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EXTREME WINDS AND THEIR VERTICAL PROFILE AT SLC-6 LAUNCH PAD, V--ETC(U)
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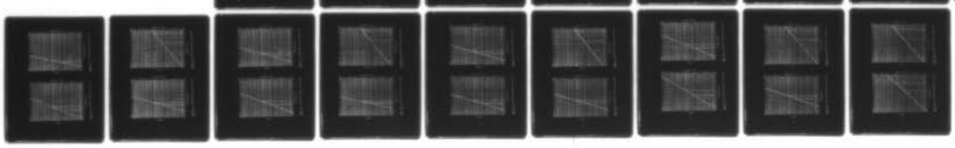

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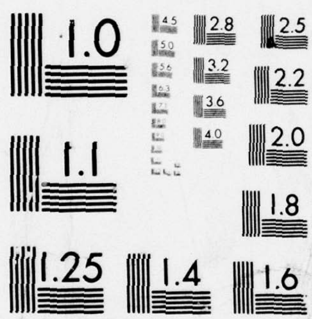

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UNITED STATES AIR FORCE
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USAF ENVIRONMENTAL
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SCOTT AIR FORCE BASE, ILLINOIS 62225

Report 8234

EXTREME WINDS AND THEIR VERTICAL PROFILE AT SLC-6 LAUNCH PAD, VANDENBERG AFB, CA.

by

Tamzy J. Cunningham, 2d Lt, USAF

February 1977

76-3871

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The study of extreme winds and their vertical profile at SLC-6 launch pad, Vandenberg AFB, CA was conducted to aid in the determination of wind loadings for the launch pad complex. Data sets from micromet wind Towers 300 and 301 were used in the analysis. Results from the extreme-value statistics indicate that winds greater than 60 kt will most likely occur at the launch site in a 10-year return period during the winter season from the south and east. For winds less than 40 kt the vertical wind (Cont'd)

20. Continued

profile was generally explained by the turbulent boundary layer power-law profile equation. Winds greater than 40 kt overcame the effect of surface friction resulting in excessive winds at all levels.

Preface

USAFETAC prepared this report in answer to a request from SAMSO Directorate of Civil Engineering (SAMSO/DEE) through SAMSO/WE for a meteorological analysis of potential wind loadings on the Space Shuttle launch pad facility, SLC-6. They desired extreme wind values for heights up to 300 feet and for the four principal wind directions (North, East, South, and West) for the SLC-6 launch pad at Vandenberg AFB, CA. This study utilizes wind data from the micrometeorological (micromet) wind Towers 300 and 301 at Vandenberg. A general vertical wind profile for the extreme winds was also requested. Graphs of extreme-value statistics are provided for the five micromet wind tower levels of Tower 300 in the four principal directions.

In the event that this report is incorporated into another report by the requester or any other agency, request that USAFETAC be furnished a copy of the new report in all cases where such dissemination is not prohibited.

USAFETAC prepared this report to answer a specific request and it is not expected to have further application. Department of Defense agencies and their contractors should refer questions on this problem or related problems to USAFETAC for consultation and study.

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EXTREME WINDS AND THEIR VERTICAL PROFILE AT SLC-6 LAUNCH PAD, VANDENBERG AFB, CA.

Introduction

Report 8234 involves the study of extreme winds and their vertical profile at SLC-6 launch pad, Vandenberg AFB, CA. The results of this project will be used in the determination of wind loadings for the launch pad complex. Micromet wind Tower 301 is located at the SLC-6 site. Since the amount of data available for the tower is very limited, a 6-year data base obtained from Tower 300 will be used to supplement the eight partial months of data from Tower 301.

Geography of Site

Launch pad SLC-6 (elev. 430 ft MSL), and micromet wind Tower 301 (elev. 400 ft MSL), are located in South Vandenberg's Punta de la Concepcion area, approximately one mile east of Point Arguello. The supplemental tower, Tower 300 (elev. 450 ft MSL), is located near Lompoc Terrace and Spring Canyon, approximately 4 miles north-northeast of Tower 301. Along this coastal section, the buttresses of the Santa Ynez Mountains slope into the ocean. Ridges 1000- to 1500-ft high, running east-west, are characteristic of this range, as well as the 2000-ft high peaks along the southern portion of South Vandenberg (Figure 1). One of the most pronounced features of this region is the deep and steep-sided La Honda Canyon, walled on the south by Honda Ridge and on the north by Target Ridge. The canyon is approximately 800 feet deep and no more than $1\frac{1}{2}$ miles across. Smaller canyons branch from these two main ridges, producing a very rugged appearance.

Data Problems

The scarcity of data from Tower 301 was the primary drawback to the analysis. Only eight partial months of data were available:

15 April 1975 - 30 April 1975

1 June 1975 - 27 June 1975

1 August 1975 - 29 August 1975

1 March 1976 - 29 March 1976

1 May 1976 - 15 May 1976

20 July 1976 - 31 August 1976

1 September 1976 - 30 September 1976

As discussed earlier, 6 years (1971-1976) of Tower 300 data were utilized as a supplement to the limited data set.

Both of these data sets contained a number of spurious records which necessitated the inclusion of quality control measures in the analysis programs. Some of the data problems involved wind gusts less than the wind speed for the 15-minute integration period as well as the occurrence of excessive wind speeds without meteorological support.

Explanation of Technique

Extreme-value statistics, based on the theory developed by Gumbel (1954, 1958), were applied to the 6-year data set available from Tower 300. The application of the statistics involved the formulation of an annual series of maximum normal wind component values for each of the five levels and in the four principal directions; north (316°-045°), east (046°-135°), south (136°-225°), and west (226°-315°). The values in each of the series were ranked in order of size from the smallest to the largest (Landsberg, 1958; Shellard, 1958). Frequencies or plotting positions were calculated from these series by using:

