ANNEX I

Procedure for Evaluating Frequency Proposals in the 162-174 MHz and 406.1-420 MHz Bands

I.1 Procedure for Evaluating Frequency Proposals in the 162-174 MHz and 406.1-420 MHz Bands

The purpose of this procedure is to evaluate potential interference involving Fixed and/or Mobile stations in the 162-174 MHz and 406.1-420 MHz bands. The propagation portion of the discussion was derived from the Longley-Rice Model (1968). Certain assumptions have been made in the propagation calculations for ease of presentation and use. In all cases, the assumptions used will result in conservative estimates of propagation loss, i.e., the actual interfering signal level should be less than that predicted.

The data used to indicate the rejection off-tuned interfering signals is based upon characteristics of recent model VHF/UHF signal channel FM voice receivers using crystal lattice type IF filters. The curves used are the adjacent channel selectivity and desensitization data taken in accordance with the latest revision of EIA/TIA-603.

STEP 1. *Choose an Interfering Threshold*

Using Figure 1, if necessary to convert from V to dBW, choose an appropriate criteria for acceptable interference. This will depend to a large extent on the RF noise environment in which the receiver operates. Several typical values are indicated on Figure 1. Enter the chosen interference threshold on Table 1.

STEP 2. *Enter Transmitter Power*

Using Figure 2, if necessary, enter the interfering transmitter power in dBW on table 1.

STEP 3. *Enter Antenna Gains*

Enter the antenna gains in dB above a dipole (dBd) of the interfering transmitter and your receiver. If the antennas are not omni directional, an estimate must be made of the respective antenna gains along their common line of direction.

STEP 4. *Determine Propagation Loss*

By the use of Figures 3 thru 9 determine an estimate of the propagation loss between the antennas. The first step is to determine the mean height (i.e., geometric mean) of the two antennas. This is found by use of either the nomogram or equation shown on Figure 3. Next, using the appropriate curves from Figures 4 through 9, the propagation loss is estimated for the given mean antenna height and distance separation. Enter the value on Table 1.

STEP 5. *Enter Additional System Loss*

Enter into Table 1 any additional known system losses at both the transmitter and receiver such as that due to coaxial cables, cavity filters, isolators, etc. If not known, enter zero. The use of zero will further slant the predictions towards conservative results.

STEP 6. *Enter Off Frequency Rejection*

If the interfering transmitter and the receiver are separated in frequency between 0 and 25 kHz, additional losses may be included to account for off frequency rejection. Figure 10 is provided as a guide to determine this value. The four curves show the adjacent channel selectivity and desensitization for: Analog to Digital, Digital to Digital, Digital to Analog, and Analog to Analog systems. Select the appropriate curve for the case being modeled and enter the resulting value in Table 1. Non-synthesized equipment will normally give an additional 5 dB of selectivity for offsets equal to or greater than 25 kHz. If this is the case of the system being modeled, add 5 dB to the value selected from the curve.[1]

STEP 7. *Calculate Predicted Received Signal*

Total the values entered on Table 1 observing plus and minus signs as appropriate. The resultant predicted value of received signal compared with the chosen interference criteria will indicate the likelihood of interference.

TABLE 1	
Transmitter Power	+ dBW
Transmitter Antenna Gain	+ dBd
Receiver Antenna Gain	+ dBd
Propagation Loss	- dB
System Losses	- dB
OFF Frequency Rejection	- dB
A. Predicted Received Power	dBW
B. Chosen Interference Threshold	dBW
If A is greater than B, unacceptable interference may result.	

[1] Data supporting Figure 10 was taken from NTIA TM-87-122 and TM-88-137.

