propagation Curves for TV and FM Broadcasting, FCC, Office of Chief Engineer, Research Div. Report No. R-6602, September 1966.



TELEVISION CHANNELS 7 - 13
ESTIMATED FIELD STRENGTH EXCEEDED AT 50 PERCENT
OF THE POTENTIAL RECEIVER LOCATIONS FOR AT LEAST 50 PERCENT
OF THE TIME AT A RECEIVING ANTENNA HEIGHT OF 30 FEET

April 12, 1966

FIGURE 19



TELEVISION CHANNELS 7 - 13
ESTIMATED FIELD STRENGTH EXCEEDED AT 50 PERCENT
OF THE POTENTIAL RECEIVER LOCATIONS FOR AT LEAST 10 PERCENT
OF THE TIME AT A RECEIVING ANTENNA HEIGHT OF 30 FEET

April 12, 1966

FIGURE 20

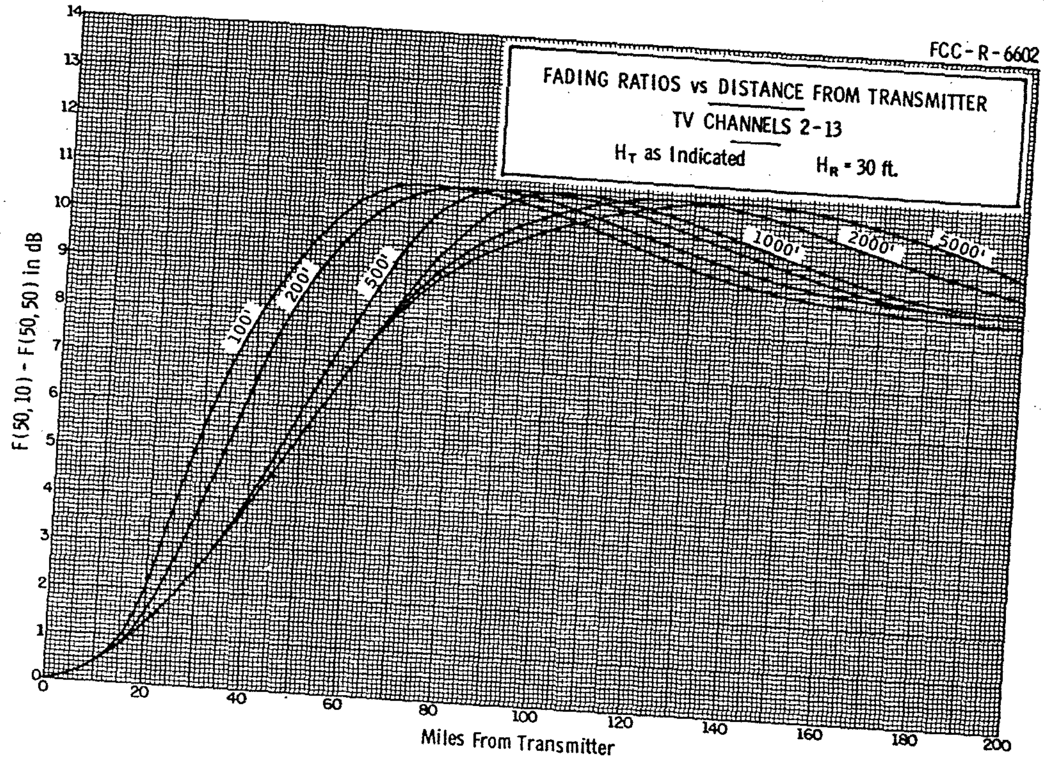

FCC-R-6602
FADING RATIOS vs DISTANCE FROM TRANSMITTER
TV CHANNELS 2-13
H_T as Indicated
H_R = 30 ft.
100'
200'
500'
1000'
2000'
5000'
F(50,10) - F(50,50) in dB
Miles From Transmitter

FIGURE 10

APPENDIX C

JOINT PROBABILITY CONSIDERATIONS FOR PREDICTION OF THE RELATIVE NUMBER OF LOCATIONS WITHOUT INTERFERENCE

It is reasonable that interference protection criteria should vary with the grade of service being protected. In the case of interference from another television station, the traditional approach requires that the minimum acceptable ratio between fields be present at L% of locations with L = 70% at the Grade A contour and 50% at the Grade B. These percentages are the same as those which define the contours in terms of coverage. At the limit of Grade B service, for example, it is expected that TV reception will be available to 50% of residences on the basis of the desired field strength alone. If there is an additional signal from a distant co-channel station, it is considered appropriate to apply a similar 50%-of-locations criterion to the ratio of the two television fields.