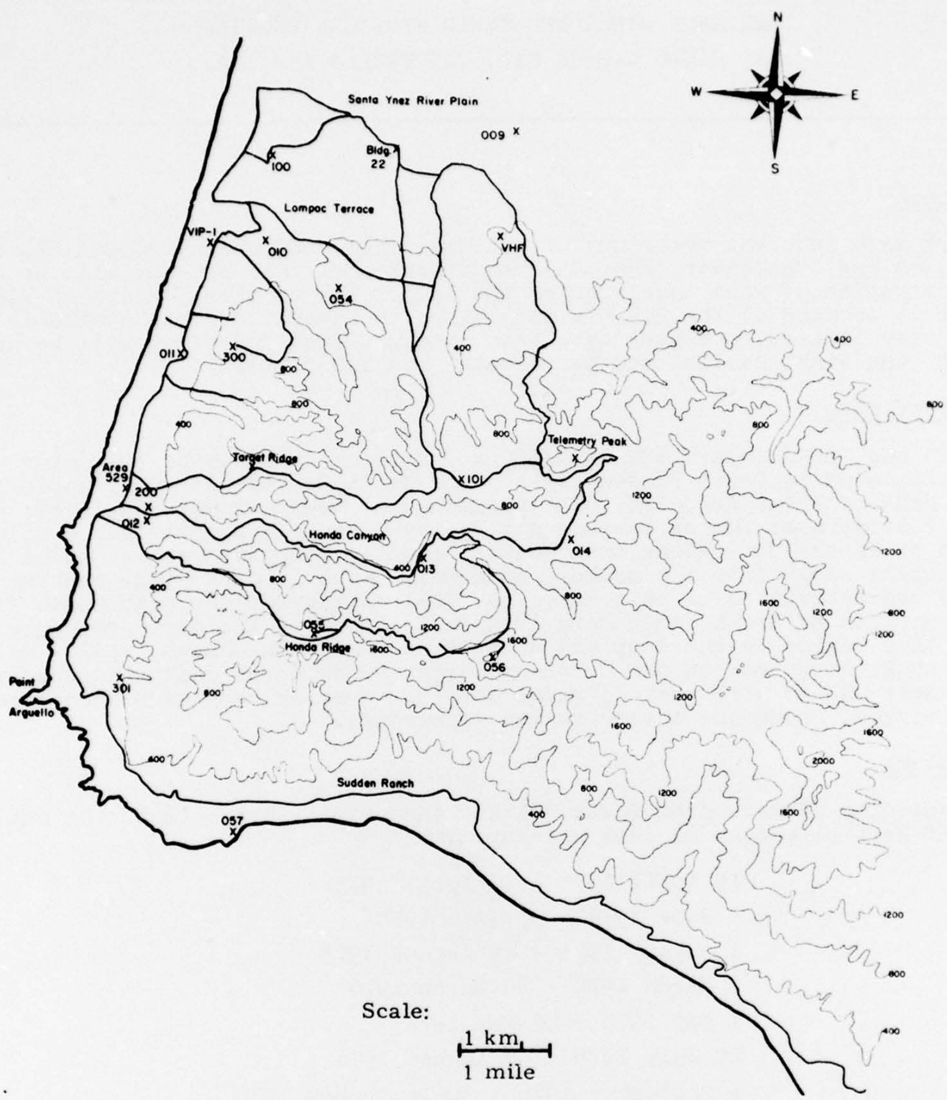

Figure 1. Prominent Terrain Features, South Vandenberg (Hinds and Nickola, 1968).

$$p = \frac{m}{n + 1} \tag{1}$$

where m is the rank and n is the number of observations. The frequencies were then used to calculate the reduced variate by the following formula:

$$y = - \ln (- \ln p) \tag{2}$$

An important result of the extreme-value statistical analysis was the determination of the annual maximum value of the normal wind component which may be expected to be exceeded on the average only once in any desired number of years (Hershfield, 1973). This value, known as the return period T is:

$$T = \frac{1}{1 - p} \qquad (3)$$

All results were plotted on extreme probability paper for ease in extrapolation of the frequency and return period beyond the range of the data.

Since there were only eight partial months of data available for Tower 301, extreme-value statistics were not applied to this data set. Due to seasonal prejudice, the results would not be representative of the extreme winds that might occur at the tower. However, to aid in comparisons, maximum normal wind component values for each of the five levels and in the four principle directions were obtained for the eight individual months. Similar values were also obtained for Tower 300.

Results

a. Extreme-Value Analysis. The graphical results obtained from the extreme-value analysis for Tower 300 are shown in Figures 2 through 6. Each figure contains graphs for the four principal directions at a particular level. From these graphs the interrelationship of frequency, return period, and the extreme normal wind component is easily discernible. For example, at the 12-ft level, an extreme northerly wind component value of 22 kt would not be exceeded in a design return period of 10 years. The probability associated with this case would be 0.90.

Although the prevailing wind direction for this region is north, the results indicate that during certain times of the year, especially in the winter season, a strong southerly and an easterly wind component are observed. This phenomenon is believed to be primarily due to the Santa Ana winds which commonly occur in this region.

As discussed earlier, Towers 300 and 301 are approximately 450 and 400 feet MSL, respectively. The terrain differences between these two towers are evident when the extreme values for the same eight partial months of data are compared. (Recall that data for Tower 301 is available for only certain spring and summer months.) Table 1 contains the normal wind component values for the eight months of data available from Towers 300 and 301 at each level and in the four principal directions. The average mean normal wind component values are also provided.

The results from Table 1 indicate that the average wind speed is greater at Tower 301 than at Tower 300. This phenomenon is to be expected since Tower 301 is located on the windward side of the Santa Ynez Mountains and is "surrounded" by approximately 270° of ocean. Tower 300 is protected by several ridges in the area and has approximately 90° of wind access from over the ocean. However, due to the terrain, both towers experience easterly and southerly downslope winds which on occasion can be rather strong, as evidenced by the extreme-wind analysis.

b. Vertical Wind Profile. The characteristics of the vertical wind profile for Tower 301 were also studied. The premise was made that the profile could be explained by the equation

$$\bar{u} = \bar{u}_1 \left(\frac{z}{z_1}\right)^{0.142} \qquad (4)$$

where $\bar{u}_1$ is the mean velocity at a fixed reference height z_1, and $\bar{u}$ is the calculated mean wind velocity at level z. Equation (4) is the generally accepted power-law profile for the turbulent boundary layer of a flat plate in a wind tunnel (Sutton, 1953).

The study uses 25 selected observations of maximum 12-ft winds from both Tower 300 and Tower 301 as input data for the wind profile equation. A comparison of the resulting profiles with the actual observed winds at each reporting level showed that 85% of the observations were within 0-3 kt of the calculated profile. The remaining 15% involved cases where equally strong winds existed at all levels. This situation generally occurred when the wind speed was greater than 40 kt. At this magnitude of wind speed the effect of the surface friction induced by the low shrubs and chaparral of the area is minimal.

Table 1. The Maximum Extreme Normal Wind Component Values (kt) and the Mean Normal Wind Component Values (kt) for Both Towers During the Same 8-Month Period of Record.

	NORTH				SOUTH			
	TOWER 300		TOWER 301		TOWER 300		TOWER 301	
	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN
12 FT	19.5	5.4	26.0	9.8	22.0	4.2	45.0	7.7
54 FT	26.5	6.3	30.0	12.2	23.0	4.9	45.0	8.0
102 FT	27.4	7.3	30.9	12.9	22.0	5.4	44.0	7.8
204 FT	27.6	7.4	35.0	12.8	23.0	5.5	44.0	7.3
300 FT	37.3	8.4	36.9	14.1	24.7	7.6	45.0	8.3

	EAST				WEST			
	TOWER 300		TOWER 301		TOWER 300		TOWER 301	
	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN
12 FT	12.0	3.2	35.3	4.7	11.9	4.1	14.7	4.3
54 FT	15.8	4.1	25.8	4.9	14.7	4.6	15.7	4.6
102 FT	17.2	4.7	23.9	6.2	15.6	3.3	17.8	5.7
204 FT	16.9	5.1	24.6	9.0	15.4	4.9	27.0	7.5
300 FT	52.0	5.0	20.5	4.7	48.5	6.2	17.9	4.5

Conclusion

Results from the extreme-value statistics indicate that winds greater than 60 kt will occur at Tower 300 within a 10-year return period. Even though the mean normal wind speeds for the four principle directions at Tower 301 are slightly larger than those calculated for Tower 300, the towers are similar enough to justify applying the extreme-value statistics of Tower 300 to Tower 301. Thus, at Tower 301, strong winds exceeding 60 kt will most likely occur during the winter season from the south and the east.

For winds less than 40 kt the vertical wind profiles at both towers were generally explained by the turbulent boundary layer power-law profile equation. Winds greater than 40 kt overcame the effect of surface friction, resulting in excessive winds at all levels.