Figure 1. Voltage to Power Conversion

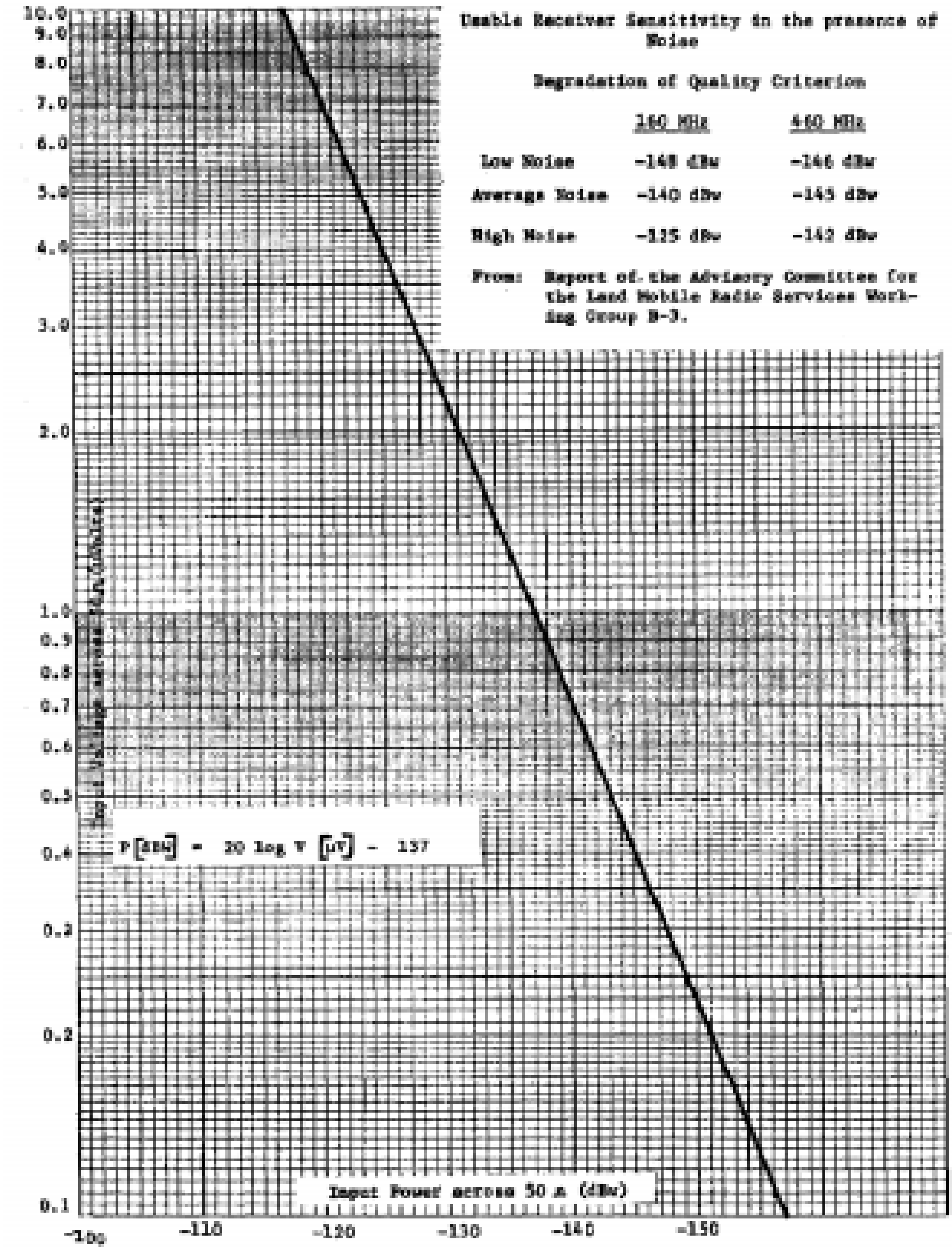


Figure 2. Power to dBw Conversion

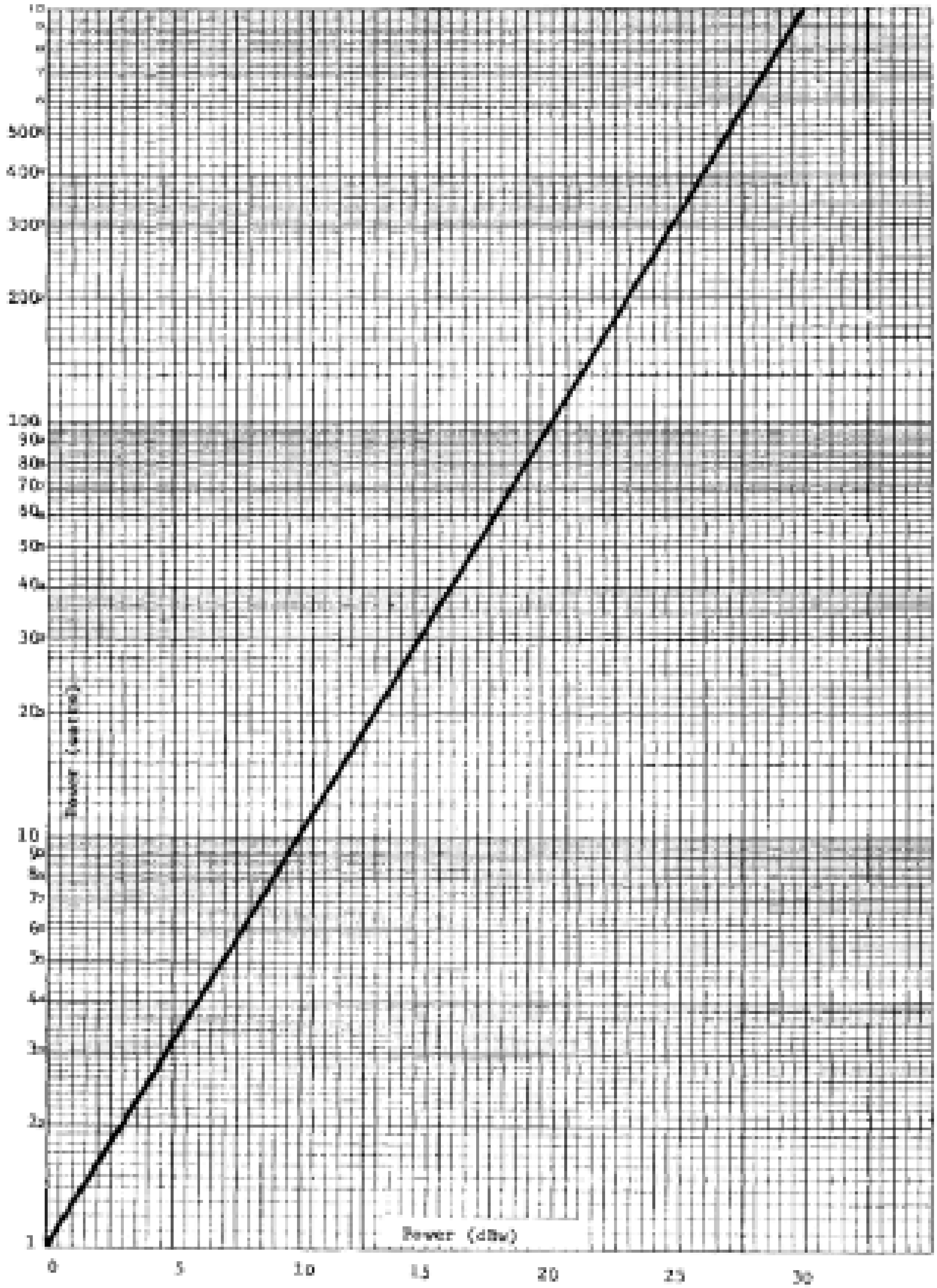