It is necesary to examine the possibilities for IWCS interference to TV in greater detail since it would be unacceptable to cause interference to as many as 50% of residences in densely populated areas. IWCS operators are required to eliminate harmful TV interference that their stations cause within Grade B contours. This might be impractical if a large number of TV sets were involved.

An analysis in greater detail includes consideration of the joint probability of two conditions: (1) The TV set must be receiving a signal that would be adequate in the absence of undesired signals, and (2) the desired-to-undesired power ratio must be above a threshold value for interference. The range of possible conditions is represented in Figure C-1. From location to location the field strengths of the desired and undesired signals will vary randomly with the most likely values being close to the repective medians. Interference results when the point representing the two field strengths falls inside the shaded area.

The probability of no interference can be calculated on the basis of the analysis represented in Figure C-1. Assuming that the desired and undesired field strengths are uncorrelated and log-normally distributed, this probability is

$$\ell(X,Y) = 1 - \int_0^\infty Z(u-X) \int_u^\infty Z(v-Y)\, dv\, du \qquad (C.1)$$

where

$$Z(u) = (1/\sqrt{2\pi}) \exp(-\tfrac{1}{2}u^2)$$

$$X = [P_d + F_d(50,50) - F_s]/\sigma_L$$

$$Y = [P_u + F_u(50,50) + A + \sqrt{R_u^2(10) + R_d^2(10)} - F_s]/\sigma_L$$

and

σ_L = standard deviation of log-normal variations of field strengths with respect to location, 8.6 dB.

The other quantities are as defined in the text. See EVALUATION OF THE INTERFERENCE POTENTIAL. Locations where the desired field is too weak for reception are counted as having no interference regardless of how strong the undesired signal may be.

The foregoing analysis of interference may be expressed in traditional terms (see reference 3) by introducing the quantity

$$G = P_d + F_d(50,50) - F_s.$$

G indentifies the grade of TV service expected in the geographical area of interest and F_s is the minimum field strength for acceptable reception. An appropriate choice for F_s is the value which makes G = 0 at the Grade B contour.

Convert to percentage by letting L = 100 times $\mathcal{l}(X,Y)$, and define R (as in Reference 3) as