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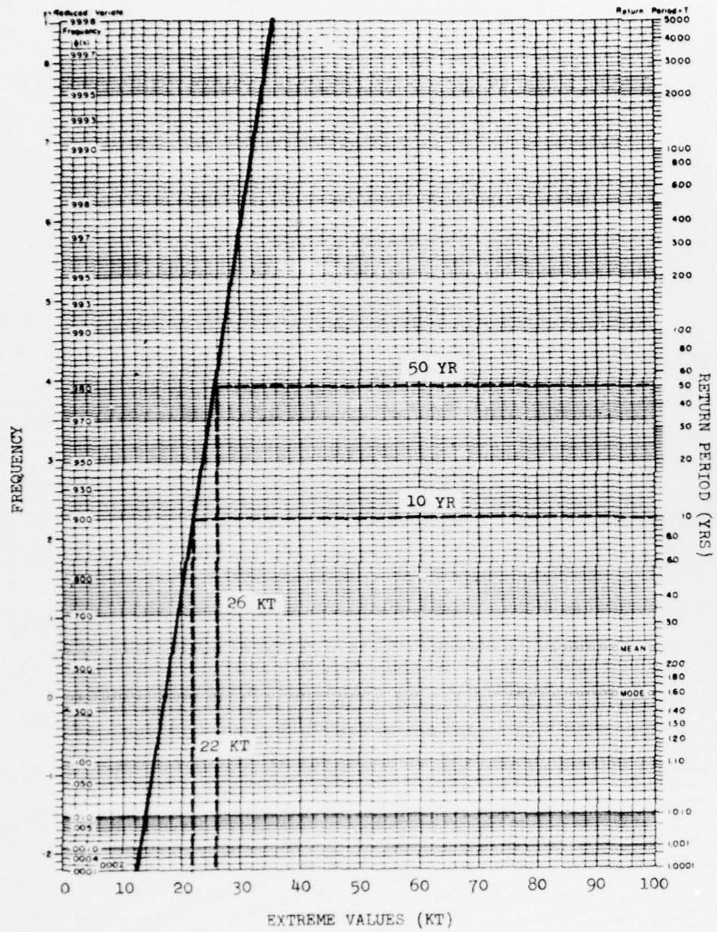

Figure 2a. Probability Graph for Tower 300: North, 12 Ft.

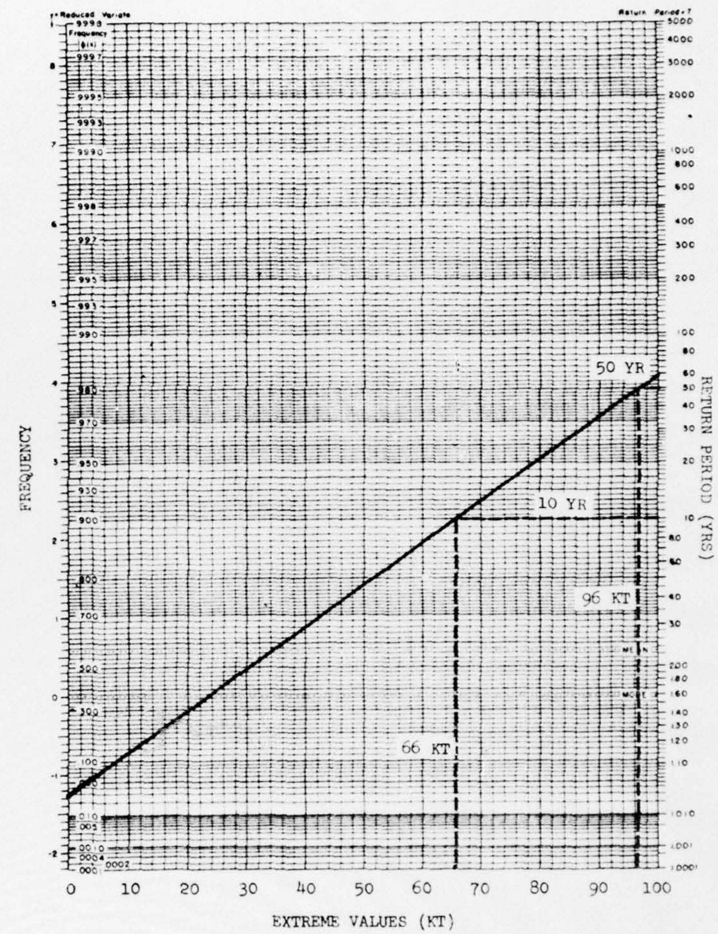

Figure 2b. Probability Graph for Tower 300: South, 12 Ft.

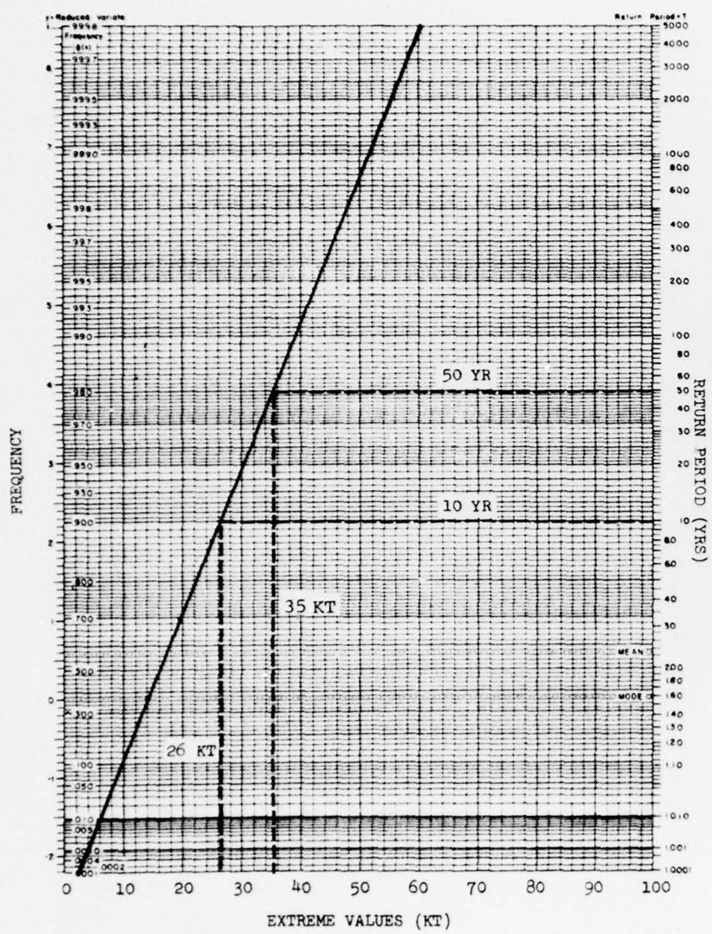

Figure 2c. Probability Graph for Tower 300: East, 12 Ft.