Figure 3. Calculations of Mean Antenna Height

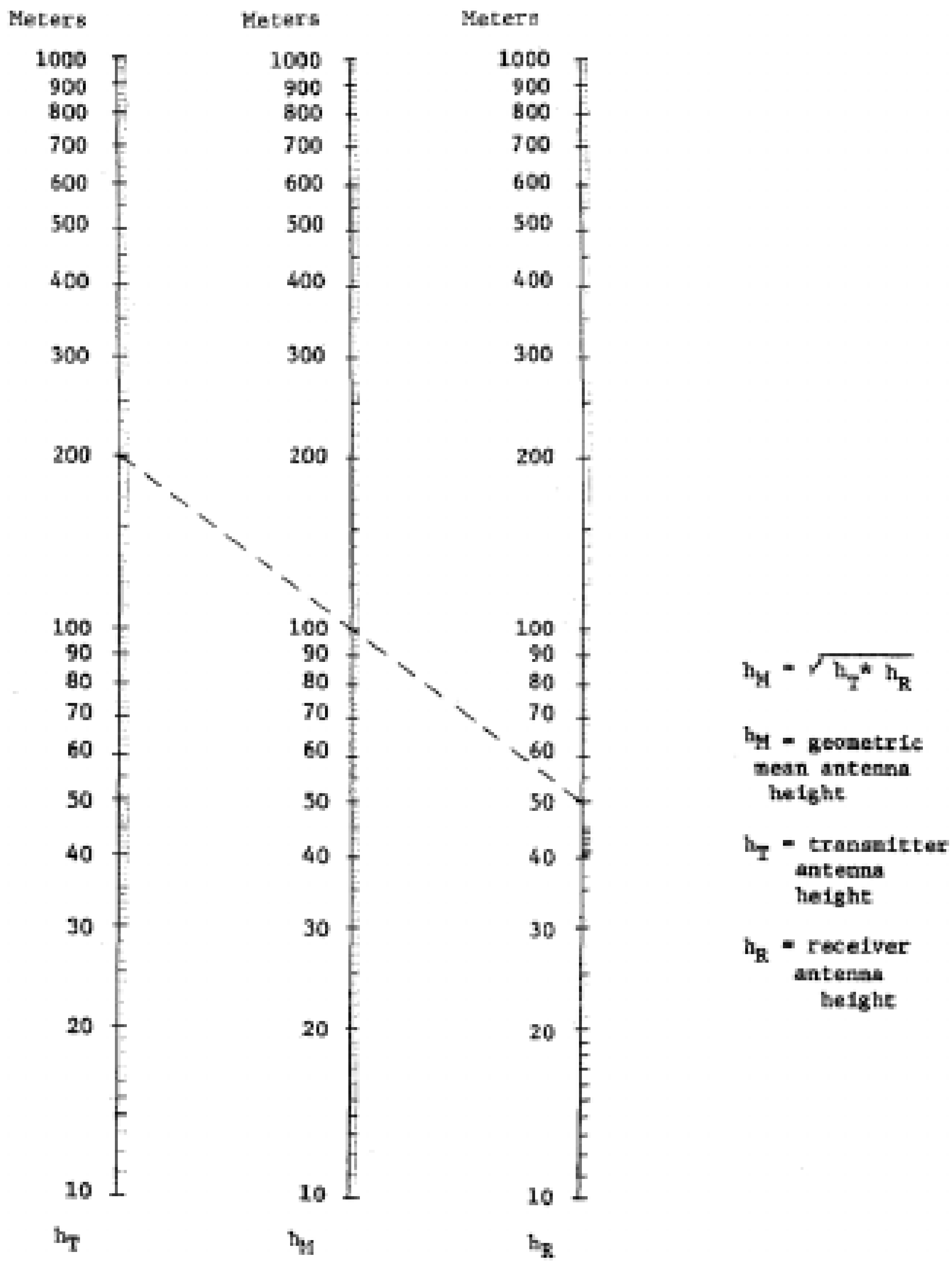


Figure 4. Propagation Loss for 168 MHz, Average Land