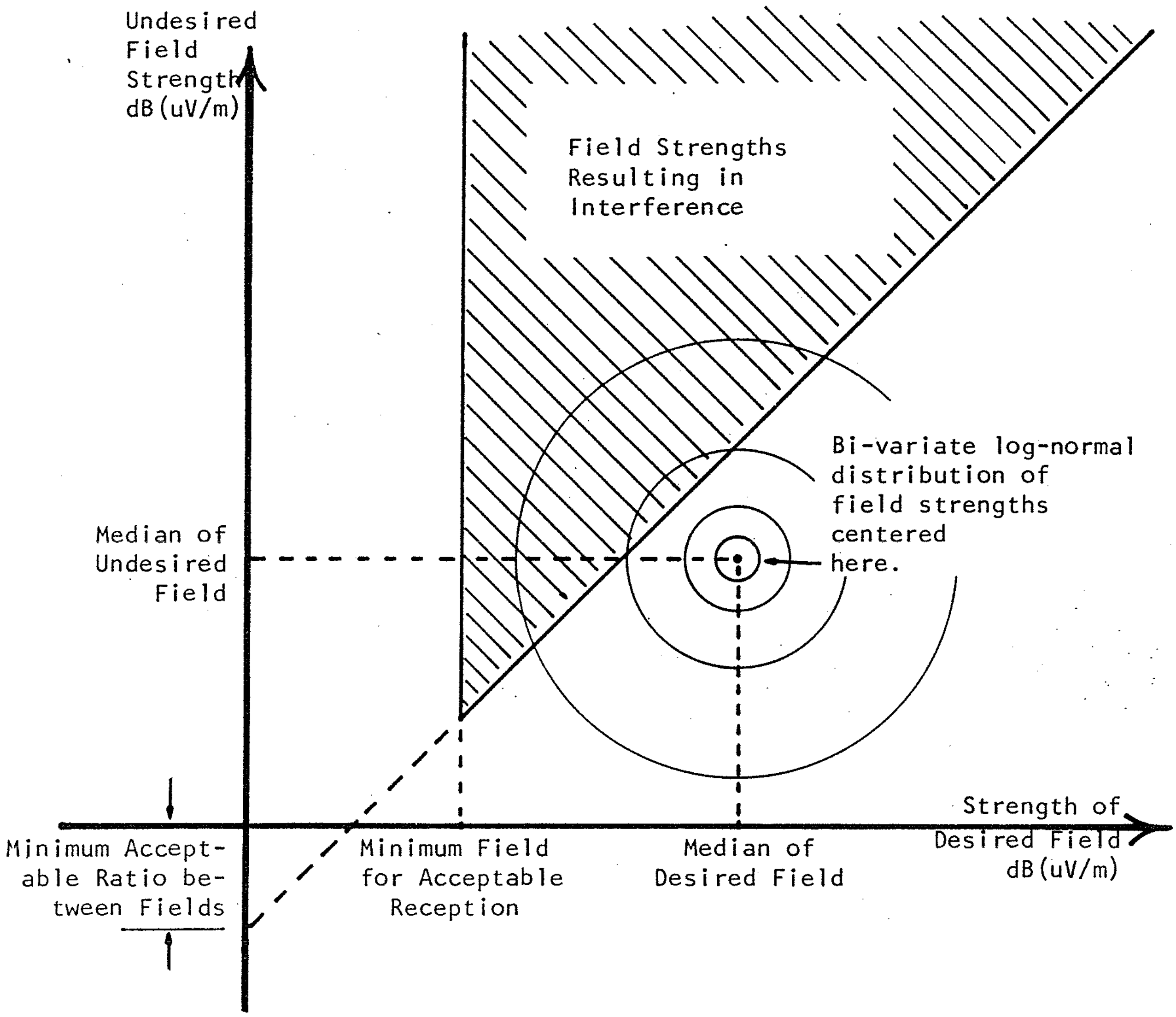
$$R = P_u + F_u(50,50) - P_d - F_d(50,50) + A + \sqrt{R_u^2(10) + R_d^2(10)}.$$

Then the relationship between R,L, and G is

$$L = 100\ \mathcal{l}(G/\sigma_L, (R+G)/\sigma_L),$$

and this determines the function R(L,G) graphed in Figure 1 of the text. Since a formula for easy calculation of R(L,G) is not available, Figure 1 was prepared by evaluating the expression (C.1) with $X = G/\sigma_L$ and $Y = (R+G)/\sigma_L$ for a large number of values of R and G.

When G is large, good reception is available to all TV sets. Under these conditions, R(L,G) = R(L) is the function traditionally used to determine the ratio of fields available to L% of locations.



The relationships illustrated above are the basis for the probability-of-interference evaluation used in this report. Field strengths are represented logarithmically, and the intersection of the x- and y-axes is an arbitrarily chosen reference at which the two fields are equal.

Interference occurs when (1) the desired field is strong enough for reception and (2) the field strength ratio does not provide enough protection.