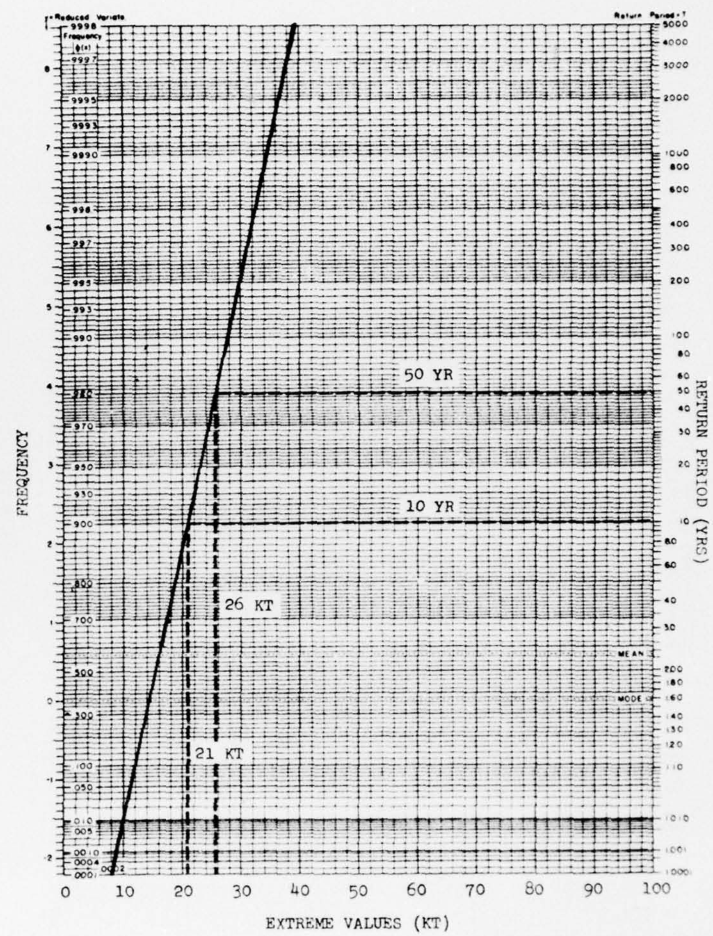

Figure 2d. Probability Graph for Tower 300: West, 12 Ft.

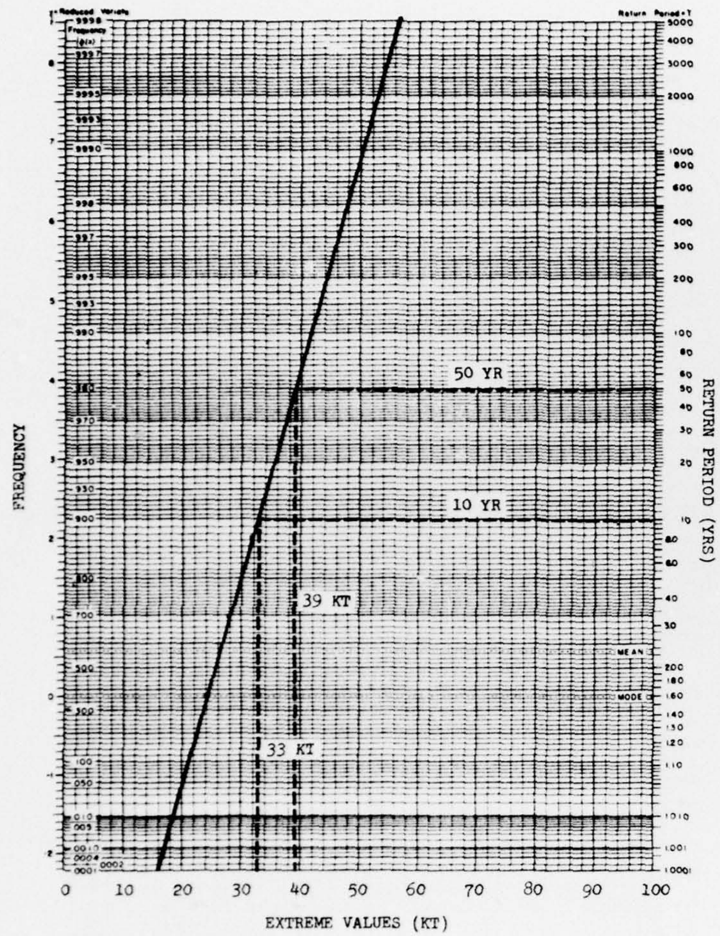

Figure 3a. Probability Graph for Tower 300: North, 54 Ft.

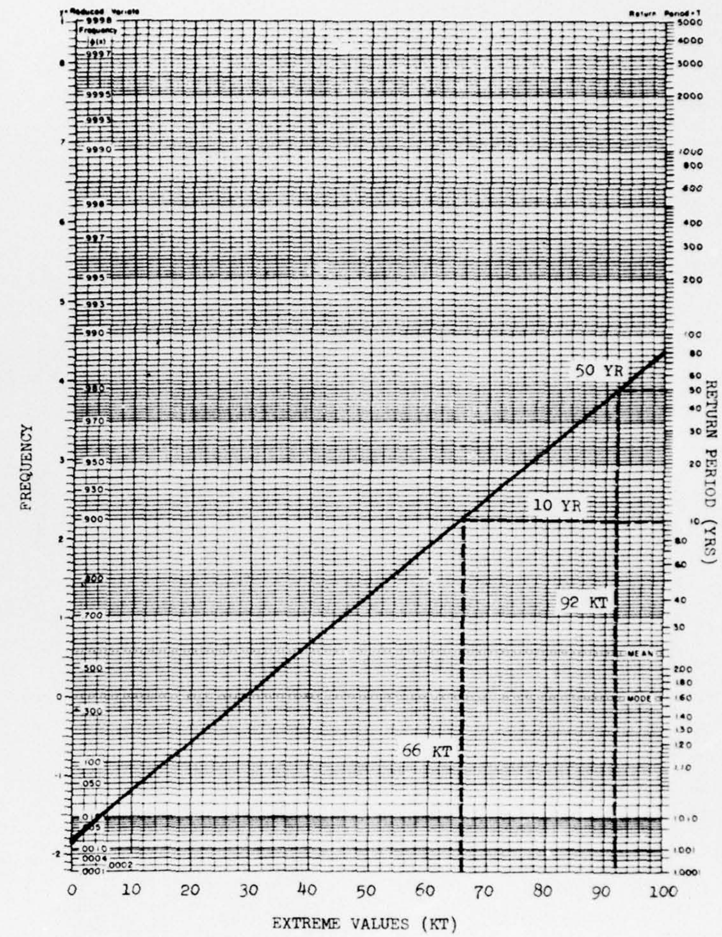

Figure 3b. Probability Graph for Tower 300: South, 54 Ft.

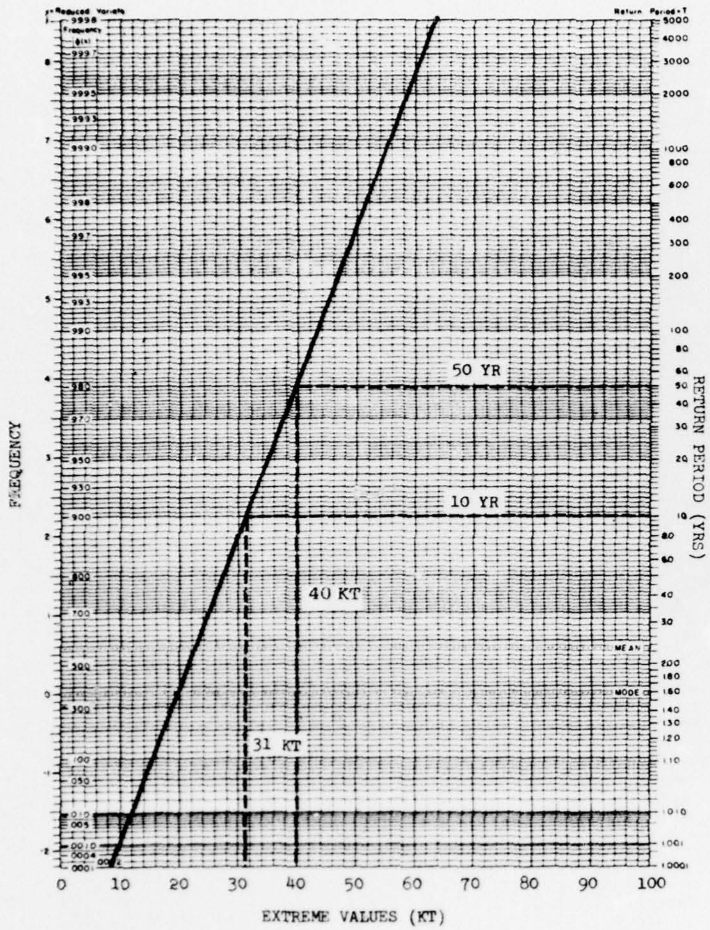

Figure 3c. Probability Graph for Tower 300: East, 54 Ft.