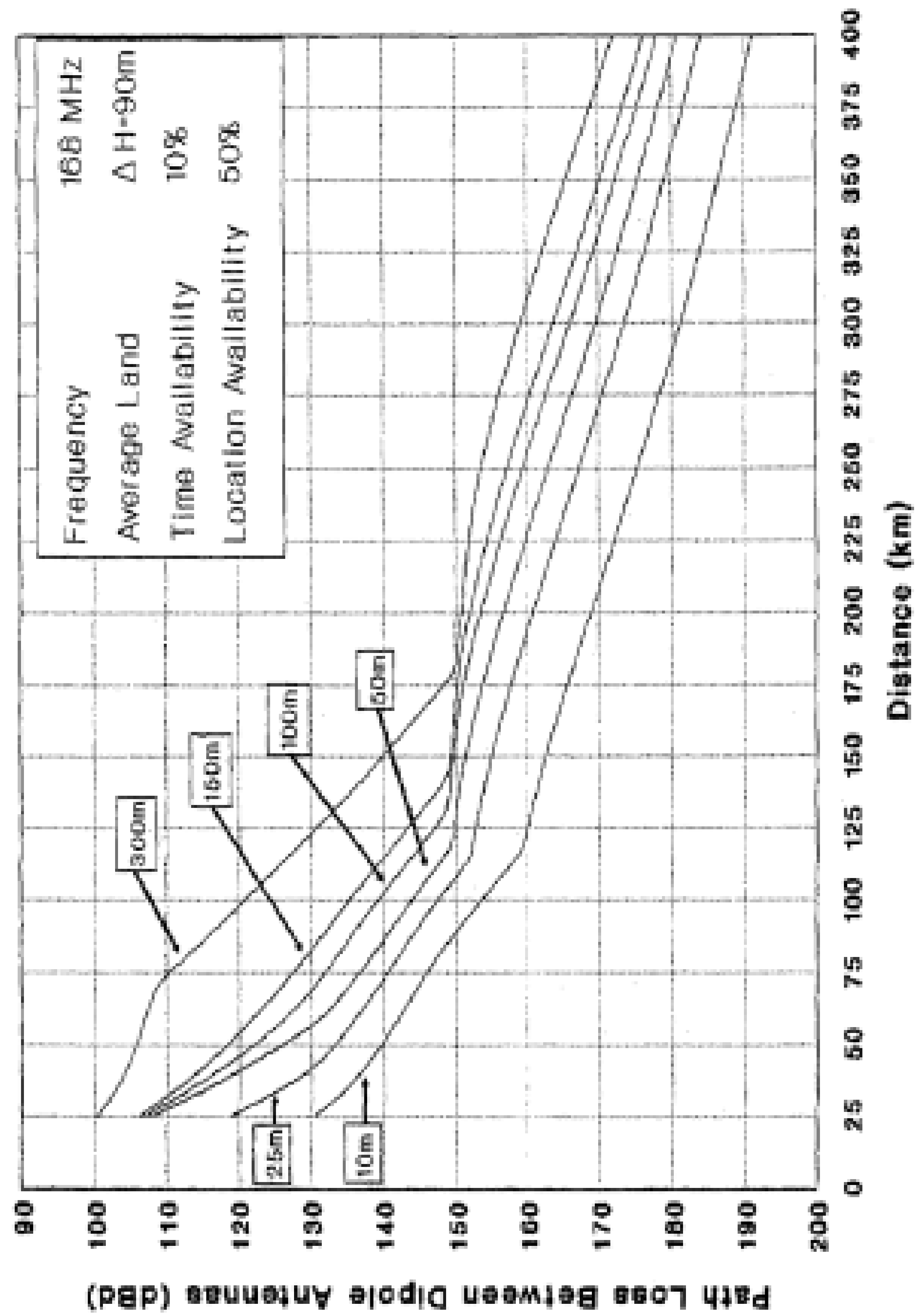


Figure 5. Propagation Loss for 413 MHz, Average Land

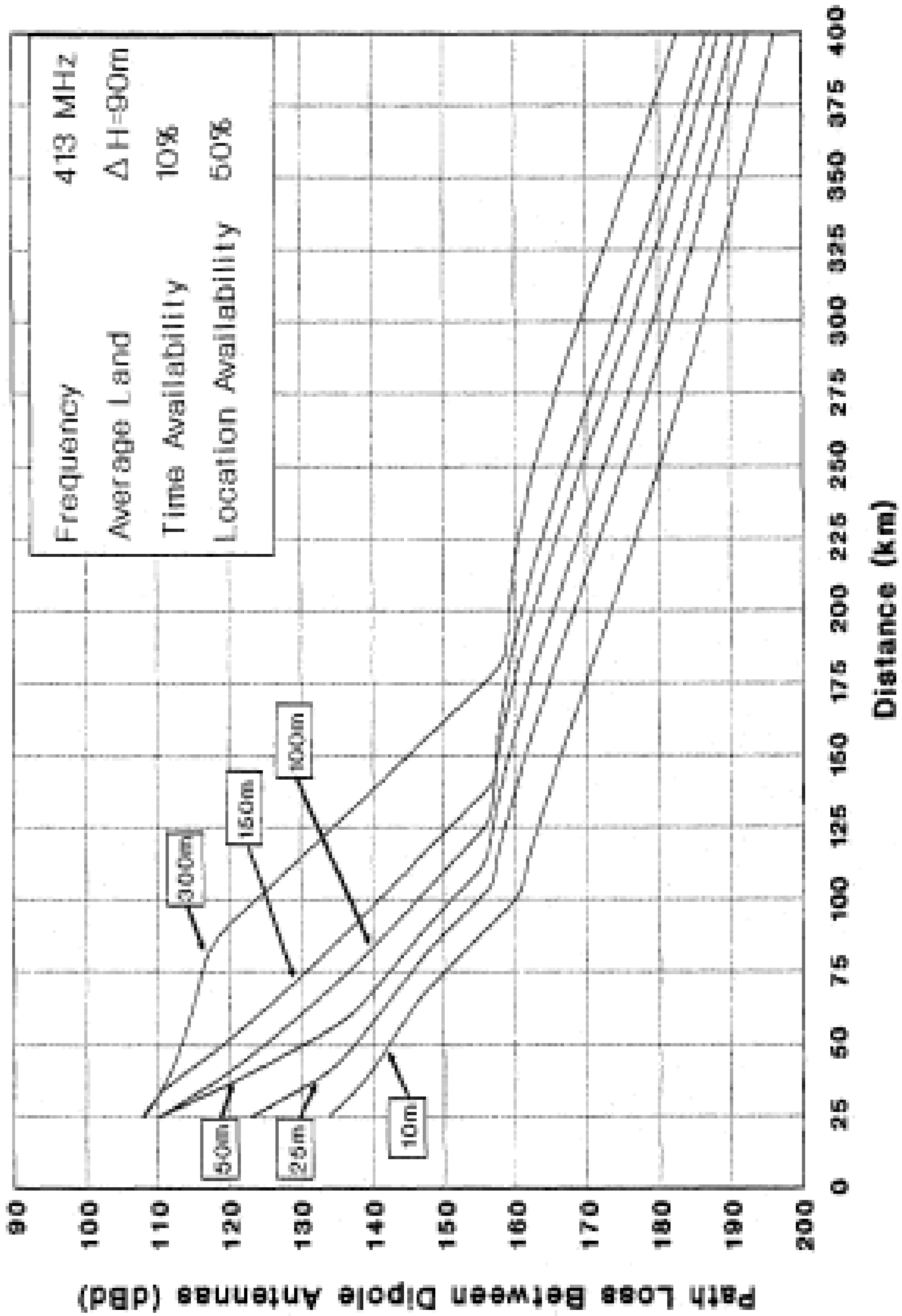