GRAPHICAL ANALYSIS OF RECEPTION AND INTERFERENCE CONDITIONS

Figure C-1

APPENDIX D

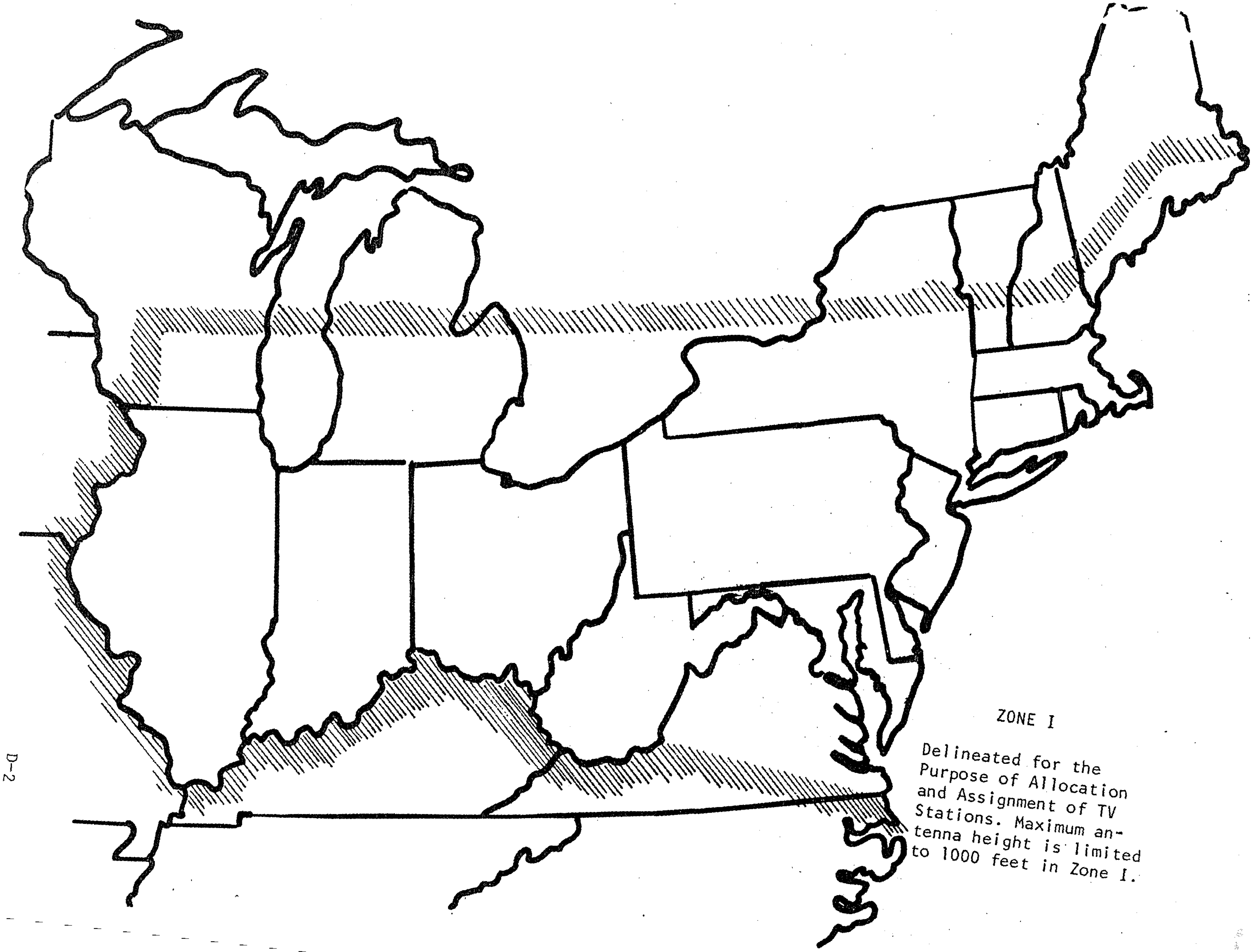
PARAMETERS OF MAXIMUM FACILITY TV STATIONS

	FACILITIES		SERVICE AREA
ZONE	ERP dB(kW)	Antenna Height (feet)	Miles to Grade B contour
I	25	1000	60
II, III	25	2000	76

Television broadcast stations are allowed certain maximum values of effective radiated power (ERP) and antenna height depending upon geographical zone. IWCS stations are required to protect the maximum TV coverage area of broadcast stations.

The values applying to channels 10 and 13 are given in the table above. Heights are measured relative to average terrain. Greater heights are permitted provided power is correspondingly reduced, and the allowed combinations all result in approximately the service radius shown above.

See map on the page following for definition of Zone I.



ZONE I

Delineated for the Purpose of Allocation and Assignment of TV Stations. Maximum antenna height is limited to 1000 feet in Zone I.