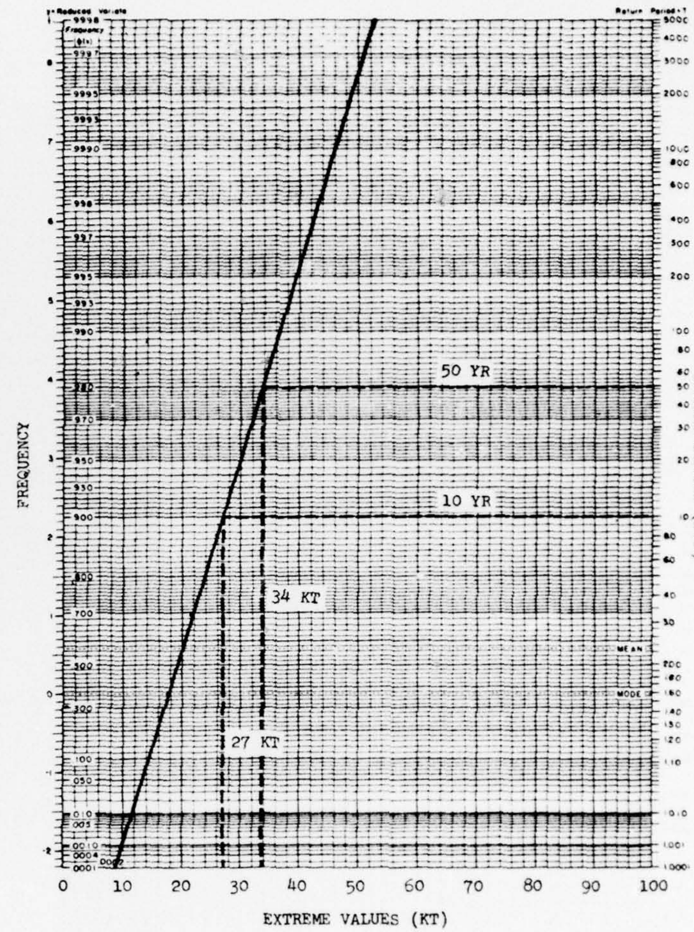

Figure 3d. Probability Graph for Tower 300: West, 54 Ft.

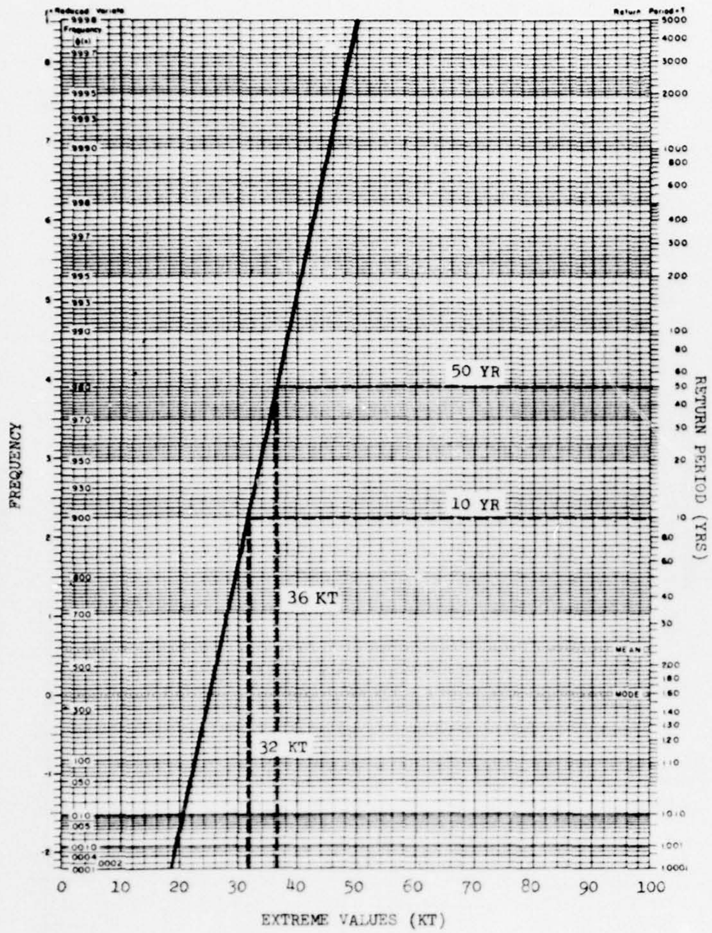

Figure 4a. Probability Graph for Tower 300: North, 102 Ft.

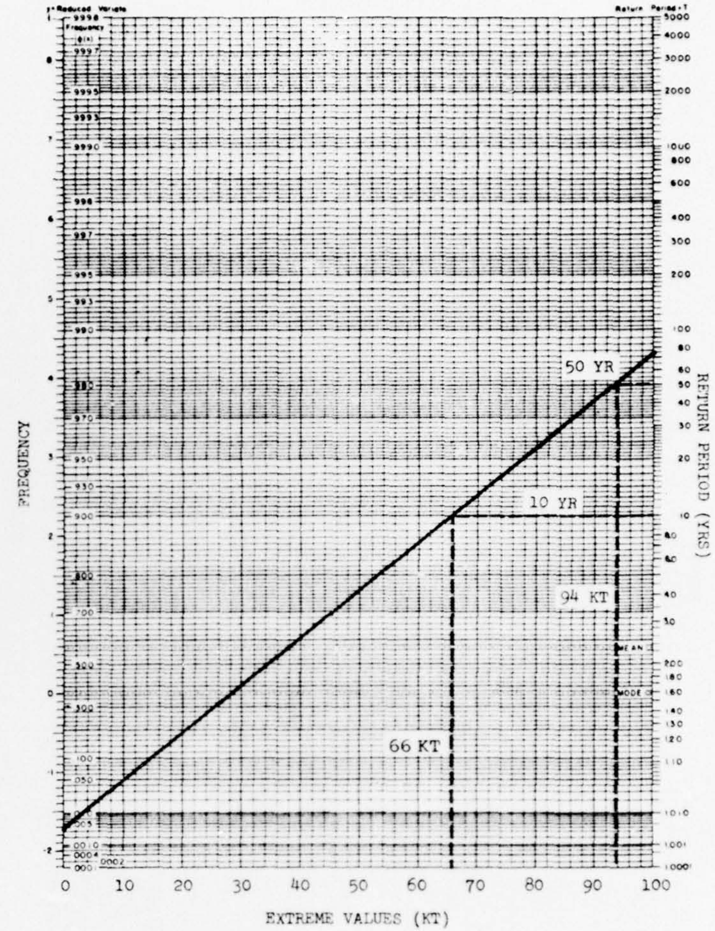

Figure 4b. Probability Graph for Tower 300: South, 102 Ft.