Figure 6. Propagation Loss for 168 MHz, Fresh Water

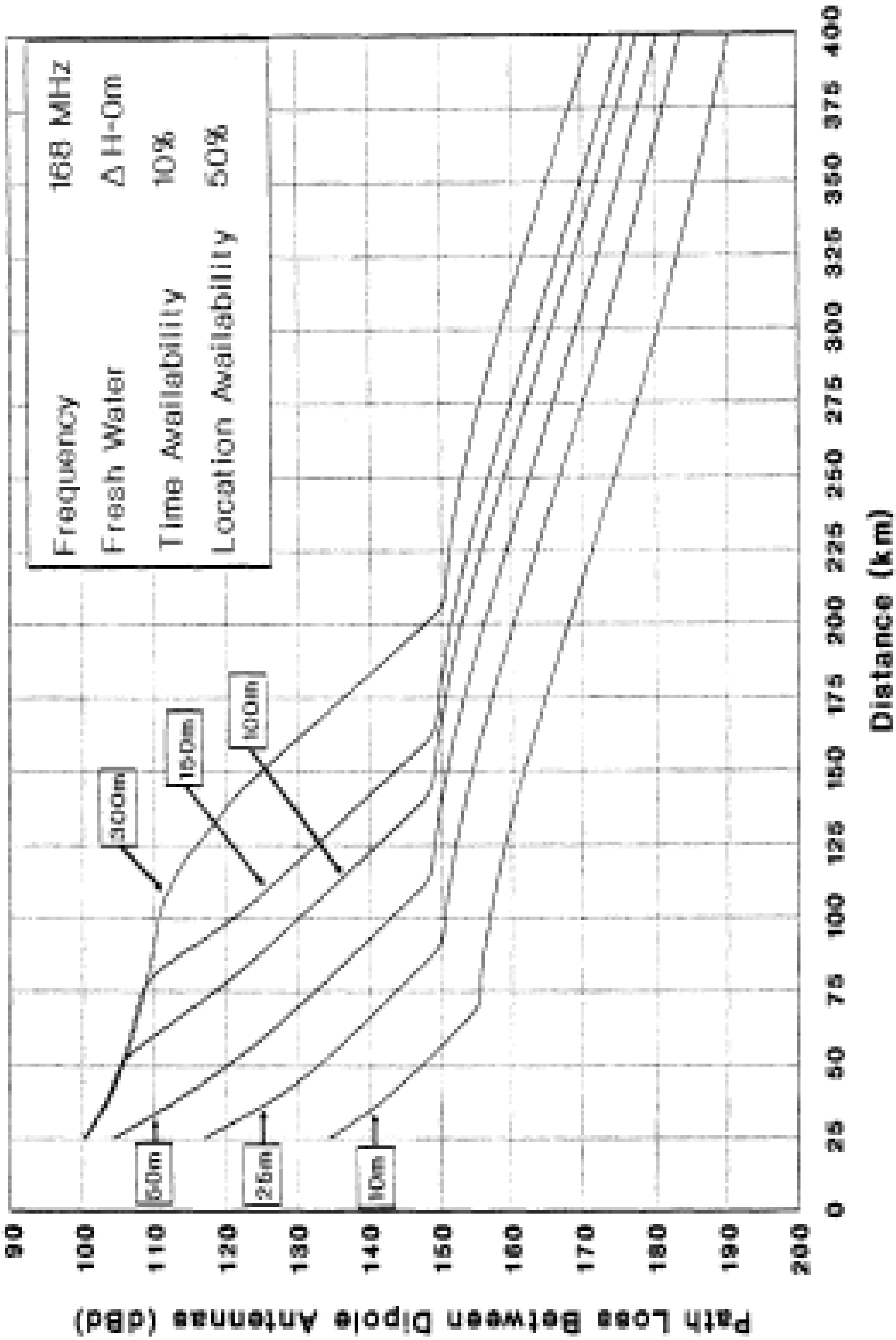


Figure 7. Propagation Loss for 413 MHz, Fresh Water

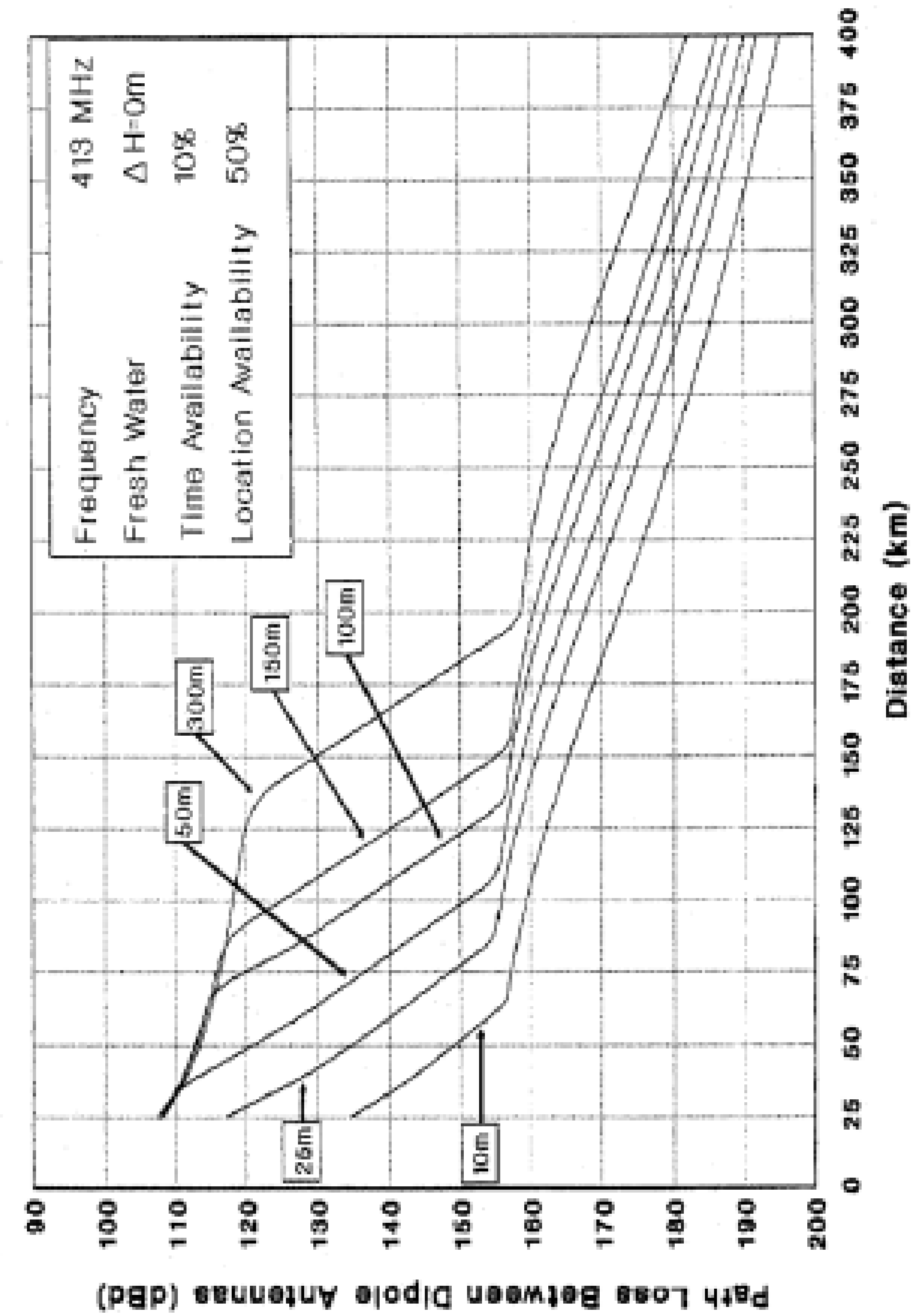


Figure 8. Propagation Loss for 413 MHz, Salt Water

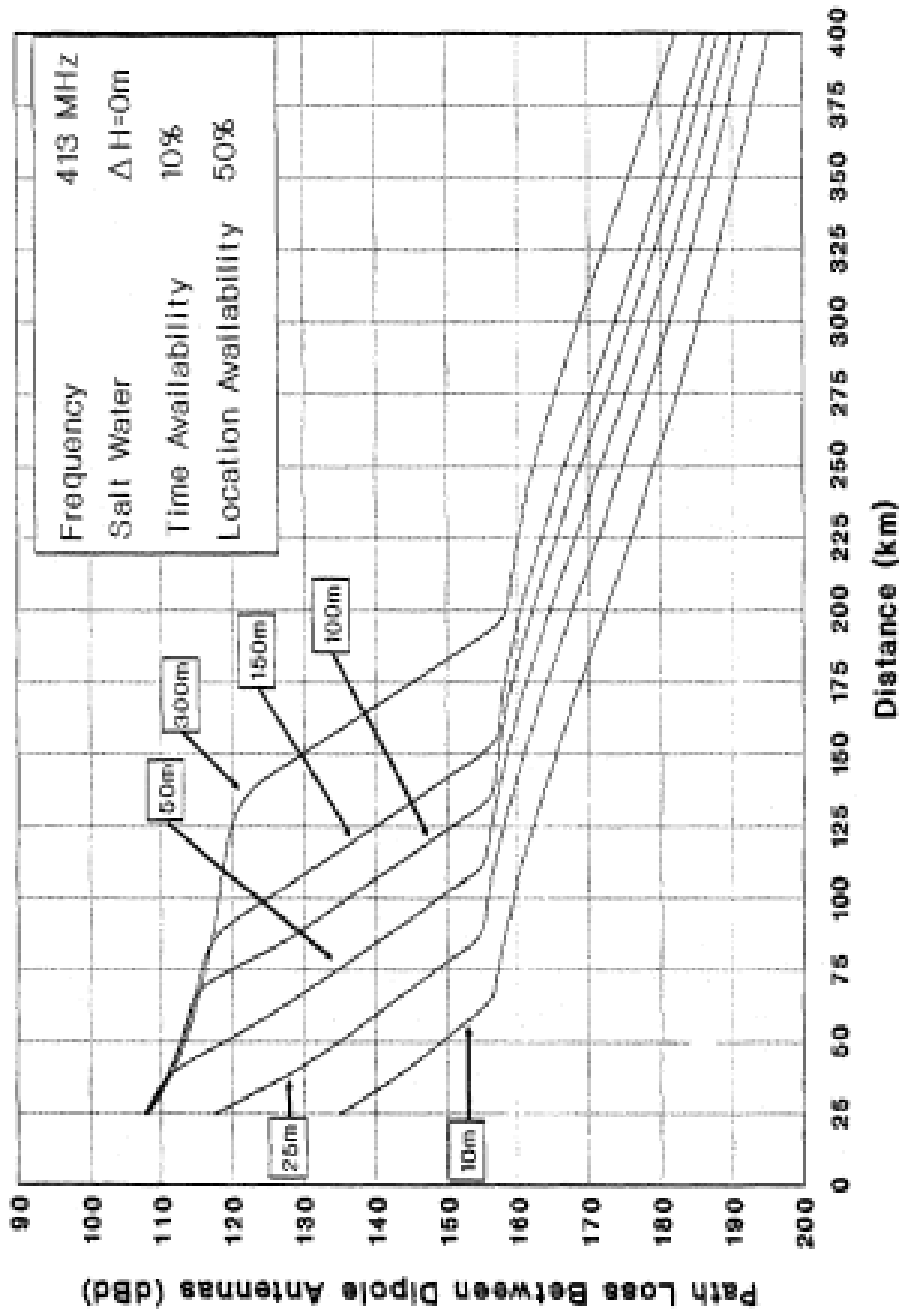