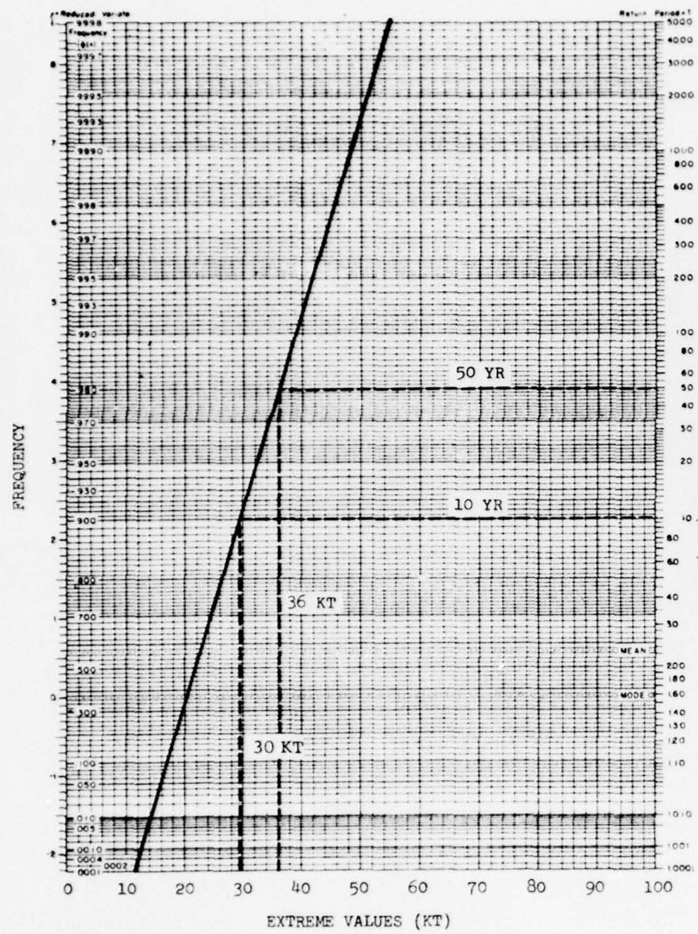

Figure 4c. Probability Graph for Tower 300: East, 102 Ft.

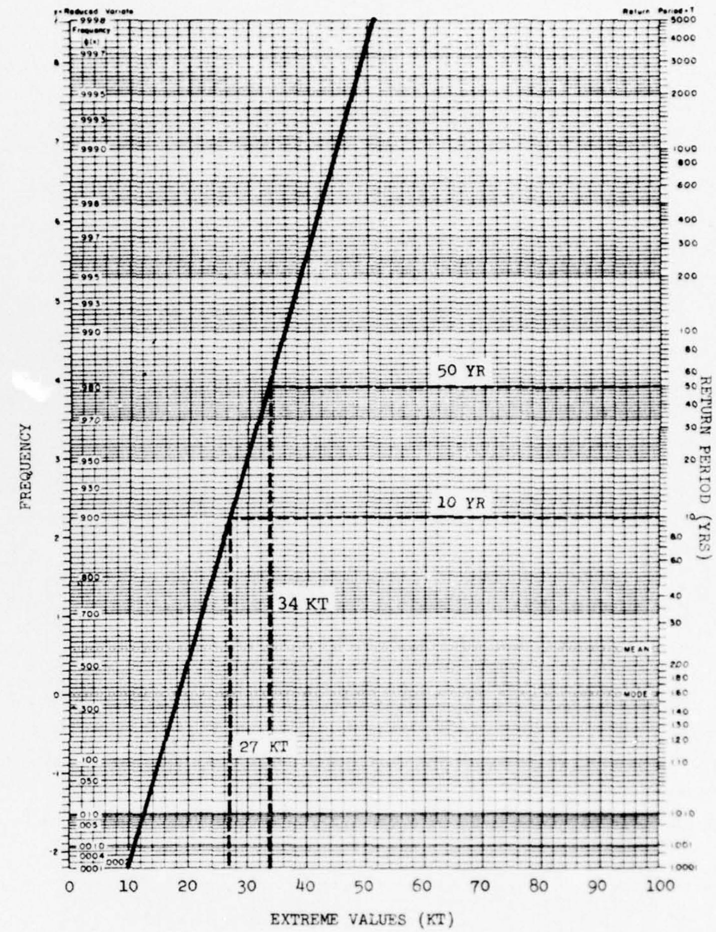

Figure 4d. Probability Graph for Tower 300: West, 102 Ft.

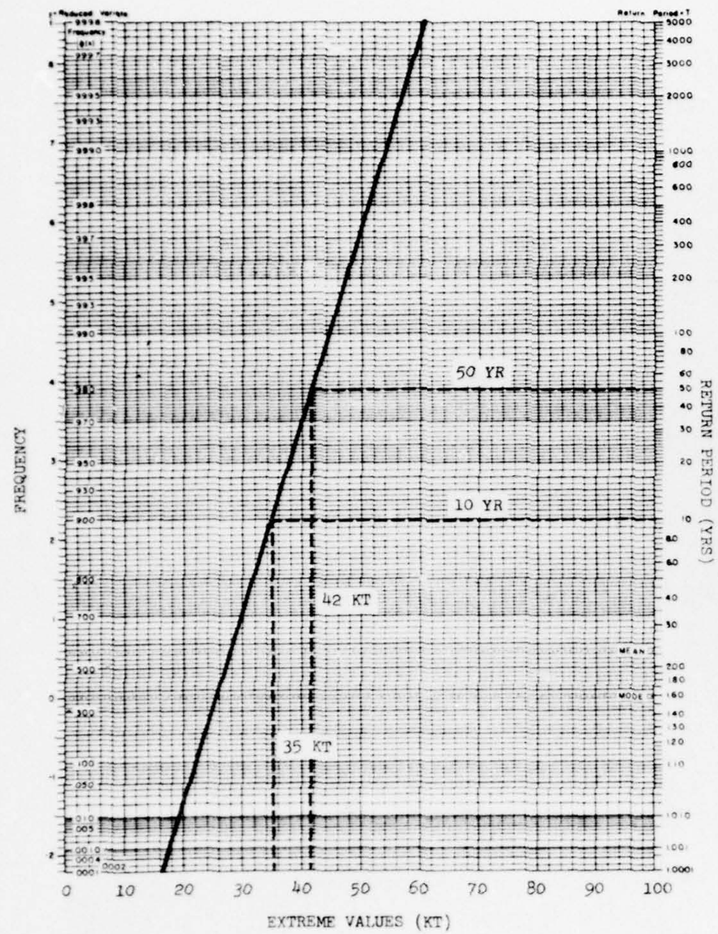

Figure 5a. Probability Graph for Tower 300: North, 204 Ft.