Figure 9. Propagation Loss for 168 MHz, Salt Water

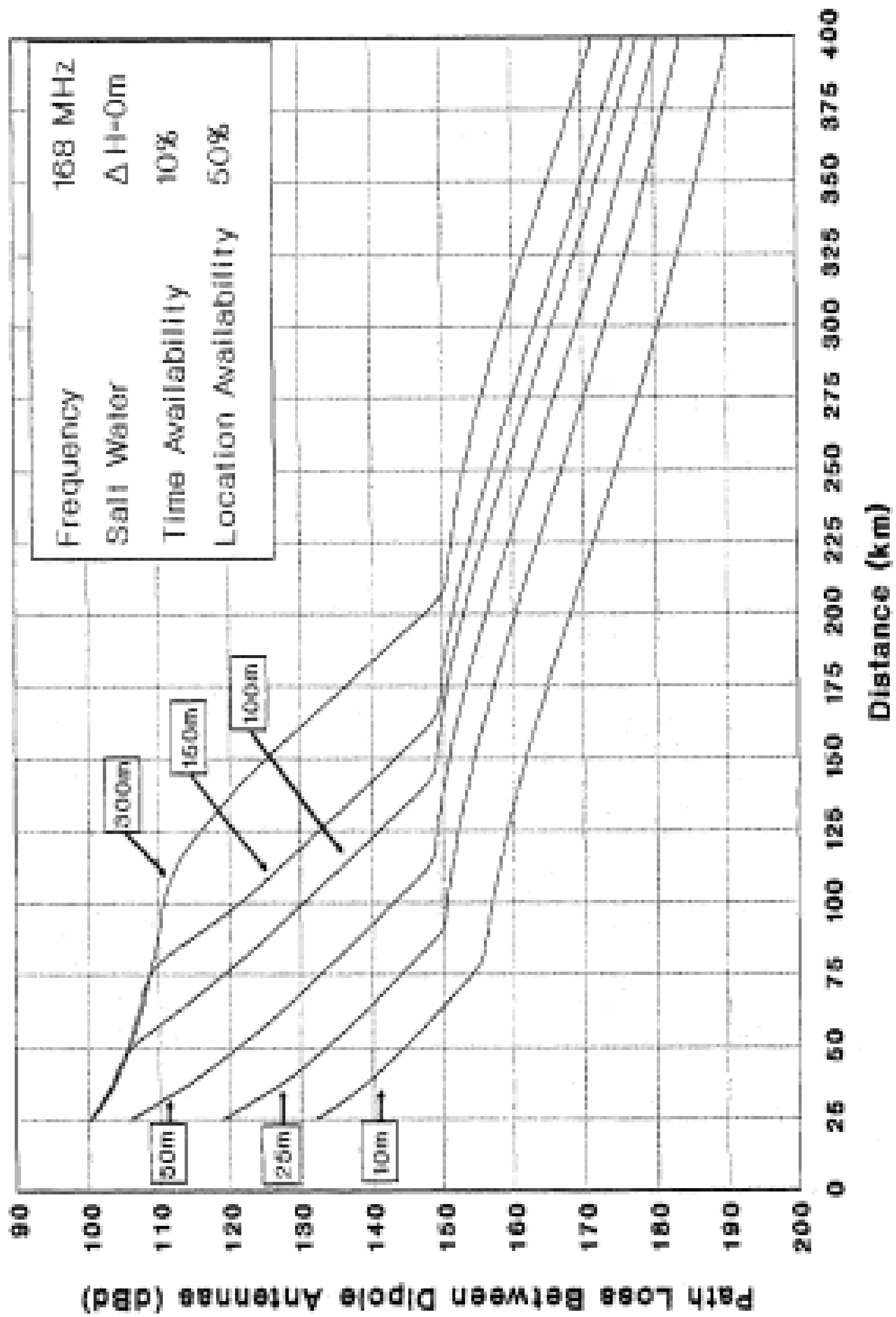
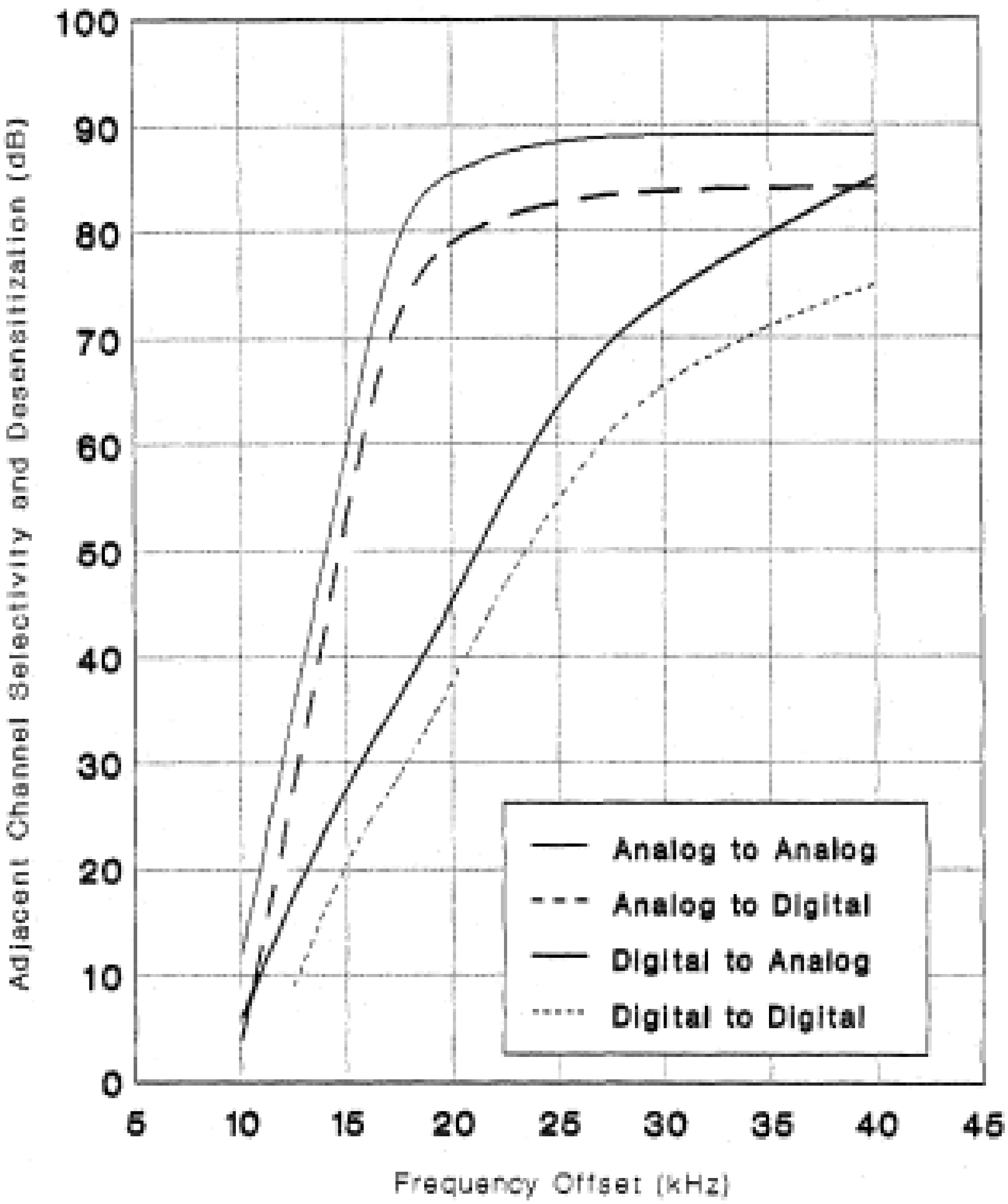


Figure 10. Adjacent Channel Selectivity and Desensitization



APPENDIX

Determination of Propagation Loss

For purposes of this procedure, the prediction of path loss between antennas was based on the methods described by Longley and Rice (1968). That report discusses a computer method for predictions of long-term median radio transmission over irregular terrain. The method is based on well established propagation theory and has been tested and validated against a large number of propagation measurements.

This model is statistical in nature and is most useful over paths where specific coordinates of the endpoints are not known. The program does require knowledge of general atmospheric and terrain parameters. One principal atmospheric parameter is the surface refractivity which largely determines the degree of bending of the radio wave through the atmosphere. A convenient method of accounting for this refracting of the radio wave is by assuming that the earth has an effective radius larger than its actual value. The value used here is an effective earth radius of 4/3 the actual size. A second atmospheric parameter to be specified is the general climate type. A continental temperature climate was assumed.

Three principal terrain dependent factors are used in the model; ground conductivity (σ) , ground dielectric constant (ε) and a terrain roughness factor (Δh). The first two are constants which depends on electrical characteristics of the surface over which the radio waves propagate with the following values assumed:

	(σ)	(ε)
Average ground	0.005 mho/m	15
Fresh Water	0.01 mho/m	81
Salt Water	5.0 mho/m	81

The terrain roughness factor is a parameter to describe the general irregularity of the surface. When surface endpoint locations are known, the (Δh) can be calculated from a terrain profile drawn between the points. Specifically, a straight line is drawn on the profile such that 10% of the points lie above the line. Similarly, a line is drawn with 10% of the points below the line. The (Δh) is the difference in elevations between these lines. When terrain profiles are not available, estimates of (Δh) may be obtained from the following:

Type of Terrain	(Δ) **in Meters**
Water	0-5
Smooth Plains	5-20
Slightly Rolling Plains	20-40
Rolling Plains	40-80
Hills	80-150
Mountains	150-300
Rugged Mountains	300-700
Very Rugged Mountains	>700

For this procedure, a (Δh) of 0 was used for water and 90 meters used as average land somewhat typical of the Eastern rolling hills.

Specific parameters for the radio link include frequency, polarization, antenna heights and a general siting criteria. Since antenna heights for both transmitter and receiver are variable, a very extensive family of curves would be required to consider all possible combinations. A more simplified approach was taken in which the geometric mean of the two antennas is calculated. The ARPROP model is then exercised using this mean antenna height at both ends of the path. Thus, transmitter/receiver heights of 100/100 m or 50/200 m would both be represented as 100 m (see figure 3). This approach greatly reduces the required number of curves while introducing only small differences in the results with the more exact approach. Moreover, such differences always result in conservative estimates of propagation loss.

A general siting parameter is also an input parameter to the model as either being random siting, careful siting or very careful siting. The former is most applicable to mobile equipment whereas the latter two are applicable to fixed or base stations where advantage is often taken of hilltops. In these cases the effective height of the antennas are increased somewhat above the actual height. Careful siting was chosen for the calculations used in attachment 1 since, in general, the results will be used for base or fixed stations.

The results of the model provide propagation loss estimates versus distance as a statistical function of both time and location. The time variation represents the long term variations of the median propagation loss such as daily and seasonal changes. Short term fading statistics are not included. The location variation statistic accounts for the fact that propagation loss over two paths of equal length but different locations will, in general, differ. These differences are represented statistically by a distribution of values around a median value (50 percentile) and any other desired value. For purposes of this procedure, values of 10% and 50% were chosen for the time and location parameters. The 10% value implies that the actual propagation loss is expected to be lower than the predicted value only 10% of the time on a long term basis. The 50% value for the location variability implies simply a median or average value. It is noted that these values are the same as those used by the Federal Communications Commission for similar propagation predictions used in interference calculations.

REFERENCES

1. Longley, A.G. and P.L. Rice (July, 1968) Prediction of Tropospheric Radio Transmission Loss Over Irregular Terrain-A Computer Method, ERL 79-ITS-67, Institute of Telecommunications Sciences, Boulder, Colorado.

2. Frazier, W.E. (October 1978) Operations manual for the APPROP Computer Model (Area Propagation) as Implemented at NTIA/Annapolis NTIA-TN-78-3.

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