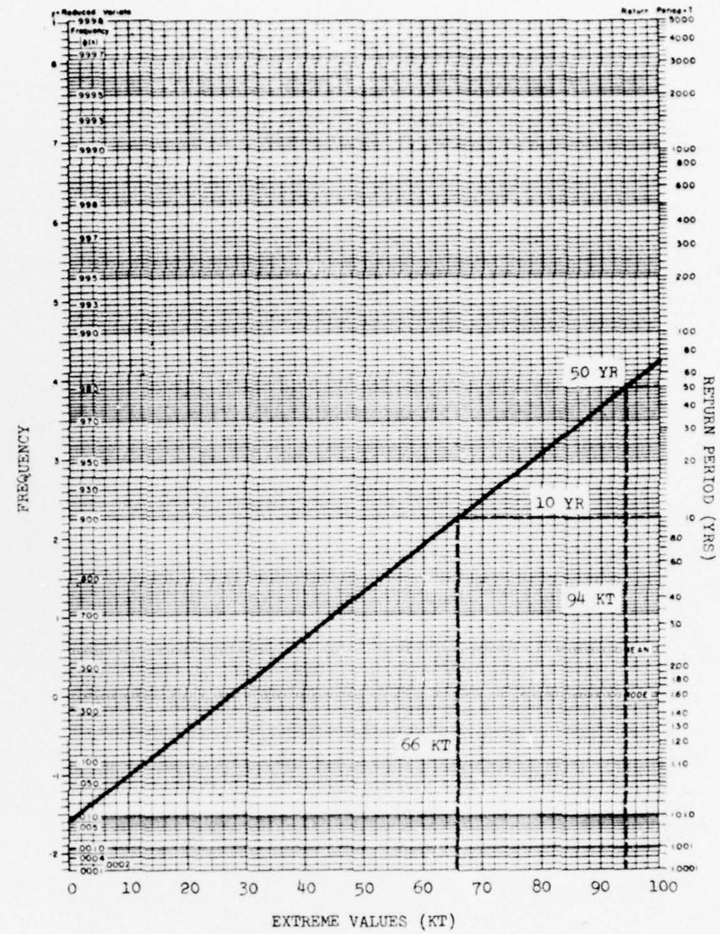

Figure 5b. Probability Graph for Tower 300: South, 204 Ft.

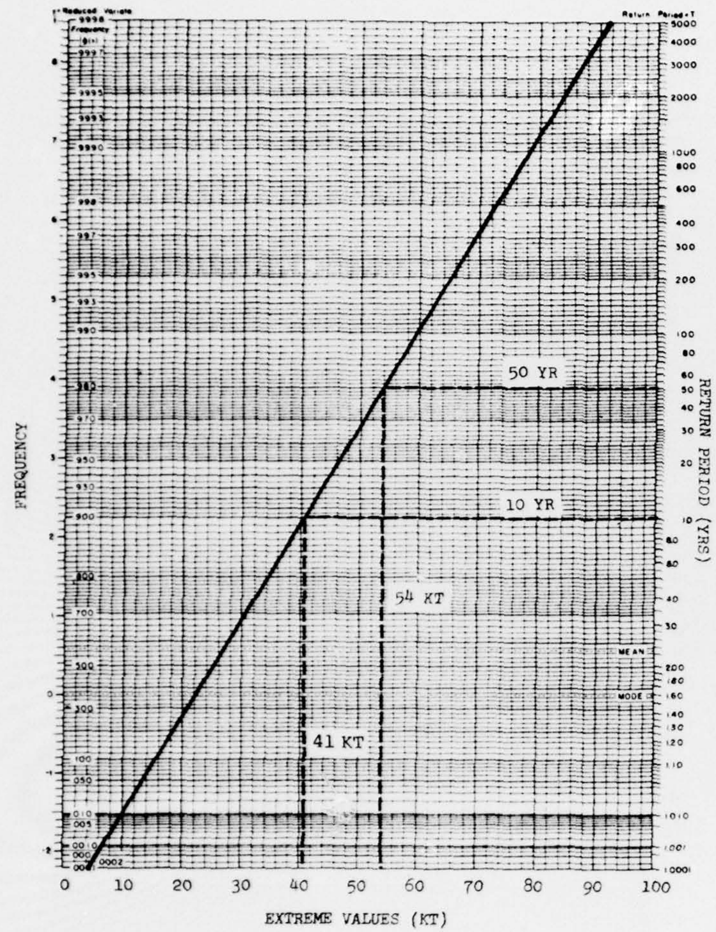

Figure 5c. Probability Graph for Tower 300: East, 204 Ft.

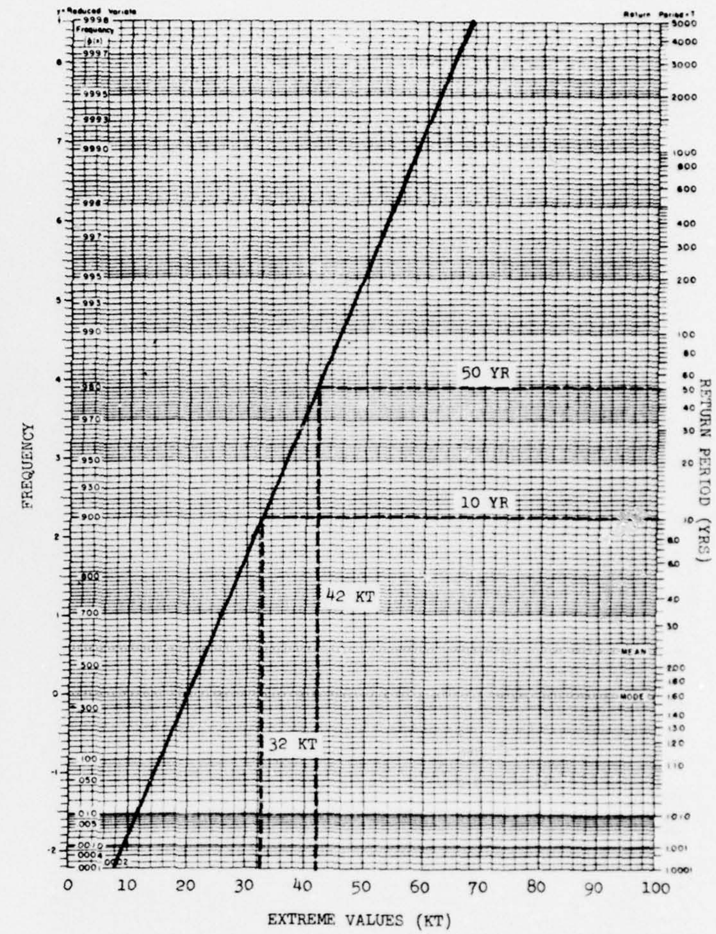

Figure 5d. Probability Graph for Tower 300: West, 204 Ft.

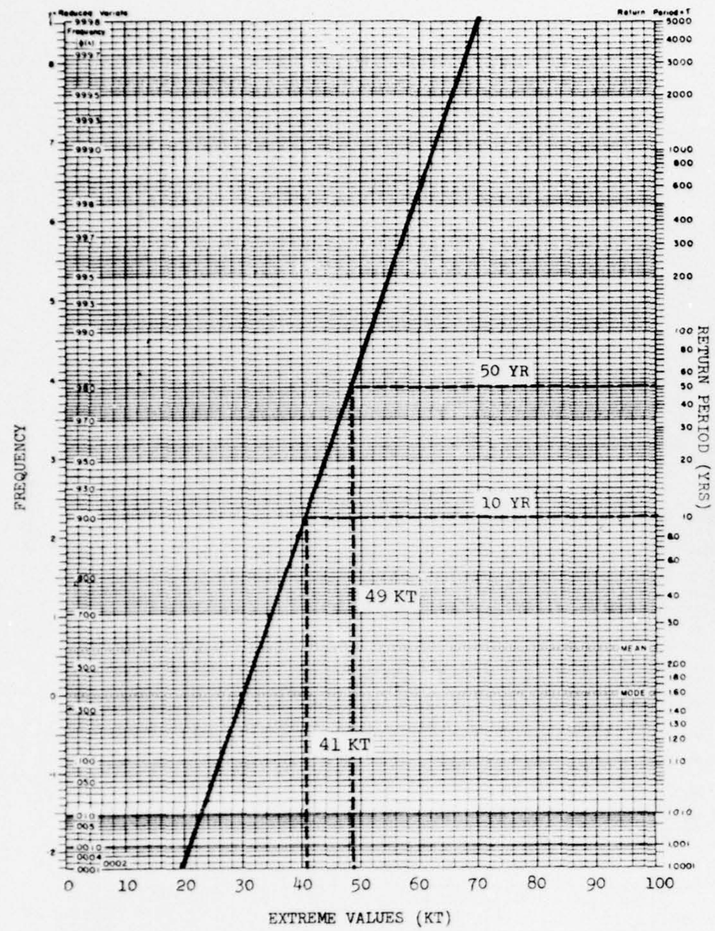

Figure 6a. Probability Graph for Tower 300: North, 300 Ft.

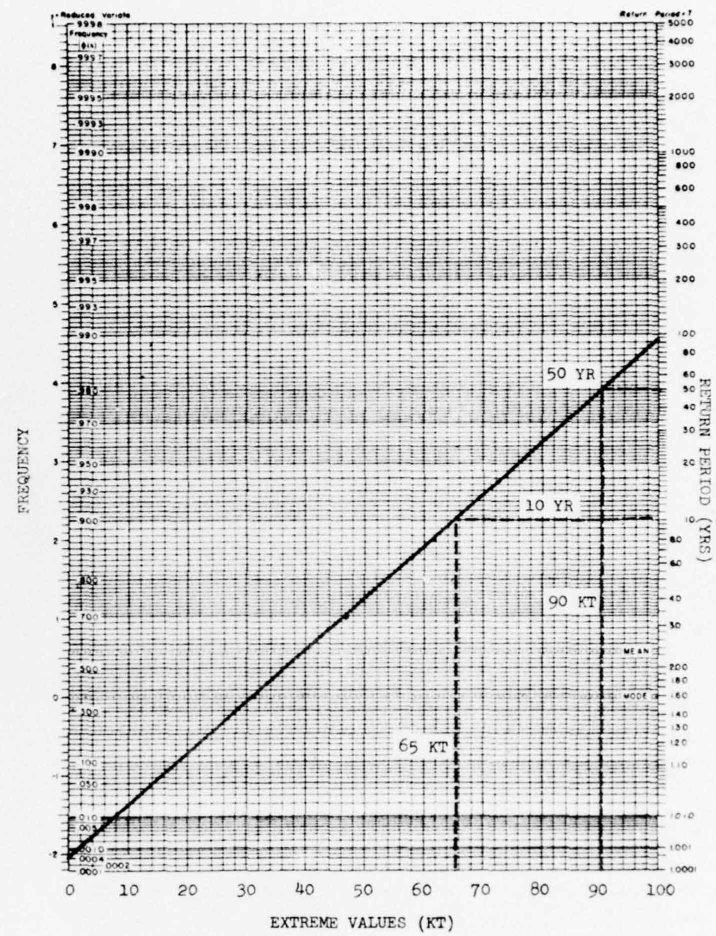

Figure 6b. Probability Graph for Tower 300: South, 300 Ft.

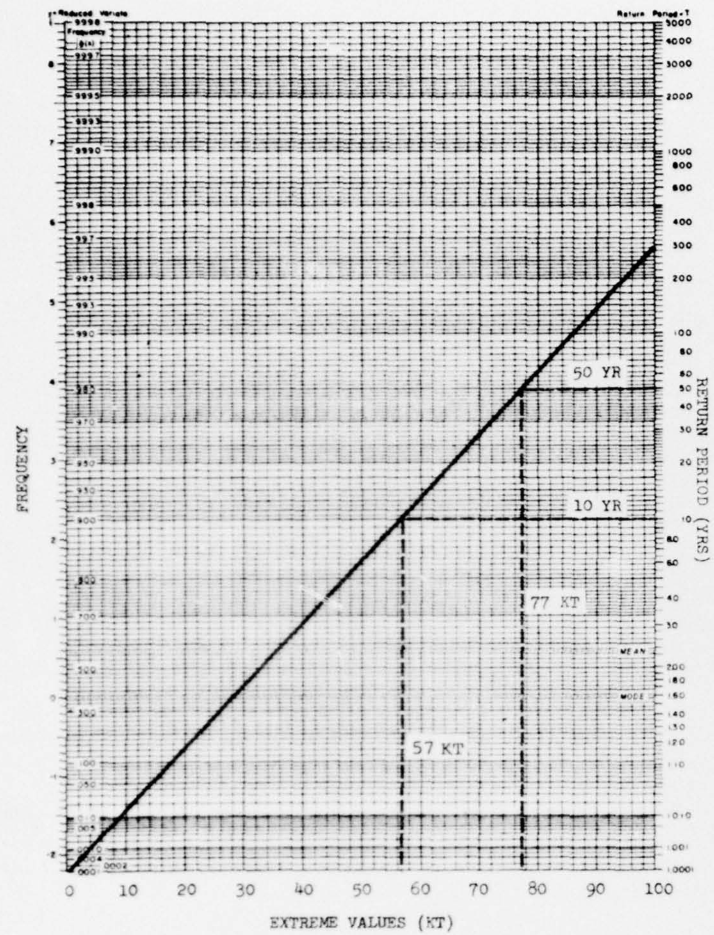

Figure 6c. Probability Graph for Tower 300: East, 300 Ft.

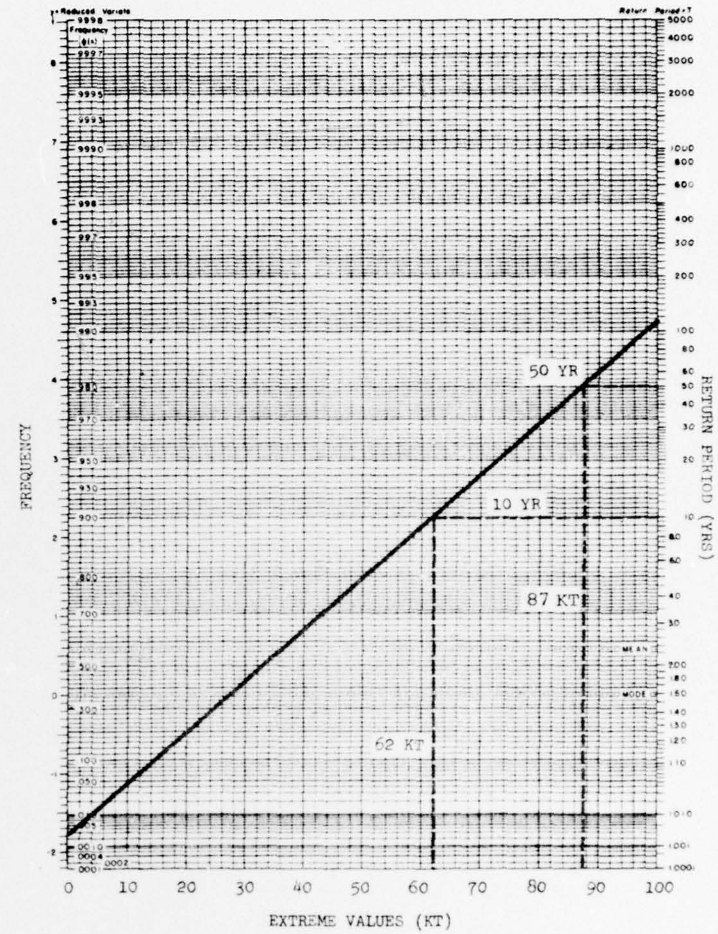

Figure 6d. Probability Graph for Tower 300: West, 300 Ft.